Alliance for Rural Electrification
Shining a Light for Progress


Photo: Long house in the outback of Malaysia powered by PV-Mini Grid

Micro Perspectives for Decentralized Energy Supply

2nd International Conference

Berlin, February 27 - March 1

Michael Wollny, Vice President
Alliance for Rural Electrification
Brussels

The Alliance for Rural Electrification

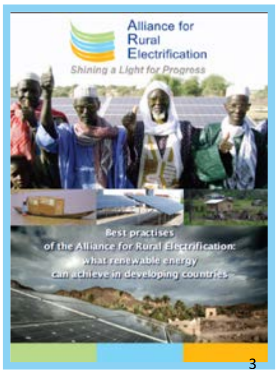
Promoting Off-Grid RETs in Developing Countries

The only **industry association** representing

- ✓ All **off-grid RETs solutions**
- ✓ The **entire off-grid RETs value chain**
- ✓ Covering **all continents**

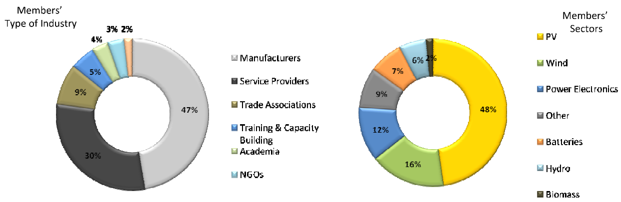
Business hub for the off-grid RETs industry

- ✓ Networking opportunities
- ✓ Market information
- ✓ Communications and Marketing
- ✓ Advocacy



ARE - Alliance for Rural Electrification

- Created in 2006
- Non-profit international organization
- Vital global network of innovative and dedicated professionals



Currently representing 68 companies

ARE members

Strong Partners

We partner with **international organizations, projects and initiatives, media** and **other businesses.**

Some of our current partners:

Current state of rural electricity markets

More than 90 % of un-electrified population is rural

Worldwide:

✓ 1.3 b un-electrified
✓ of which, 1.1 living in rural areas
✓ + 1 b under electrified

Regions with lowest Electrification rates:

✓ Africa (except for North Africa)
✓ Developing Asia

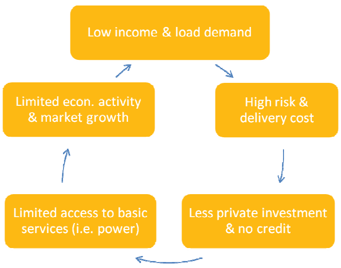
Population without access to electricity				
Continent	Total Population		Rural-Urban Million	
	Million	Share	Rural	Urban
Africa	587	58	466	121
North Africa	2	1	n.a.	n.a.
Developing Asia	675	19	595	81
Latin America	31	7	26	4
Middle East	31	11	26	2
Developing countries	1314	25	1106	208
World	1317	19	1109	208

Source: IEA 2011 "World Energy Outlook"

Constraints in Rural Energy Markets

3 major constraints impeding the development of rural energy markets

•low demand, high service delivery cost, geographically scattered customers;
•high risks due to the lack of proper mechanisms to manage risk in the sector;
•and poor access to available credit and equity needed to enhance market demand.

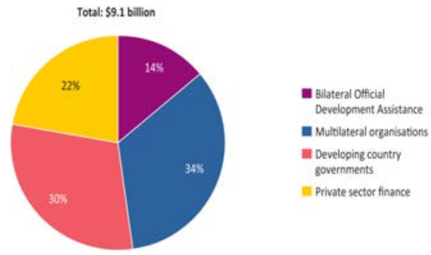


Vicious circle impeding development

Brijesh Mainali, *Renewable Energy Market for Rural Electrification in Developing Countries: Country Case Nepal*, Licentiate Thesis 2011, KTH School of Industrial Engineering and Management

Energy in developing countries remains a donor driven sector

78% from public sources!



Source: IEA 2011 "World Energy Outlook"

Challenges faced by local public authorities in RE

- ✓ **Limited knowledge** on RE from public authorities
- ✓ **No partnerships** amongst key actors
- ✓ **Legislation & policy**: No processes, dialogue, guidance, coordination
- ✓ **Lack of institutions** specifically dedicated to RE in rural areas
- ✓ Inadequate of **public and private financing structure**
- ✓ **Regulation:** heavy burden & problem of reflectivity of tariffs.
- ✓ **Infrastructure** only ready for grid connected and conventional energies
- ✓ **Subsidies:** Fossil & grid-tied oriented support schemes leading to market distortion

Fostering Renewable Rural markets through an enabling framework

How can Governments optimize the use of their own instruments in order to foster rural electrification ?

