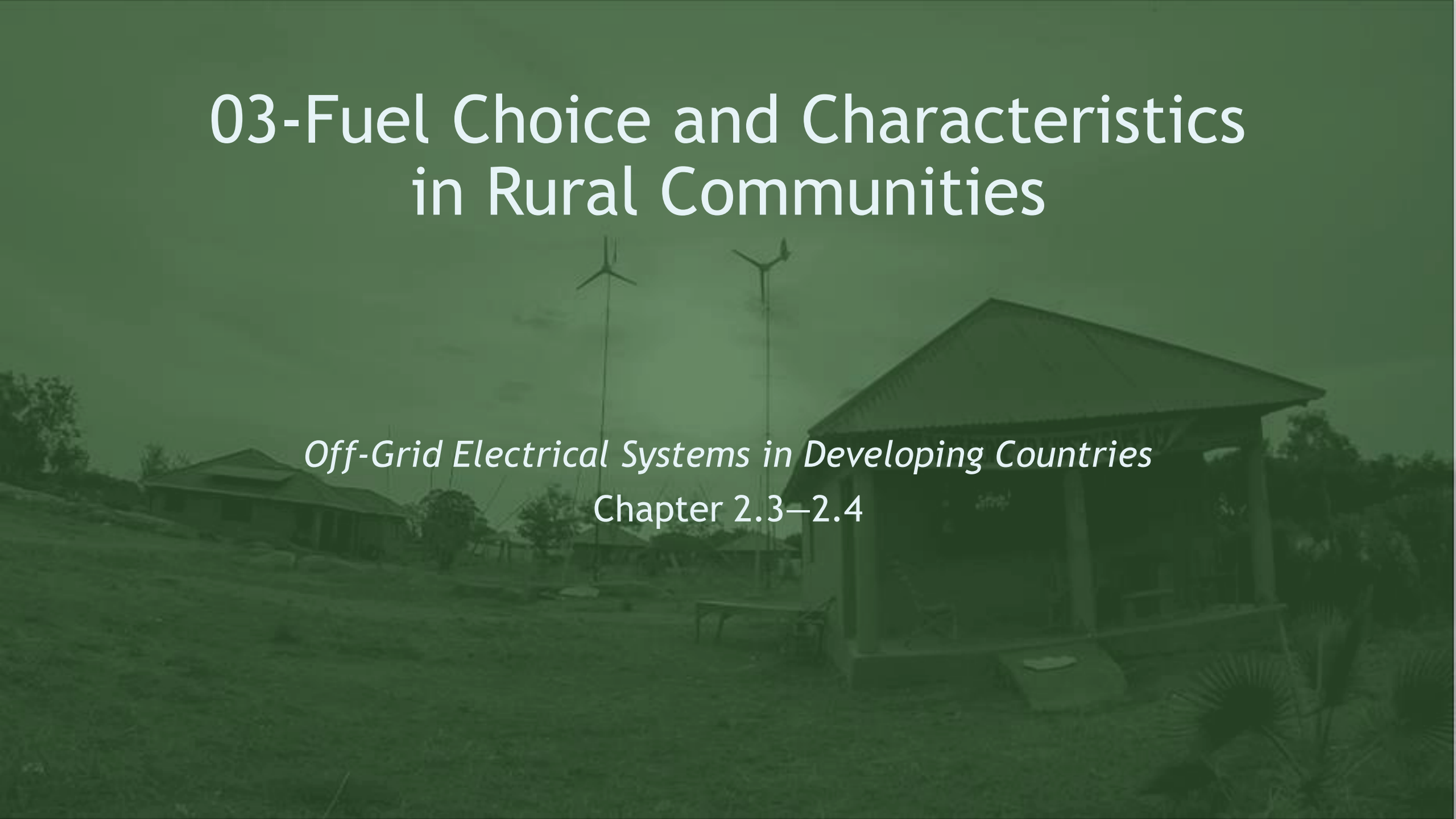


# 03-Fuel Choice and Characteristics in Rural Communities

*Off-Grid Electrical Systems in Developing Countries*

Chapter 2.3—2.4





# Learning Outcomes

At the end of this lecture, you will be able to:

- ✓ describe the characteristics that affect fuel choice in rural off-grid households
- ✓ define “energy ladder” and “fuel stacking”
- ✓ evaluate the cost, convenience, and quality of rural fuels

