# Discover How You Can Save Money and Help the Environment with Local Energy Markets: An Australian Case Study!

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Have you ever wondered how trading electricity with your neighbours, energy companies, and the grid operator could save you money and benefit the environment? With an increasing number of solar panels and energy storage systems in use, this question is becoming more and more relevant. This article presents a case study of a peer-to-peer local energy market (LEM) from Australia and shows how it can benefit everyone. We've analysed the economic impact and suitability of this market, so you can see how it could work for you too!

As we rely more on renewable energy, we face new challenges like grid congestion and power quality issues. But have you heard of a solution that's revolutionising the energy industry? It's called the Local Energy Market (LEM), and it's changing the game. By enabling peer-to-peer (P2P) trading between consumers and prosumers, the LEM empowers communities to buy and sell their local energy, distributing surplus energy during peak solar hours and evenings. This optimises the use of battery energy storage systems (BESS) and ensures fair exchange rates between the grid tariff and solar feed-in tariff (FiT). Not only does LEM create a more balanced grid, but it also reduces the amount of energy supplied by the wider network, and maintains the retailer's margin, benefiting the environment and saving money. See Fig. 1 to see the overall impacts of LEM.

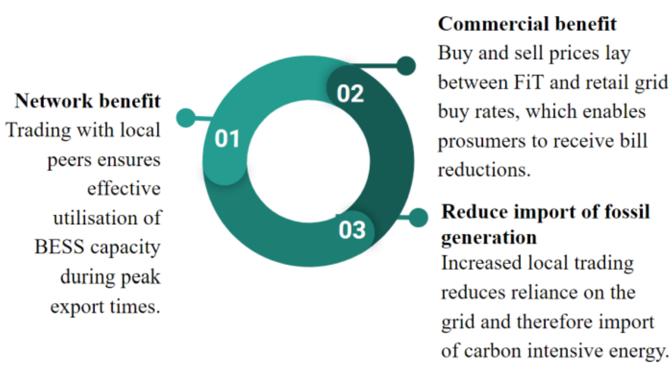


***Figure 1*** *Impacts of LEM.*

## LEM OPERATING PRINCIPLE

The P2P-empowered LEM trading platform is developed using blockchain technology [1-2] and the dashboard view is shown in Fig. 2. The platform enables participants to trade energy amongst each other by matching buy and sell offers in forward-facing time intervals. Buyers bid in the LEM at buy rates lower than their tariff rate, while sellers bid at rates above prevailing FiT. The traded volumes are indicated to the retailer(s) at the awarded prices to be reflected in the energy bills. LEM registers each of the participants through their retailers and receives their electricity bills in the same way as a traditional retail arrangement.

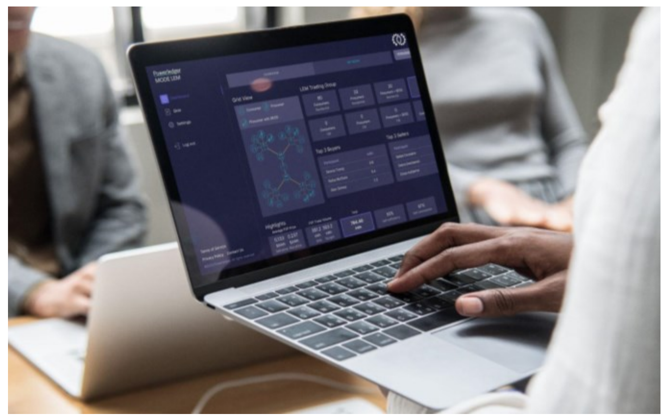

***Figure 2*** *Powerledger LEM trading platform*

## OVERVIEW OF THE CASE STUDY

We present a case study of a LEM from an Australian perspective. Fig. 3 illustrates the architecture of the LEM considered in this case study, which consists of 300 residential customers equipped with rooftop solar PV systems (i.e., prosumers) and a commercial customer. It is considered that a commercial customer has 3 buildings, of which 1 is equipped with solar and BESS, 1 has just solar, and the other building doesn't have any on-site power generation or storage systems. Therefore, the proposed case study represents a diverse set of electricity customers.

The main objectives of the P2P trading with the LEM are:

- Electricity bill reduction for LEM participants.
- Maintain current income margin for retailers.
- Reduction in grid import and export peaks.
- Improve network self-sufficiency.

The key assumptions of the case study are as follows:

- Households and commercial buildings are part of a distribution network under a single substation.
- LEM performed trading of solar PV excess energy and shared BESS flexibility within the market.
- Trading takes place if buy and sell orders are matching with respect to grid electricity price and FiT.