Institutional and Policy framework

- ✓ **Well structured policy framework**
- Law that ensures long term commitment and sets the principles
- Policy establishing concrete targets
- Master plan which establishes a path to achieve targets (with monitoring system)

- ✓ **Rural Electrification Agency as coordinator**
- Centralised management of public technical, policy, financing aspects
- Politically, financially and administratively autonomous
- Coordinator of international, national / public, private and NGO efforts

Regulation

✓ **De-regulation and Re-Regulation**
- Light and flexible
- Transparent and fully enforced

✓ **Tariffs**
- Tariff must be reflective (LCOE), but affordable
- Additional measures such as tax credits; low import duties for the equipment.

✓ **Standards**
- Ensure quality of products and services (reliability)
- Consumer and environmental protection
- Necessary that service providers offer after-sales services

Subsidies and other Financing Mechanisms

✓ **Subsidies**
•Complement the tariff in order to foster Rural Electrification
•Phasing out fossil fuel subsidies

✓ **Financing mechanisms**
•Complementing subsidies with credit and guarantee for risk mitigation
•Banks (for companies) and Microfinance institutions (for SMEs and consumers)

Ensuring sustainability of the installed system

- ✓ **Securing market size**
- Productive use (i.e. GSM towers, Agriculture etc.)

- ✓ **Project formulation**
- System adaptability to demand trends

- ✓ **Business model**
- From energy as a product to energy as a service
- Involvement of public, private and NGO actors (Hybrid model)

- ✓ **Participatory approach**
- Operations and maintenance
- Capacity building

Expected outcomes

Multiple aspects to look at in order to ensure sustainability of the project

- ✓ **From policy side:** Fully adapted institutional framework and an enabling policy framework will grant better coordination and performance of public programmes
- ✓ **From financial side:** Tailored private financing mechanisms will lower the need for subsidies and attract additional private capital used to upscale interventions
- ✓ **From project side:** Right technology and size of the system to grant reliability and affordability of the service.

Main objective:

Development of Rural Energy Markets breaks vicious circle in rural areas

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Thank you!

2nd International Conference - Micro Perspectives for Decentralized Energy Supply

The Mini-Grid Workshop - *Enabling energy supply for low-income markets through mini-grid solutions*

Berlin, 27 February 2013

19 years Field Experience: barriers and solutions for RE "mini grids" development

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in collaboration with:

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH – University Research Institute for Sustainability Science and Technology

European Comission External Cooperation Programmes

Trama TecnoAmbiental (TTA)

- SME Founded in Barcelona en 1986. Offices in Spain, Costa Rica, Ecuador and Brazil.
- Independent Engineers and Consultants in distributed Renewable Energy, Engineering, Research, Project management, Social aspects, Financial, …
- Since 1988: Off-grid rural electrification practitioners, pioneers in renewable energy based micro grids development
- Design and Project management of RE-hybrid micro-power plants and micro grids for rural electrification in southern Europe, Africa, Latin America, Oceania …

Member of:

Alliance for Rural Electrification – solartys – *IEA PVPS* - Task 11 PV hybrid systems within mini-grids

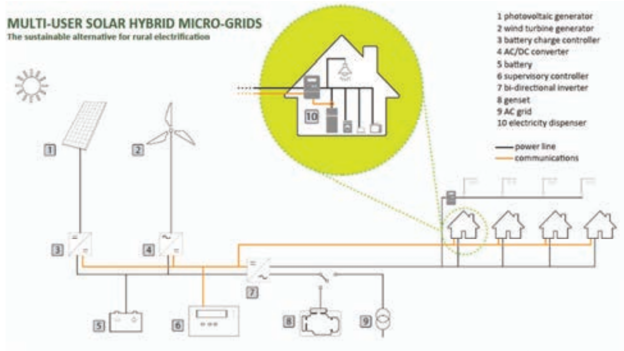
Pioneer PV rural micro grid

"La Rambla del Agua" Granada, Andalucía - Southern Spain (1994)

Since then, TTA has been involved in more than 30 microgrids in Europe, South America and Africa

