Electricity Tariffs and Energy Transitions: An evaluation of electricity cost as a core barrier to electric cooking adoption

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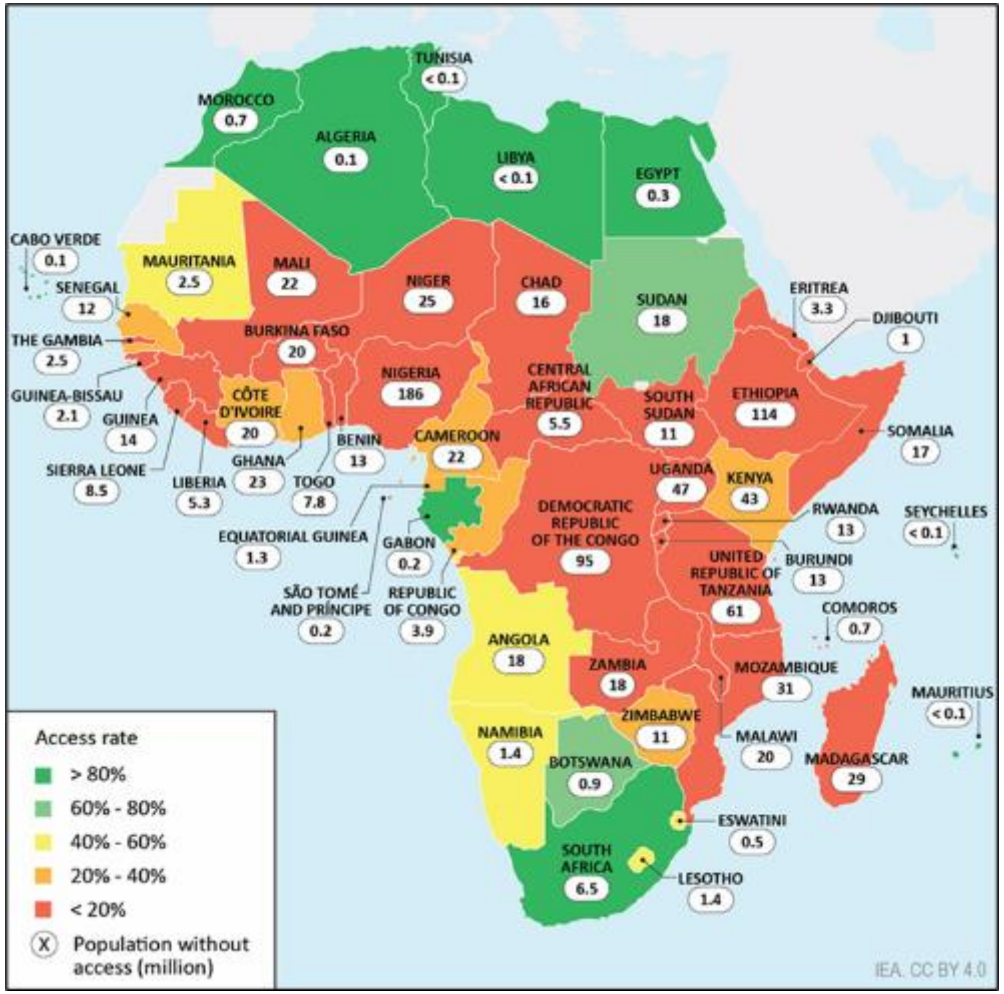
1.1 Introduction

The Burning Issue; Kitchens in Crisis

- Approximately **2.3 billion people** lacked access to clean cooking solutions (IEA, 2023).
- About **1.9 billion people** will still lack access by 2030, with Sub-Saharan Africa accounting for 60% of those affected.
- The use of **traditional forms of cooking** (including firewood and charcoal) has negative impacts on:
  - **Health and Wellbeing**: Between 400,000 and 700,000 premature deaths per year attributable to household air pollution (Khavari, B., et al, 2023)
  - **Global Climate Change**: Cooking is the leading source of greenhouse gases in most Sub-Saharan African countries (Bensch, G., Jeuland, M., & Peters, J. (2021).
  - **Natural Ecosystems**: Significant driver of forest degradation and deforestation (Rose, J., Bensch, G., Munyehirwe, A., & Peters, J. (2022)

