

Rwanda Energy Demand Analysis in Households; An end-use sector demand analysis



Rene Kageruka Nsanabo: nsarene@gmail.com; Ministry of Infrastructure; Rwanda
Fidele Ntawumenyumunsi: umunsifidele@gmail.com; Rwanda Energy Group; Rwanda
Fabrice Bucyedusenge: fabricebu@gmail.com; Rwanda Energy Group; Rwanda

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Context, Challenges, and Main findings

Introduction:

- 72% of the population lives in rural areas; with over 97% using traditional fuels.
- Rwanda's households are set to double by 2050, with rising urbanization.
- Clean cooking adoption is low at 5%.
- Study shows clean energy can cut demand while increasing useful energy demand.

Challenges:

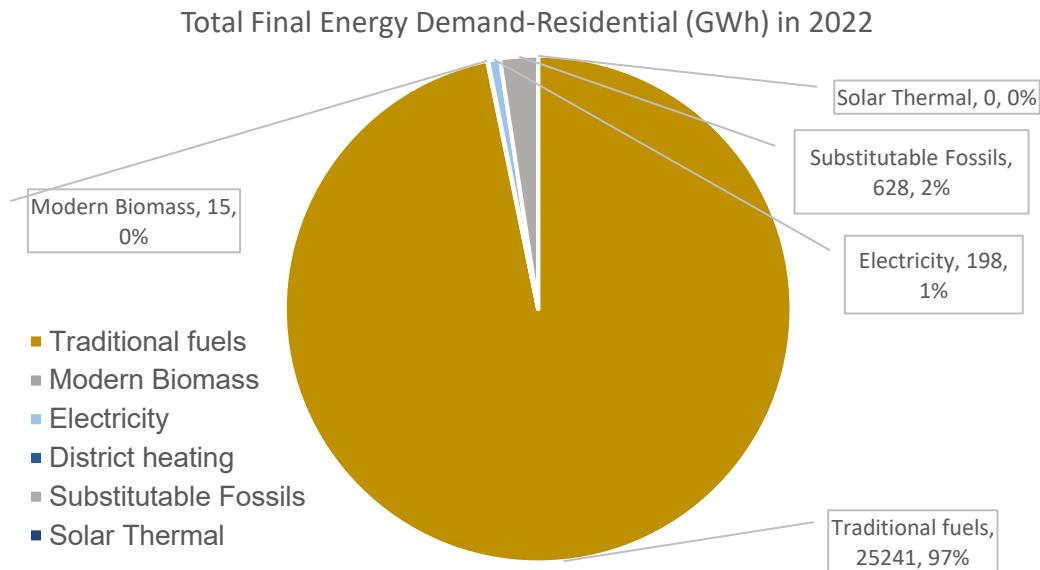
- Primary reliance on traditional energy forms, esp. in Rural.
- High-cost limits adoption of modern energy.
- Traditional fuel use remains dominant.

Research question:

How does the economic transformation and the clean energy transition shape household energy demand in Rwanda?

Main findings:

- **Household energy demand** is expected to shift following urbanization, population growth, and improved living standards with traditional fuels reducing from 96% of residential TFED in 2022 to 38%_{BAU}, 37%_{Vis}, 17%_{EE} by 2050.
- **Traditional biomass** continue to dominate TWh 25.2, but energy transition momentum in the 2030s sees rising adoption of modern biomass TWh 4.2_{Vis} TWh 3.7_{BAU} TWh 1.7_{EE}, and increased use of substitutable fuels TWh 5.8_{Vis}, TWh 5.2_{BAU}, TWh 7.6_{EE} and electricity TWh 6.7_{Vis}, TWh 5.8_{BAU}, TWh 8.2_{EE}, highlighting the need for targeted interventions.
- **Efficient technologies** are more rapidly adopted in urban areas.