Focus: Energy service

Generation micro plant + Distribution micro grid



RE micro grids: Limiting factors vs advantages

Component	Goal (as a service)	Advantages	Possible Limiting Factors
Technical-Technological	*Reliability*	Very wide range of uses and applications, adaptable to any type of rural demand. Modularity. Commercial maturity - some technologies. Lower maintenance than generators set. Use of local energy resources.	Resource availability (wind, water and biomass). Space availability for some equipment. Lack of formalisation and supply chain control (price quotations, contracting, inspection, warranties, spare parts availability, after-sales service,…).
Institutional – Managerial	*Empowerment*	Improves user co-responsibility. Basic O&M can be undertaken by local staff; in very remote areas, this is the only *de facto* option. Community or Mixed management models enable local contracting.	Regulatory framework of e- sector Awareness of the diversity of roles needed in the development, design, installation, maintenance and good management of the electricity service. Professionalisation, capacity to perform the key roles and responsibilities.
Financial-Economic	*Viability*	Competitiveness with grid extension for the supply of low and/or dispersed demands. More intensive on CAPEX, lower OPEX Potential for developing eco tourist activities.	Underestimation of WTP levels. There is no monetary valorisation of social benefits with respect to conventional energy supply options. Lack of references on social evaluation of rural electrification investments available to planners.

Technical Solution: Standardisation

- Electricity generation based on renewable energies or mixed (RE + genset)
- Steady village-level electricity service, offering also the possibility to be upgraded to either more capacity, clustering or interconnection
- Installed capacity up to 100 kW (according to IEC)
- Low voltage distribution lines
- Single or 3-phase grid

(adapted from IEC 62257 TS series, IEA PVPS Task3 and Task11 recommended practices)

PV Hybrid Micro Grid in West Bank, Palestine

Managerial solution: Energy Daily Allowance (EDA)

- Traditionally in conventional grid connection: users pay for consumed kWh, and there is no active individual load management approach
- In autonomous electrification with RE: Key aspect is the constrain on available energy
- In RE electricity, user should pay for **availability** not for the consumed energy
- Tariff based on the **Energy Daily Allowance** (fee for service ≠ prepayment)
- Clearer and easier financial planning for operator and for client
- It reduces transaction costs because of flat fees

Technical solution: Electricity Dispenser/meter

Single phase electric meter with **dispenser** functions

Main Current Switch (40A):
- Energy Daily Allowance (EDA) management according to the contracted tariff
- Virtual storage of saved energy: 6 x EDA
- Programmable power limitation

Auxiliary Smart switch (5A) :
- for deferrable loads

Smart RFID card for:
- Tariff management
- Energy swapping between users
- Invoicing management

- **Certified energy meter**

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Financial – Economic component → Viability!

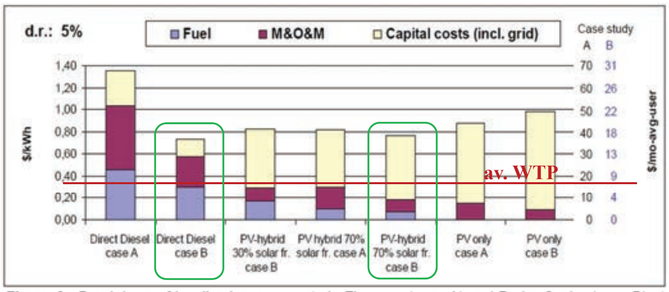

Figure 3.- Breakdown of levelized energy costs in Floreana (case A) and Padre Cocha (case B) at 10% and 5% discount rates. Average kWh cost are acceptable to compare different solutions for one application, but for different systems for different locations and small demands, transaction costs, local management, etc, represent a high fraction of the service costs, and the cost per user must also be assessed.

Exciting new projects in 2013

- 5 PV microgrids in Chad - UNIDO - currently under first pre-design studies
- Feasibility study of biomass hybrid microgrids for rural communities in West Africa – ECREEE (just signed)
- CYTED Action - MIGEDIR (just signed)

(MIcrorredes con GEneración DIstribuida de Renovables)

Involving Research Centres, NGOs and private companies from Spain, El Salvador, Cuba, Dominican Republic, Bolivia, Colombia, Mexico, Perú, Portugal, Chile, Argentina, Guatemala

Thanks for your attention!

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http://grecdh.upc.edu/projects/other/e4a-2030 www.tta.com.es

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Example MSG

Monte Trigo, Cape Verde

Site: Monte Trigo, 17º01'N , 25º19'O , 00 m s.l.

