SOLAR ENERGY TECHNOLOGY

Solar Energy Delivery Models

> Introduction

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14-18 June 2010

Jakarta
Indonesia

What is a Solar Energy Delivery Model?

A Solar Energy Delivery Model deals with the supply of energy to users

It involves:

- Technology (what?)
- Finance (how?)
- Implementing body (who?)
- Policy (why?)

What do we want to Achieve?

Delivery of off-grid sustainable energy services to the rural population in the best, i.e. most efficient, effective manner with the biggest possible impact.

- Electricity (& LPG)
- Not a pilot project: integral part of rural electrification

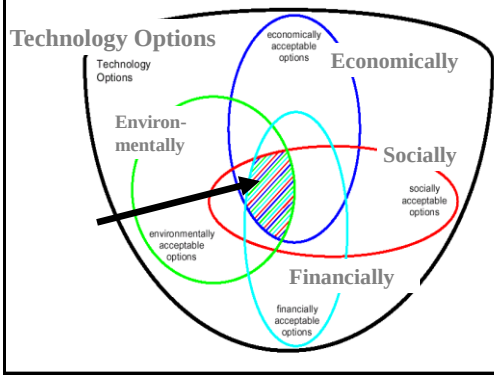
WHAT DOES THE CUSTOMER WANT ?

Look at Alternatives

- **Grid Supply**
- **GenSet**
- **Hydropower**
- **Windgenerator**
- **Biodigester**
- **Solar Heater**
- **Efficient Stove**

- **Grid-Connected PV**
- **Mini-Grid PV**
- **Community Systems**
- **Solar Home Systems**
  classic,comfort, AC, DC
- **PV-Pumps**
- **Small-PV**
  Lanterns, Battery Charging

Solar Energy Delivery Model is Complex



Barriers

- Information & perception barriers
- Financial barriers
- Technical barriers
- Legal/Policy barriers
- Institutional/Organisational barriers

Information & Perception Barriers

- Insufficient knowledge technologies & technological developments
- Information not easily accessible
- Wrong perceptions

➔ Reinventing the wheel

➔ Difficulties financing

➔ Unrealistic expectations consumers

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Financial Barriers

- Unsustainable donor-funded consumer prices
- Unavailability of credit for private sector
- Level & structure financial payments for consumers not conducive

➔ Market distortion

➔ Slow growth renewable energy market

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Technical Barriers

- Complex and/or inappropriate technologies
- Unproven technologies
- Inappropriate system sizing & system design

➔ High cost systems

➔ Consumer disappointment

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Legal/Policy Barriers

- Weak incentives renewable energy

➔ Unfavourable competition terms between grid electricity and renewable energy

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Institutional/Organisational Barriers

- Donor-funded pilot project format
- Renewable energy not integral part rural electrification efforts
- Lack of integrated planning
- Weak linkage public and private sector
- Insufficient public sector capacity

➔ Supply driven & not easily replicable

➔ Disjointed planning & implementation

➔ Lack of institutional ownership

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Conclusions on Barriers

- Barriers are inter-linked
- Delivery Model has to tackle all barriers in a comprehensive way

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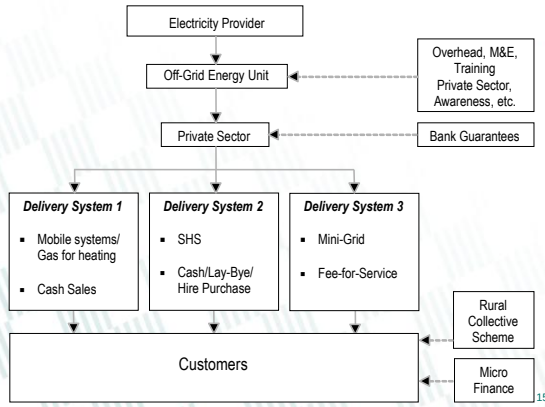
Stakeholder Involvement