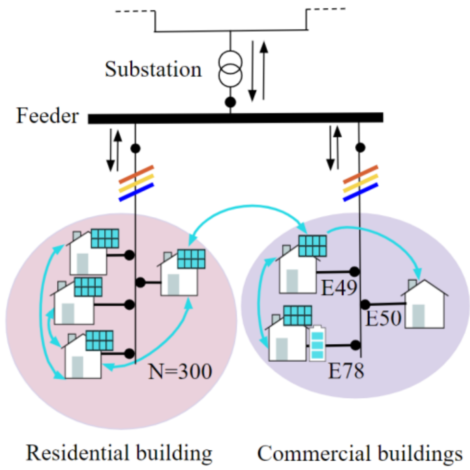


***Figure 3*** *Architecture of LEM Simulation Model.*

Considered load consumption and solar PV generation profiles for commercial and residential participants are shown in Fig. 4 and installed capacities of solar PVs and BESS are shown in Table 1.

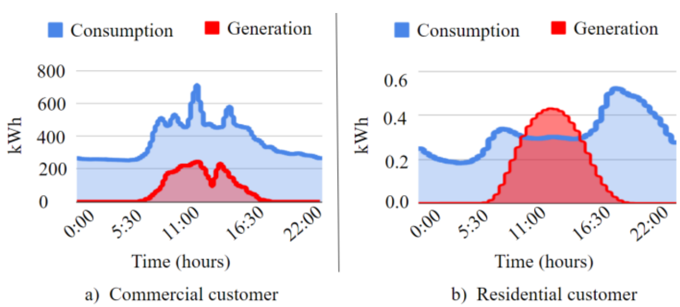


***Figure 4*** *Data profiles of an example day.*

Table-2 shows the rates of the network operator, retailers, LEM transaction fee and energy fee for both business-as-usual (BAU) and P2P energy trading, as considered in this case study. The concept of cross retailers trading is introduced, where the tariff structure of retailer-1 is considered for residential prosumers, and the tariff structure of retailer-2 is considered for the commercial customer. In order to get maximum benefit and increase P2P trading volume, the time-of-use (ToU) tariff structure is considered for residential prosumers. The rates of daily supply, FiT, network distribution and transmission, renewable energy target (RET), and retailer margin are considered fixed at different ToU periods for both trading scenarios. The LEM transaction fees only apply when P2P transactions happen and ensure all the stakeholders are getting their benefits. Energy price is fixed for BAU, but it varies for P2P trading depending upon bids placed by the participants. For each P2P transaction, there could be a single or cross retailer, i.e., the seller and buyer could be the customers of the same retailer or different retailers.

***Table 1*** *Input parameters*

| | *Qty (EA)* | *Average daily load (kWh/day)* | *Solar PV Capacity (kWp)* | *Average daily generation (kWh/day)* | *BESS Capacity (kW/kWh)* |
|---|---|---|---|---|---|
| Commercial customer [5] | 1 | 33,637 | 4,000 | 14,110 | 2,200/4,300 |
| Residential prosumers [6] | 300 | 16.6 | 10 | 38.1 | N/A |

***Table 2*** *Tariff structure for retailer-1 and retailer-2*

| *Retailer's Tariff [3]* | *Retailer-1* | | | | | | *Retailer-2* | |
|---|---|---|---|---|---|---|---|---|
| | *Peak* | | *Shoulder* | | *Off-Peak* | | | |
| | *BAU* | *LEM* | *BAU* | *LEM* | *BAU* | *LEM* | *BAU* | *LEM* |
| FiT (c/kWh) | 5.00 | | | | | | 1.6 - 26.5 | |
| Network fee (c/kWh) [4] | 18.06 | 18.06 | 8.42 | 8.42 | 6.33 | 6.33 | 0.85 | 0.85 |
| RET (c/kWh) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.0 | 1.0 |
| Retailer fee (c/kWh) | 1.5 | 1.5 | 1 | 1 | 1 | 1 | 0.5 | 0.5 |
| LEM Transaction fee (c/kWh) | 0 | 0.75 | 0 | 0.75 | 0 | 0 | 0 | 0.75 |
| Energy/P2P fee (c/kWh) | 13.73 | 12.28 | 12.46 | 11.2 | 12.88 | 11.7 | 1.6 - 26.5 | 5.75 |
| Tariff | 34.79 | 34.1 | 23.88 | 22.9 | 21.71 | 21.3 | 5.7 - 25.3 | 8.85 |

To ensure prosumers receive a benefit from retailer-1, the off-taker (commercial customer) has to offer a buy price above the FiT of 5 c/kWh. In this case study it was set at 15 % above the FiT, as shown in the figure. The residential prosumers can also trade with each other at prices in the range of FiT and grid buy rates. Spot prices are 1.6 to 26.5 c/kWh over an investigated period of 24 hours as shown in Fig. 5. It is considered that the commercial customer has a fixed buy price above the FiT rate of prosumers to ensure benefit for prosumers. In the instances when P2P buy price is above the spot price led to reduced income for commercial customers as they could procure energy cheaper from the grid during these periods and this can be restricted in the P2P trading rules. P2P trading can be combined with high-load demand peaks to improve peak demand charges.

