Session IV: Access to Electricity Services in Rural Areas
Mini Grids: Experience from India

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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
- Multiple technology adopted
Technology Transition

Solar Mini-Grid
Wind + Solar
Mini Hydro

GRID
WIND
HYDRO
Stand-alone Solar Systems

Smart Mini Grid

1980
1990 - 2000
2010 …….
Conducive Policy framework

- **REST Mission (2001)**
  - Acknowledged the role of distributed generation/mini-grids

- **Electricity Act-2003**
  - Universal service obligation to provide electricity by both central and state Government

- **Rural Electrification Policy (2005)**
  - Decentralized Distributed Generation (DDG) to be considered where grid extension is not feasible
  - No license required for generation and distribution - tariff can be determined based on mutual consultation with consumers

- **Rajiv Gandhi National Rural Electrification Scheme (2005)**
  - Decentralized Distributed Generation (DDG) and Supply

- **National Solar Mission (2009)**
  - 1000 MW by 2017 and 2000 MW by 2022 of off-grid capacity
A mini/micro grid is an electricity distribution network operating typically below 11 kV, providing electricity to a localized community and derives electricity from a diverse range of small local generators using both fossil fuels (diesel, gas) and renewable energy technologies with or without its own storage (batteries).
How mini grid works

- Either AC or DC
- Typically 1kWp to 500 kWp
- Technologies
  - Solar PV
  - Biomass gasifiers
  - Mini/micro hydro
  - Biogas
- Usually community managed
- Covers around 50 - 500 households
Biomass Gasifier Power System

- Fuel Preparation
- Biomass Gasifier
- Cooling cleaning train
- Engine - Alternator
- Biomass drying
- Power evacuation
Managing Mini Grids: Institutional Model

FUNDING AGENCY

- Grant from Central Government
- Equity by PIA/NGO or Beneficiaries

Consultant (DPR, system design, TA support)

System Supplier

System Owner

System Engineering

Installation & Commissioning

Power Plant

VEC

- System custodian
- O&M
- LT line Maintenance

Village Energy Committee (VEC) Model

Consumers

Electricity

Revenue: Tariff, billing, collection
Lessons from early Mini grids

- Decentralized, usually low capacity, covering remote areas
- Usually domestic loads served
- Can be installed at remote inaccessible areas
- Community as stakeholder
- Tariff based on flat rate, locally decided, depending on fuel cost, O&M cost and WTP (US$ 1 per point/month)
- Non commercial in nature

- Inability to meet increased demand
- Low plant load factor
- Single energy resource catering to fixed load for fixed time
- Battery - Weakest Link, over drawl by most consumers
- Difficulty in O&M because of remoteness
- Limited technical knowledge of VEC - frequent system shutdown
- Not linked to any productive enterprise / irrigation pumpsets
Managing Mini Grids: Institutional Model

- VEC
- USERS
- Gasifier Power Plant
- Economic Activities
  (Shops, cold storage, Milling etc)

Flow:
- Revenue
- Power
- Power for SMiEs
- Money from higher tariffs
**Mini Grid - Developer + VEC + ESP**

**Funding**
- (Grant + Equity + Loan)

**Technical Consultant**

**Developer**
- System engineering, System owner
- LT line maintenance
- Plant O & M

**Power Plant**
- Fuel Supply (SHGs) for Biomass projects

**VEC**
- Tariff & fuel cost determination
- Grievance redressal
- Fuel supply facilitator
- VEC acts as a regulator

**ESP**
- Annual Maintenance contractors

**Consumers**
- (Residential + Rural Business Hub)

**Billing & Metering, Revenue Collection**

**Energy Service Provider (ESP) Model**

**DPR, Capacity Building, Social Engineering, Livelihood Development**

**Fuel Supply (SHGs) for Biomass projects**
- Interconnected to the local LT network (3¢ 415V line)

**SMiE owned by developer (Self use and excess supply to the grid)**
Key Features - ESP Model

- Interconnected to the local LT Network - Grid can act as a balancing sink / source (where grid is available)
- Productive load / irrigation pumpsets /agri processing can be served on demand
- Villagers prefer grid connected power to off-grid - partial supply from the grid - may be cheaper
- Electricity can be consumed only locally - distributed generation and supply, only excess energy after local consumption stepped up to 11kV
- Lower AT&C losses through closer monitoring of energy sales and collections
- May interest private developers as reliability increases - Reduced risk for developers
Choice of Technology

Factors responsible

- Population and topography
- Quality and quantity of fuel
- Load pattern and power delivery area
- Local infrastructure availability
- Capital cost, means of finance and final affordable consumer tariff structure
- Environmental impact of the fuel & plant location
- Load growth and possibility of grid interconnection
Selection of the technology is based on

Availability of Resources

and

Comparison of the cost of electricity from each of the feasible options

Generally, the order of priority in India is
SHP plants wherever adequate perennial water resources are available and technical feasibility is established, - first priority

Biomass power plants using biomass gasification systems or bio-fuel based in conjunction with 100% gas based engines if small hydro is not feasible or not sufficient.