# Fuels in Use

- Animal dung
- Batteries
- Charcoal
- Crop residue
- Electricity
- Fuel wood
- Kerosene
- Liquid Petroleum Gas (LPG)



# Energy Content

Specific Energy



energy per unit mass

Energy Density



energy per unit volume

Moisture content of  
the fuel matters

# Energy Content

Fuel	Unit	MJ/Unit
Charcoal	kg	30.8
Dung	kg	14.5
Electricity	kWh	3.6
Kerosene	liter	35.0
LPG (Gas)	kg	45.0
Wood (Dry)	kg	16.0
Straw	kg	13.5

Note: 1 J = W s  
1 MJ =  $1 \times 10^6$  J  
1 kWh = 3.6 MJ

# Example

A household uses 100 GJ of fuel wood per year. Compute the required mass of the fuel wood needed each year.

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A household uses 100 GJ of fuel wood per year. Compute the required mass of the fuel wood needed each year.

From previous table: 1 kg of fuel wood has 16 MJ. There are 1000 MJ in 1 GJ. Therefore:

$$\text{Fuel wood mass} = \frac{100 \text{ GJ}}{0.016 \text{ GJ/kg}} = 6250 \text{ kg}$$

This is a considerable mass of wood!

# Exercise

A household uses 10 GJ of kerosene per year. Compute the required volume of kerosene needed each year.



# Exercise

A household uses 10 GJ of kerosene per year. Compute the required volume of kerosene needed each year.

$$\text{Kerosene volume} = \frac{10 \text{ GJ}}{0.035 \text{ GJ/liter}} = 285.71 \text{ liter}$$

# Fuel Choice Characteristics

## Quality



- High efficiency
- Controllable output
- Consistent performance
- Low/zero emissions

## Convenience



- Point-of-use delivery/locally-available
- Reliable supply
- Little/no processing required
- Familiar/easy to use
- Versatile
- Safe
- Does not require storage

## Cost

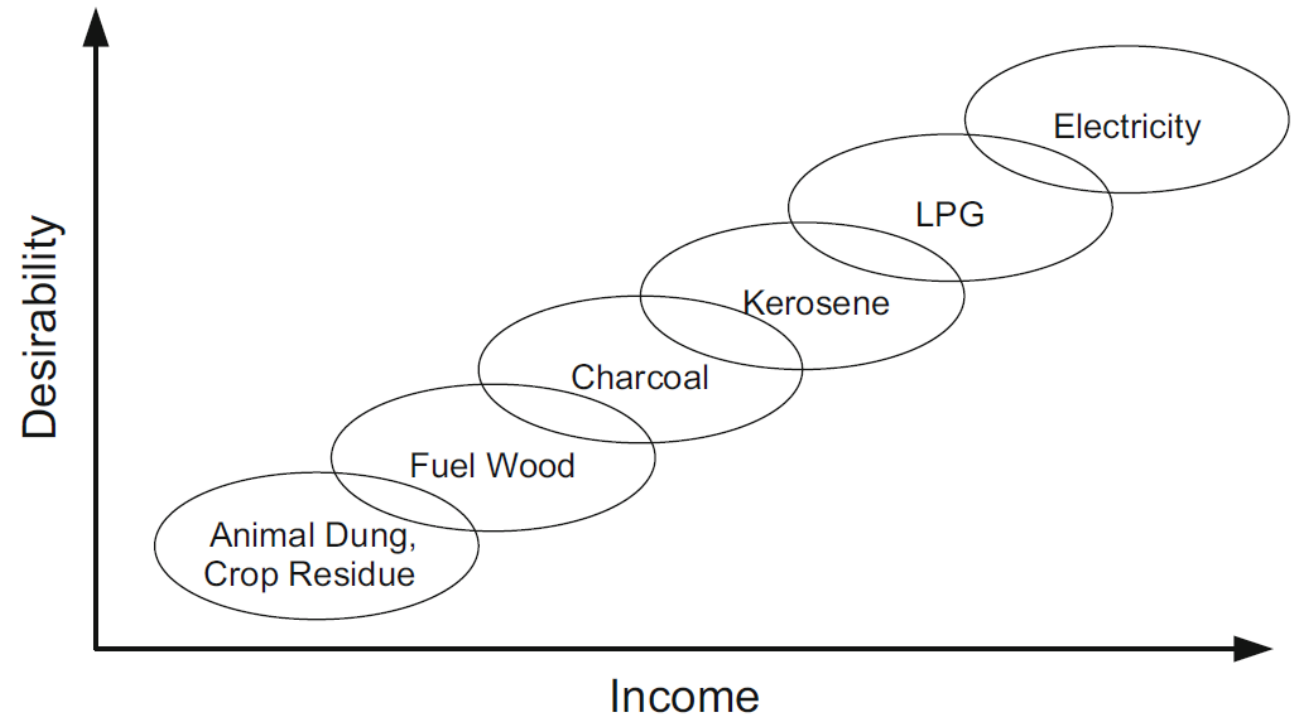


- Low fuel cost
- Low equipment cost
- Stable price
- Can be purchased in small or large quantities