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Profile Average Customer

- Poor, living near or on subsistence level
- Priority is food security & survival household
- Low and mostly irregular sources of cash income
- Minimises risks and avoids uncertainties
- Only partially integrated in market economy
- Limited access to information

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Energy Options People Use

- Cooking
- Spatial Heating
- Lighting
- Water Heating
- Entertainment
- Refrigeration/Ironing
- Income Generating Activities

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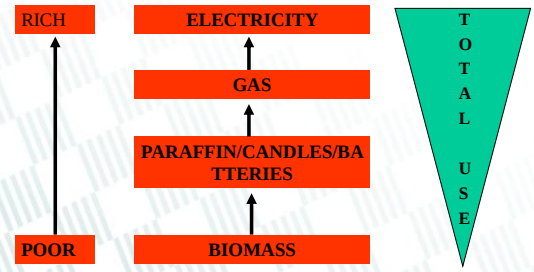
Energy Resources & Use

Resource Patterns



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Resource Patterns

Three Important Issues:

1. Want new resource but do not necessarily need it
2. When new resource taken up existing resources still used
3. Every time new resource taken up (marginal) increase energy expenditure budget

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Stakeholder Roles

- Which bodies should play which roles in the proposed delivery model?
- How can sustainable supply-demand linkages be created?

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Three Important Premises

1. Delivery model is *not* a project proposal but an integrated part of the existing rural electrification program
2. Actual delivery of energy & related services is *private sector* role
3. *Public sector* retains overall supervising responsibility

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Proposed Roles

Government & Parastatals

1. Enabling Legal, Policy, Subsidy & Taxation Framework
2. Supervision & Tendering Requirements & Procedures
3. Standardisation & Certification
4. Monitoring & Quality Assurance
5. Demand Assessment

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Proposed Roles

NGO's, CBO's, Private Sector & Finance

5. Demand Assessment
6. Awareness Creation
7. Delivery
8. Training and Training Needs Assessment
9. Operation & Maintenance

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Technical Options

- Solar lanterns and small portable systems
- Solar Home Systems
- Central Battery Charging Stations for consumptive use
- Centralised PV systems and PV-gas hybrid systems for productive and consumptive use
- LPG for heating and cooking

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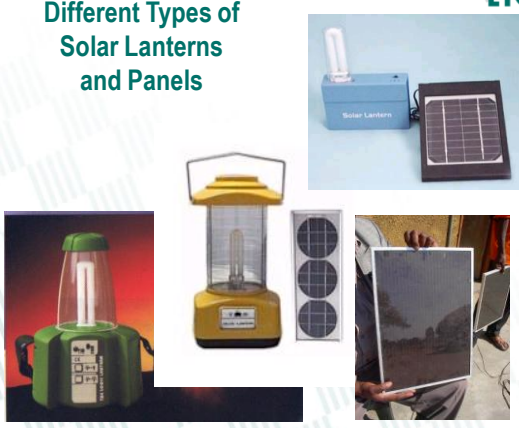
Different Types of Solar Lanterns and Panels



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Portable Solar System (1)

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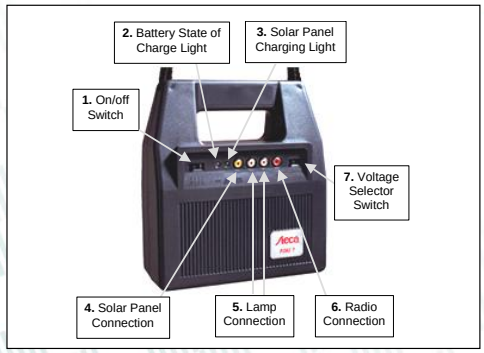
Portable Solar System (2)



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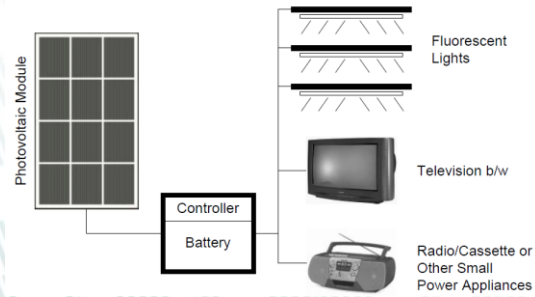
Solar Home System