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Monte Trigo: the village



- One hour by boat from nearest village
- 600 people aprox., fishing is main income generating activity
- 80 houses (60 connected), school, medical centre, kindergarten
- hostel for visitors, several small shops, connection for telecommunications and TV
- Deferrable load: ice making
- PV electricity since February 2012

RURAL RE MICROGRID (kWh/day	
PV GENERATOR	
Installed PV capacity	27 300 Wp
Module type	130 Wp 36 cell – mono crystalline
Number of modules	210
Inclination / orientation	15º / +20º S
PV CHARGE CONTROLLER	
Rated power	2x12 000 Wp
Control algorithm	MPPT - Boost
BACK UP GENSET	
Rated power	20 kVA 3- phaseS
Fuel	Diesel
BATTERY	
Number of elements (voltage)	24 (48V)X2
Type	Lead acid OPzS tubular
Capacity (C100)	3 850 Ah – 370 kWh
Autonomy	4 days
INVERTER	
Voltage input / output	48 V DC / 230 V AC
Rated power	2 X 8 000 W
Harmonic distortion	< 2,5%
DATA LOGGER	
Type of data	Energy, voltage, radiation, etc.
ELECTRICITY DISPENSER – METER	
Input	230 V AC 50 Hz
Maximum current	Configurable
Algorithm	Configurable Energy Daily Allowance
DISTRIBUTION LINE AND STREET LIGHTING	
Line Length	800m
Number of lamps	20
Type	70 W hp Na / 2 level electronic ballast
INDIVIDUAL LOADS	
Households 825 Wh/day	20
Households 1100 Wh/day	18
Households 1650 Wh/day	14
Households 2200 Wh/day	6
School 1650 Wh/day	1
Ice machine 4200 Wh/day	1

Added value solution: PV pergola



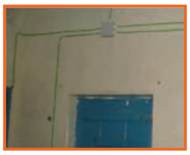
Added value solution: Engage the users



Technical solution: mechanical room




Technical solution – Single phase LV distribution

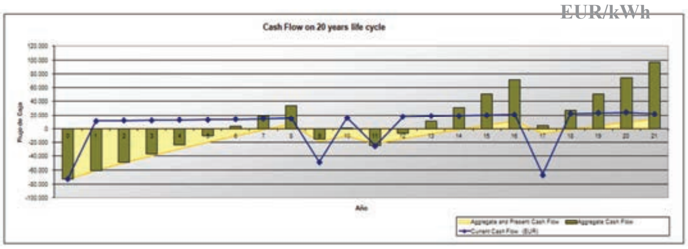



Technical solution – User interface

PV microgrid in Monte Trigo (Cape Verde)

Discount rate: 8,5%
Lifetime: 20years

LCOE (generation) : 0.24 EUR/kWh
LCOE (net demand): 0.36 EUR/kWh



NPV 13.871 EUR Sustainable Project

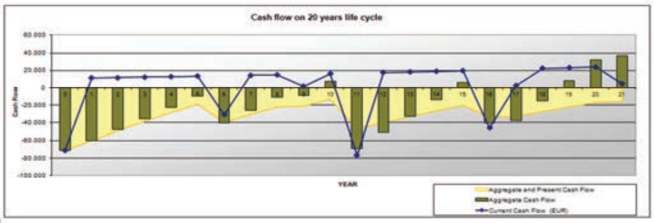
University Research Institute for Sustainability Science and Technology

PV microgrid in Monte Trigo (Cape Verde)

Without demand management system → reduced components life

Discount rate: 8,5%
Lifetime: 20years

LCOE (generation) : 0.29 EUR/kWh
LCOE (net demand): 0.43



NPV -15.606 EUR Project NOT Sustainable

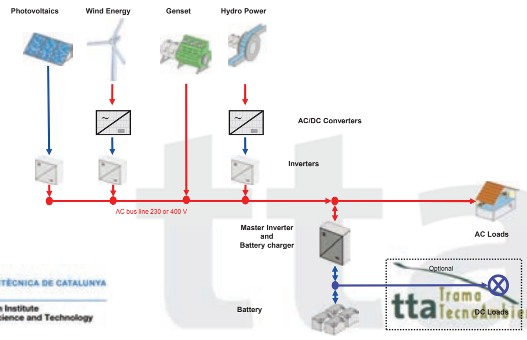
Structure of Hybrid Micro power plants-AC coupling

All electricity generators are connected to the AC line.

