

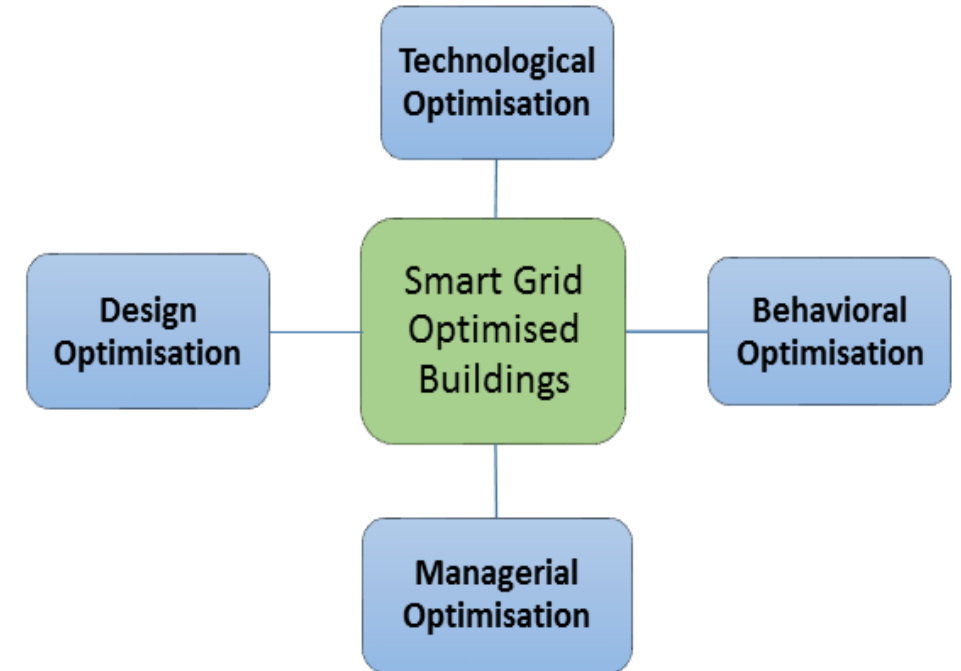
# Battery Storage Systems in Smart Grid Optimised Buildings

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# Smart Grid Optimised Buildings (SGOBs)

- The existing literature and projects have followed an ad-hoc approach to increase the energy efficiency in existing buildings.
- The SGOB meets its service obligations to its occupants, minimises its operational cost to its owner, by actively engaging with the electricity provider and enabling best use of the resources available.
- Design and the incorporated energy systems of Buildings can be optimised for the Smart Grid.
- Their energy storage characteristics will play a crucial role in ensuring that they function as an effective sub-system a Smart Grid environment.



**Figure 1** – The concept of Smart Grid Optimised Buildings

# SGOB Hypothesis

- SGOBs must work in synergy with the grid to relieve pressure on the infrastructure. By using electricity storage, they are capable of shifting their electrical loads effectively, becoming distributed energy storages themselves and providing balancing services to the grid.
- SGOBs are assumed to be fully electric in order to take full advantage of the installed ESS and maximise the potential of their interaction with the electrical grid.

