

Solar DC Grids for Rural Electrification



Third International Conference

MICRO PERSPECTIVES FOR DECENTRALIZED ENERGY SUPPLY

April 23-25, 2015 Bangalore, BMS College of Engineering



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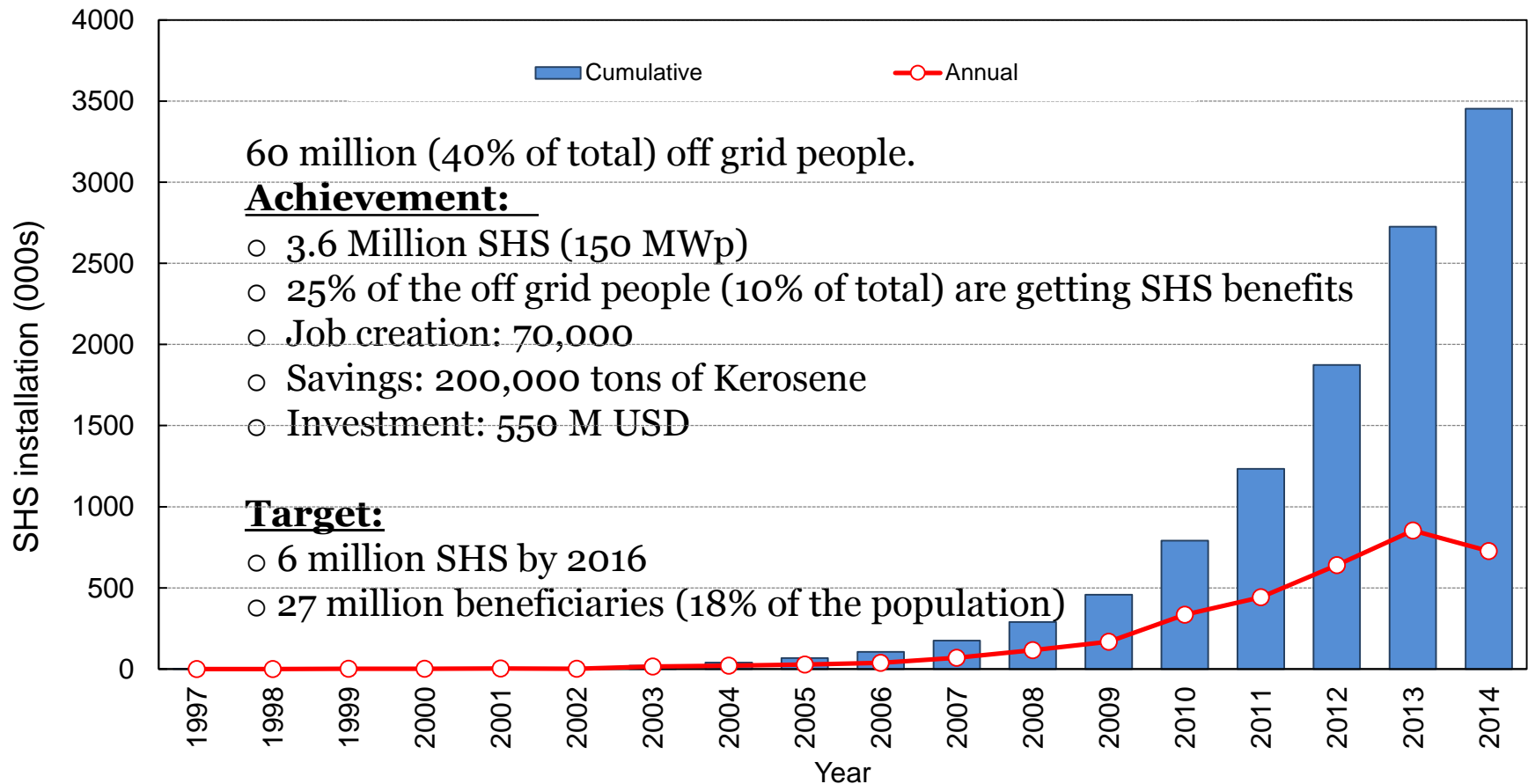
Genesis

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- Status of Off grid Electrification in Bangladesh
- Opportunities of Solar PV based Minigrids
- DC / AC Relative comparison for rural electrification
- Possible Topologies of Different Isolated DC grids
- Relative Advantages, Disadvantages and Application of Different Topologies
- Conclusion and Outlook

Bangladesh : Successful Example of SHS Based Rural Electrification

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Other Off grid RE Solutions

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- Solar Diesel hybrid Isolated Grid (2.2 MWp Solar+2 MWp Diesel + 5 MWh Li-ion battery)- on going project
- 10 Solar-Diesel Hybrid AC Minigrids (4 in operation, 6 under implementation)- Ranges from 100 kWp to 247 kWp
- 50 Solar DC nano grids (Max 10 kWp)
- Wind –battery isolated grid – 1 MW (Kutubdia).
- Biomass gasification and biogas based electricity: 6 MW

