Sustainable Village Energy

TSC 220

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Sectors of energy use

**Industrial:** facilities and equipment used for producing and processing goods

**Transportation:** vehicles for people good on ground, air, or water

**Residential:** private living quarters

**Commercial:** service-providing facilities and equipment
But what do we mean by *sustainable village energy*?
Is it just households? Businesses? Schools?
In most societies, a portfolio of fuels is used to satisfy energy needs.

Why?
Residential energy use in the home

- Lighting
- Comfort
- Entertainment
- Space Heating
- Cooling
- Refrigeration
- Cooking
- Water Heating
- Water Boiling
Residential energy use outside the home

Water access
Family Business
Machinery
Mobility
Cooking in Vietnam

Step 1: Preparation of food
Step 2: Cooking - continuous water access - tending fire
Step 3: Dishing up food
Step 4: Dining
Step 5: Washing utensils
Step 6: Drying utensils

Different fuels for different uses

Separated ‘kitchen’ spaces due to unhealthy, unsafe, and unhygienic cooking solution
Is there one energy source, with today’s technology, that can meet needs in all societies of the world?
There is no universal solution

The world is too diverse...

• Culture
• Economics
• Social structure
• Resource availability
• Geography
• Access to markets
• Political climate
• Need
• ...

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“Experience has shown that social, environmental, economic, cultural, and ethical aspects of a project are often more important than the technical aspects.”

Local contexts influence sustainability

Human

User  Technology

Natural  Built
Contexts, more specifically

- Socio-cultural
- Natural
- Political
- Financial
- Human
- Physical

Department for International Development, 1997
Technologies that fail to address local contexts are not sustainable (e.g., stoves)

- **Human Contexts**
  - Stove cannot cook my meal
  - Harder to use than three stone fire
  - I wouldn’t be seen with that in 100 years
  - Cost!

- **Natural Contexts**
  - Fuel is in short supply
  - Rain erodes stove

- **Built Contexts**
  - No infrastructure to transport replacement parts
  - Lack of manufacturing tools
  - No place available to keep fuel dry
There is no universal solution
Because a solution depends on local contexts
First, consider where you are

Stand-alone

Market-connected

... access to markets means access to technology, resources

... stand-alone, resource is the land
Next, consider options for local ownership and sustainability

Consumer acceptance and demand
*Will people buy it?*

Energy availability assessment
*Where is the energy source? What type of fuel?*

Business model and value chain recommendations
*How can we establish a solution that is locally sustainable?*
Example:
Residential biofuels for South Africa
Where are we?

Stand-alone

Market-connected
Country-wide opportunity assessment

**Market opportunity**
60/40 Urban/Rural
~3.5% growth pa

**Demand**
Emerging consumer location
Urban municipality poverty
Rural family poverty

**Arable land concentration**
Higher agri outputs, sustainability
Crop failure in drier regions
Better climate less no-till

**Supply**
Residue availability
High production in East
Competition Cape region

**Emerging consumer location**
Urban municipality poverty
Rural family poverty

**Residue availability**
High production in East
Competition Cape region

- **Good availability**
  - Maize
  - Sugarcane
  - Forestry
  - Mixed farming

- **Poor availability**
  - Cattle and game farming
  - Sheep farming
### How does your consumer cook?

<table>
<thead>
<tr>
<th>Time</th>
<th>Morning</th>
<th>Break</th>
<th>Noon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Cook pap 30-35 min</td>
<td>Heat water for bathing 20-45 min</td>
<td>Cook pap 30-35 min</td>
<td>Cook pap 30-35 min</td>
</tr>
<tr>
<td></td>
<td>Boil chicken feet 15-20 min</td>
<td></td>
<td>Boil veg 15-20 min</td>
<td>Boil veg 15-20 min</td>
</tr>
<tr>
<td></td>
<td>Tea 8-10 min</td>
<td>Tea 8-10 min</td>
<td>Fry worms 8-10 min</td>
<td>Cook eggs 10-15 min</td>
</tr>
<tr>
<td>60-80</td>
<td></td>
<td></td>
<td>*Heat water for bathing 20-45 min</td>
<td></td>
</tr>
</tbody>
</table>

*Heat water for bathing 20-45 min
Does your consumer want a new technology?

<table>
<thead>
<tr>
<th>Category</th>
<th>Wood</th>
<th>Paraffin</th>
<th>Gel</th>
<th>Your Stove</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-ignition</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Great</td>
<td>Great</td>
</tr>
<tr>
<td>Fuel storage, handling</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fuel procurement</td>
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<td></td>
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<tr>
<td>Appliance storage</td>
<td></td>
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</tr>
<tr>
<td>Ignition</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Great</td>
<td>Great</td>
</tr>
<tr>
<td>Fuel loading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Easy of ignition</td>
<td></td>
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<td></td>
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<tr>
<td>Time to start cooking</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cooking</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Great</td>
<td>Great</td>
</tr>
<tr>
<td>Quick to cook</td>
<td></td>
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<tr>
<td>Safety and cleanliness</td>
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<tr>
<td>Adaptable to meal type</td>
<td></td>
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<td></td>
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<tr>
<td>Comfort, ease of use</td>
<td></td>
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<tr>
<td>Heat regulation</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Extinguish</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Great</td>
<td>Great</td>
</tr>
<tr>
<td>Smoke &amp; ash</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Start/stop fire</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fuel conservation</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clean up</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Great</td>
<td>Great</td>
</tr>
<tr>
<td>Black pots or person</td>
<td></td>
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<tr>
<td>Ash removal</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Stove cleaning</td>
<td></td>
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</tr>
</tbody>
</table>
Assess your fuel supply

