SUSTAINABLE ENERGY FOR ALL

REPOBLIKAN'I MADAGASIKARA
Fitiavana - Tanindrazana - Fandrosoana

MADAGASCAR

Integrated Energy Access Planning

CLEAN COOKING

JUNE 2024

IN PARTNERSHIP WITH:

Global Energy Alliance for People and Planet

OPEC FUND for International Development

Photo: WFP

INTEGRATED ENERGY PLANNING TOOL

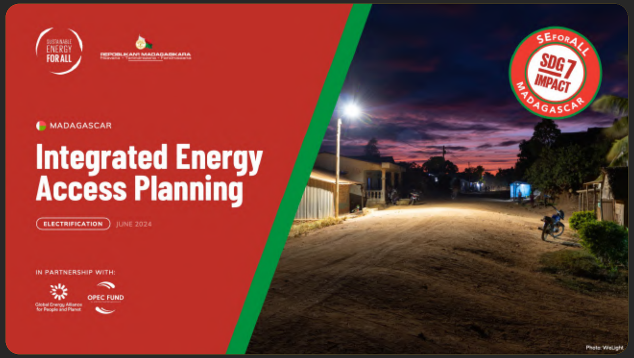
EXPLORE THE RESULTS FOR YOURSELF

madagascar-iep.sdg7energyplanning.org

ANY QUESTIONS:

uiep@seforall.org

Other reports in this series



Madagascar – Electrification Summary Report

This summary report covers the least-cost electrification pathways for Madagascar to reach universal electrification. It provides actionable spatial intelligence on technological options and energy end-uses that can contribute to decision-making for the public sector, donors, and private and civil society organisations.

DOWNLOAD HERE →

Madagascar – Cold Chain Summary Report

This summary report includes the results of cold chain capacity utilization and assessment, facility energy needs assessment and recommendations for effective cold chain management for both the medical and agricultural sectors in Madagascar.

DOWNLOAD HERE →

ℹ The full-length technical reports for all components of the Madagascar IEP are available for download here

Photo: Africa GreenTec

Acknowledgements

This document was drafted by Sustainable Energy for All (SEforALL), with support from MECS and the consultancy teams at NRECA International, Arizona State University, D-GRID Energy, Fraym, JSI and AIDES. The Madagascar IEP was developed in close collaboration with the Ministry of Energy and Hydrocarbons (MEH), the Rural Electrification Development Agency (ADER), JIRAMA, and the Office of Electricity Regulation (ORE), as a part of a programme funded by the Global Energy Alliance for People and the Planet (GEAPP) and the OPEC Fund for International Development.

The Madagascar IEP was overseen by the Energy Planning Unit, with additional guidance and input from the National Clean Cooking Working Group. The project was supported by focal points from the Ministry of the Environment and Sustainable Development (MEDD), Ministry of Agriculture and Livestock (MINAE), Ministry of Industry and Commerce (MIC), the Ministry of Fisheries and the Blue Economy (MPEB), and the Ministry of Public Health (MSanP).

We would like to warmly thank government stakeholders from INSTAT, Ministry of Economy and Finance, and other ministries and public entities for their input and support, as well key development partners that provided data and feedback throughout the project including AfDB, EU, FCDO, GIZ, UNIDO, UNDP, USAID, World Bank, WFP and others.

Finally, we would like to thank the private sector, civil society, and research organizations that contributed to the development of the IEP by sharing data, experiences, and planning needs. These include AfricaGreenTec, ANKA, CIRAD, Project Gaia, WeLight, WWF, and others.

POWERED BY:

SUSTAINABLE ENERGY FOR ALL

FUNDED BY:

Global Energy Alliance for People and Planet

OPEC FUND for International Development

IN PARTNERSHIP WITH:

MEH

O.R.E Office de Régulation de l'Électricité

Agence de Développement de l'Électrification Rurale

JIRAMA

Acronyms

ADER	Rural Electrification Agency/Agence de Développement de l'Electrification Rurale
AfDB	African Development Bank
ARELEC	Regulatory Electrification Authority (Autorité de Régulation de l'Electricité)
ESMAP	Energy Sector Management Assistance Program (World Bank)
FNE	National Electricity Fund (Fond National de l'Electricité)
FNED	National Sustainable Energy Fund (Fonds National de l'Énergie Durable)
GIS	Geographic Information System
GoM	Government of Madagascar
IEP	Integrated Energy Access Plan
INSTAT	National Office of Statistics (Institut National de la Statistique)
HV	High Voltage
JIRAMA	Jiro sy rano malagasy is the Malagasy public electric utility
LEAD	Least-Cost Electricity Access Development Project
LPG	Liquefied petroleum gas
LV	Low Voltage
MECS	Modern Energy Cooking Services
MEH	Ministry of Energy and Hydrocarbons (Ministère de l'Energie et des Hydrocarbures)
MPAE	Ministry in Charge of Agriculture and Livestock (Ministère auprès de la Présidence en charge de l'Agriculture et l'Elevage)
MTF	Multi-tier framework
MV	Medium Voltage
NEP	New Energy Policy/Nouvelle Politique de l'Energie
ORE	Electricity Regulatory Authority/Office de Régulation de l'Electricité
PV	Photovoltaic
SEforALL	Sustainable Energy for All
SSS	Standalone solar system
UN	United Nations

Clean cooking – The challenge in numbers

CHALLENGES:

- < 12 % of Madagascar's population used clean cooking technologies or improved cookstoves as of 2020, with just 1% of households and 4% of institutions using modern energy cooking solutions like LPG, electricity or alternative biofuels
- >80% of rural households use fuelwood for cooking
- >60% of urban households use charcoal for cooking
- Without action, 36 million people are estimated to lack access to clean cooking solutions by 2030

IMPACTS:

- Health: 21,000 deaths every year due to indoor air pollution in Madagascar
- Deforestation: 25% forest is expected to be lost by 2030. While 80–90% is due to agriculture, the remaining amount is attributable to wood and charcoal use by households and institutions for cooking, heating water and productive uses.
- Gender: the burden of cooking commonly falls to women including fuel collection and purchase; apart from negative health effects, there is a considerable time burden, sometimes consuming a third to half of the day for fuel collection, food preparation, cooking and serving food, and cleaning

PERSPECTIVES:

- Clean alternative cooking fuels include electricity (e-cooking), LPG, bioethanol, biogas, biomass pellets or briquettes and solar
- The Government of Madagascar is working to develop a comprehensive clean cooking policy and is actively working with partners to support the development of clean cooking value chains

Photo: Anka Madagascar

Clean cooking methodology overview

The Madagascar IEP undertook an holistic analysis of Madagascar's clean cooking sector by:

- Synthesizing primary data from a clean cooking survey with secondary data from public reports to create a comprehensive picture of clean cooking in Madagascar for the situation in 2023
- Quantifying estimated production potentials and availability for 7 different fuel types (fuelwood, charcoal, electricity, LPG, biogas, bioethanol, biomass pellets/briquettes) for each of the 1,579 communes and municipalities in Madagascar
- Describing cooking- and technology-use patterns, quantifying stove-ownership rates, quantifying usage rates of 7 fuels across 15 different cooking stoves, with differences identified and disaggregated by region, by urban or rural location, and by type of customer (household or institution)
- Developing two prospective scenarios through 2030 based on cooking, bioenergy development and electrification targets set out in Madagascar's New Energy Policy (2015–2030) and its National Energy Compact (2022) for the baseline scenario and on more ambitious SDG7 targets for the universal scenario.
- Completing scenario analysis of clean cooking transition pathways using information on energy potential, consumer preferences, barriers to adopting clean cooking solutions, costs of cookstoves, fuel collection practices, costs of fuel and cookstove production/procurement requirements
- Quantifying clean cooking costs associated with stoves and fuels for each scenario and the affordability gap that must be bridged between what customers can pay and the price of clean cooking technologies
- Emphasizing co-benefits of clean cooking to women and youth by quantifying impacts to health, time spent cooking and time spent collecting fuel
- Identifying co-benefits of clean cooking to reduce deforestation and GHG emissions from cooking, and improve energy security for households and institutions in Madagascar
- Providing a geospatially explicit analysis of the opportunity space and challenges to transitioning to clean and cleaner cooking across the two modelled scenarios

The analysis provides explicit national geospatial scenario-based forecasts to 2030 for the clean cooking technologies (stoves and fuels) needed to ensure access to clean energy for all. Both household and institutional cooking were modelled in the analysis.