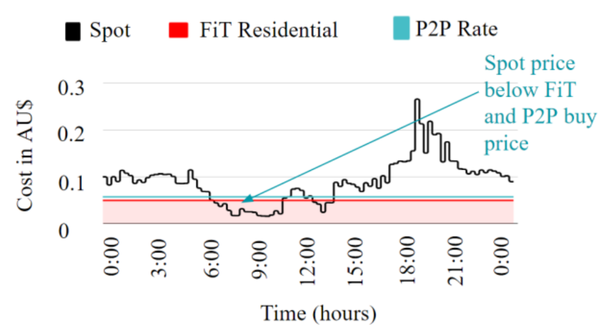


***Figure 5*** *Spot prices over a period of 24 hours*

Fig. 6 demonstrates an illustrative example of the peak-time P2P energy flow, cash flow and internet of things (IoT) signals for two retailers-facilitated LEM when the commercial customer procures 1kWh from a residential prosumer. The LEM transaction fee 0.75 c/kWh includes the LEM platform fee 0.50 c/kWh and retailer-2 (selling) fee 0.25 kWh.

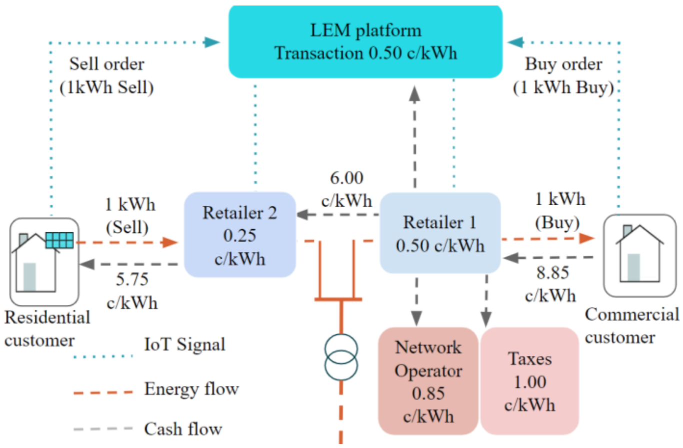


***Figure 6*** *P2P energy flow, cash flow, and IoT signals for a retailer-facilitated LEM.*

## CASE STUDY RESULTS

LEM case study is conducted in an Australian context, containing consumers, prosumers, retailers, and the network operator. The trading period is set every 15 minutes apart. The P2P energy trading results are compared with the BAU to analyse the benefits of using the P2P trading-based LEM platform.

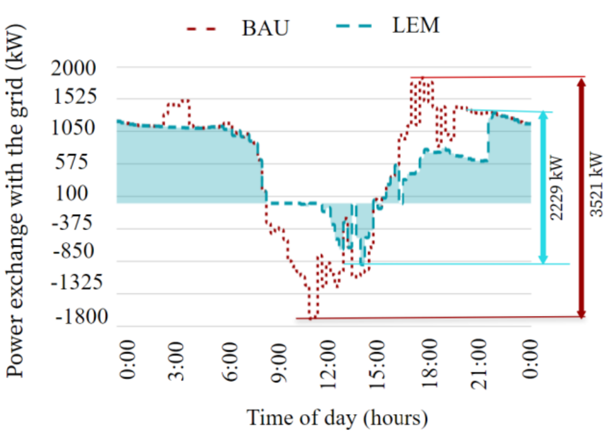


***Figure 7*** *Grid import and export comparison.*

The export and import of the power grid for a typical day are represented in Fig. 7. In comparison with BAU, proposed LEM, a reduction of the difference between maximum import and export of ~1,300 kW is achieved. The power grid import is lessened due to BESS discharging and energy trading with neighbouring users during peak time. The import of solar energy from residential peers to charge commercial customers' BESS increases its expenses during midday/afternoon. In addition, offsetting demand through BESS discharge during periods of high spot prices in the evening decreases expenses for grid imports. Overall, for the commercial customer, the proposed LEM reduces the energy import cost to 11.04%.