# Discussion

Compare the quality, convenience and cost of fuel wood with electricity.

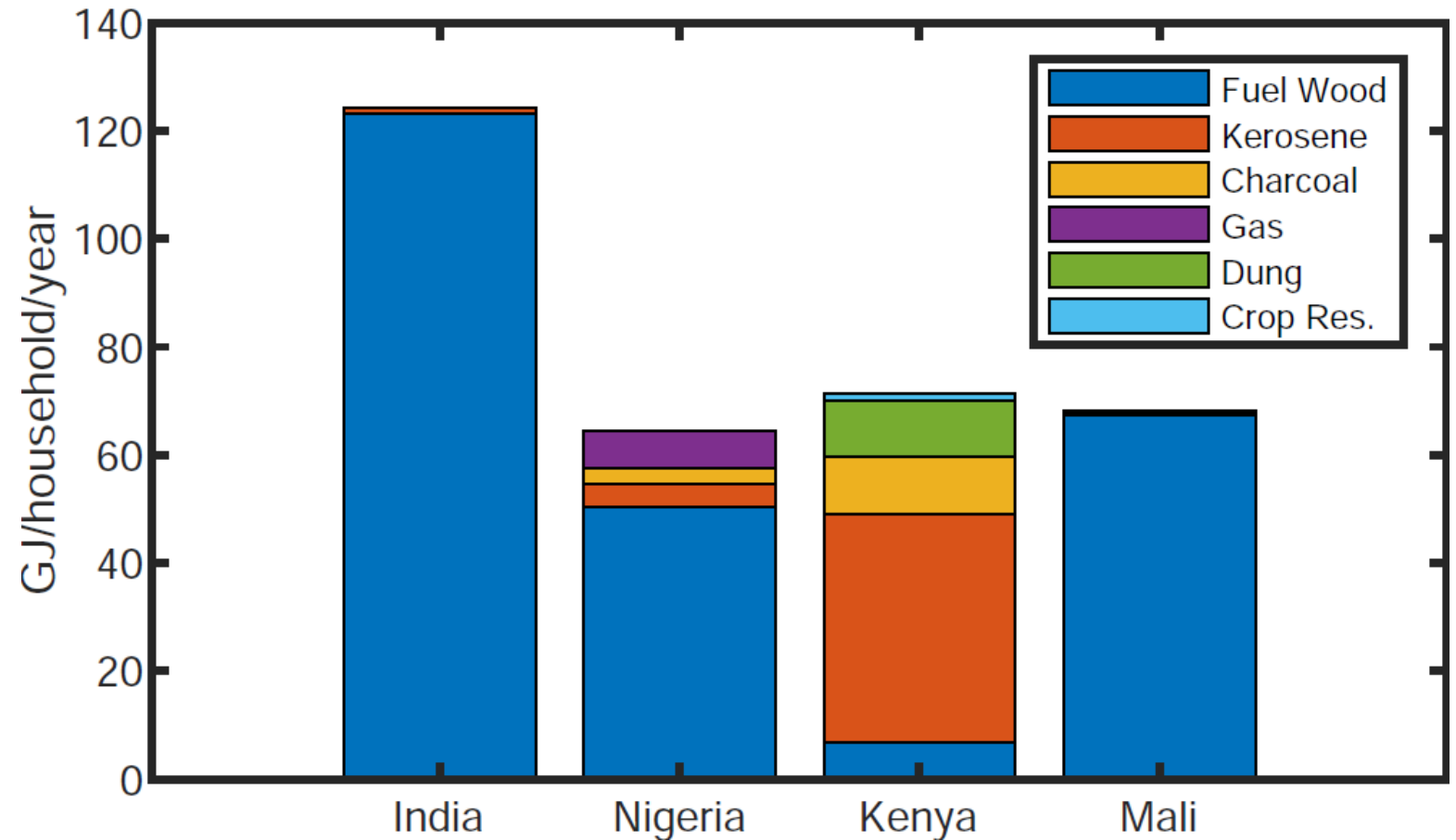
Energy Ladder:  
households tend to  
transition from less  
desirable fuels to more  
desirable as income  
increases