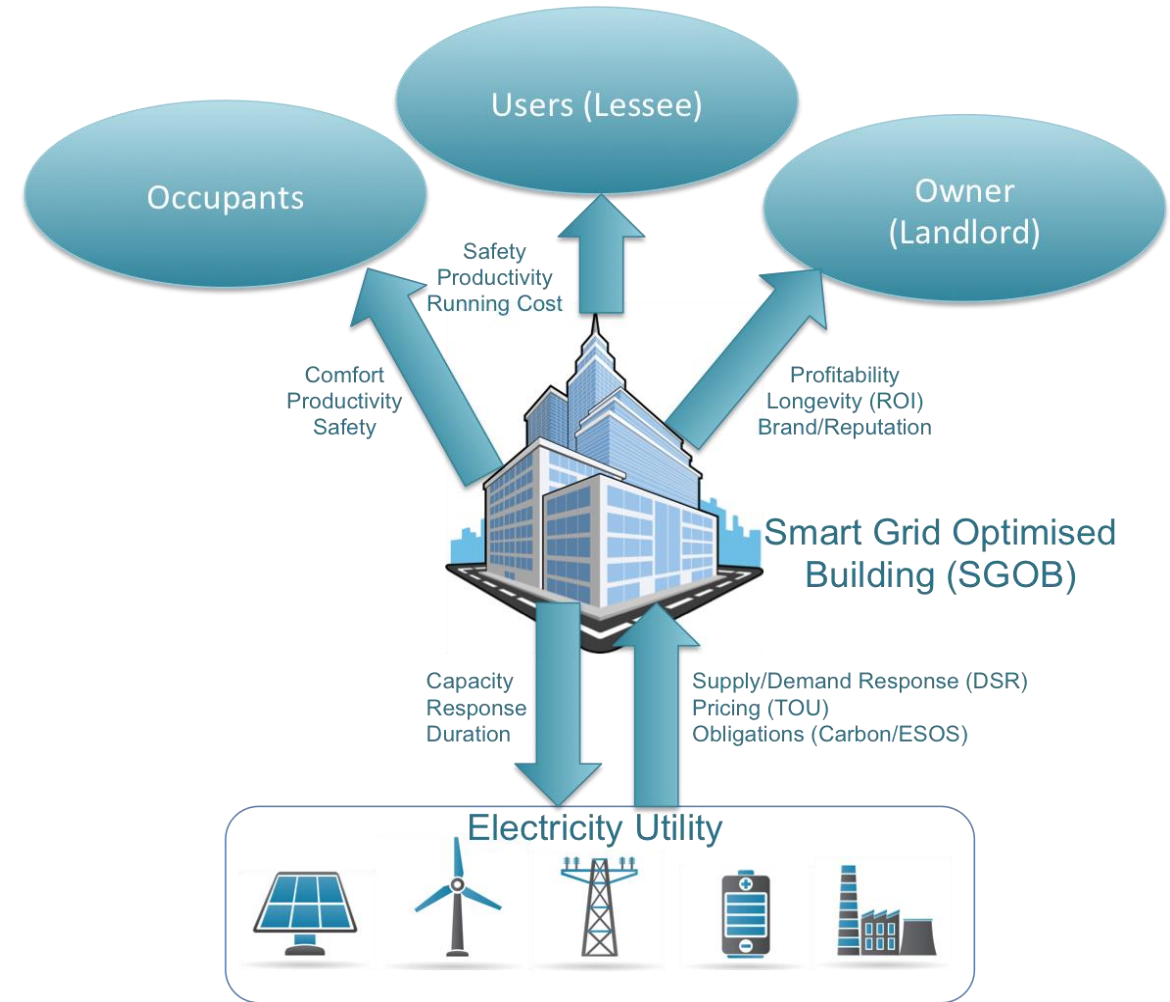
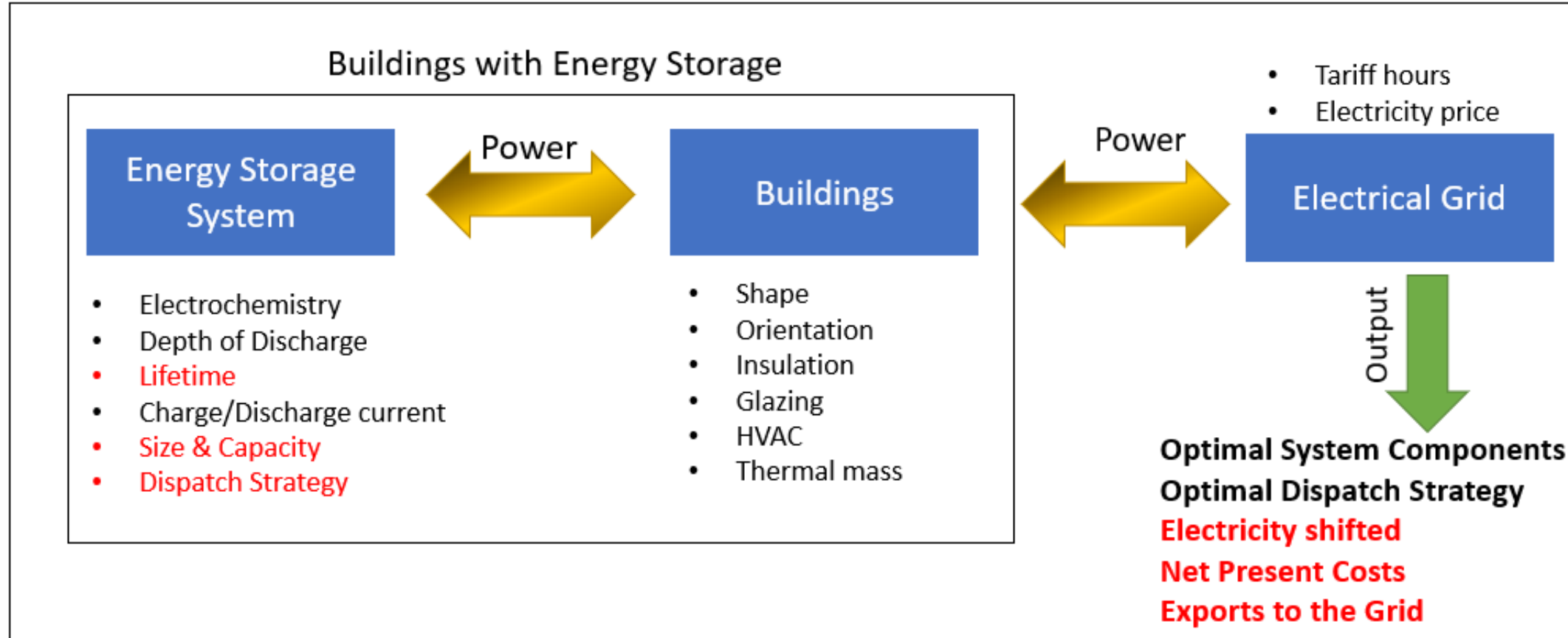