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What can it do for you? (1)

Technology	Description	Typical daily Energy Available	Appliances that may be powered
Solar Lantern	Light, battery and electronics integrated in one unit. One light of typical 3W-9W. Battery typical 4Ah-7Ah. Solar panel typical 3Wp-10Wp.	12Wh to 40Wh	1 light
Portable Solar System	Battery and electronics are integrated in one unit. Often possibility for radio/hifi connection. Two lights of typical 3W-9W each. Battery typical 5Ah-12Ah. Solar panel typical 5Wp-15Wp.	20Wh to 60Wh	1 to 2 lights radio/hifi
Small to Medium SHS DC System	Often individual components. 2 to 6 lights typical 7W-13W each. One to three batteries of typical 100Ah each. One to three solar panels of typical 50Wp each.	200Wh to 600Wh	2-6 lights, radio/hifi
Large SHS AC System	Often individual components. 6 to 12 lights typical 7W-13W each. Four to ten batteries of typical 100Ah each. Four to twelve solar panels of typical 50Wp each.	800Wh to 2.4 kWh	6-12 lights, radio/hifi, VRC, TV, fan, sewing machine and other small power appliances, small fridge for largest systems

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What can it do for you? (2)

Technology	Description	Typical daily Energy Available	Appliances that may be powered
Battery Charging Station	Typical central PV system of 250Wp-1kWp for 10 to 50 users. Users have batteries ranging from 20Ah-50Ah. Users connect 1 or 2 lights to the battery and radio/hifi.	50Wh to 150Wh per user	1 to 2 lights radio/hifi
PV minigrid	Central PV system. Systems are sized for a particular application. Typical system sizes of 1kWp-20kWp. Typical 10 to 50 users.	4kWh-80kWh	6-12 lights, radio/hifi, VRC, TV, fan, sewing machine and other small power appliances, small fridge for largest systems
PV-LPG Hybrid System	Central hybrid systems powered by PV and LPG. Systems are sized for a particular application. Typical generator sizes of 10kW-50kW. Typical 20 to 100 users.	Mainly depends on the size and running time of the generator	Lights and most domestic appliances.

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Battery Charging Station

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Battery Charging Station

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PV Power Station for Mini-grid

- Autonomous PV
- or PV - diesel hybrid operation
- 6 kW Array => 24 kWh/day
- 20 x ASE 300 Solar Panels
- 48 V DC
- 20 foot container

LPG in the Energy Package

- For cooking and water heating
- Replacement of fuel wood
- Existing distribution channels do not reach rural areas
- What mechanisms are required to supply gas to rural areas?

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Financing Mechanisms

- ~~Donations~~ — Cash & Carry
- Cash — Cash sale
- Savings
- Lay-bye
- Credit — Dealer credit / Credit institution
- Hire-purchase — Lease
- Fee-for-Service

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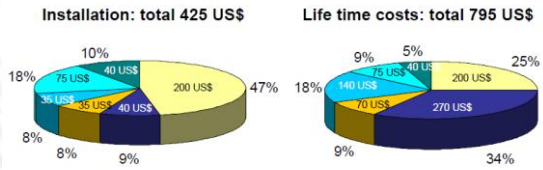
Solar Home System Cost Structure



No costs for financing calculated

Source: World bank 1996 (installation cost), Indonesia, 5,000 systems per year

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Technology and Finance Matrix

Financing Mechanism	Technology Option				
	Social Consumptive use			Economic Productive and consumptive use	
	Solar Lanterns & Portable Systems	SHS	PV-Battery Charging Station	PV mini-grid	PV-LPG mini-grid
Donations					
Cash					
Lay-Bye					
Savings					
Credit					
Fee for Service					

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Technology and Finance Matrix