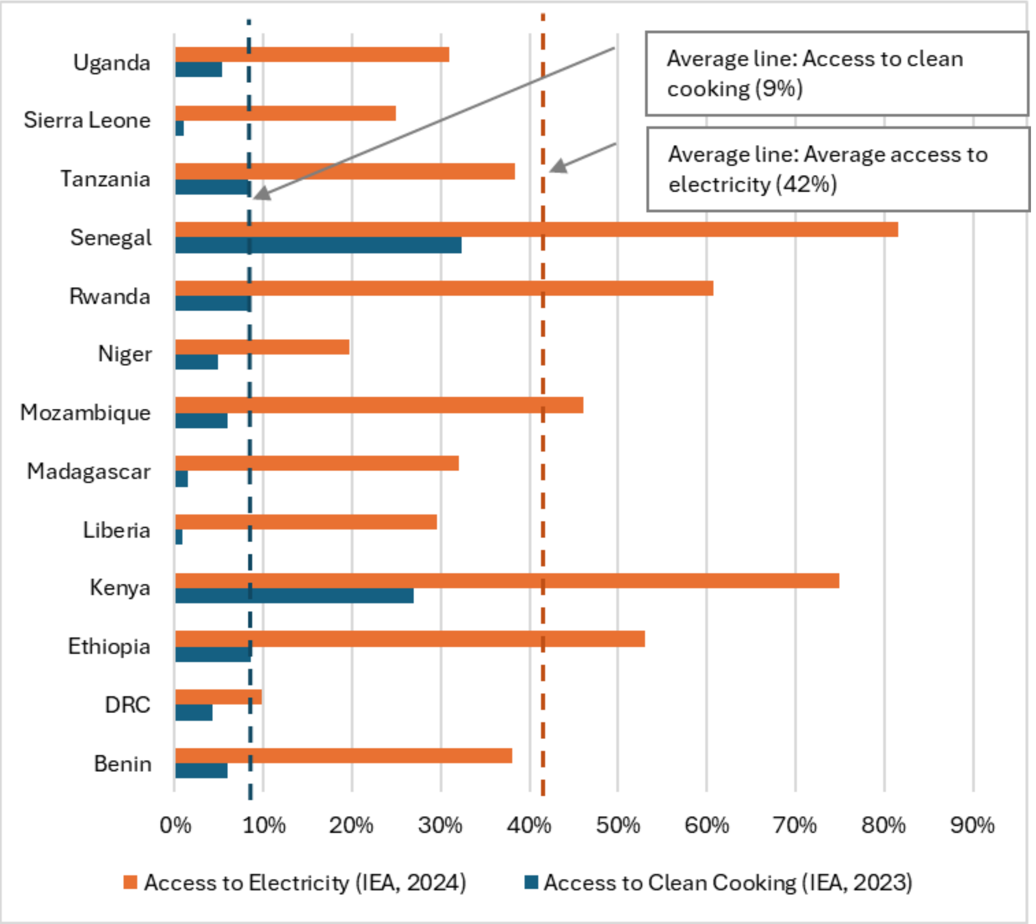


Access Rate and Total Population Without Access to Clean Cooking Solutions IEA (2023)