Recent research questions the validity of the Energy Ladder. Households simultaneously use multiple fuels (“fuel stacking”), and can be reluctant to change due to cultural reasons or to improve resiliency

# Fuel Stacking

Majority of household energy in rural areas is from fuel wood

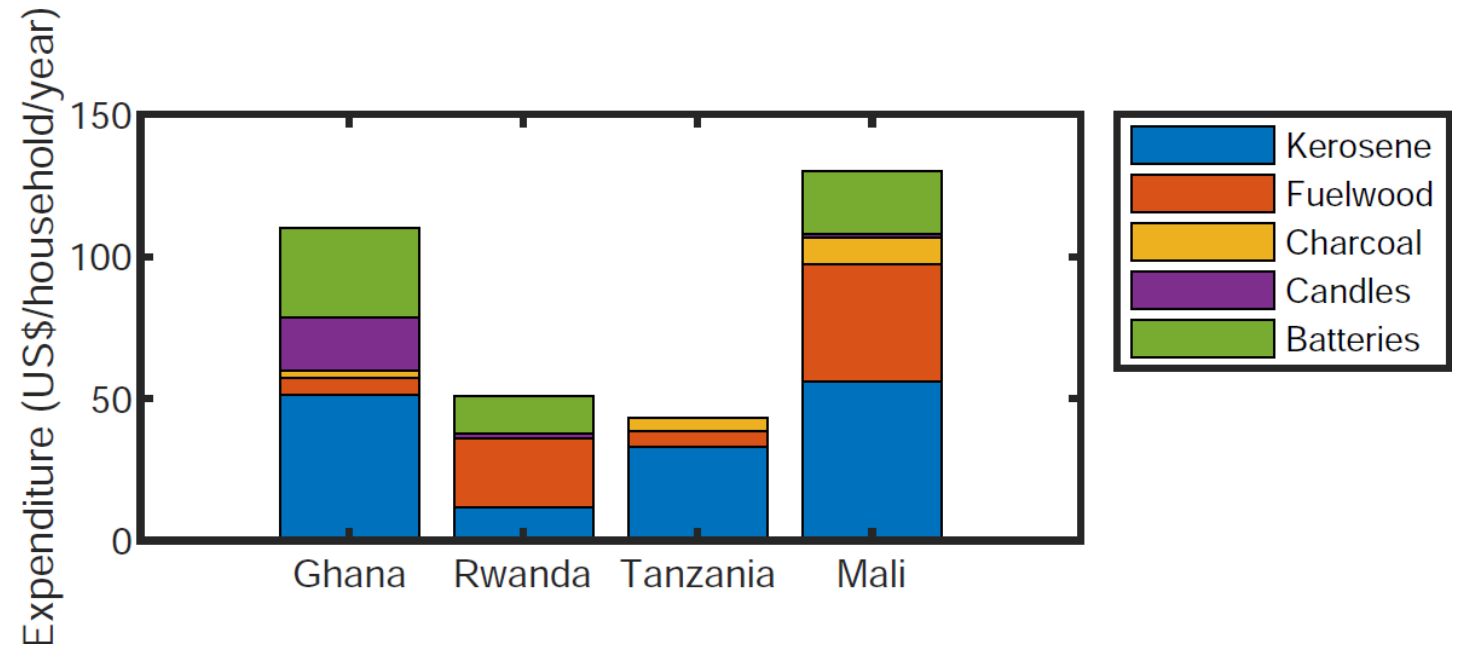


# Fuel Expenditure

- Energy is often a serious financial burden for off-grid communities, reducing money available for
  - food
  - medicine
  - tuition
  - agriculture inputs (seeds, fertilizer, etc.)
- Households should spend no more than 10% of income on fuel, but some spend up to 30%