Solar photovoltaic power plants, if none of the above is feasible

Combination of the above in hybrid mode can also be an alternative solution
Optimal Economic Distance - An example

<table>
<thead>
<tr>
<th>Load (kWp)</th>
<th>X (km)</th>
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</thead>
<tbody>
<tr>
<td>7.5</td>
<td>7.7</td>
</tr>
<tr>
<td>15</td>
<td>15.0</td>
</tr>
<tr>
<td>25</td>
<td>24.1</td>
</tr>
<tr>
<td>50</td>
<td>47.8</td>
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</tbody>
</table>

The values of ‘X’ respective to different loads give the optimal economic distance (OED) from load centre to nearest 11kV line for feasibility of a solar power plant. If distance is larger than ‘X’, solar power plant will be preferable and if the distance is smaller than ‘X’, grid extension will be preferable.
Grid vs. Mini grid - Rule of Thumb

Based on least cost technology options and with minimum maintenance requirements

Grid extension is favourable if number of connections per km of distribution line are high say more than 25

A mini-grid based on locally available renewable energy sources is an attractive option if

- threshold number of households is 100 and distribution network is within 2 km for system capacity of 10 kWe

If number of consumers is less than 50 or number of connections per km of distribution line is less than 4, individual systems (SHS) are preferred
New Technology: Solar DC Micro Grid

Renewable Power Generation: 100 households would require 500-700 watts-peak of solar panels. Panels are installed on the rooftop of a village house.

Battery Bank: 100 households would require around 500 Amp-hours of storage capacity. Batteries are stored in a cabinet inside the same house or distributed battery storage at individual households.

Power Distribution: Distribution lines run along the rooftops from the battery bank to households within the village. Power is distributed for 8 hours each night at 24 volts direct current.

LED: Each household is installed with two or four LED modules.
# New Technology: Smart Grid

Electricity delivery network modernized using latest digital/information technologies to meet key defining functions

<table>
<thead>
<tr>
<th>Enabling active participation by consumers</th>
<th>Enabling new products, services, and markets</th>
<th>Optimizing assets and operating efficiently</th>
<th>Access to quality power</th>
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*The evolution of a smart grid will be one of continuous improvement*
**What is Smart Mini grid?**

<table>
<thead>
<tr>
<th>Mini grid</th>
<th>Smart Mini grid</th>
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</thead>
<tbody>
<tr>
<td>• Grid involving one or more types of renewable energy sources</td>
<td></td>
</tr>
<tr>
<td>• Operating Voltage level below 11kV</td>
<td></td>
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<td>• Islanded operation to power off-grid remote area</td>
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<tr>
<td>• Optimization of resources &amp; intelligent demand management using state-of-art digital technology</td>
<td></td>
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<tr>
<td>• Decentralized control makes the system efficient and modular</td>
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</table>
What is Smart Mini grid?

- Solar PV
- Wind Gen
- Battery
- Load

Bi-directional Digital Control
- DC-DC Converter
- AC-AC Converter
- DC-AC Converter
- Intelligent Dispatch Controller
India’s First Smart Mini-Grid at TERI

Ensuring
• Maximum utilization of renewable energy
• Improvement in overall system efficiency
• Better autonomy and control to customers
• Intelligent load and energy resource management
• Minimum network disruptions and number of blackouts

A. 10.5 kW crystalline SPV
B. 1.0 kW Thin-film SPV
C. 2.0 kW crystalline SPV
D. 28.8 kWh Battery Bank
E. 3.2 kW Wind Generator
F. 100 kWe Biomass Gasifier
G. Diesel Gen-set
Smart Mini grid at TERI

- **Solar PV** (10.5+1+2kW)
- **Battery** (48V, 600Ah)
- **Biomass** (100kW)
- **Wind** (3.2kW)
- **Diesel** (250+160+100kVA)

Diagram includes:
- Charge Controller
- Converter
- Generator
- DAS
- Intelligent Load Dispatch
- Digital Interface
- Load

Other components:
- Digital Interface
- Load
Challenges for Mini-grid in India

Policy
- Dissemination suffers from uncertainty in the political framework conditions
- Absence of standard set of implementation guidelines

Technology
- High cost of technology and or service

Finance
- Capital subsidy inadequate for ensuring long term sustainability & replicability
- Credit provided independent of income level
Framework for Mini Grid

**Small-scale RETs**
Ideal for isolated and vulnerable communities.

**Facilitated**
- Minimum electricity needs
- Dispersed productive activities
- Increased demand for electricity in the region
- Inadequate for
  - Productive activities requiring motive power

**Facilitating**
- Greater community welfare (health, education, telecom, etc.)
- Rural industry
- But is still constrained by
  - Lack of innovative financing
  - Limited power supply, particularly with RET-based schemes
  - Unresolved regulatory issues and market penetration barriers

**Off-grid village-scale DG**
(or minigrid)
Ideal for a larger village or a cluster of villages

**Targeting**
- A market orientation for rural electricity provision, with adequate regulation
- Diversification and growth of industrial and other economic activities
- Long-term grid interconnectivity and system stability

**Network of DG schemes**
Connected to state grid
Ideal for villages in a region

Could develop into ...
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
Village Scale Solar Systems: The Solar Transitions

How can the use of new renewable energy technology be implemented and organised in ways that

- Embed the technology in local communities and cultures;
- Make the energy supply useful in practice, to solve sentral problem that people have;
- Create functioning systems for operation and maintenance locally;
- Improve opportunities for income generation and a good quality of life, and facilitate climate adaptation;
- Give more people access to the technology;
- Overcome vested interests, political and institutional barriers for change;
The Solar Transitions

And how can learning on such issues happen across geographical contexts?

Not “how can we make people use these technologies”, but how can more people get access to and benefit from these technologies”
Way forward

Catalyst for scale up
- Improved access to capital/financial innovation
- Development of after-sales service infrastructure
- Customer centric market development
- Regular stakeholder involvement

Improved system design efficiency, economy of scale
- Use of LEDs for lighting for minimizing cost
- Anchor load e.g. BTS stations, productive load
- Smart mini grid for optimum efficiency

Adopting standard process & metrics for scaling up
- Appropriate business models for up-scaling
- Regional level cooperation
2012: International Year of Sustainable Energy for All

*Let us together make a change*