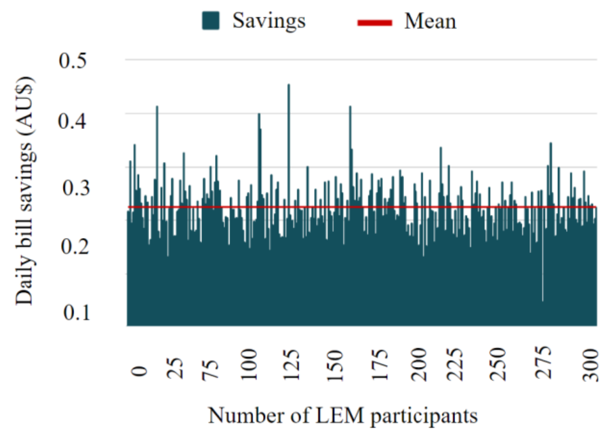


***Figure 8*** *Bill savings for LEM 300 participants*

Fig. 8 shows the participants' bill savings due to the commercial benefit of P2P trading and the optimal use of BESS. Prosumers in the LEM have an average bill reduction of 11.7 % or 22.5 c/day by selling at a rate higher than FiT to the commercial customer. The selected buy price of the commercial customer ensures every prosumer derives a benefit.

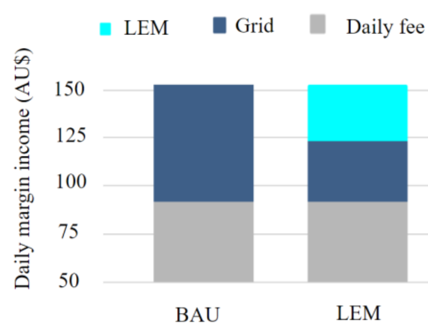


***Figure 9*** *Retailers' daily income margins in LEM vs BAU*

Fig. 9 portrays that the retailer's margins are kept at or above the BAU level. An increase in daily margin is a result of an additional fee per P2P traded kWh as well as increased P2P trading volume due to BESS charging from other prosumers. Note that the network operator may not be getting profit like the LEM energy users owing to reduced BAU trading. However, P2P trading in the LEM lessens the renewable penetration into the electricity network significantly which can eventually cut down the capital expenditures (CapEx) and operational expenditures (OpEx) of the electricity grid, leading to encouraging the network operator to permit more consumers to turn into prosumers.

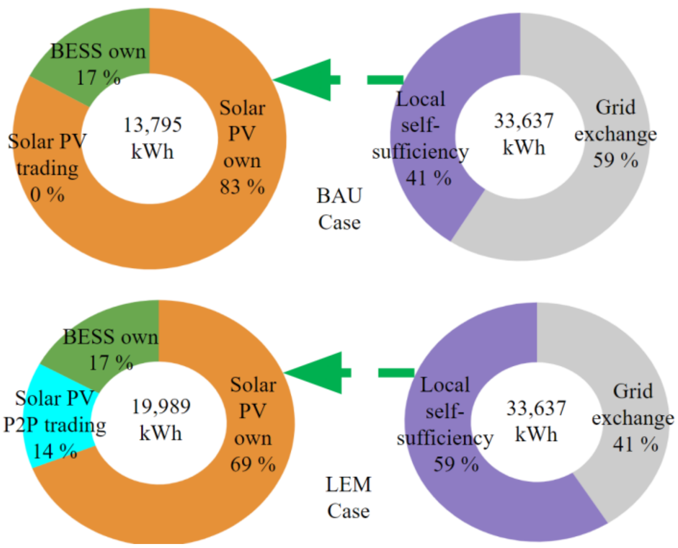


***Figure 10*** *Self-sufficiency of LEM vs BAU*

LEM trading increases local self-sufficiency as shown in Fig. 10 and, therefore, reduces the dependency on external fossil fuel-based generation sources (Black coal & Gas) by 6,054 kWh daily where 14 % contribution is with solar PV P2P trading.

## CONCLUSION

LEM trading platform uses a unique objective function to consider all fees and network charges, creating a fair playing field for participants. The presented case study illustrates that this innovative LEM model empowers consumers and prosumers alike to engage in frequent peer-to-peer energy trading, all while maintaining the economic interests of everyone involved. The results show that the proposed LEM offers a higher bill reduction of 11-22 % for prosumers than any other incentive scheme because of the P2P trading range between FiT and grid buy energy price. Any reduction in network fees would result in additional bill reduction. While BESS reduces the difference between maximum grid import and export to 36 % with the utilisation of the operational principle to control the charging or discharging behaviour at set regular time intervals. This reduction in grid import and export improves power quality which results in better voltage regulation, improved thermal behaviour of cables and transformers with reduced grid congestion. LEM maintains the income margin of retailers and P2P trading decreases the renewable penetration into the network which can eventually bring down the CapEx and OpEx of the network operator. The creation of a LEM under substation feeders increases self-sufficiency by 18 % thereby reducing power flow reversals across transformers.

The analyses showed superior performance of this new trading strategy, resulting in lower electricity costs, reduced grid imports and exports, and improved self-sufficiency of the network. It's a win-win for everyone involved, and we're excited to see where this model will take us next!

## ACKNOWLEDGEMENT

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