AC generating components may be directly connected or may need a AC/AC converter to enable stable coupling.

A bidirectional master inverter controls the energy supply for the AC loads and battery charging.

DC loads can be optionally supplied by the battery.



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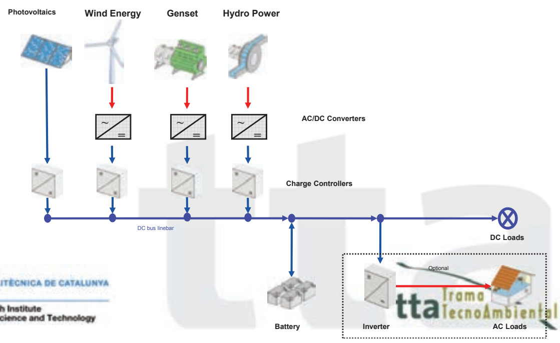
Structure of Hybrid Micro power plants-DC coupling

All electricity generators are connected to a DC bus bar from which the battery is charged.

AC generating components need an AC/DC converter.

The battery, protected from over charge and discharge by a charge controller, supplies DC loads and AC loads through the inverter.



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International Conference on Micro Perspectives for Decentralized Energy Supply

Enabling Energy Supply for Low Income Markets through Mini-Grid Solutions

February 27, 2013, Reiner Lemoine Institut, Berlin

Experiences from the field: Barriers & Solutions

Debajit Palit
Associate Director and Fellow
The Energy and Resources Institute, New Delhi
Email: debajitp@teri.res.in

Off-grid Access System in South Asia

The OASYS Project Objectives:

✓Are there cost-effective and reliable off-grid electricity supply solutions that can meet the present & future needs, are socially acceptable, institutionally viable and environmentally desirable?

✓Do these local solutions have the scaling-up and replication potentials and can these solutions be brought to the mainstream for wider electricity access in the developing world?

www.oasyssouthasia.info

Mini-Grids in India

- Pioneer of Mini-Grid system
  - First solar mini grid commissioned in 1996 in Sunderbans Islands
- State-of-the-art system designs & use of components (converters & inverters), continuing till date
- Cooperative model of service delivery
  - Involvement of local community from planning stage
- Policy enablers from time to time
- Around 5000 villages covered through mini-grids, serving more than 50,000 HHs
- Multiple technology adopted

Why mini grids in India

- Technically, mini-grids are preferred for remote areas over other options such as solar home systems,
  - as mini-grids provide electricity services for lighting & for powering various appliances, whereas SHSs typically provide only lighting services
  - Can support small productive applications
- Organisationally, managing mini-grids are easier compared to individual systems due to their centralised operation through a proper institutional arrangement

Solar PV Mini-grid

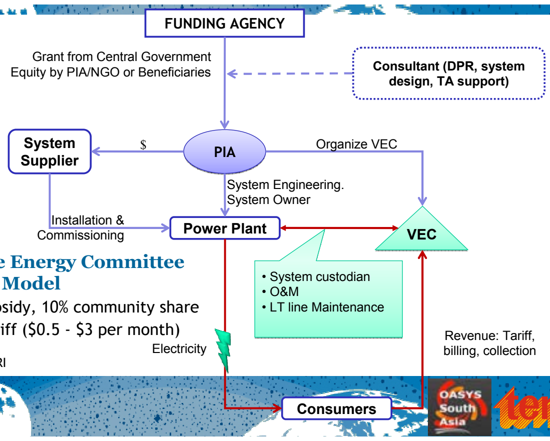
Source: CREDA and TERI

Biomass Gasifier Power System

- Fuel Preparation
- Biomass Gasifier
- Cooling cleaning train
- Engine - Alternator
- Biomass drying
- Power evacuation

Source: TERI

Managing Mini Grids: Earlier Model



Village Energy Committee (VEC) Model

- 90% subsidy, 10% community share
- Flat tariff ($0.5 - $3 per month)

Source: TERI

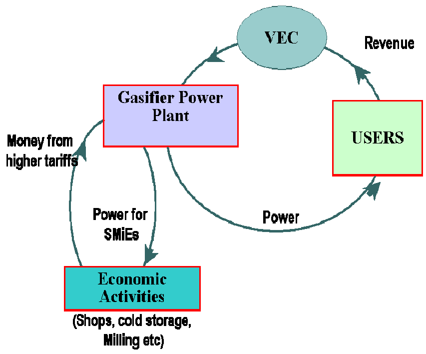
Hybrid System

55 kW Solar and 3.5 kW Wind Electric Generator based hybrid system

Wind Diesel Hybrid system

Source: TERI

Managing Mini Grids: Addressing low load



Source: TERI

Emerging Models

Solar Charging Station

Charging stations are expandable to solar energy hubs providing :

