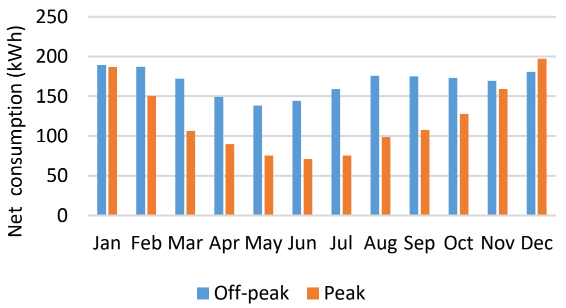
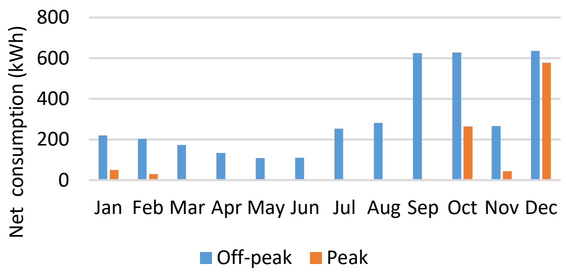
purchased from the grid is included in off-peak periods and the remaining 28% corresponds to the purchase of energy during off-peak hours.
Regarding scenario A1, Figure 9 (a), it is concluded that with the introduction of PV production systems for self-consumption it is possible to reduce energy imports during peak hours, by around 73% compared to the scenario without PV. This reduction has a positive impact on the energy bill since photovoltaic production takes place during periods where the tariff price for the end customer is higher.
With the implementation of storage units, Scenario A2, it is possible to reduce about 67% of energy imports in peak periods compared to scenario A1. Analyzing the graph of scenario A2, Fig. 9 (b), it can be seen that between April and August, during 5 months, the import of energy during off-peak hours is zero. On the other hand, it appears that there is an increase in energy imports during peak hours by over 1622.5 kWh compared to the A1 scenario. Since, in the off-peak period, the price is lower compared to the peak price, this increase does not have a significant impact on the energy bill, Figure 9.



(a)



(b)

Fig. 9. Comparison between net consumption during off-peak and peak hours for one working day of each month, in scenario A1 (a) and A2 (b), respectively.

5. Conclusion

This paper aims to create a tool using linear programming capable of optimizing the energy flows of a REC. Two scenarios were considered. Scenario A1 considers the REC with the integration of energy production systems. Scenario A2 also considers the integration of ESS, and the proposed optimization model is applied to maximize the CER's profit. The goal was to determine when and how much energy to buy/sell to the grid and charge/discharge the battery based on the demand, the production, the adopted tariff, and the energy selling price, considering the costs associated with the integration and maintenance of the ESSs. Concerning scenario A1, it was concluded that of the total energy purchased from the grid in January, about 49.7% of the energy fell in the off-peak periods. This value decreases by 17.7% if a summer month is analyzed. This means that considering only the integration of photovoltaics, the import of energy from the grid in the winter months is quite high, which makes the system not very autonomous.
In scenario A2, ESS with a total capacity of 105 kWh is used. Through data analysis, it is concluded that it is possible to reduce about 67% of energy imports in peak hours compared to scenario A1. On the other hand, there is an increase in net consumption during off-peak periods when energy prices are significantly lower. Thus, when the energy sale price is competitive, the batteries discharge by injecting the energy into the grid. Conversely, battery charging can occur before peak periods when energy purchase prices are lower, maximizing community profits.

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