1.2 Introduction

Fueling Change; The Potential of Electric Cooking

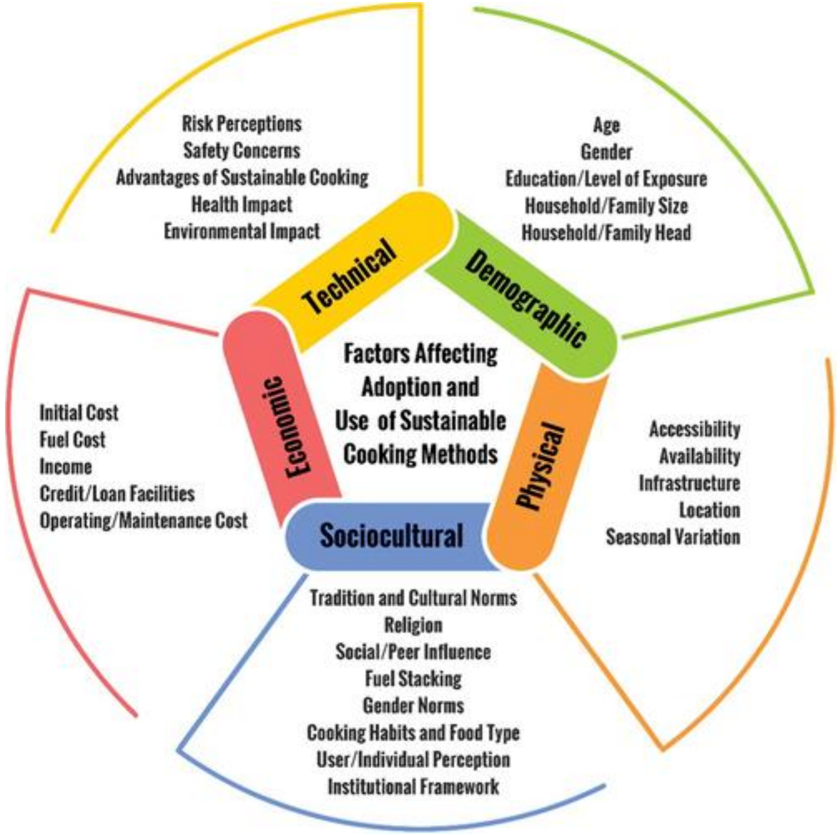
- Many countries in Sub-Saharan Africa have prioritized electrification, while progress in access to clean cooking has largely stagnated.
- The drivers of potential change include:
  - **Electrification Rates**: More than 50% of residents in Africa now have access to electricity
  - **Carbon Finance**: Capital from carbon markets is not a leading source of finance lowering the upfront cost of modern cooking solutions.
  - **Technological Innovation**: Rapid evolution in the design and efficiency of electric cooking options including electromagnetic induction cookers and infrared stoves