- Battery charging
- Mobile charging
- Lantern charging
- Water purification

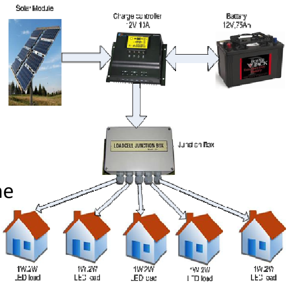
Solar Multi Utility

Self Help Groups, Farmer's Associations & Individuals from the surrounding villages access the SMU & utilize services for a fee.

Source: TERI, 2012

Solar DC micro grid

DC distribution lines (voltage varies depending on distance) run along rooftops from the battery bank to households over a short distance to power lights, mobiles etc.



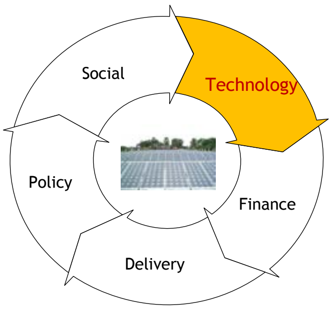
Running time : 5-6 hours

Installation Cost: $ 65 – $ 80 per HH

Tariff: $ 2-3 per month, charged by the operators

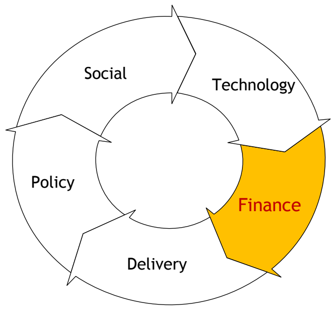
Barriers & Solutions

Technology ......



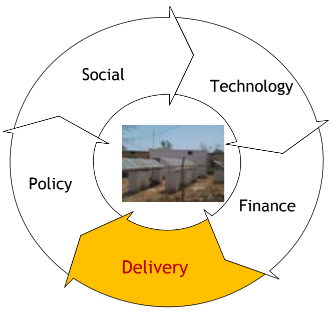
- Untested products/Absence of performance benchmarking/ standards
- Generation not as per design - quality issues of solar panel
- Limited local technical capacity
- Battery technology still vulnerable (over drawl by most consumers)

Finance ......



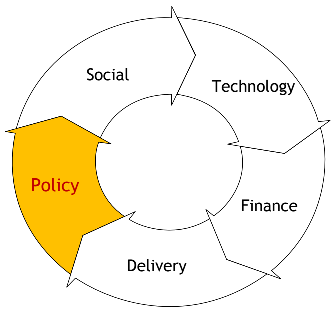
- Financial mechanisms are not in line with income level of poor HHs (the section w/o electricity access)
- Debt financing from banks difficult due to higher perceived financial & technology risks in rural setup
- Capital subsidy inadequate for ensuring long term sustainability
- Non flexibility in financial instruments

Institutions/delivery ......



- Absence of organized delivery model (e.g. involving DISCOMS)
- Inability to meet increased demand
- Lack of standard process and metrics for scaling up
- Last mile access for products and (spares) - missing link
- Social issues - tampering, non payment etc.

Policy......



- Dissemination suffers from uncertainty in political framework conditions
- Absence of clear regulation for off-grid sector
- Cross- subsidy in grid electrified villages - a deterrent for solar PV
- No clarity on LT grid connection, rules out grid as an anchor load

Key Lessons

For any model to be sustainable, scalable & socially acceptable

✓Choice of technology – Size vs. Demand?

✓Financing – Capital & Operational

✓Electricity tariffs – Regulated or Negotiated

- Access to electricity is merit good

✓Service delivery

- Management
  - Community based or Private
  - Organized vs. Un-organized approach
- Community participation – What should be their role – Operator/Local Regulator/??
- Contrary to prescribed community based models, top-down approach/ organized structure seems to be working better
- Customer service – How do we define?

✓Socio economic benefits –

- Productive applications – Is economic linkages essential for sustainability
- ✓ Strong govt. support and political will

Framework for Mini Grid