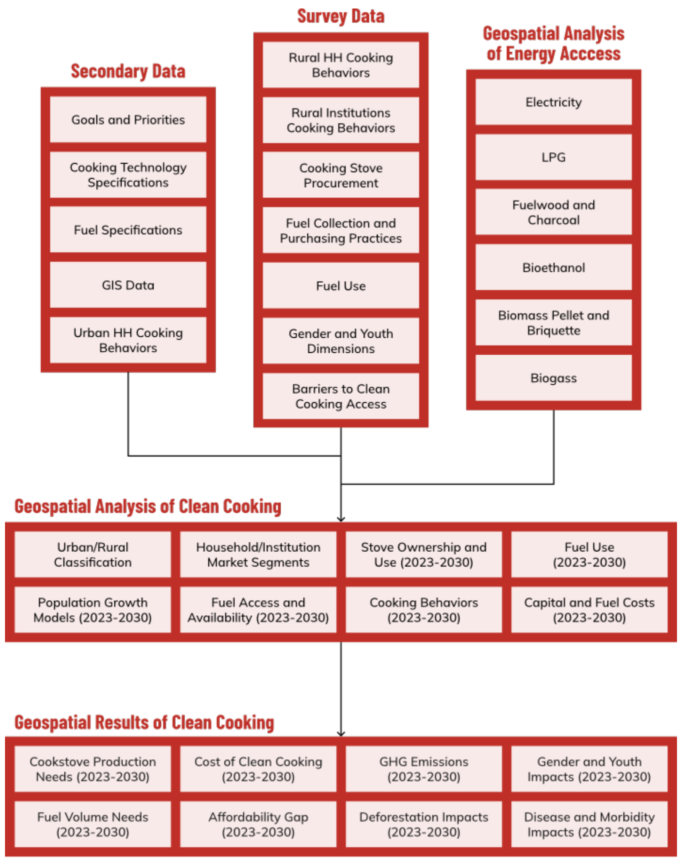


Figure 1: IEP clean cooking methodology overview

Primary data collection

A clean cooking survey was carried out in June–July 2023 to evaluate patterns of stove ownership and use in rural communities in Madagascar.

With a sample size exceeding 1,500, the surveys targeted three distinct zones in the country (northern, central and southern) to assemble a representative sample. Survey participants were selected from randomized housing structures to achieve a survey sample with a 95% confidence interval and 5% error rate. Each survey sample included residential, commercial and public facility consumers (health centres and schools).

In addition to stove ownership and use, the survey also included information on cookstove procurement, fuel collection and purchasing practices, fuel use, barriers to access, gender, time-use considerations and stove use for household or informal business revenue generating activities, among others.

Figure 2: Survey results: Cooking stove and fuel type by MTF Tier

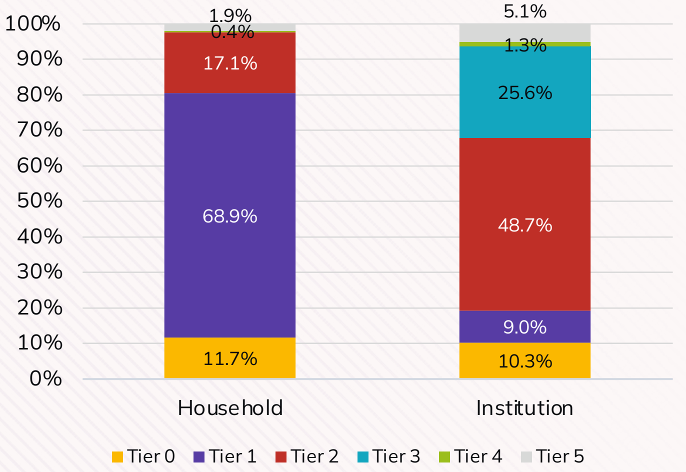
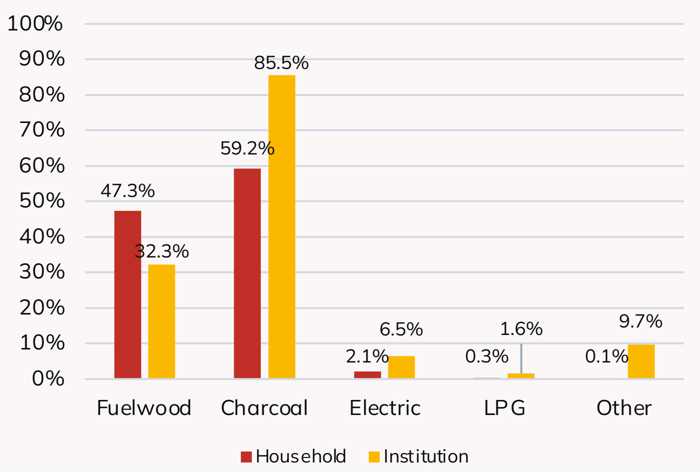
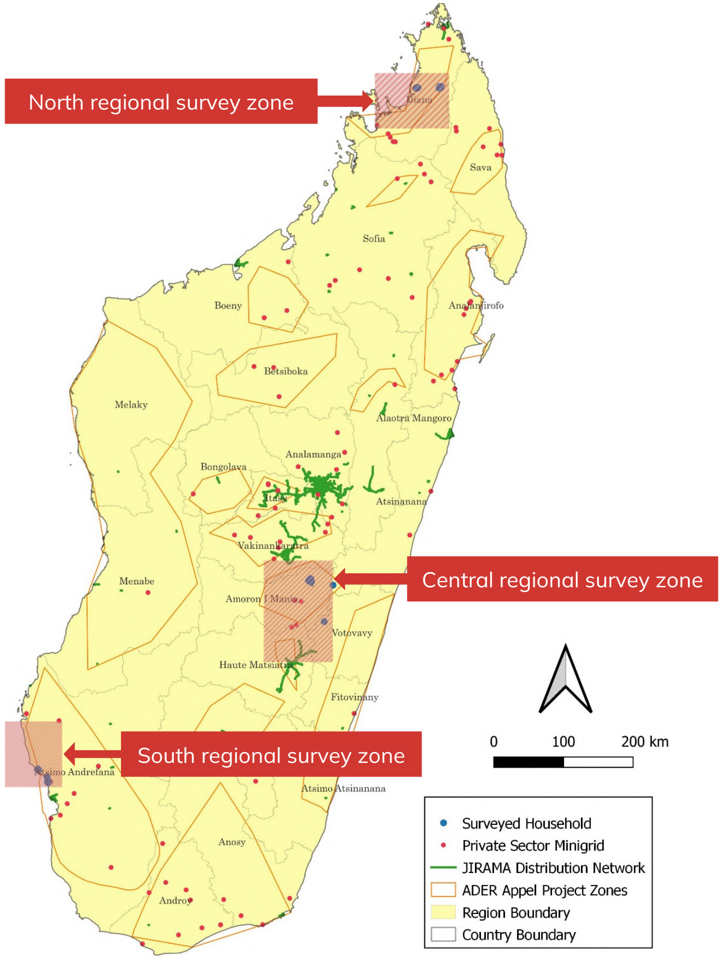


Figure 3: Survey results: Cooking fuel type





Map 1: Survey Locations for Energy Expenditure Surveys

Cookstove and fuel assumptions

Table 1: Cooking technologies observed in Madagascar and corresponding data

FUEL (STOVE)	PRICE ($)	LIFETIME (Y)	EFFICIENCY (%)	MTF RATING
Fuelwood (3-stone)	0.10	1	14%	0
Fuelwood (basic)	1.19	2	25%	1
Fuelwood (improved)	1.73	5	27%	2
Fuelwood (basic institutional)	6.68	10	30%	2
Fuelwood (improved institutional)	9.71	10	35%	3
Charcoal (basic)	3.29	1	10%	1
Charcoal (improved)	4.77	2	24%	2
Charcoal (basic institutional)	12.88	5	25%	2
Charcoal (improved institutional)	18.72	5	30%	3
Briquette/pellet (single burner)	20.00	4	35%	3
Biogas (stove top and oven)	84.00	3	44%	4
Bioethanol (dual burner)	24.50	3	52%	4
LPG (stove top and oven)	92.00	6	56%	4
E-cooking (rice cooker)	15.00	6	45%	5
E-cooking (hot plate)	18.20	2	62%	5
E-cooking (induction)	40.00	6	90%	5

Cookstove costs, lifetime and efficiency are applied to existing stoves present in the market and new stoves being added to the market in the scenario analysis. These are generalized values representative of some common technologies and should not be considered to reflect all vendor technologies. Fuel parameters use globally accepted values for clean cooking analysis. Fuel prices reflect a mix of primary data collected during this study for rural areas and secondary data from reports on urban areas; where data are unavailable a 1:1 scaling for urban and rural prices is used.

Table 2: Cooking fuels observed in Madagascar and corresponding data

FUEL	ENERGY VALUE (MJ / KG)	CO2E EMISSIONS FACTOR (KG / KG_FUEL)	REFERENCE
Fuelwood	18.41	1.775	Clean Cooking Alliance (2019)
Charcoal	31.98	3.662	Jetter and Kariher (2009)
Briquette/pellet	16.75	2.409	Mlotha (2019)
Biogas	22.65	1.476	Decker et al. (2018) with 60% methane
Bioethanol	22.80	1.943	Energypedia (2023)
LPG	45.00	3.242	Benka-Coker et al. (2018)
Electric	N/A	0.520 (per kWh)	Randrianarison et al. (2022) for Antananarivo region

Table 3: Cooking fuels observed in Madagascar and corresponding price

FUEL	PRICE RURAL ($ / UNIT)	PRICE URBAN ($ / UNIT)	UNIT	REFERENCE
Fuelwood	0.03	0.06	kg	IEP cooking survey, SEforALL (2023), urban scaling twice rural price
Charcoal	0.08	0.16	kg	IEP cooking survey, SEforALL (2023)
Briquette/pellet	0.42	0.84	kg	Matek et al. (2020), urban scaling twice rural price
Biogas	0.74	Not used	kg	Matek et al. (2020)
Bioethanol	1.04	1.04	liter	SEforALL (2023)
LPG	1.65	1.65	kg	SEforALL (2023)
Electric	0.13 (grid connected) 0.50 (mini-grid)		kWh	Madagascar IEP electrification component


Photo : WFP

Scenario development

The Madagascar IEP developed modelling based on two scenarios of clean cooking adoption to 2030.

