Abstract: 2nd European PV-Hybrid and Mini-Grid Conference, Topic: 2 or 4

PV-generators integrated without storage into isolated diesel-based supply grids - a case study in Brazil

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A large number of villages in the northern and northeastern parts of Brazil are not connected to central supply grids. In total, a consumption of around 500 MW is supplied by private companies and distributed to the customers through local grids, which are mainly supplied by diesel generator sets (DGS). The capacity of the individual grids is typically in the range of several 10 kW.

As shown by Rüther and Montenegro (2001) the resource conditions and the economical conditions in northern Brazil are in favor of the integration of a 'raw' PV-generator (without storage) into the existing grids. A respective reference system, located in the state of Rondonia (10^o13' S; 65^o 21' W) was put in operation in 2001. The actual mean power consumption in this system is about 27 kW; the PV-generator has nominal power of 20 kW.

For a more general analysis of the possible benefits of this type of PV-integration in term of the load carrying capability and the fuels savings, we have performed simulations for two sites in Brazil, representing the worst and the best radiation conditions in the country. Special emphasis was put on the assessment of the limitations and benefits by the operation without storage. Both, losses due to surplus production in chase of low loads and the additional constraints caused by the requirement of the diesel operation (now operation in part loads below 15% of the nominal power of the diesel generator set) have been taken into account. The simulation results are evaluated by comparison with the performance of the reference system mentioned above.

The discussion of the achievable technical benefits will focus on the comparison with the possible benefits of PV-hybrid systems with storage in terms of the figures ´fuel savings per installed PV-power´ and ´renewable fraction´.
The economic evaluation of the system performance will refer to both the situation of the independent companies operating the systems and the state institutions subsidizing the energy supply in remote regions. For this purpose the cost for the PV-integration in existing systems, the reduction of the fuel costs and possible benefits due to an enhanced buy-back rate for electrical power from non fossil sources are taken into account to assess the economic situation with respect to the different actors.

Rüther, R., A.A. Montenegro, Design and preliminary performance results of the first hybrid diesel/photovoltaic system without storage for isolated mini-grids in the Brazilian Amazon region, Proc. of the ISES Solar World Congress, Adelaide, Australia (2001)

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PV-generators without storage in supply grids based on diesel generator sets in Brazil, explanatory pages (page 1)

Results of Simulation calculations for PV-diesel Systems without storage

For the meteorological conditions of Fortaleza (Brazil) and realistic assumptions on the load characteristics, the annual system performance is analyzed. Figure 1 gives an example of the results.

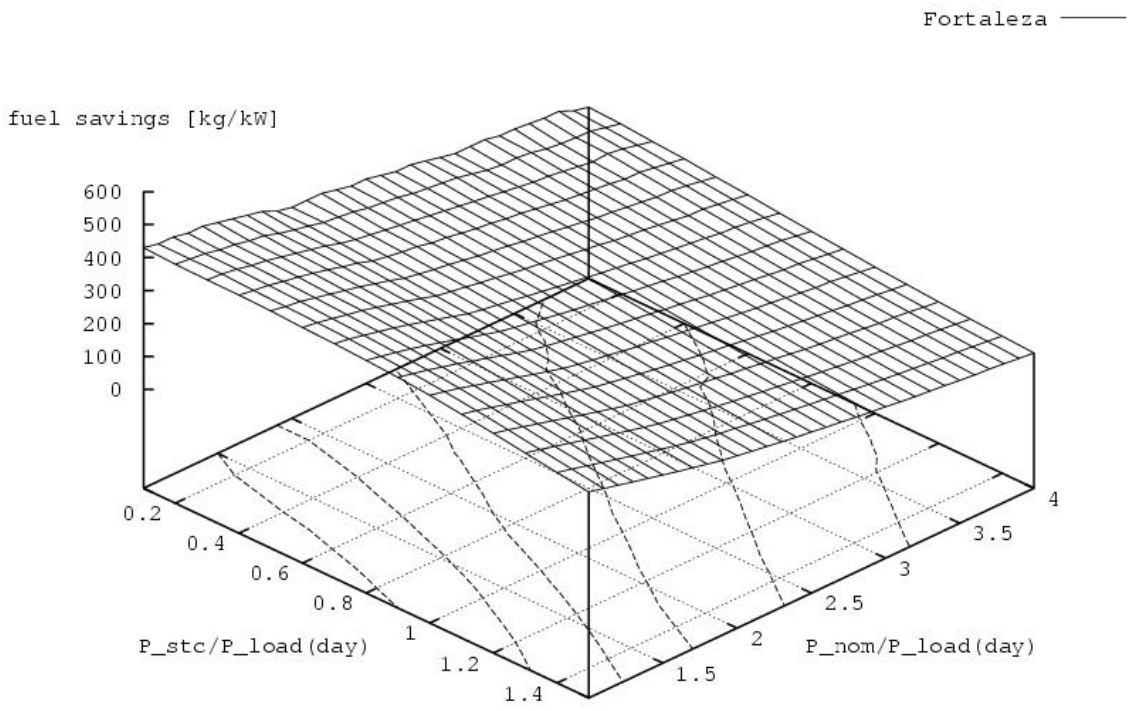

Figure 1.
Fuel savings per installed PV-capacity (STC power P_stc) as function of the PV-capacity and the nominal size of the diesel gen-set P_nom. Both P_stc and P_nom are normalized with the average load during daytime P_load. The specific fuel savings are reduced with both the increase of the PV-capacity and the nominal size of the diesel. For the case of an installed PV-capacity equal to the average daytime load and a nominal size of the diesel generator of twice this value, the specific annual fuel savings amount to about 250 kg/kW.