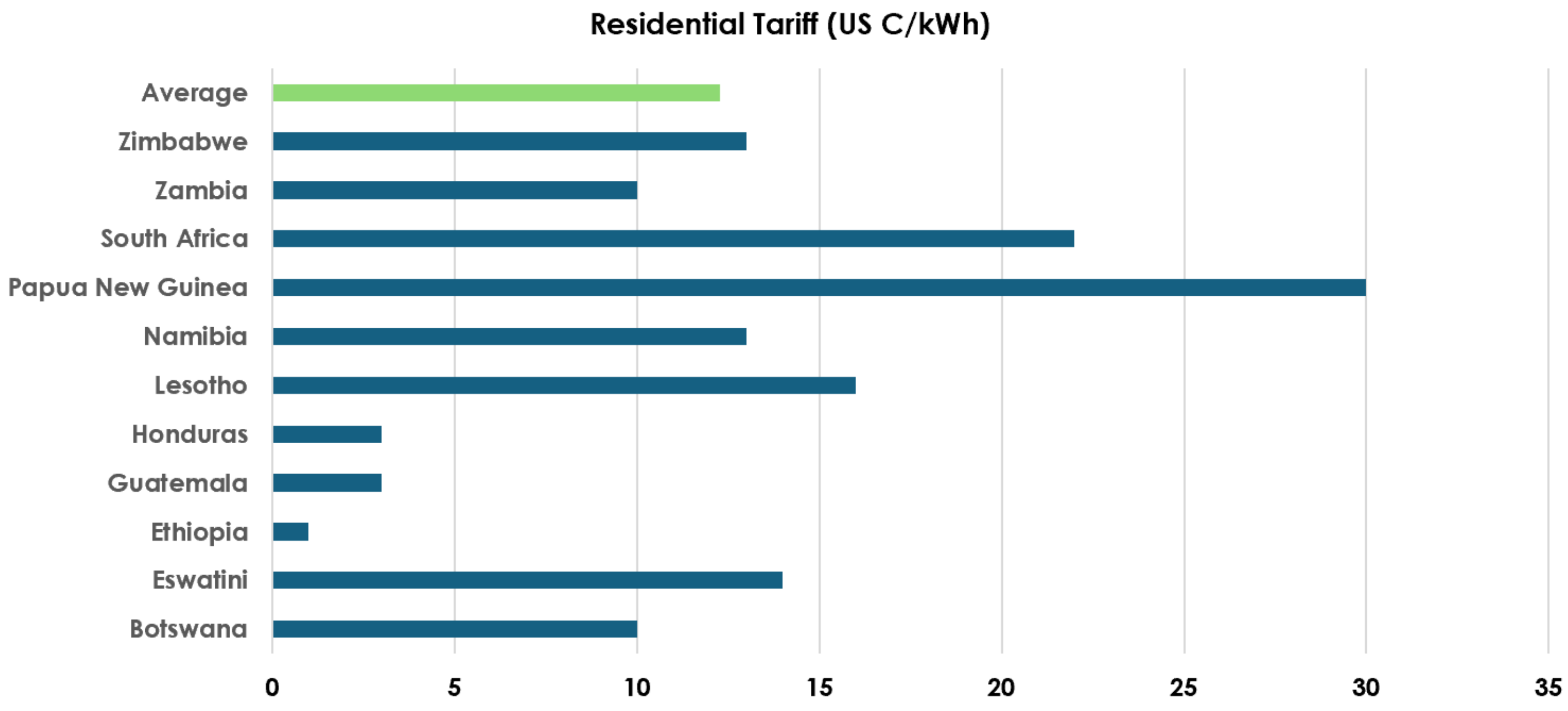


Comparing access to electricity and access to clean coking solutions (IEA, 2023 & 2024)

2.1 Research Problem

Barriers to Modern Cooking Solutions & the Role of Tariffs





Source: Ibe, K. K., & Kollur, S. P. (2024).

Source: IRENA (2023)

2.2 Research Problem

Barriers to Modern Cooking Solutions & the Role of Tariffs

<table>
<tr><th rowspan="2">#</th><th rowspan="2">Country</th><th colspan="30">kWh/month vs US ₵/kWh</th></tr>
<tr><th>10</th><th>20</th><th>30</th><th>40</th><th>50</th><th>60</th><th>70</th><th>80</th><th>90</th><th>100</th><th>110</th><th>120</th><th>130</th><th>140</th><th>150</th><th>160</th><th>170</th><th>180</th><th>190</th><th>200</th><th>210</th><th>220</th><th>230</th><th>240</th><th>250</th><th>260</th><th>270</th><th>280</th><th>290</th><th>300</th></tr>
<tr><td>1</td><td>Kenya</td><td colspan="3">9.4</td><td colspan="7">12.8</td><td colspan="20">18.57</td></tr>
<tr><td>2</td><td>Zambia</td><td colspan="10">2.2</td><td colspan="10">5.2</td><td colspan="10">11.5</td></tr>
<tr><td>3</td><td>Ghana</td><td colspan="3">5.7</td><td colspan="27">12.9</td></tr>
<tr><td>4</td><td>Zimbabwe</td><td colspan="5">8</td><td colspan="5">9</td><td colspan="10">16</td><td colspan="10">23</td></tr>
<tr><td>5</td><td>Senegal</td><td colspan="15">15</td><td colspan="10">24</td><td colspan="5">28</td></tr>
</table>