Baseline scenario: This scenario assumes that Madagascar reaches the 2030 targets set by national policy and the SDG7 Energy Compact prepared by the Ministry of Energy and Hydrocarbons (MEH). Key targets include: access to improved cookstoves for 50% of households; use of fuels of biological origin for 20% of households; and adoption of clean cooking solutions for 2.5 million households

Universal access scenario: This scenario reaches more aggressive targets for cleaner cooking technologies and fuels, assuming a full transition to modern energy cooking services for both households and institutions by 2030 in line with SDG7. In terms of stove and fuel mix, this scenario emphasizing e-cooking in areas where this solution is deemed market ready, followed by bioethanol and then other fuels.

The tables below present the current repartition of fuels and stoves, as well as the 2030 targets for each scenario, for both households and institutions at a national level. Scenarios were further detailed to show the difference between urban and rural consumer categories and modelled individually for each group.

Table 4: Household fuel and stove targets for modeling scenarios (Baseline and Universal Access)

	%			COUNT		
	2023	2030 BASELINE SCENARIO	2030 UNIVERSAL SCENARIO	2023	2030 BASELINE SCENARIO	2030 UNIVERSAL SCENARIO
SINGLE STOVE OWNERSHIP						
Firewood (3-stone) - Total	13.8%	1.1%	0.0%	1,349,813	114,055	-
Firewood stove - basic - Total	20.8%	1.6%	0.0%	2,041,094	172,645	-
Firewood stove - improved - Total	7.0%	20.9%	0.0%	691,203	2,186,432	-
Charcoal - basic - Total	31.4%	2.5%	0.0%	3,078,563	260,128	-
Charcoal - improved - Total	19.5%	25.5%	0.0%	1,909,092	2,671,453	-
Bruquette/pellet - Total	0.0%	2.0%	12.7%	-	209,392	1,332,516
Biogas - Total	0.1%	2.0%	12.7%	5,245	209,392	1,332,516
Bioethanol - Total	0.0%	16.0%	38.2%	-	1,675,133	3,997,548
LPG - Total	0.3%	2.4%	2.4%	32,363	250,000	250,000
Electric - hot plate - Total	0.2%	9.6%	0.0%	23,067	1,000,000	-
Electric - induction plate - Total	0.0%	9.6%	27.1%	-	1,000,000	2,835,869
MULTIPLE STOVE OWNERSHIP						
Fuelwood- basic + Charcoal - basic	2.1%	0.9%		207,631	94,226	
Fuelwood-improved + Charcoal - improved	2.8%	3.6%		271,360	376,905	
Fuelwood basic + Electric hotplate/ricecooker	0.5%			53,934		
Fuelwood improved + Electric induction plate/ricecooker	0.5%	1.2%	3.4%	47,388	125,000	360,566
Charcoal basic + Electric hotplate/ricecooker	0.5%			53,934		
Charcoal improved + Electric induction plate/ricecooker	0.5%	1.2%	3.4%	47,388	125,000	360,566

Table 5: Institutional fuel and stove targets for modeling scenarios (Baseline and Universal Access)

	%			COUNT		
	2023	2030 BASELINE SCENARIO	2030 UNIVERSAL SCENARIO	2023	2030 BASELINE SCENARIO	2030 UNIVERSAL SCENARIO
SINGLE STOVE OWNERSHIP						
Firewood (3-stone) - Total	2.1%	0.0%	0.0%	1,517	-	-
Firewood stove - basic - Total	6.2%	0.0%	0.0%	4,528	-	-
Firewood stove- improved	1.6%	0.0%	0.0%	1,162	-	-
Firewood stove - basic - institutional	2.9%	0.0%	0.0%	2,098	-	-
Firewood stove - improved - institutional	2.5%	4.0%	0.0%	1,807	3,003	-
Charcoal - basic - Total	0.0%	0.0%	0.0%	-	-	-
Charcoal - improved - Total	1.6%	0.0%	0.0%	1,162	-	-
Charcoal - basic - Institutional	34.2%	0.0%	0.0%	25,187	-	-
Charcoal - improved - Institutional	16.5%	26.3%	0.0%	12,144	19,946	-
Briquette/pellet - Total	0.0%	0.0%	0.0%	-	-	-
Biogas - Total	0.0%	0.0%	0.0%	-	-	-
Bioethanol - Total	0.0%	20.0%	42.3%	-	15,168	32,061
LPG - Total	1.5%	2.4%	2.4%	1,106	1,811	1,811
Electric - hot plate - Total	2.0%	9.6%	0.0%	1,471	7,244	-
Electric - induction plate - Total	0.0%	9.6%	27.1%	-	7,244	20,542
MULTIPLE STOVE OWNERSHIP						
Fuelwood - basic + Charcoal -basic	1.5%	0.0%	0.0%	1,079	-	-
Fuelwood -improved + Charcoal - improved	6.0%	7.3%	0.0%	4,426	5,505	-
Fuelwood - basic + Charcoal -basic (Institutional)	11.6%	0.0%	0.0%	8,547	-	-
Fuelwood -improved + Charcoal - improved (Institutional)	8.0%	19.1%	0.0%	5,906	14,453	-
Fuelwood -improved + Electric induction plate/ricecooker	0.0%	0.0%	7.1%	-	-	5,356
Charcoal basic + Electric hotplate/ricecooker	0.8%	0.8%	0.0%	598	598	-
Charcoal improved + Electric induction plate/ricecooker	1.2%	1.1%	21.2%	869	869	16,068

Cooking fuels and technologies : electricity for cooking

Electricity access data provided by the electrification component to IEP analysis categorize customers as being connected to a grid, having access to a mini-grid or a solar home system and having no access.

While e-cooking can be technically viable in multiple contexts, the IEP scenarios assumed e-cooking in grid-connected and large, dense MV mini-grids where solutions are most market ready and commercially viable.

At least in initial uptake phases, e-cooking is likely to be "stacked" or used in combination with other technologies. This is particularly true since some e-cooking appliances, such as an electric kettle or rice cooker, have specific uses. The IEP has modelled a stove-equivalent hot plate and induction plate and takes into account stove/appliance stacking behaviour that is common as users add modern technologies to their cooking technology mix.

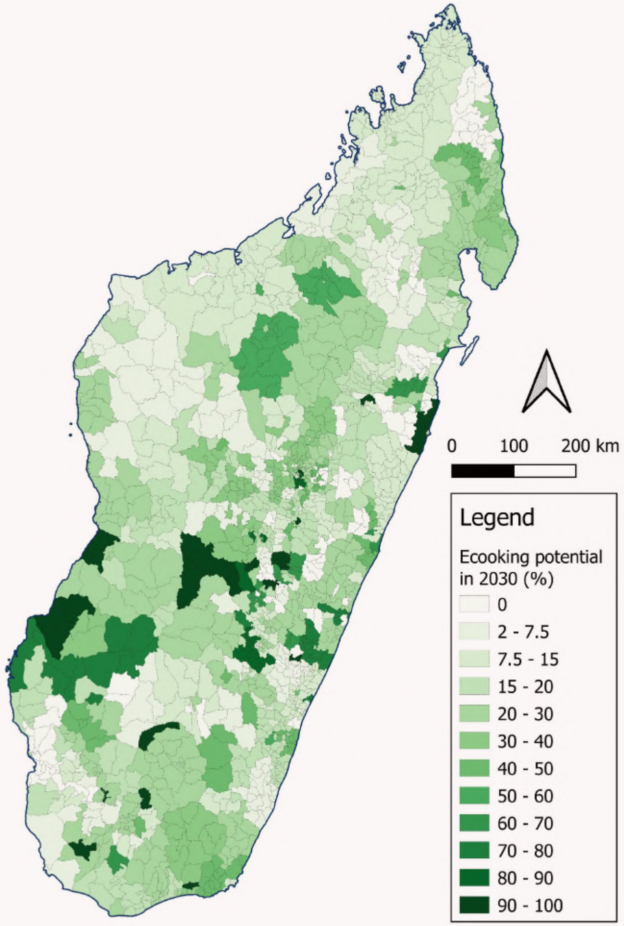
Table 6: Assumed constraints on e-cooking uptake through 2030

ELECTRIC COOKING MODELLED AS A FUEL OPTION (MAINS CONNECTION)	ELECTRIC COOKING NOT MODELLED AS A FUEL OPTION (ISOLATED CONNECTION)
• Existing JIRAMA grid-connected customers • Densification/Grid extension customers of JIRAMA networks (interconnected and isolated) • MV grid edge mini-grids	• Isolated MV mini-grids • LV mini-grids • Standalone solar system • No access

Table 7: Assumed e-cooking household energy consumption, assuming 100% of needs are met by this technology

STOVE TYPE	MJ/ YEAR	KWH/ YEAR	KWH/ MONTH	KWH/ DAY
Electric- hot plate (low efficiency)	4,003	1,112	91	3
Electric – induction plate (high efficiency)	2,778	772	63	2

Map 2: E-cooking potential in 2030



Cooking fuels and technologies: LPG for cooking

According to existing reports, less than 1% of households use LPG, and almost all of these users are in urban areas.