Assuming (realistic) conditions for the fuel price and varying buy back rates for PV-generated electricity, the limits for the normalized PV-capacity that would result in a positive lifetime economy of the system can be evaluated. Figure 2 gives the results for varying normalized PV-sizes and a Diesel size of twice the daytime load. The meteorological conditions refer to Fortaleza.

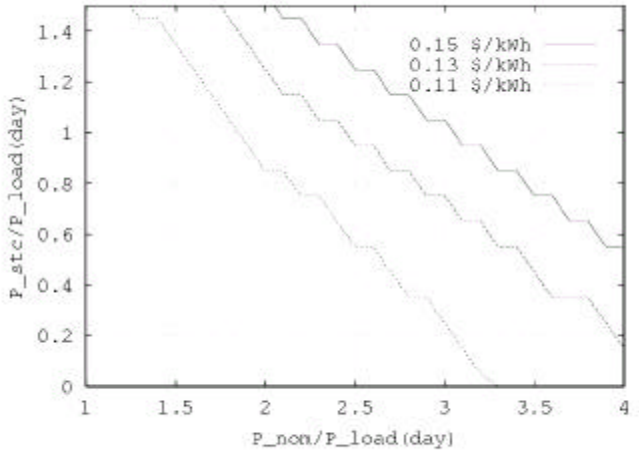

Fig. 2
Limit for the normalized PV size resulting in positive lifetime savings as function of the normalized nominal power of the DGS for the site Florianopolis. The lines refer to various values of the buy back rate (0.11, 0.13, 0.15 $ kWh) for the PV electricity. They are derived from a data set with a resolution of 0.1 for the PV size $P_{stc}/P_{load(day)}$.

Performance results of the PV-diesel system at Araras (Rondonia)

In this system, the average daytime load of the system is about 21 kW, the nominal size of the P-system is 20 kW. This actual load has dropped by a factor of 2 compared to the planning phase due to external reasons (dwelling partly abandoned due to the depletion of the local gold reservoir).

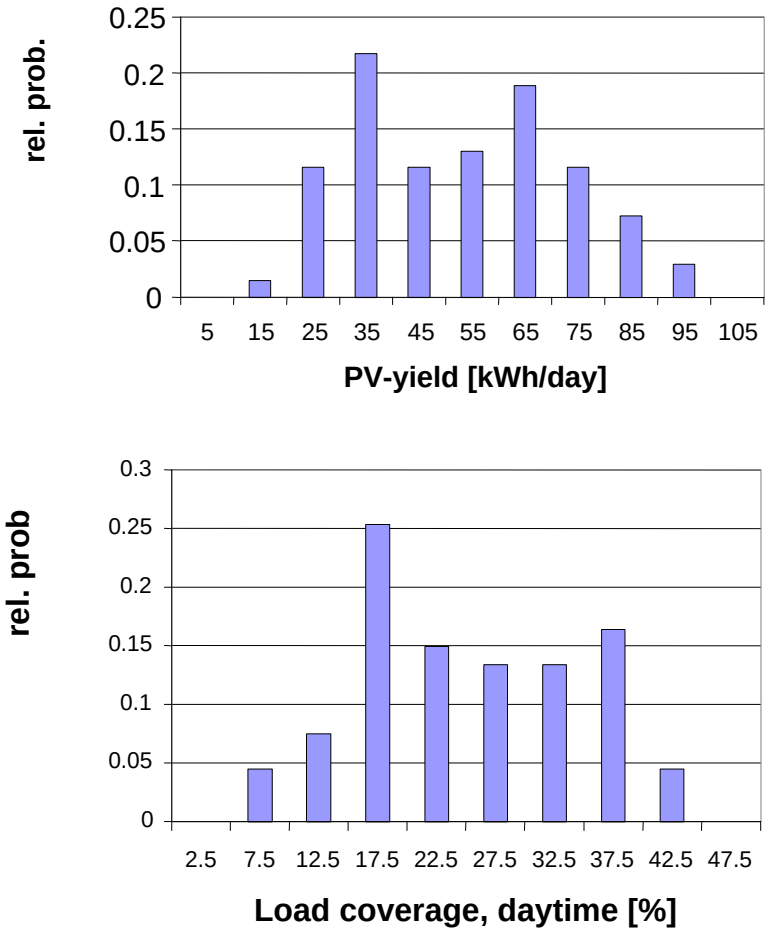

Fig. 3: Performance figure for the PV-diesel system at Araras. The upper graph shows the distribution of daily yield figures for the PV-generator extracted from 3 month of data. The lower graph gives the distribution of the percentage of daytime load coverage by PV for this time period.