Opportunities for Solar PV based Minigrids

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SHS provides basic needs of the rural people but can not provide sufficient energy for productive use in off grid areas

- Demand of following productive use of electricity are observed in rural Bangladesh, these loads generally draws power during day time, which reduces the relative storage demand and thus the cost of electricity:
 - ✦ Irrigation pumps (demand is highest when insolation is also highest)
 - ✦ Cottage industries (Sewing, weaving, loom etc.)
 - ✦ Husking mills
 - ✦ Sawmills
 - ✦ Lathe machine
 - ✦ Welding machines
 - ✦ Grinding machines (spice)
 - ✦ Photocopier machine
 - ✦ Computer training centres
 - ✦ Poultry firms
 - ✦ Cold storages
 - ✦ Ice making industry (for fish preservation in island areas)
 - ✦ Offices /Schools/Madrasas etc.

Why DC?

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DC system has some advantages over AC system for solar based isolated grids:

- Solar PV generates DC power, the generated energy is stored in DC form. Therefore no need of inverter for the conversion of DC to AC.
- All the modern appliances such as LED lights, Televisions, mobile phones, laptops etc. that run on AC are also fully functional on DC in the same voltage range.
- Battery DC voltage (12V) can't be transferred for long distance due to voltage drop. But 110V to 220V DC can be easily transferred in few hundreds meters without any significant losses.
- Adding up or scaling up of DC system (energy sources) in parallel is much easier than by AC. Paralleling of AC sources need synchronizing of the systems.
- Power factor is not a concern in DC systems.
- DC system has no inductive or capacitive losses.
- Management of harmonics distortion is much easier in DC than AC.
- DC motors (cooling fans, irrigation pumps etc.) are more efficient than conventional AC motors (BLDC motors are efficient than induction motors).
- DC power transmission is more efficient and less expensive than AC power transmission.
- Simple 2 wire distribution network
- DC floating systems are less prone to shocking hazards (Neutral grounding is necessary in ac)

Five Different Topologies for DC grids

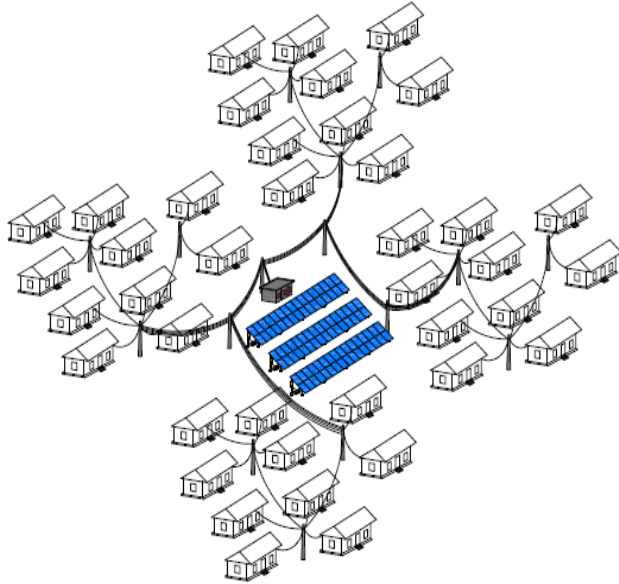
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- ❑ Centralized Generation and Centralized Storage
- ❑ Centralized Generation Distributed Storage
- ❑ Distributed Generation and Centralized Storage
- ❑ Distributed Generation and Distributed Storage
- ❑ Hybrid System



Centralized Generation and Centralized Storage

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Advantages:

- Easier Monitor, control and O&M is easier - system can be monitored in a single place.

Disadvantages:

- Large area needs to install the PV panels and Storage system.
- All costs and risks are on the project developer

Application:

- Common system now a days.
[In Bangladesh SolarIC is implementing this system]

Centralized Generation Distributed Storage

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Advantages:

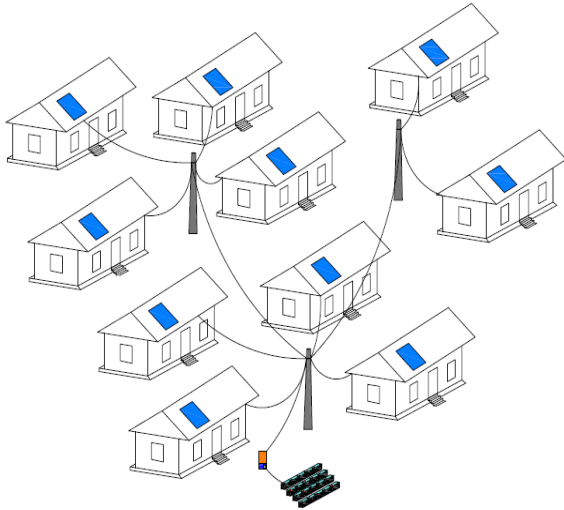
- The consumer can choose the storage capacity according to their need
- Grid operator may not need to invest for the storage system.
- Cost of energy at the consumer end is much lower than the previous system.
- Storage battery and controller can be sold to the customers through micro credit.
- Lower Risk of investment.