The LPG market in Madagascar is currently underdeveloped. Household consumption has remained relatively stable over the past 10 years, at around 0.2 to 0.3 kg per person.

A large proportion of current consumption is channelled to commercial and industrial uses including mining and industrial plants, roasting units, bakeries, hotels and restaurants.

In rural areas, it is unlikely that many households will switch to LPG from inexpensive fuels (firewood and charcoal) and less expensive clean fuels (pellets, bioethanol) if they are developed.

LPG supply is entirely imported to Madagascar via two import terminals. For this reason, no local LPG production potential is calculated in the IEP analysis, and the scenarios assume that Madagascar will be able to increase LPG imports to meet future demand.

Map 3 : LPG infrastructure (Source: Vakana 2023)

Cooking fuels and technologies: Wood and charcoal potential

The Madagascar IEP calculated the fuelwood potential of each forest type using land use and forest cover data. As shown in Map 4, most fuelwood potential in Madagascar is projected from dense forests located along the midwestern and northeastern coasts.

While households and institutions in rural areas use primarily fuelwood that is purchased or freely collected, charcoal is generally used to supply fuel to denser urban and peri-urban areas, and production tends to be concentrated in regions with higher fuelwood potential.

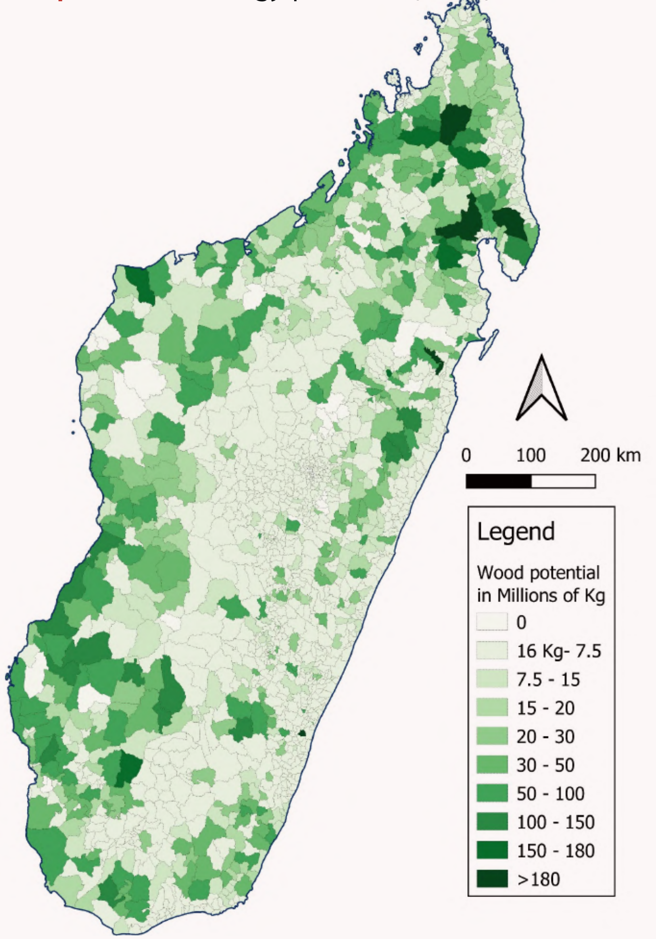
Kiln technology can have a significant influence on wood consumption needed to produce charcoal, and also affects the end quality and energy density of the end-product.

Charcoal is produced in Madagascar both lawfully and illicitly. Sustainable and regulated charcoal production is a priority and several efforts in Madagascar are examining the potential for dedicated plantations and alternative production methods or biomass feedstocks that reduce deforestation.

Table 8: Unconstrained wood energy potential based on land use and tree cover data

FOREST TYPE		SUM OF AREAS (HA)	WOOD DENSITY (KG PER HC)	WOOD ENERGY POTENTIAL (KG)
	Coastal forest	72,729	1,000	72,728,713
	Degraded forest	2,414,599	1,000	2,414,598,926
	Dense forest	9,116,015	2,000	18,232,030,149
	Reforested area	311,902	1,000	311,901,888
	Riparian forest	120,359	1,000	120,358,796
	Wooded savannah	17,707,977	47	839,144,604
	Grassy savannah	19,119,165	47	906,017,889
Total		**48,862,746**	**N/A**	**22,896,780,965**

Map 4: Wood energy potential (2023)



Cooking fuels and technologies: Bioethanol potential

Bioethanol can be produced from sugarcane, corn, rice, cassava, sweet potatoes and potatoes. All are grown in Madagascar. The preferred crops for ethanol production in Madagascar appear to be sugarcane, corn or manioc.

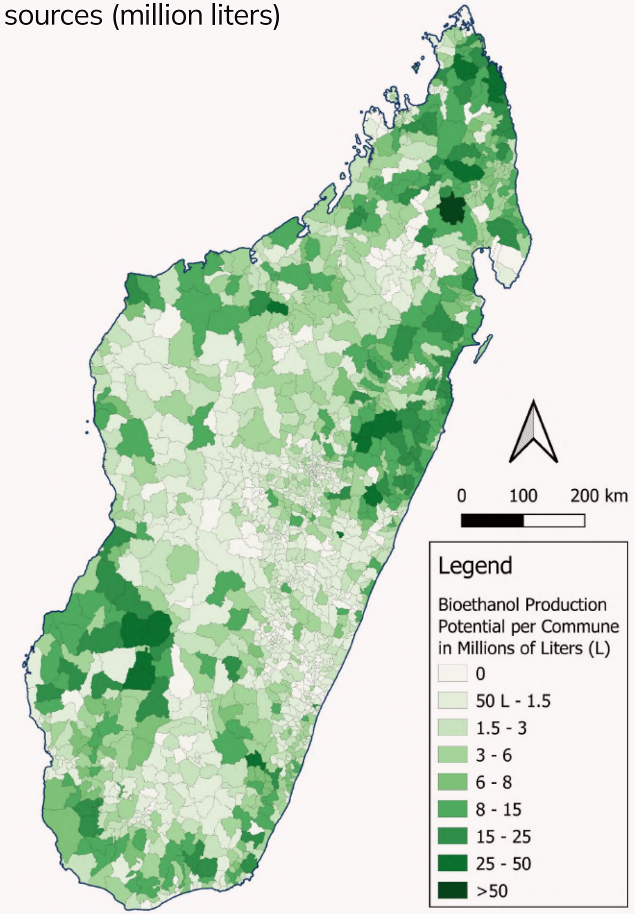
This study estimates the unconstrained production potential of all crops (maximum quantity if all crops were used) to show the upper limit of what is possible. It does not attempt to set an artificial limit, but informs and enables stakeholders to engage in a dialogue about the amount of crop production they wish to devote to ethanol production.

Crop production was estimated and spatialized based on national statistics, data obtained from FAOSTAT and USDA and land cover data. There were insufficient data to accurately forecast potential crop volumes to 2030, particularly given extended periods of drought, and thus a constant annual production volume was assumed for 2023 to 2030. For example, the production volumes for maize have been stable for the past 5 years but are half the production levels of 10 years ago.

Table 9: Unconstrained bioethanol production potential (assuming 100% of production used)

CULTURE	CROPS (TONS)	ETHANOL VOLUME (LITERS)	ENERGY VALUE OF ETHANOL (MJ)
Sugar cane	3,122,685	2,185,879,948	39,023,203,184
Corn	225,000	87,750,000	1,566,548,100
Rice	4,391,386	2,305,477,650	41,158,309,199
Cassava	2,439,642	1,219,821,000	21,776,732,420
Sweet potatoes	1,143,320	250,249,903	4,467,561,377
Potatoes	251,257	52,350,419	934,580,624
Total	**11,573,291**	**6,101,528,921**	**108,926,934,904**

Map 5: Potential for bioethanol production from all sources (million liters)



Cooking fuels and technologies: Biomass pellets and briquettes potential

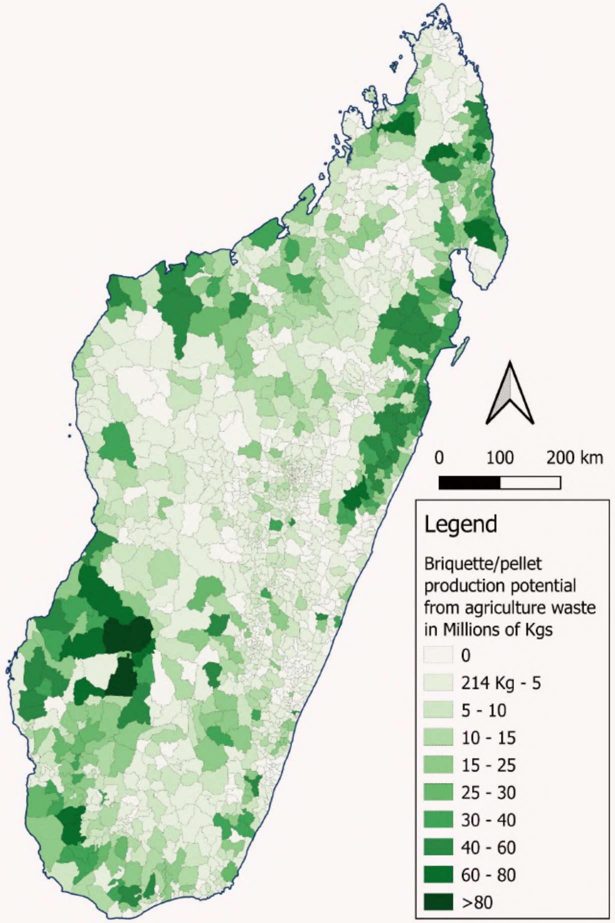
Agricultural waste can be collected and used to make compressed pellets and briquettes (for example, using the corn stalk rather than the corn kernel). Each crop has a different grain-to-waste ratio and a different grain-to-ethanol conversion rate. Data on sawdust waste from mills are not available and are not taken into account in the Madagascar IEP.