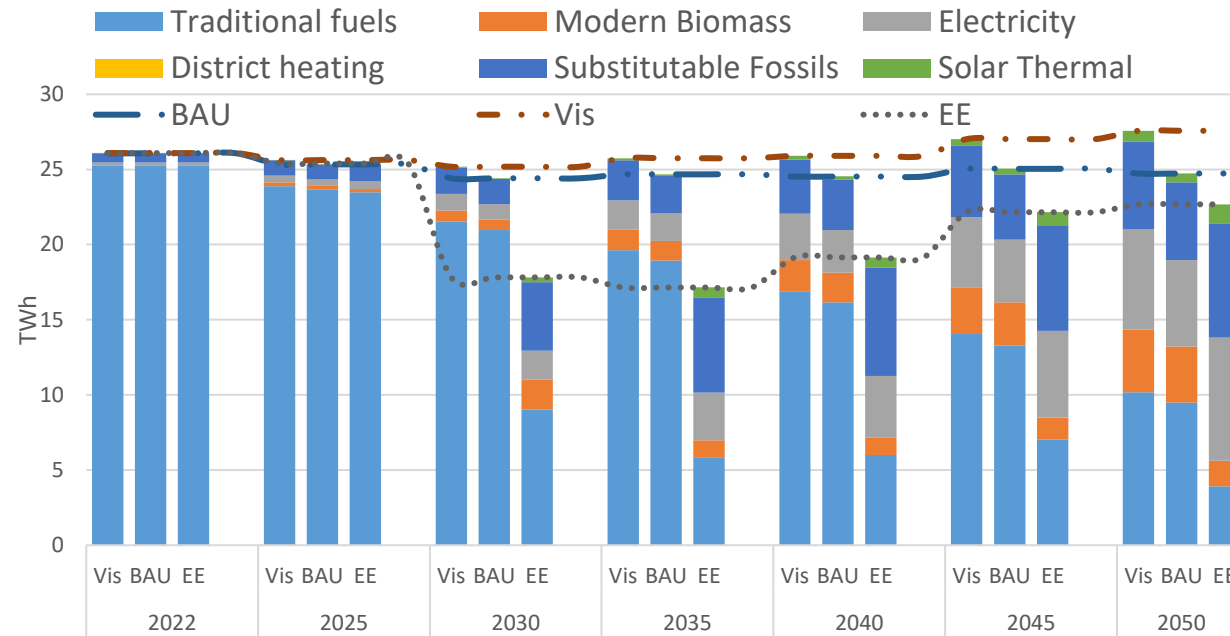
Scenarios

Using the Model for Analysis of Energy Demand (MAED), the following scenarios were investigated:

Scenario Label	Scenario Description	Key Assumptions
Business As Usual (BAU)	Assumes slow socio-economic growth/change with demand growth driven by limited urbanisation and technological change. Population growth follows a low growth trajectory. Universal access to electricity by 2030	<ul style="list-style-type: none"> • Average GDP growth rate 8.4%. • Urbanisation rate follows historical patterns: double to 55% by 2050 • Traditional fuels cookstoves (Tier 3) still dominate 60%, 30% in rural and urban HHs by 2050. • Electricity access: 100% by 2030 • Average population growth rate 1.95%.
Visionary (Vis)	Reflects a shift to a dynamic system with aggressive economic growth to achieve high income status by 2050. Massive technological change ensues, and population growth follows the high growth trajectory.	<ul style="list-style-type: none"> • Average GDP growth 12%. • Urbanisation rate increases to 66.5% by 2050. • Traditional fuels cookstoves (Tier 3) still dominate 49%, 20% in rural and urban HHs by 2050. • Average population growth rate 2.06%.
Energy Efficiency (EE)	Builds on the economic transformation in the visionary scenario, but emphasises on efficient energy forms and technologies/appliances driven by initiatives such as clean cooking transition by 2035.	<ul style="list-style-type: none"> • GDP growth, urbanisation and population growth prospects identical as in the Visionary scenario (above). • Clean Cooking adoptions by 2035: <ul style="list-style-type: none"> ○ Tier 4&5: (Urban; Rural: 96.01%; 58.7%) ○ Tier 3: (Urban; Rural: 3.99%; 41.27%).