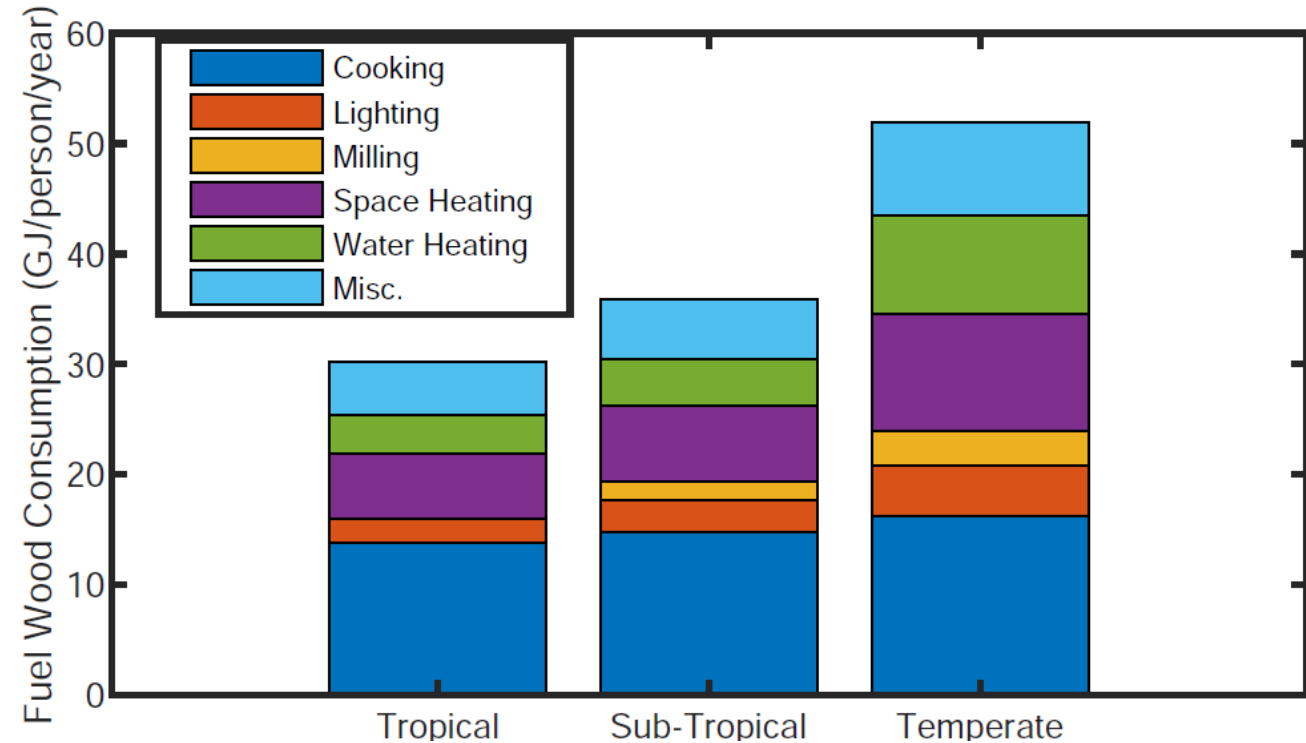
# Fuel Expenditure

Wide variety in expenditure, typically ranges from US\$40 to US\$140/household/year



# Fuel Wood Use

- Most important fuel for rural households
- Can be obtained with no or little cost (travel of 5km common)
- Burden on collection and processing (usually women/girls) 5 to 25 hours per week
- Typical consumption 1 to 5 kg/person/day but up to 10 kg/person/day in cold climates (several tonnes per year)





# Charcoal Use

- Charcoal is biomass (wood) in a convenient and affordable form
- Charcoal is a major household energy source in SSA
  - 36 million tonnes worth \$11 billion per year
  - 90% of urban homes rely on charcoal
  - Rural use is lower (15% in Zambia)
- Well-developed supply chains in many developing countries
- Can be a significant contributor to GDP and employment
  - Zambia: 500,000 informally employed, 3 percent of GDP

Charcoal market in Zambia



Charcoal and jiko in Kenya



# Charcoal Production

- Charcoal is made by heating wood over a period of several days or longer in a low-oxygen environment (“pyrolysis”)
- Carbon content ranges from 50% to 95%
- Wood-to-charcoal conversion rates are approximately 20%
- Charcoal production can lead to forest degradation and in some case deforestation





# Kerosene (“paraffin”)

- Commonly used in many parts of Sub-Saharan Africa
- Often subsidized by government
- Used for lighting, starting fires
- Less than 10% of energy supply, but can be 50% of expenditure
- Dangerous & unsafe
  - Cancer, respiratory infection, asthma, tuberculosis, cataracts
  - Accidental ingestion
  - Fires and burns




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