The modelled potentials represent the maximum amount of biomass pellet/briquette fuel that could be produced if all available agriculture waste was sourced and converted. Agriculture waste can be collected at farms or agro-processing facilities, and the cost and complexity of collection from many distributed sites could reduce potential for biomass pellet/briquette fuel significantly.

Table 10: Unconstrained biomass pellets and briquettes production potential

CULTURE	WASTE (TONNES)	ENERGY (MJ)
Sugar cane	2,654,282	39,234,852,321
Corn	418,500	2,827,003,032
Rice	8,167,977	55,175,384,607
Cassava	1,219,821	30,652,779,249
Sweet potatoes	285,830	14,365,197,286
Potatoes	62,814	3,156,915,165
Total	**12,809,226**	**145,412,131,660**

Map 6: Biomass production potential



Cooking fuels and technologies: Biogas potential

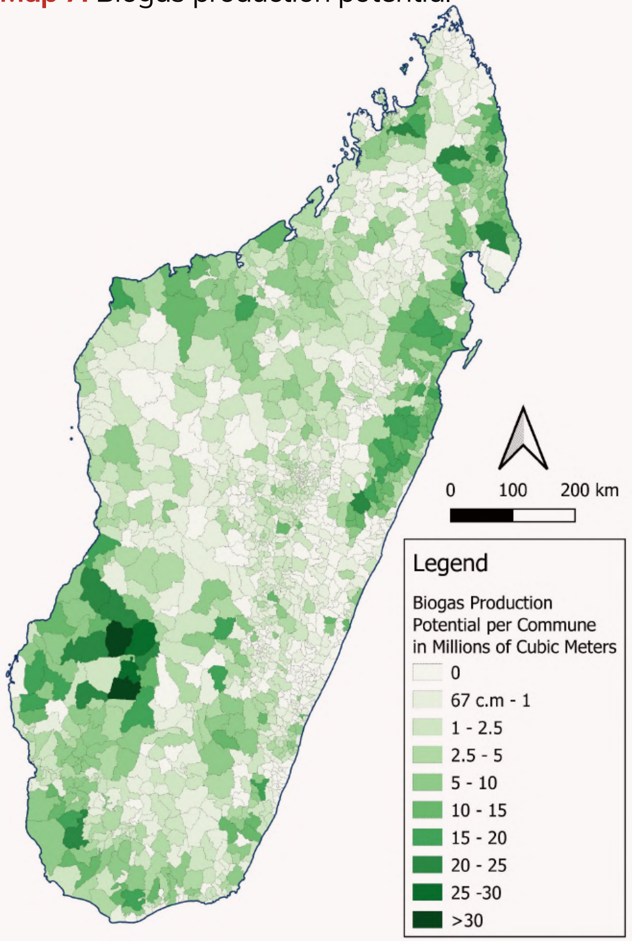
Biogas can be generated by the anerobic digestion of organic waste.

Biogas potential is calculated from livestock numbers, geospatial location of farmland, livestock-to-waste conversion factors and waste-to-biogas conversion factors, assuming that 100% of waste can be collected and converted. As for other fuels, logistical and commercial constraints will likely substantially reduce the actual production potential.

Table 11: Unconstrained biogas production potential

CULTURE	WASTE (TONNES)	ENERGY (MJ)
Livestock	3,626,648,256	144,115,748,397
Goats	45,905,934	1,824,210,022
Sheep	10,824,897	430,159,762
Pigs	184,388,144	7,327,216,065
Chickens	138,829,656	5,516,812,870
Total	**4,006,596,888**	**159,214,147,116**

Map 7: Biogas production potential



Scenario Results: Household stove ownership

The baseline scenario reduces ownership of solid-fuel stoves (firewood and charcoal) from 97.5% in 2023 to just 58.9% in 2030.

The universal scenario considerably improves on this target, reducing the rate of solid-fuel stove ownership to 6.4% in 2030. Similar results were calculated for institutional stove ownership and are presented in the full version of the report.

Figure 4: Baseline scenario stove ownership results for households

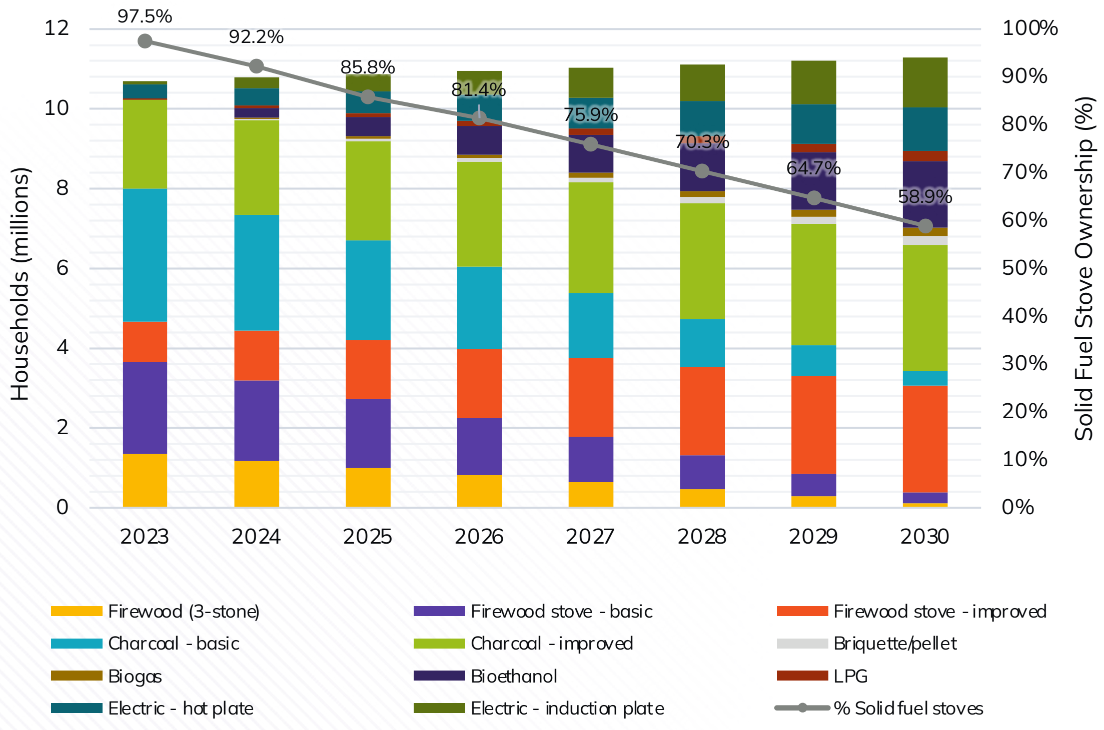
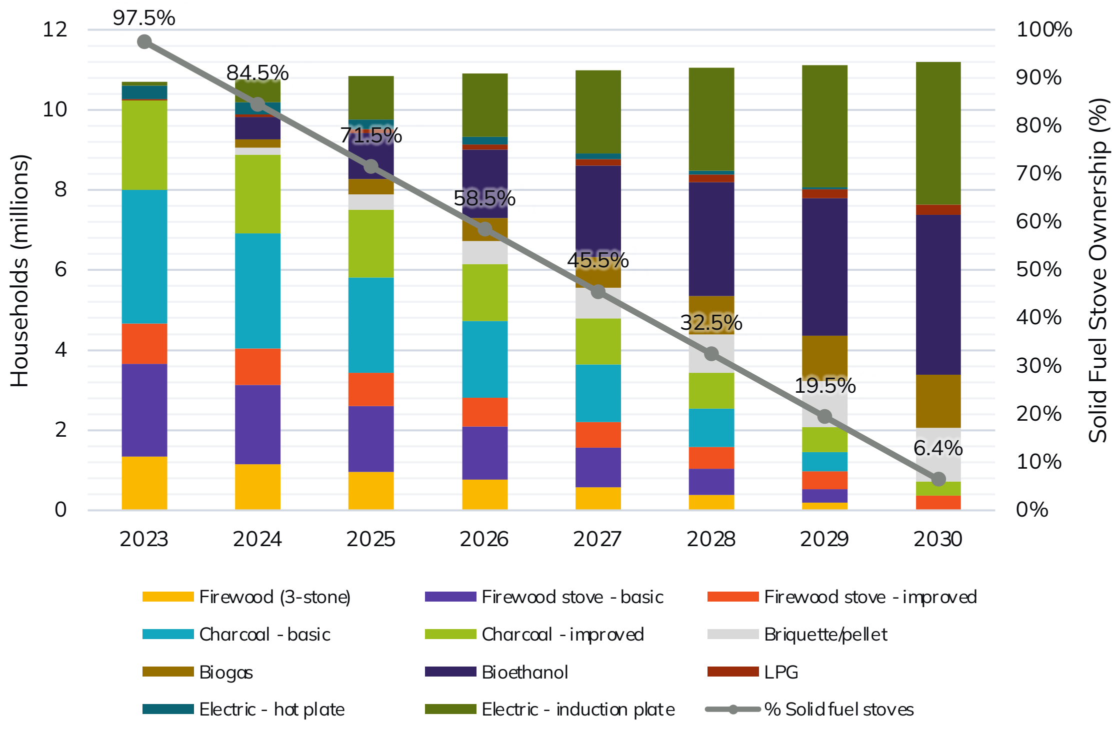