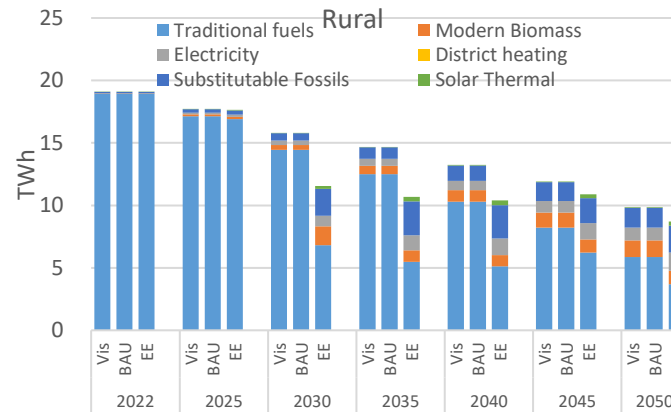
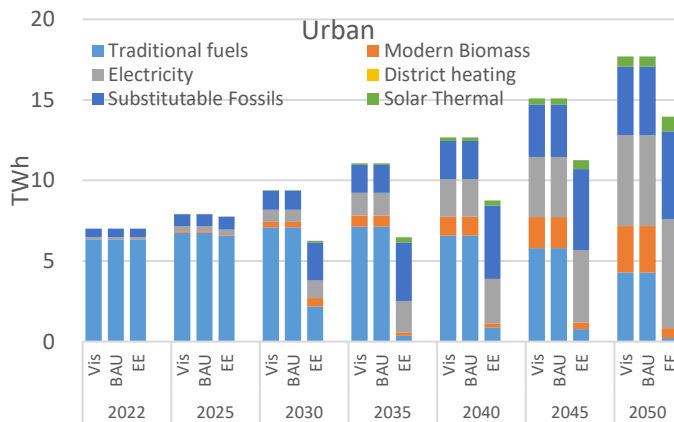
Results – Total Final Energy Demand by energy forms

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- Urbanization is a driving key parameter contributing to changing geographical patterns for final energy demand from **27%** in 2022 to **55%**_{BAU}, and **66.5%**_{Vis&EE}. **Urban/Rural** energy demand increases **TWh 7/19.1 to TWh 17.7/9.871**_{BAU/Vis} and **TWh 13.9/8.7**_{EE} by 2050.

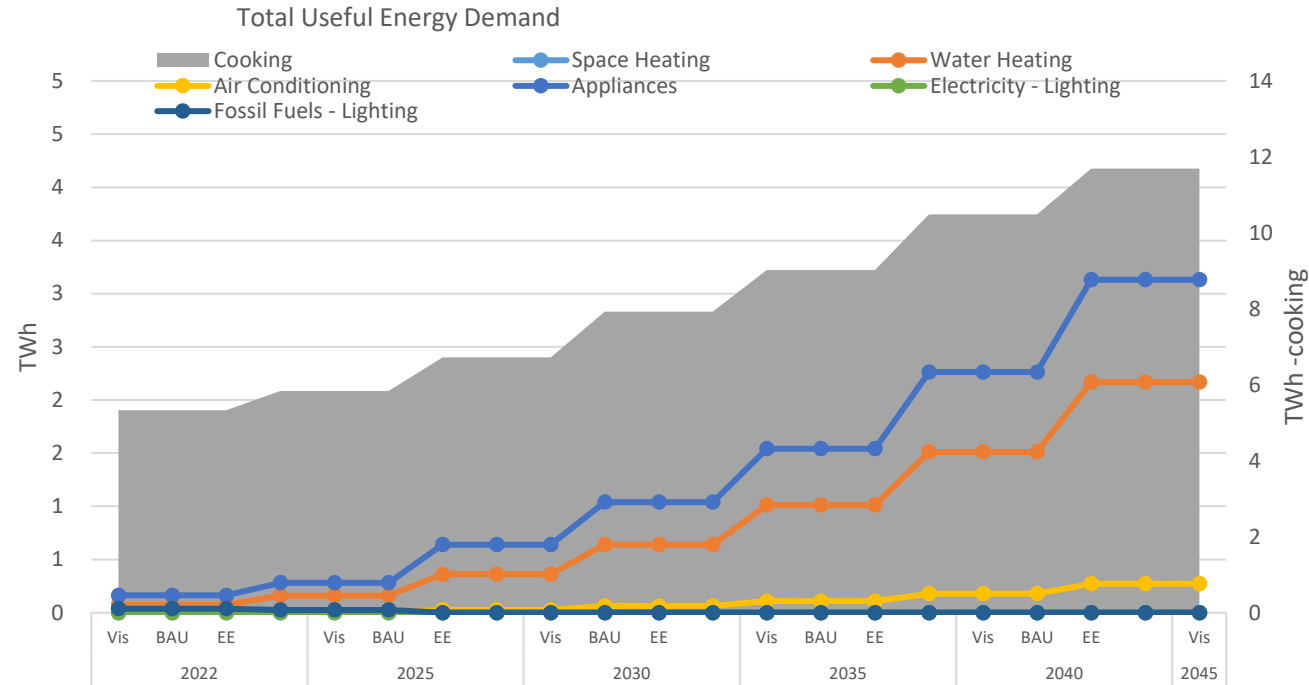
- Cleaner energy forms emerge around 2030 and accelerate primarily in the Efficient trajectory. Below are TFED by fuels in **TWh** by **2030** and **2050**