**Sugarcane bagasse**
Accessible at milling factory

**Availability**
- ▲ Good
- ▲ Fair
- ▲ Poor

**Sugarcane trash** (tops, leaves)
Accessible at field, non-burned cane

**Availability**
- ▲ Good
- ▲ Fair
- ▲ Poor

10-15% of cane is green harvested

**Maize stover**
Accessible at farms in bails

**Availability**
- ▲ Good
- ▲ Fair
- ▲ Poor

**Forestry related** (sawdust; logging waste: thinning, tops, bark, stump)
Sawdust accessible at sawlog factory (saw mill)
Logging waste (thinning, tops, bark, stump) accessible at logging site

High to low production; softwood and eucalyptus high production, wattle fair

<table>
<thead>
<tr>
<th>Pine and other softwood</th>
<th>Eucalyptus (hardwood)</th>
<th>Wattle (hardwood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPL north</td>
<td>MPL south</td>
<td>KZN midlands</td>
</tr>
<tr>
<td>MPL south</td>
<td>Zululand</td>
<td>KZN north</td>
</tr>
<tr>
<td>Eastern Cape</td>
<td>KZN midlands</td>
<td>MPL south</td>
</tr>
<tr>
<td>KZN midlands</td>
<td>MPL north</td>
<td>KZN south</td>
</tr>
<tr>
<td>KZN south</td>
<td>KZN south</td>
<td>KZN south</td>
</tr>
<tr>
<td>KZN north</td>
<td>KZN north</td>
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</table>

High trashing
Establish your value chain

Your product may not be this complex

<table>
<thead>
<tr>
<th>Cost per kg</th>
<th>0</th>
<th>0.25</th>
<th>0.30</th>
<th>0.20</th>
<th>0.67</th>
<th>2.0</th>
<th>2.28</th>
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<tbody>
<tr>
<td>Materials</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Primary transport</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Production and packaging</td>
<td></td>
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<tr>
<td>Secondary transport</td>
<td></td>
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<tr>
<td>Gross margin</td>
<td></td>
<td></td>
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<tr>
<td>Channel mark-up, two layer</td>
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<td></td>
</tr>
<tr>
<td>VAT</td>
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</tr>
</tbody>
</table>

Map showing Factory location.
Sustainability lessons

Biofuel supply monitored year-round

Determine your competitors (kerosene, wood, electric)

Create a product people want to buy, and can afford

Produce appliance and fuel centrally, use established distribution system for delivery to villages

Point of sales include commonly visited shops & markets
Example:
Residential biofuels in Mali
Where are we?

Stand-alone

Market-connected
Take the best of local & global technology

Locally manufactured
Meets cooking needs
Low cost

Insulative ceramic
Durable
Local materials

Clay/mud

Biomass
An improved local ceramic

- **Bricks**
  - Testing clay to biomass ratios between 1.5:1 to 3:1
  - Biomass: peanut shell, straw, sawdust

- **Firing**
  - Warm to 100°C over 3 hours
  - Ramp to 900°C over 6 hours
  - Hold at 900°C for 1 hours
  - Good for sawdust, not for peanut shell

- **Specific gravity**
  - 0.5 to 0.8, “float test”
  - Insulative yet structural
Construction

• Press and mold to form bricks

• Bricks for one stove
  – 5cm X 10cm X 15cm (12)
  – 5cm X 10cm X 22cm (2)

• Built at the home

• Upgradeability
  – Mud-clay seal
  – More durable model with 12:1 mud to cement ratio for seal
Kiln

- Temperature: 900C
- Volume: 1 m$^3$ volume
  - 40 water filters
  - 600 stove bricks
- Footprint: 5’ x 7’
- Tested and verified for use on filters, stoves
Sustainability

- Local materials
  - Clay
  - Biomass: peanut shell, straw, saw dust

- Local construction
  - Family of brick maker/layer

- Local management
  - Family of brick maker/layer
  - Cultural acceptance
  - Business development ($3/stove)
3 take-aways
There is no universal solution

The world is too diverse...

• Culture
• Economics
• Social structure
• Resource availability
• Geography
• Access to markets
• Political climate
• Need
• ...

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Local contexts influence sustainability

- Human
- User
- Technology
- Natural
- Built
Use systems thinking to better conceptualize sustainability

Systems map
(of local contexts)

Different users

Different technologies

Different systems