Figure 5: Universal scenario stove ownership results for households



Scenario Results: Biofuels demand

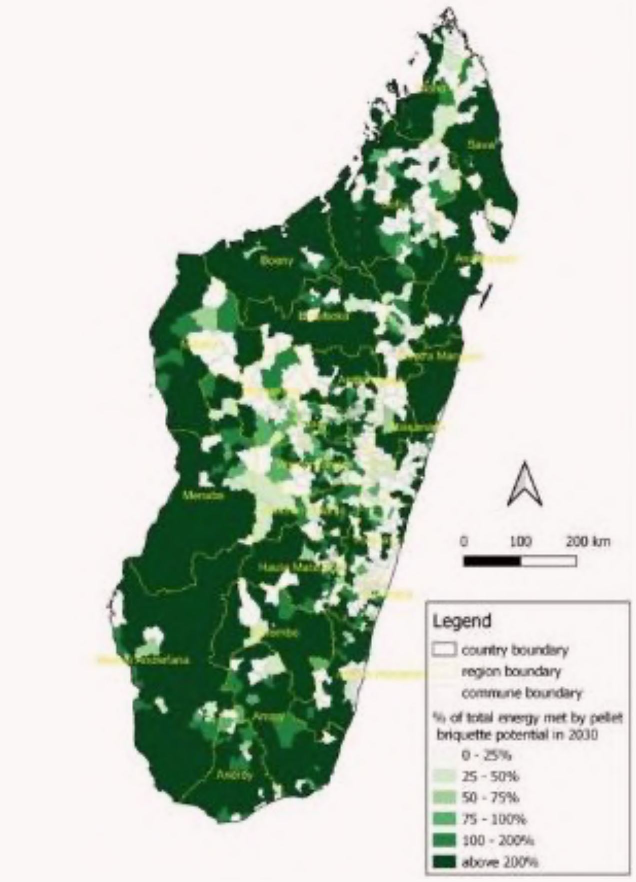
Based on stove ownership and use patterns projected in each scenario, the Madagascar IEP estimates the total production requirements for biofuels in MJ as well as a percentage of total unconstrained fuel potential.

Spatialized production potentials and demand forecasts also allowed for the visualization of localized market potentials. Map 8 at right shows an example of commune-level supply-demand balance calculations for biomass pellets and briquettes.

Table 12: Total biofuels demand and share of potential requirements

FUEL TYPE	2030 BASELINE DEMAND MJ 000,000 (% OF FUEL POTENTIAL)	2030 UNIVERSAL DEMAND MJ 000,000 (% OF FUEL POTENTIAL)	2030 UNCONSTRAINED FUEL POTENTIAL AS ENERGY MJ 000,000
Pellets/Briquettes	1,496 (1.03%)	9,518 (6.55%)	145,412
Biogas	1,203 (0.76%)	7,658 (4.81%)	159,214
Bioethanol	8,792 (8.07%)	20,816 (19.11%)	108,926

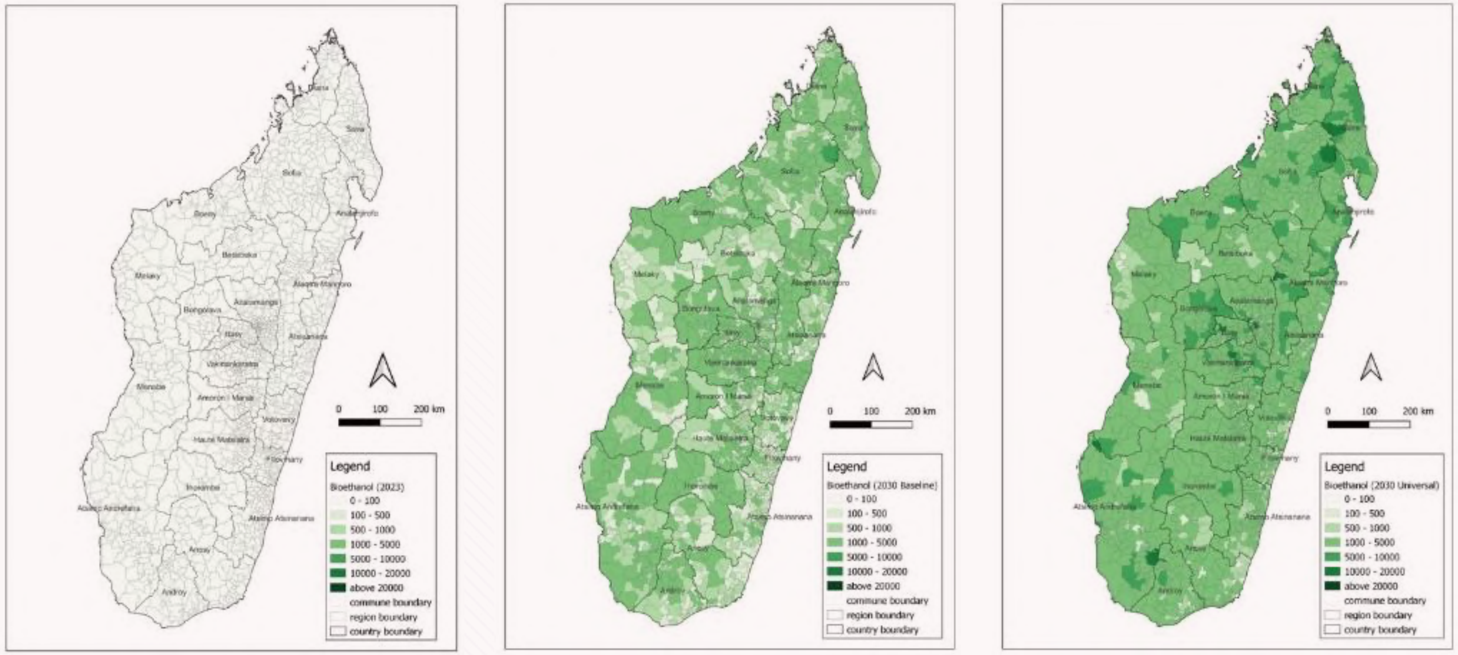
Map 8: Local biomass pellets/briquettes supply-demand balance (2030 baseline scenario)



Scenario Results: Geospatial household stove ownership

Geospatial projections for cooking equipment ownership were calculated for each group and for all consumer segments in both scenarios. Examples of the spatialized results for bioethanol stoves and efficient induction electric cookstoves for households are shown in this summary report.

Map 9: BIOETHANOL STOVES



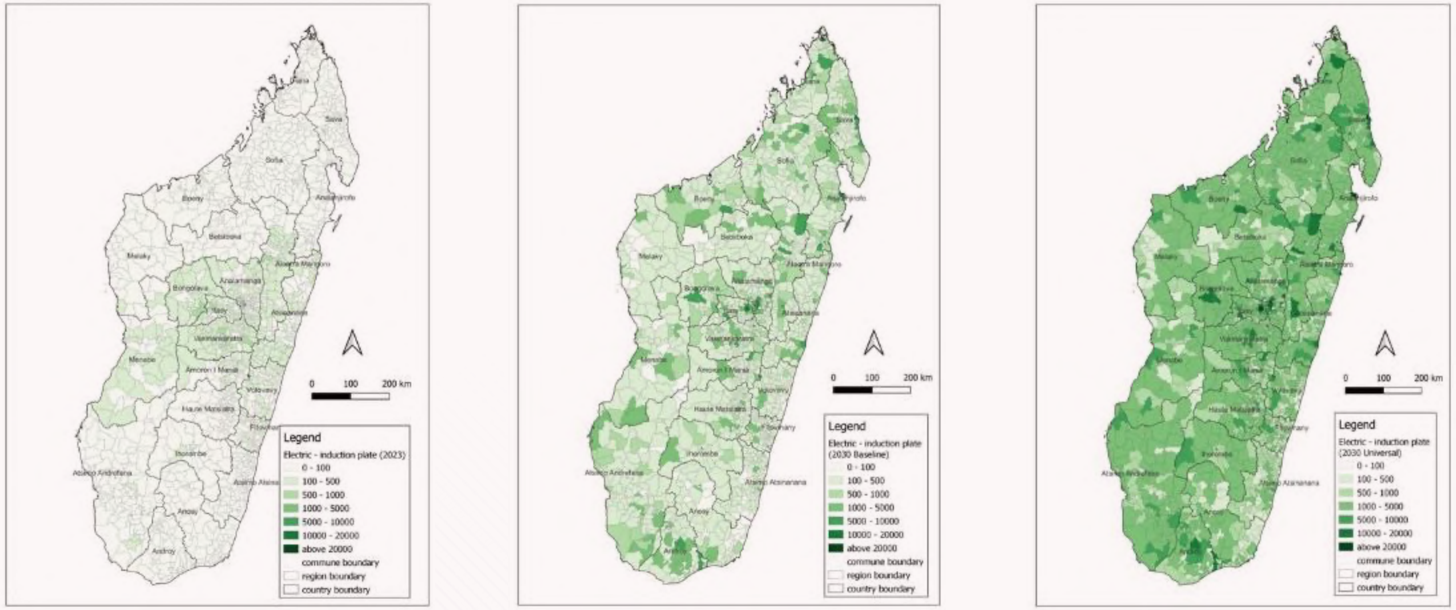
(2023) (baseline scenario 2030) (universal scenario 2030)

Bioethanol is expected to play an important role in both scenarios of clean cooking transition, with penetration across rural and urban consumer segments.