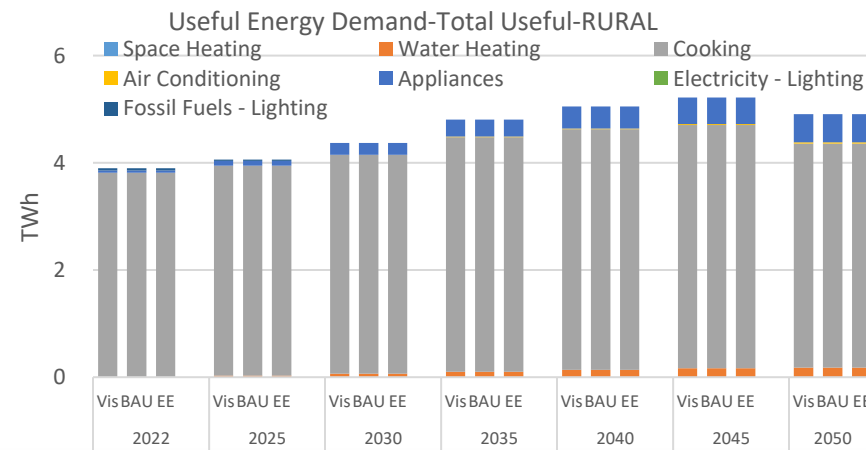
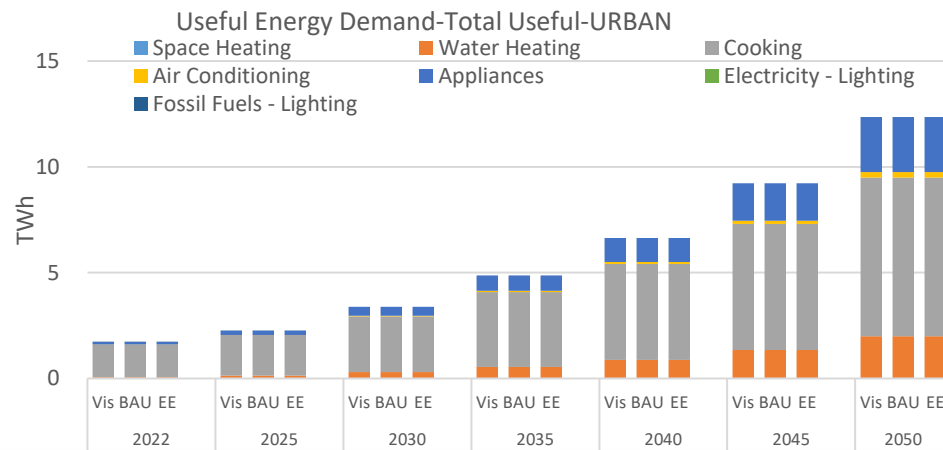
	2030			2050		
	Vis	BAU	EE	Vis	BAU	EE
Traditional fuels	21.5	21.0	9.0	10.2	9.5	3.9
Modern Biomass	0.7	0.7	2.0	4.2	3.7	1.7
Electricity	1.1	1.0	1.9	6.7	5.8	8.2
Substitutable Fossils	1.8	1.7	4.5	5.8	5.2	7.6
Solar Thermal	0.1	0.1	0.3	0.7	0.6	1.3
Total Final Energy Demand	25.2	24.4	17.8	27.6	24.7	22.7

