Rural electrification in Sub Saharan Africa in a context of fluctuating oil-prices

Nygaard, Ivan; Bindner, Henrik W.; Katic, Ivan

Published in:
Energy solutions for CO2 emission peak and subsequent decline

Publication date:
2009

Citation (APA):
Rural electrification in SSA in a context of fluctuating oil prices

Is the time ready to move from SHS to hybrid PV-diesel systems?

Ivan Nygaard, UNEP Risø Centre, RISØ DTU, Denmark
Henrik Bindner, Wind Energy Division, RISØ DTU, Denmark
Ivan Katic, Energy & Climate Division, Technological Institute, Denmark
Outline of Presentation

• Rural electrification – the context
• Solar PV and development aid
• Changing economic conditions
• Hybrid PV-diesel for small isolated grids
• Simulation results
• Conclusion
Rural electrification in SSA

- Electricity is one among other preconditions for development
- Per capita CO₂ emissions are low, so priorities are
  - Increased access
  - Clean development path
- Increase still slow:
  - Liberalization
  - New structures

Historically low electrification in Africa, 27% in SSA
Rural electrification technologies

Price per kWh

Individual use

Collective use

Lighting

Communication

Productive use

Dry Cell Batteries

Car batteries
PV – gen. set

Mini-grids
Diesel - hybrid

Grid connection
Fossil - renewable
Solar PV (SHS) historically

- High expectations in the 1970’s
  - high and increasing oil prices
  - rapid development of technology
  - aspirations of economic development in rural areas
- Converging interests between donors and industry
  - green movement, decentralisation, SHS as a liberal approach, climate change concerns
  - PRS contract (10 % of annual EU production of PV panels in 1989)
- Seemingly good arguments
  - leap-frog technology, high solar irradiation, long lifetime, low maintenance, difficult access to fossil fuel
**SHS - status in the new millennium**

**Bad reputation**
- Donor driven agenda
- Second best solution
  - SHS mainly for communicative and not for productive use
  - Not an alternative to grid connection
- Donated systems to schools, health centres, community centres have a high failure rate
- Theft a great problem

**Matured technology**
- Increasing markets
  - 2.5 million SHS worldwide
  - > 0.5 million SHS in Africa
- Especially in a few countries
  - Kenya 200,000
  - South Africa 150,000
  - Morocco 100,000
  - Mali 70,000
  - Zimbabwe 15,000
Solar PV in hybrid systems

• PV hybrid is more flexible compared to SHS
  – Supply to mini-grids
    • productive use, standard appliances
    • future grid connection, useful for building up load

• PV hybrid (wind) is mainly used for specific purpose
  – isolated nature camps (Thailand)
  – small islands communities
  – test plants (ex. 500 kW in Thailand)
  – Gobabeb research centre, Namibia
  – SYS-LAB test system at Risø DTU

• Increasing no. of reports that hybrid systems are competitive to diesel systems
Hybrid PV-diesel system in Mali

• Technical Specifications:
  – Diesel 100 kVA
  – PV, 72 kWp
  – Battery, 24720 Ah
  – Present max load, 25 kW
  – Consumers, 217

• Economy
  – Investment 512,000 EUR
  – Subsidy 60 %
  – Import tax exemption, 100 %
  – Consumer price: 0.27 EUR/kWh

Sources: Presentation by Amadou Isaac Diallo, Director General of Yeelen Kura, Presentation by Djibril SEMEGA, Technical responsible at SSD-EN SA at meeting in Club Agences en charge d’ER-Bamako 2008
Changing conditions: oil prices

Inflation Adjusted Monthly CRUDE OIL PRICES (1946-Present) In November 2008 Dollars
©www.InflationData.com
Updated 1/8/2009

Dec. 1979 Monthly Ave. Peak $106.43 in Nov 2008 Dollars
June 2008 Monthly Ave. Oil Price $122.64 in Nov. 2008 Dollars
Nominal Peak $38 (Mo. Ave. Price) Intraday Prices peaked much higher
Inflation Adjusted Oil Price
Nominal Oil Price

Source of Data:
Oil Prices - www.iogs.com/Special/crudeoil_Hist.htm
CPI-U Inflation Index - www.bls.gov
Oil prices forecast, DOE

Crude Oil Prices

- West Texas Intermediate (WTI)
- Average Refiner Acquisition Cost (RAC)

Dollars per barrel


Forecast

Short-Term Energy Outlook, August 2009
Price reduction of PV modules

Doubling of cumulated production reduces prices by 20 %

Accumulated capacity, 1995-2008

Solar module retail prices
Simulation preconditions

- Retail price EUR/liter:
  - 0.3
  - 0.4
  - 0.5
  - 0.6
  - 0.7

- Oil price $/barrel:
  - 0
  - 0.1
  - 0.2
  - 0.3
  - 0.4
  - 0.5
  - 0.6
  - 0.7

- Load Profile (Synthesized Data):
  - Demand (kW):
    - 0
    - 20
    - 40
    - 60
    - 80
    - 100
  - Hour:
    - 0
    - 6
    - 12
    - 18
    - 24

- Global Horizontal Radiation:
  - Daily Radiation
  - Clearness Index

- Efficiency Curve:
  - Efficiency:
    - 0
    - 5
    - 10
    - 15
    - 20
    - 25
    - 30
    - 35
  - Output (%):
    - 0
    - 20
    - 40
    - 60
    - 80
    - 100
Production costs for diesel, PV-hybrid and PV alone

**Small system (37 kW)**

**Large system (150 kW)**
Production costs for diesel, PV-hybrid and PV alone

Oil price 25 USD/barrel

Oil price 75 USD/barrel
Simulation conclusion

• SHS will increasingly be interesting for
  – dispersed villages and outskirts of nucleated villages,
  – not competitive to mini-grid systems
• PV – hybrid systems for mini-grids are feasible compared to diesel systems, but depending on context
• Calculations are sensitive to:
  – system size, system configuration
  – existing and future load patterns
  – battery lifetime
Policy recommendations

• Ensure a level playing field for PV and diesel solutions
  – fuel subsidies, (fuel tax)
  – Equal tax on material (also replacements)

• Increase project volume to reduce costs
  – Move from single projects to programmes
  – Economy of scale and reducing technology risk

• Institutional framework
  – Rural electrification agencies (planning)
  – Utilities
  – Concession: Mali (EDF), Senegal (ONE), SA (several)

• Given continuing high oil prices
  – It is likely that PV-hybrid systems will prevail in rural electrification schemes in SSA within the next 10 years
Thanks for your attention!