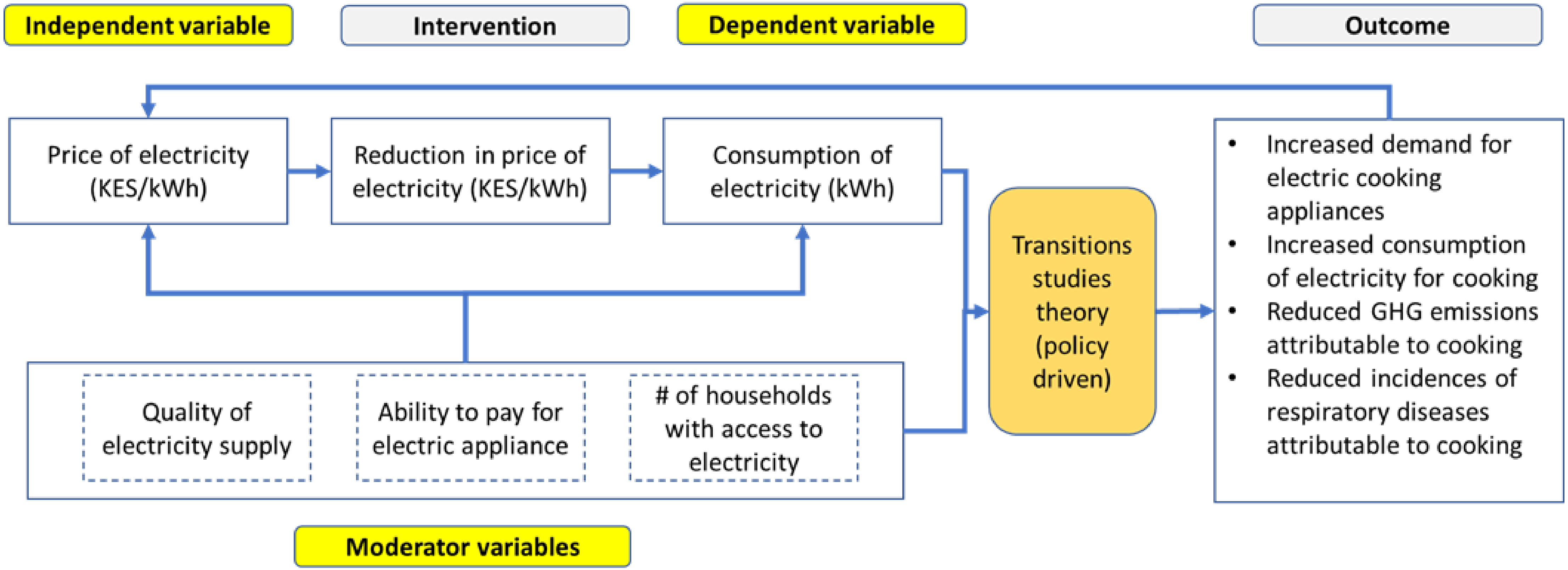
KEY

US ₵/kWh 0 - 10
US ₵/kWh 11 - 20
US ₵/kWh >20

Source: Ibe, K. K., & Kollur, S. P. (2024).

2.3 Research Problem

Theory of Cause and Effect – Conceptual Framework



2.4 Research Problem

Core Research Question

- What is the relationship between electricity tariffs and demand for electricity from cooking?

Specific Questions

1. What is the price elasticity of demand for electricity from cooking among residential users?
2. What are the potential effects of increased adoption of electric cooking technologies on the load profile at the utility level?
3. What strategies can utilities employ to design and implement preferential tariff structures that promote the adoption of electric cooking?
4. How do consumer attitudes and behaviours differ regarding the use of traditional electric appliances compared to improved electric appliances in the context of electric cooking?

Sources: www.alibaba.com
**For illustrative purposes only and not the specific models to be used*

2.5 Research Problem

Price Elasticity Experiment

- This experiment simulates a reduction in (i) the general residential tariff and (ii) a specific cooking tariff, to assess the impact of such action on electricity demand, both in terms of power and energy.
- Two types of electric cooking appliances will be distributed across 400 homogenous middle-class households in Nairobi; i) double electromagnetic induction and ii) double hot plate cooker.
- This is designed as an exploratory experiment, with the selection of a homogeneous segment intended to control for other moderating factors such as income, household size, and cooking needs. Additionally, research indicates that lower-income residential consumers in Africa exhibit little to no demand elasticity (Klug et al, 2022).
- The 400 households will be divided into specific cohorts nested within four nested categories as show. 3 cohorts will receive tariff subsidies (simulating tariff reductions) and 1 will be the control group as follows: CH1 – 25% subsidy, CH2 – 50% subsidy, CH3 – 75%, and CH4 0% (control).