- Energy transition occurs in all cases, with accelerated effects by 2030–2035.

Results – Useful Energy Demand

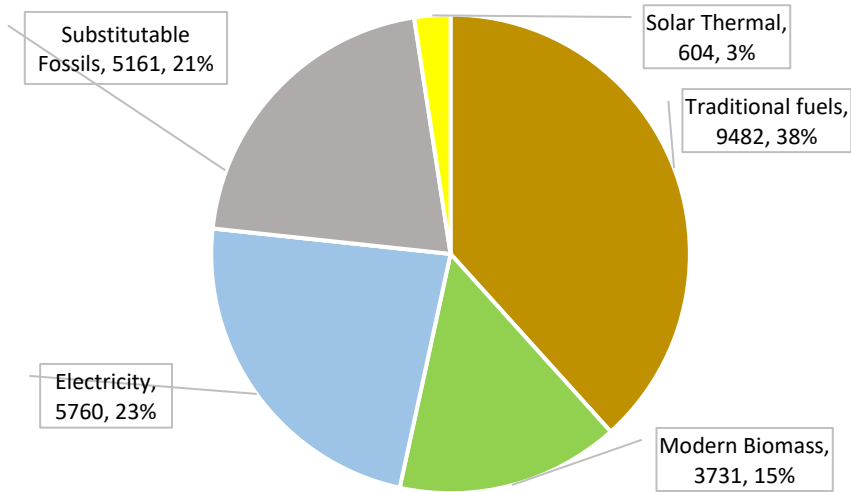


- Of all residential end-uses, cooking remain the most energy consuming throughout the horizon
- Clean and efficient energy adoption over time is largely driven by urbanization, : higher in urban areas, mainly arising from clean cooking.
- Useful energy demand increases across all residential uses.
- Appliances and Lighting amplifies over the time.
- Water heating, and residential cooling build up considerably around 2030 onwards

