With the DG-PV-ESS proposed system's employment, it is possible to reduce all impacts caused by the traditional DG-PV profile, improving the PQ indices and to still minimize lines and the distribution transformer losses. It is important to remember that the self-consumption of locally generated energy increases, representing an improvement in the use of the renewable sources and a decrease in consumer energy cost.

Finally, the use of a concentrated ESS proved to be effective. A good improvement is obtained regarding voltage drops. However, it is not as effective as DG-PV-ESS systems in containing voltage rises. It also shows an VUF% increase. However, it remains well below the 3% limit required by ANEEL. Total losses also increase, assuming a value of 16.65 kW, which is slightly lower than the original 17.26 kW. The most exciting point in this sense is that there is an increase of losses in the lines conductors while reducing transformer losses. This decrease is probably due to the significant reduction in the active power demand from the primary network, thus restricting the transformer's energy dissipation. The increase of power dissipation in the conductors, on the other hand, happens because there is a bidirectional energy flow to the single storage. In this configuration, there will be a power flow throughout the day charging the ESS. There will be an inversion of it, discharging the accumulated reserve and feeding the loads. What allows these energy exchanges are, precisely, the distribution lines, and for that reason, there will be a greater dissipation on them.

5. Conclusion

The integration of ESSs, both distributed and concentrated, improves a high penetration grid-connected DG-PV. Both the maximum and the minimum bus voltage variations measured are reduced. There is also a considerable easing of total losses, which increase with the usual DG-PVs penetration. There are also improvements in this regard in comparison to the original network configuration.

Improvements are also observed in the VUF% since voltage variations are reduced. However, in the concentrated ESS case, since it is integrated into the system by a frequency inverter (and all DERs), its output power is always the same for the three phases. As the consumption of the residential units connected to the network is not balanced between the conductors, the ESS control cannot match these values. Therefore, there will still be a considerable reverse active power flow in the transformer and the VUF% deterioration in some points.

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