By 2030, Bioethanol stove ownership is expected to reach 1.6 million households (16% of household stoves) in the baseline scenario, and nearly 4 million households (38% of household stoves) in the universal scenario.

The location of bioethanol stove ownership does not take into account likely supply channels (which are outside the scope of this study).

Map 10: E-COOKING - INDUCTION STOVES



(2023) (baseline scenario 2030) (universal scenario 2030)

By 2030, e-cooking is expected to account for approximately 19% of the total household stove ownership mix in the baseline scenario and 27% of stove ownership in the universal scenario.

Efficient induction stoves will account for about half of total e-cooking appliances in the baseline scenario, and 100% in the universal scenario.

E-cooking will be concentrated in grid-connected areas, due to the lower expected energy costs compared to users connected via smaller, isolated mini-grids or solar home systems (SHS).

Scenario Results: Final energy consumption for cooking

Reaching the IEP scenario targets for clean cooking will reduce total final energy consumption for residential cooking by 35% in the baseline scenario and by 65% in the universal scenario from 2023 levels, accounting for projected population growth.

Similarly, per household energy final use will decline by 50% in the baseline scenario and by 69% in the universal scenario from 2023 levels.

These reductions are directly attributed to households switching from traditional solid fuel use to alternative fuels and stoves with higher efficiency, and from efficiency improvements in improved wood stoves over traditional stoves.

Similar improvements are observed in both scenarios for institutional and commercial cooking.

Figure 6: Total final energy consumption for residential cooking – baseline scenario

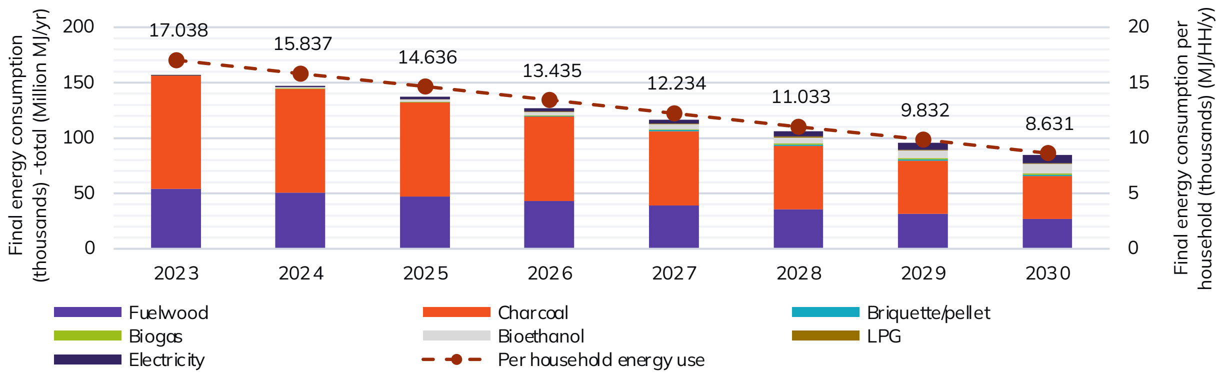
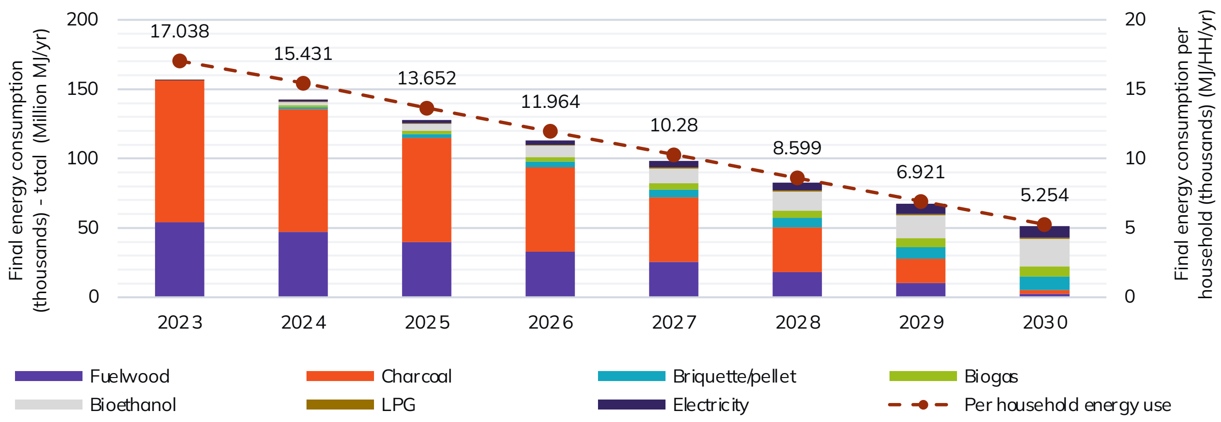


Figure 7: Total final energy consumption for residential cooking – universal scenario



Scenario Results: Clean cooking costs for users

The total estimated cumulative costs for stoves and fuel for the baseline scenario through 2030 are USD 12.7 billion; these rise to nearly USD 23 billion in the universal scenario, which assumes a more rapid switch to modern energy cooking technologies. These costs represent the costs borne by consumers, and exclude associated infrastructure or other costs associated with the transition, such as communication and community outreach. The per-unit stove and fuel cost from 2023 to 2030 is assumed static.

From a user perspective, fuel costs are the main factor in the transition to cleaner cooking, accounting for 97.1% of the cost of the transition. Efforts to subsidize the cost of acquiring stoves are useful, but the cost of fuel should also be addressed through policy measures to ease the transition for households.

Household expenditure on fuels is partially offset by the transition to more efficient technologies, as shown through the reduction in final household energy consumption. Transitions from basic to improved stoves within the same fuel type (basic fuelwood to improved fuelwood) can imply a reduction in annual household fuel costs for this reason. However, despite important efficiency gains, the transition from free or inexpensive traditional biomass fuels to modern market-based fuels may still imply an increase in expenditure in absolute terms. According to IEP cost and efficiency estimates, an urban household that transitions from a basic charcoal stove to an LPG stove may see fuel costs increase by 30%, for example.

Table 13: Programme costs from 2023 to 2030 (baseline scenario)

STOVE AND FUEL TYPE	STOVE	FUEL	Total
Firewood	$23,227,227	$581,479,768	$604,706,995
Charcoal	$103,849,793	$2,093,153,266	$2,197,003,059
Briquettes/pellets	$5,955,140	$158,876,696	$164,831,836
Biogas	$30,403,744	$170,779,141	$201,182,885
Bioethanol	$70,247,062	$4,412,741,829	$4,482,988,890
LPG	$26,581,775	$705,137,452	$731,719,227
Electric	$101,879,227	$4,188,255,463	$4,290,134,690
Total	$362,143,968	$12,310,423,614	$12,672,567,581

Table 14: Programme costs from 2023 to 2030 (universal scenario)

STOVE AND FUEL TYPE	STOVE	FUEL	Total
Firewood	$11,200,040	$451,745,996	$462,946,036
Charcoal	$69,455,821	$1,684,694,433	$1,754,150,254
Briquettes/pellets	$37,895,240	$1,019,247,938	$1,057,143,178
Biogas	$191,194,024	$1,072,817,303	$1,264,011,327
Bioethanol	$167,660,997	$9,876,753,672	$10,044,414,669
LPG	$26,581,867	$705,240,594	$731,822,461
Electric	$168,032,082	$7,499,775,800	$7,667,807,882
Total	$672,020,070	$22,310,275,737	$22,982,295,807

Scenario Results: Affordability gap

The affordability gap is calculated as the difference between a reference case and each scenario. The reference case assumes households and institutions maintain the same stove-ownership and fuel-use practices from 2023 to 2030 with no stove or fuel switching, with annual increases in costs only attributed to population growth. (Table 15)

Table 16 and 17 show the affordability gap between the reference case and the total programme costs for the baseline and universal scenarios, respectively. Negative numbers indicate the total potential financial savings of switching users away from those stoves and fuels, and hence, those savings could be applied to cleaner stove and fuel combinations.

Through 2030, financing the affordability gap for the baseline scenario would require USD 3 billion in additional consumer expenditure compared to present day costs, while the universal scenario would require USD 8.6 billion to finance the affordability gap compared to the reference case.