Financing Mechanism	Technology Option				
	Social Consumptive use			Economic Productive & Consumptive use	
	Solar Lanterns & Portable Systems	SHS	PV-Battery Charging Station	PV mini-grid	PV-LPG mini-grid
Donations	✓	✓	✓	✓	✓
Cash	✓	✓			
Lay-Bye	✓	✓			
Savings	✓	✓			
Credit	✓	✓			
Fee for Service	✓	✓ ?	✓	✓	✓

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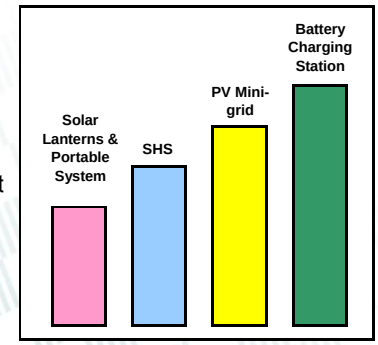
What does it Cost?

Apples & Oranges

Costs:

- Equipment
- Installation
- Maintenance
- Replacement
- Service
- Transaction
- Training



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Cost of electricity grid extension, per single household

677 - 1,852	US$	Brazil, 2001, different provinces
1,530	US$	Kenya, 1970 - 2000, average value from 30 years and 77,000 new connections
830 - 3,780	US$	China, 2002, village 30 km from grid, 300 resp. 60 households

Interests for loans, cost of electricity production, revenue collection, grid operation and maintenance not included!

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Household electrification

Empirical values for daily electricity use in (grid-) electrified low income rural households:

0.27	kWh/day	Senegal	(Lorenzo, 1997)
0.23 - 0.35	kWh/day	Vietnam	(Tuan & Lefevre, 1996)
0.5	kWh/day	Indonesia	(Cabraal, Cosgrove-Davies & Schaeffer, 1998)
0.33 - 0.47	kWh/day	Brazil	(Dos Santos & Zilles, 2001)
10	kWh/day	Germany	

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Income Generating Activities (1)

Sector	Application
Agriculture	• Pumping for irrigation, livestock watering, potable water • Electric fences • Lighting of poultry /livestock • Veterinary services (refrigeration, lighting, etc.) • Lighting for fishing • Fish tank aeration • Refrigeration of agricultural products, meat, dairy, fish • Pest control
Workshops	• Tailor shop • Bicycle repair workshop • Handicrafts workshop (basket weaving, etc) • Office equipment (computers, etc.)

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Income Generating Activities (2)

Sector	Application
Others	• Village cinema (TV + VCR) • Battery charging station • Advertising kiosks • Lighting of billboard • Karaoke bar • Internet service • Cellular telephone service • Water purification PV to power UV or ozone water • Water desalination reverse osmosis or other water desalination

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Many Stakeholders Involved

- Government
- NGOs
- Utilities
- Academe
- Manufacturers
- Suppliers
- Installers
- Financing Institutions
- Foreign Assistance

- **Project Implementation Chart**
- design system configuration
- develop payment scheme
- identify site
- conduct information drive
- get, evaluate applications
- appraise site, check options
- install demo system
- enroll applicants
- secure financing
- procure material
- test components
- train technicians
- collect BOS payment
- install systems
- train users
- organize maintenance
- organize collection
- supervise operation

START WITH THE USER !

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Key elements of a sustainable Energy Delivery Model

- Customer satisfaction
- Affordability
- Flexibility
- Effective supply and service chains
- Profitability

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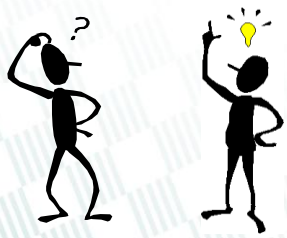
The rewards are high

- Improved Service
- Rural Employment
- Productivity of Rural Citizens
- Productivity of Rural Energy Sector
- Technical Advancement, New Economies
- The Least Cost Service to Rural People

... but it is not available for free !

QUESTIONS ?



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