Application:

- Schneider has introduced the system in India, Bangladesh and Myanmar.

Distributed Generation and Centralized Storage

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Advantages:

- Suitable where land for PV installation is scarce
- Individual consumer's suitable rooftops can be used / rented for installing of the PV plants.
- New and Existing SHS can be incorporated

Disadvantage:

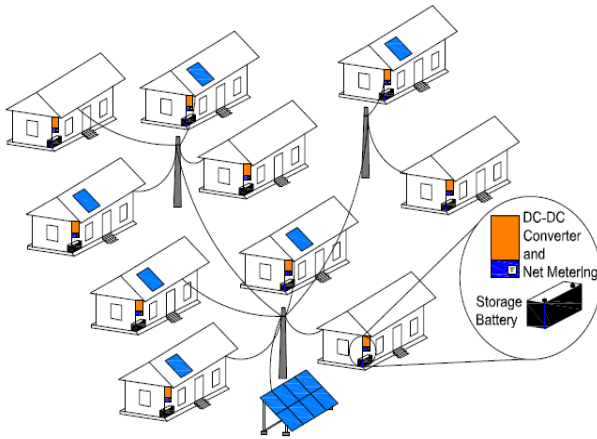
- Two way power flow (generation – Storage- consumption) makes it less efficient T&D loss is higher.

Application:

- Suitable for densely populated region where land is very scarce.
- Losses can be less if the storage system is installed near to the anchor load (needs to have a higher anchor load)

Distributed Generation and Distributed Storage

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Advantages:

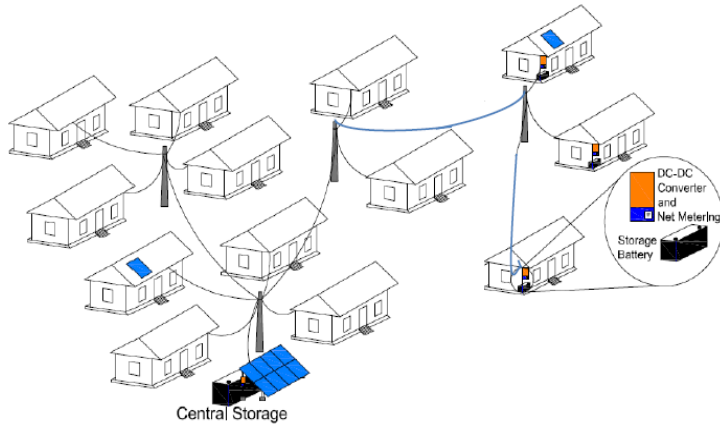
- New and existing solar home systems can be incorporated with the system.
- Excess energy can be sold to those who cannot afford to finance to solar home systems.
- Scaling up of the power system is very simple through adding a large system and new systems.
- Integration with grid is also possible in schemes like *swarm electrification*.

Application

- Applicable to those places where solar home system penetration is high.
- This system is suitable in areas where land is scarce for installing PV panels.
- This system can be a substitute of the SHSs but can provide flexibility to the users.

Hybrid Systems

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The combination of all the above.

Advantages:

- Provides flexibility
- New and existing solar home systems can be incorporated with the system.
- Excess energy can be sold to those who cannot afford to finance to solar home systems.
- Scaling of the power system is very simple
- Integration with grid is also possible in schemes such as *swarm electrification*.

Application

- Suitable for any type of areas.

Conclusions and outlook

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- Every topology discussed here has some advantage but also limitations.
- Solar DC small grids can be a cost effective solution for off-grid area electrification in the developing world.
- Off grid areas do not have access to grid electricity and thus they are not familiar with the common AC gadgets, high efficient DC gadgets can be introduced easily in this area, no question of changing AC eco systems.
- Cost of energy use can be much lower in case of isolated DC grids than with AC.
- The choice of topology depends upon the demand, energy use pattern, local micro climate and availability of land etc.
- The battery is an integral part of any stand-alone mini grid system. The size of the battery depends on the demand at night and insolation level at the area under consideration. If the sunshine is steady and reliable, there is no need to store power for more than 1 night. On the other hand, unreliable solar insolation compels the mini grid designer to add significantly higher capacity battery. .

Conclusions and outlook

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- All the topologies discussed can provide modular growth. Research in the field will proof technological and financial feasibility
- Smart DC isolated grid can be solution for future rural off grid area electrification

(Smart isolated grid: Efficient, Economic, Safe, Reliable, Controllable, Predictable, comfortable and Scalable)

Thank you

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