

economic crisis or unemployment, for example, the irregular connections may raise again in areas where existing methods for reduction commercial losses were already applied. In the case of distributed generation, in theory, even if the families stop paying the loan used to buy the PV systems, the energy used by them keeps being generated and the DU does not need to buy energy from another generator to supply them (this fact needs a legal analysis that is not considered by this research).

The risky areas are a challenge for the operation teams of distributor companies and for the combat energy theft. It is a highly complex social issue for the Brazilian society, the support of governmental institutions, including law enforcement, is essential, and it would be necessary also to make the insertion of DG possible. However, the installation of PV systems has some characteristics that may increase the acceptance by the population. The creation of prosumers give the users a new role in the power system and may turn the citizens aware of the contribution that PV systems generate to the communities. The communities could even organize cooperatives to promote the efficiency division of the energy among the members. If the impact of the systems in the families' budget is smaller than the energy bill and other potential benefits are clear to the consumers, the acceptance can be higher than other methods that aim to avoid theft.

Technical and managerial methods can be seen by the population just as ways to make disconnection easier without any direct benefit for the consumers. It is reasonable to look for a market in which everyone consumes energy legally. Social campaigns have helped to show that energy theft is a crime in Brazil and illegal connections cause damage. Despite of all the effort already done using the traditional methods, even if they include new technological solutions, the non-technical losses are still quite high in certain locations of Brazil. It requires continuous efforts from companies and the Government in order to tackle the problem. LIGHT itself has made significant progress in certain locations to reduce non-technical losses, with initiatives like the "Área Perda Zero (APZ)" (Zero-Loss Area) that focus on areas with high indexes of theft and defaults, but the total commercial losses keep being significant.

DG based on PV also reduce greenhouse-gas (GHG) emissions. Depending on the scenario, the insertion of DG in Belford Roxo could avoid emissions between 2,031.72 and 24,854.71 tons of CO₂eq per year. In the case of the risky areas, the values vary from 10,306.90 and 206,137.98 tons of CO₂eq per year.

The initial investment to install many PV systems may become a barrier because it requires a huge amount of money. Considering that, loans are required to make feasible that consumers and distributors invest in DG. The simulations exemplify optimistic results for financing the systems for low-income consumers which depend on factors that are far from the current conditions available in the Brazilian market. However, it shows that there are various possibilities that can reduce the cost of PV systems to low-income consumers.

9. Conclusion

This work has proposed a method to reduce the non-technical losses by the insertion of DG in low-income communities, which can provide economic and technical benefits. It includes a discussion about conditions regarding projects financing.

The developed case study shows that the financial impact of non-technical losses in Brazil is relevant. Moreover, it indicates that the distributed generation could be considered an alternative solution to reduce these losses and generate technical and economic benefits in low-income communities. It may also reduce greenhouse-gas (GHG) emissions.

The introduction of DG in areas with high levels of commercial losses can be a more effective way of reducing losses than the traditional methods. The current illegal users can be transformed in "prosumers" and reduce the electricity bills for the regular consumers and distributors that currently subsidize the illegal supply. The quality of the supply may improve and reduce the maintenance costs of the distribution utilities. If number of illegal connections is reduced, the frequency and the duration of supply interruptions can be reduced.

The massive insertion of DG to reduce commercial losses in low-income communities, including risky areas, depends on loans that are affordable to that population. Government, distributors and society should work together in integrated actions to the make the proposed solution feasible.

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