	Modern Electric Appliance		***Traditional Electric Appliance***	
General Residential Tariff Reduction	***C1***	***C2***	***C1***	***C2***
	C3	***C4***	***C3***	***C4***
Specific Cooking Tariff Reduction	***C1***	***C2***	***C1***	***C2***
	C3	***C4***	***C3***	***C4***

Each specific cohort will have 25 households (Total = 400)

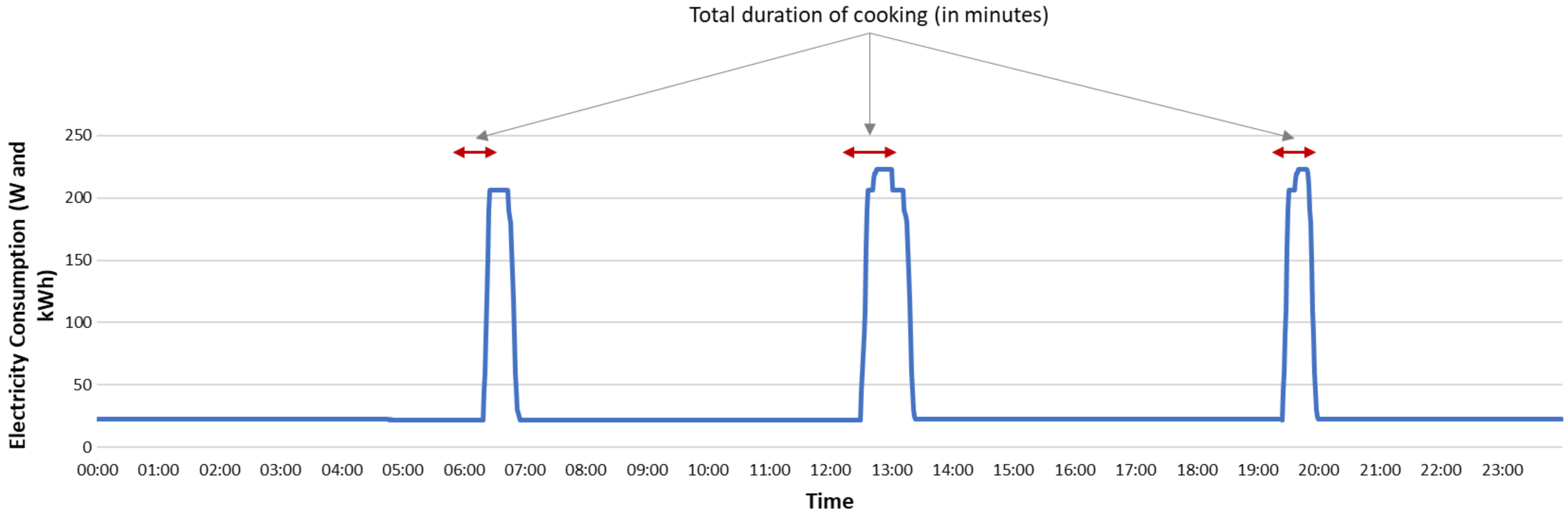
2.6 Research Problem

Price Elasticity Experiment

- Measurements will include the power (W), and energy (kWh) used over 4 months. The data collected will be compared across the specific cohorts and the nested categories, and elasticity estimated as shown below.