Table 15: Reference case stove and fuel expenditures

STOVE AND FUEL TYPE	STOVE	FUEL	TOTAL
Fuelwood	$18,641,372	$466,923,504	$485,564,876
Charcoal	$136,850,267	$2,521,647,781	$2,658,498,048
Briquettes/pellets	$ -	$ -	$ -
Biogas	$1,222,772	$8,199,773	$9,422,545
Bioethanol	$ -	$ -	$ -
LPG	$4,338,952	$59,917,544	$64,256,496
Electric	$15,433,507	$308,361,980	$323,795,487
Total	**$176,486,870**	**$3,365,050,582**	**$3,541,537,452**

Table 16: Consumer affordability gap – Baseline Scenario

STOVE AND FUEL TYPE	STOVE	FUEL	TOTAL
Fuelwood	$4,585,856	($148,122,549)	($143,536,693)
Charcoal	($33,000,474)	($859,789,247)	($892,789,721)
Briquettes/pellets	$5,955,140	$148,859,104	$154,814,244
Biogas	$29,180,972	$151,838,207	$181,019,179
Bioethanol	$70,247,062	$2,021,745,095	$2,091,992,157
LPG	$22,242,823	$134,138,008	$156,380,831
Electric	$86,445,719	$1,376,377,550	$1,462,823,269
Total	**$185,657,098**	**$2,825,046,168**	**$3,010,703,266**

Table 17: Consumer affordability gap – Universal Scenario

STOVE AND FUEL TYPE	STOVE	FUEL	TOTAL
Fuelwood	($7,441,332)	($231,486,599)	($238,927,931)
Charcoal	($67,394,446)	($1,241,217,594)	($1,308,612,040)
Briquettes/pellets	$37,895,240	$947,276,658	$985,171,898
Biogas	$189,971,252	$988,864,472	$1,178,835,724
Bioethanol	$167,660,997	$4,793,947,921	$4,961,608,918
LPG	$22,242,915	$135,821,524	$158,064,439
Electric	$152,598,575	$2,755,902,539	$2,908,501,114
Total	**$495,533,201**	**$8,149,108,921**	**$8,644,642,122**

Scenario Results: Clean cooking co-benefits

The transition to cleaner cooking entails numerous social and environmental co-benefits. For each scenario, the Madagascar IEP quantified the health and time-use impacts on the population, as well as the GHG emissions reduction potential and the deforestation impacts of the transition to cleaner cooking. Detailed results are available in the full report.

SOCIAL CO-BENEFITS

Table 18: Disability life-years (DALYs) averted through reduction in household air pollution due to clean cooking transition

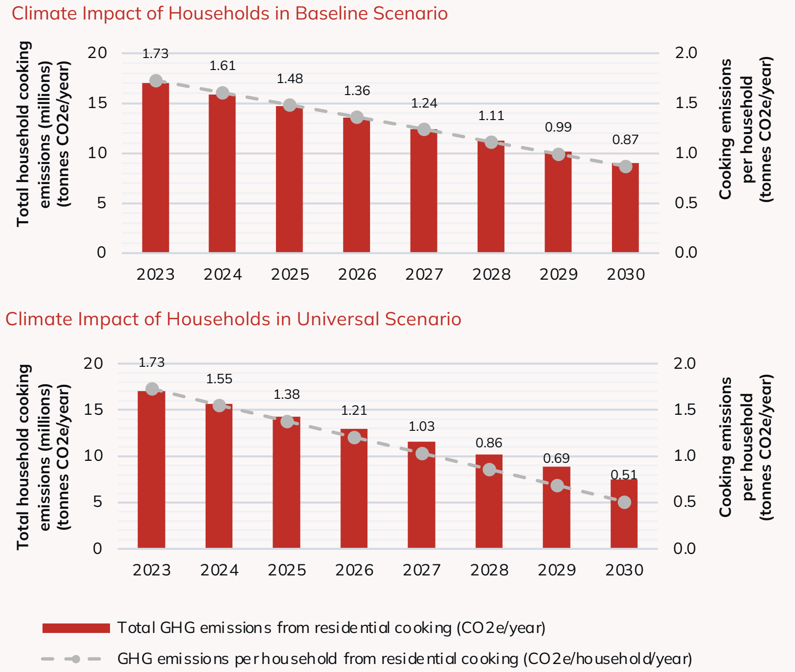
HEALTH IMPACT	BASELINE SCENARIO	UNIVERSAL SCENARIO
DALYs averted (child)	64,934	689,349
Deaths averted (child)	756	8,022
DALYs averted (adult)	97,164	1,225,051
Deaths averted (adult)	3,653	49,183

Table 19: Time use impact of clean cooking transition

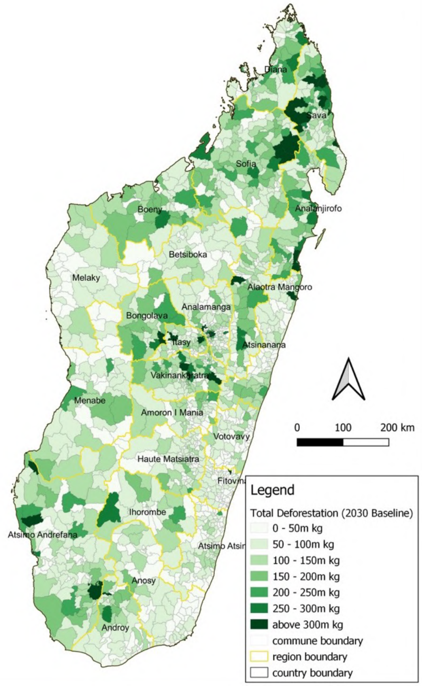
	HOUSEHOLD STOVE OWNERSHIP (% TOTAL HOUSEHOLDS)			AVERAGE HOURS SPENT COOKING
STOVE FUEL TYPE	PRESENT DAY (2023)	BASELINE (2030)	UNIVERSAL (2030)	HOUSEHOLD
Fuelwood	44.4%	27.4%	3.2%	3.22
Charcoal	53.1%	31.5%	3.2%	3.44
Electric	2.2%	20.1%	31.8%	1.77
LPG / other	0.4%	20.9%	61.8%	1.60
Avg (h / day)	3.30	2.66	1.77	

ENVIRONMENTAL CO-BENEFITS

Figure 8: GHG emissions reductions linked to clean cooking transition (tons CO2e/yr)



Map: Deforestation impacts – Baseline scenario example



Conclusions

Biomass derived fuels such as bioethanol, biogas and pellets/briquettes show significant potential to meet clean cooking needs in Madagascar. Even in the universal scenario with the most aggressive clean fuel adoption rates, the energy needed for cooking fuel would only utilize 19.11%, 4.81% and 6.55% of the biomass needed to produce bioethanol, biogas and pellets/briquettes, respectively, suggesting that at a national level the diversion of biomass for fuels may not have a substantial effect on food availability (e.g., maize) or natural fertilizer (e.g., manure).

Urban and rural customers have opportunities to transition away from fuelwood and charcoal. Portability of fuels is essential, specifically bioethanol and biomass pellets briquettes in rural areas, with e-cooking and LPG expected to have improved access and adoption (purchasing) in urban areas. Approximately 72% and 10% of urban households are expected to use electricity and LPG for cooking in the universal scenario, respectively, with urban institutions following a similar trend.

Targeted investments, supply chain planning and commercial pilots can demonstrate the opportunity space for e-cooking and improved biofuel stoves that increase customer awareness and attract private-sector participation. Associated policy innovations and government advocacy work is also needed to create the enabling environment that enables self-sustained growth of the clean cooking sector in Madagascar.

Cleaner and more efficient cooking can substantially reduce residential greenhouse gas emissions and deforestation and generates important social co-benefits. Household cooking tasks are predominantly the responsibility of women, who spent an estimated 3.30 hours per day cooking in 2023. This is reduced to an average of 2.66 hours per day in the 2030 baseline scenario, and further reduced to an average of 1.77 hours per day in the 2030 universal scenario. Health benefits for adults and children are significant, with an estimated 756 and 8,022 childhood deaths averted in the baseline and universal scenarios, respectively, and an estimated 3,653 and 49,183 adult deaths averted in the baseline and universal scenarios, respectively.

Affordability of clean cooking solutions is a significant gap to reaching national goals. Survey data indicated that approximately 75% of households identified costs of cooking as the primary barrier, whereas a small percentage of institutions indicated challenges to using clean cooking solutions. When noting that the capital cost of procuring a stove is modest relative to the cost of fuel, the approach to subsidize stove cost is helpful but must be paired with interventions that aim to reduce the cost of fuels.

Collaboration and partnerships will be key to address barriers to universal access to clean cooking. The projected clean cooking future for Madagascar under the IEP scenario will require interministerial collaboration for energy, finance, agriculture, transportation, trade and other sectors of the Madagascar government. Further, greater collaboration between the government and stove developers and fuel producers will be essential to collaboratively planning and evaluating opportunities for clean cooking. Non-governmental organizations can play a facilitatory role in helping plan and support interventions by the private sector and public sector.

EXPLORE THE RESULTS FOR YOURSELF

madagascar-iep.sdg7energyplanning.org

ANY QUESTIONS:

uiep@seforall.org