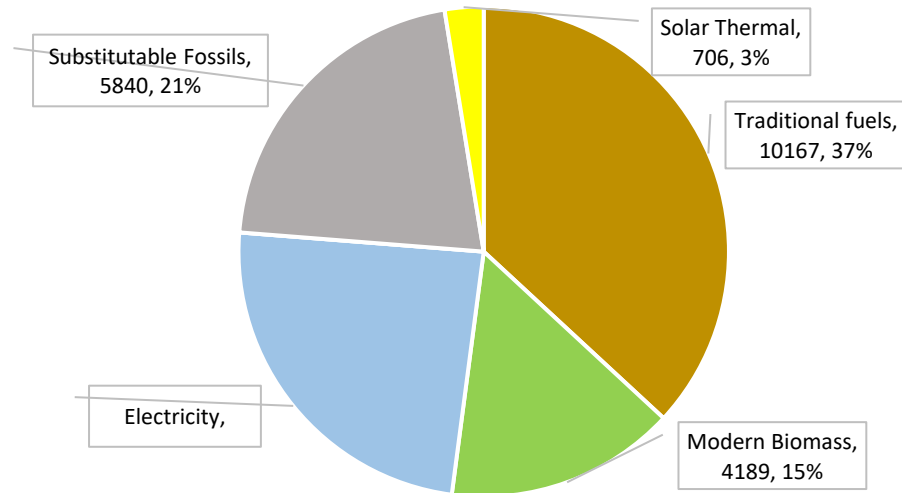


Results – Total final energy demand by scenarios

Total Final Energy Demand-Residential (GWh) in 2050-BAU

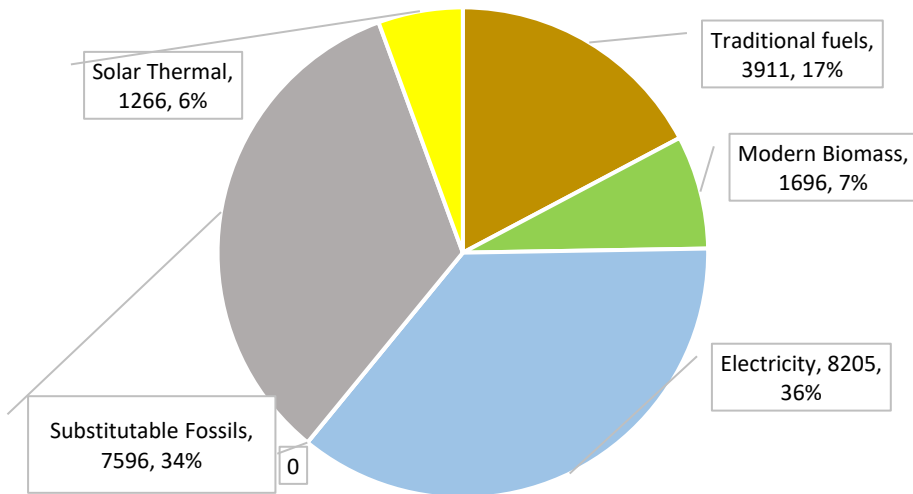


Total Final Energy Demand-Residential (GWh) in 2050-Vis



- Progressive adoption of clean energy forms and efficient technologies
- Reduced biomass dependence: from 97% of traditional fuels in 2022 to 38%_{BAU}; 37%_{Vis}; 17%_{EE} in 2050
- Market potentials in terms of:
 - ✓ new energy products:
 - solar thermal (SWH), solar-power induction cookers,
 - Modern biomass (ethanol, biogas)

Total Final Energy Demand-Residential (GWh) in 2050-EE



- Market potentials in terms of (cont'd):
 - ✓ and streamlined distribution systems
 - substitutable fuels (LPG, kerosene)

- Potential for residential electricity demand growth: from **GWh 198** in 2022 to **GWh 5,760_{BAU}**; **GWh 6661_{Vis}**; **GWh 8,205_{EE}** in 2050.

- Modern biomass and Substitutable fuels increase from GWh 15 and GWh 628 in 2022 to **GWh 723_{Vis}**, **GWh 696_{BAU}**, **GWh 1998_{EE}** and **GWh 1758_{Vis}**, **GWh 1664_{BAU}**, **GWh 4539_{EE}** by 2030 and **GWh 4189_{Vis}**, **GWh 3731_{BAU}**, **GWh 1696_{EE}** and **GWh 5840_{Vis}**, **GWh 5161_{BAU}**, **GWh 7596_{EE}** by 2050

Conclusions and Policy Insights

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Conclusion

- **Household energy demand** is expected to rise due to urbanization, population growth, and improved living standards with traditional fuels moving from **96%** in 2022 to **38%** in the BAU, **37%** in the visionary scenario, **17%** in the efficiency scenario.
- **Traditional biomass** continue to dominate, but transition sets in **the 2030s** with adoption of modern biomass, and increased substitutable fuels and electricity, highlighting the need for targeted interventions.
- **Efficient technologies** are more rapidly adopted in urban areas.

Policy Insights

- Urbanisation will play a key role in enabling energy transition in households: Need to **promote clean and efficient technologies (appliances) and streamline supply chains distribution** systems/markets especially in rural areas, through **subsidies, micro-financing, and awareness campaigns**.
- Prospects of economic developments give rise to markets of new energy forms: Need to **support for Renewable Energy Adoption**
- Accelerated **energy efficiency programs and policies** presents opportunity for reduced residential total final energy demand, which would avail useful energy to other (more productive) sectors.

Future Work

- Conduct comprehensive national energy consumption surveys to best capture end-use sector energy products and uses.