$$\varepsilon = \frac{\Delta q/q}{\Delta p/p}$$

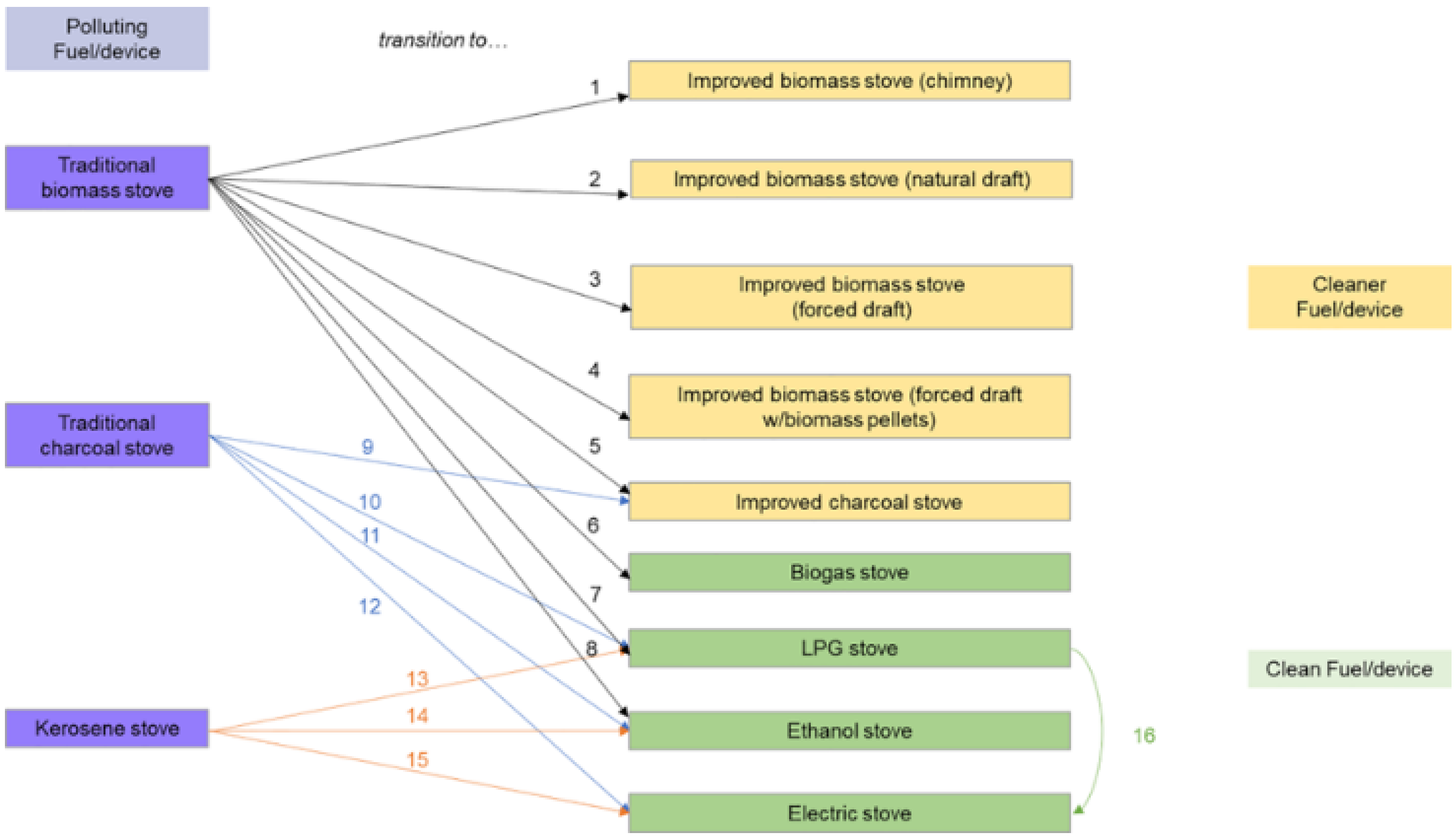
where **ε** is the price elasticity, ***p*** is the electricity price, and ***q*** is the electricity demand



2.7 Research Problem

Transition Theories and Cooking Practices

- Most household cooking with multiple cooking fuels and solutions a practice known as stacking (Jewitt, S., Atagher, P., & Clifford, M. 2020)
- Transitions do not typically follow a linear progression (Williams, S., & Doyon, A. 2019).
- Understanding the relationship between electricity tariffs and electricity demand for cooking could provide a **framework for utilities** to set preferential tariffs
- An uptake in use of electric cooking appliances will have multiple benefits including health and climate change mitigation



Das, I., Lewis, J., Ludolph, R. et al. 2021

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