Figure 2 – The SGOB concept

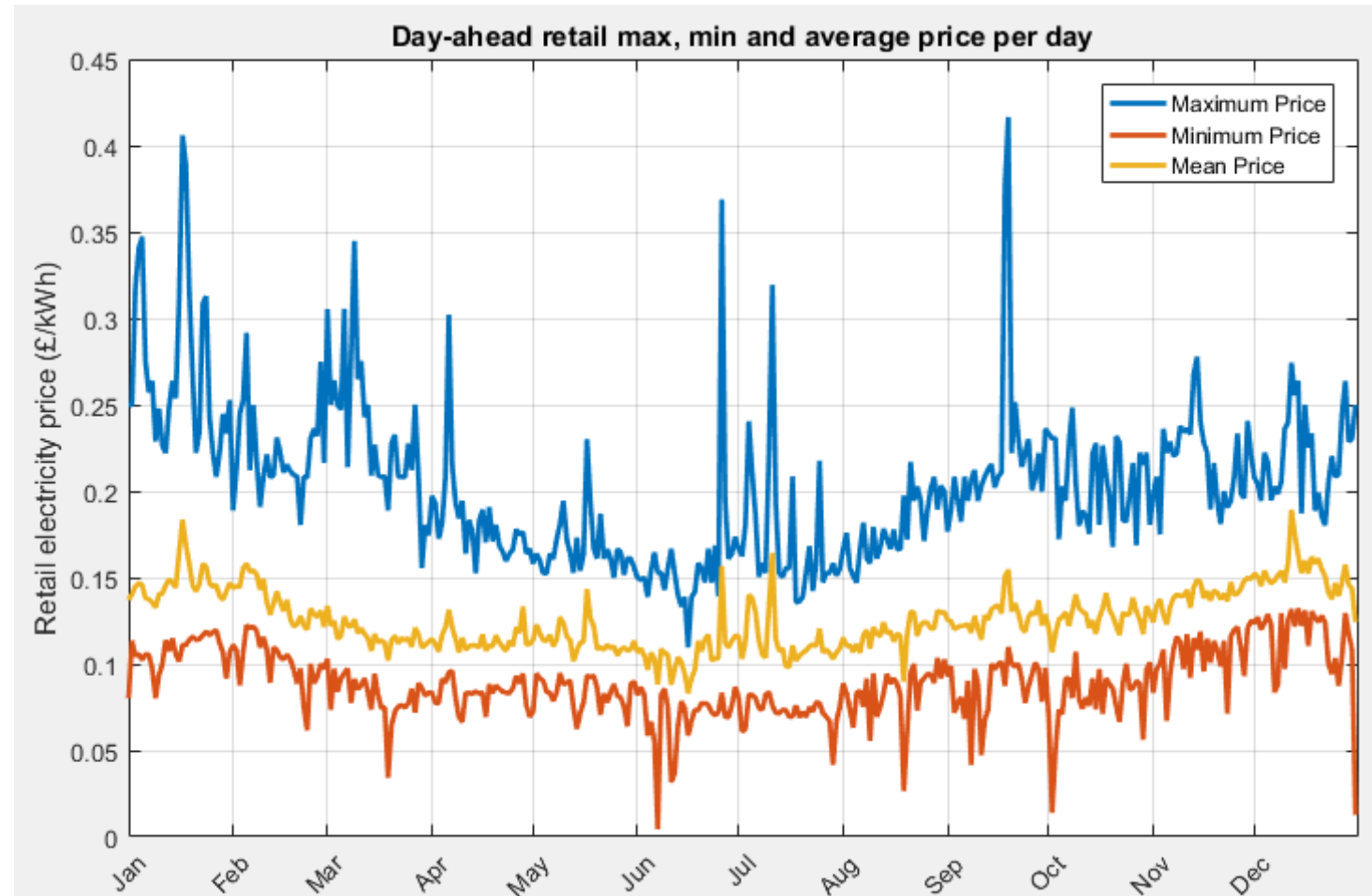
# Modelling Methodology

## Smart Grid Optimised Buildings



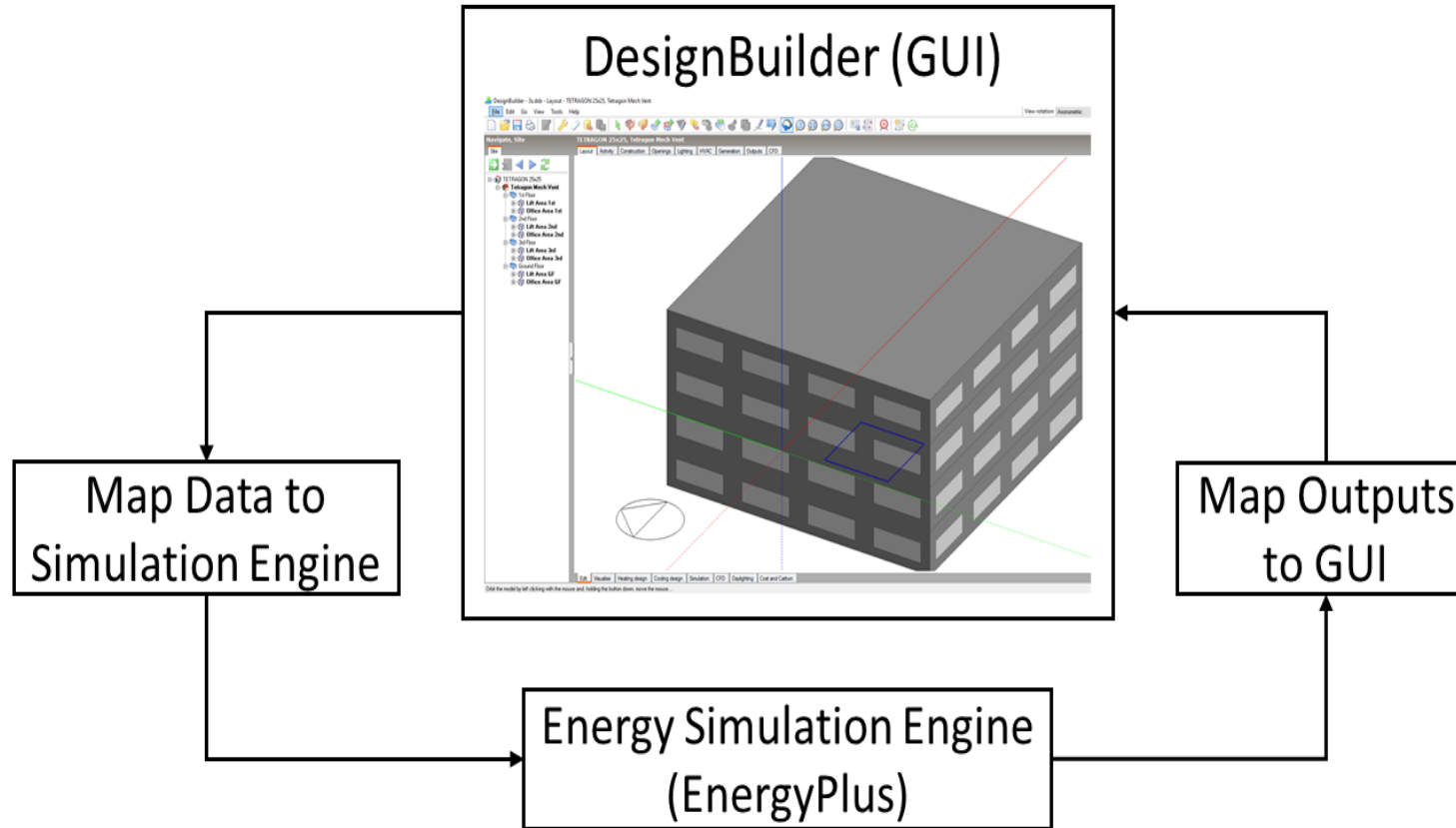
# Real Time Electricity Pricing

- SGOBs must have access to the NordPool day-ahead electrical energy market in order to know in advance the hourly real-time prices of the following day.
- In this way, they can optimise their operational-dispatch strategy on a daily basis, considering the set of the 24 hourly prices and the respective building loads.
- In 2017, wholesale costs were responsible for 36.7% of the total non-domestic electricity price that includes distribution/network costs, operating costs, VAT, environmental and social obligation costs.



**Figure 3** – Minimum, maximum and average retail electricity prices per day (NordPool, 2017)

# Building Simulation Software



**Figure 4** - Interoperation between DesignBuilder GUI and the EnergyPlus engine

# Building Simulation Results

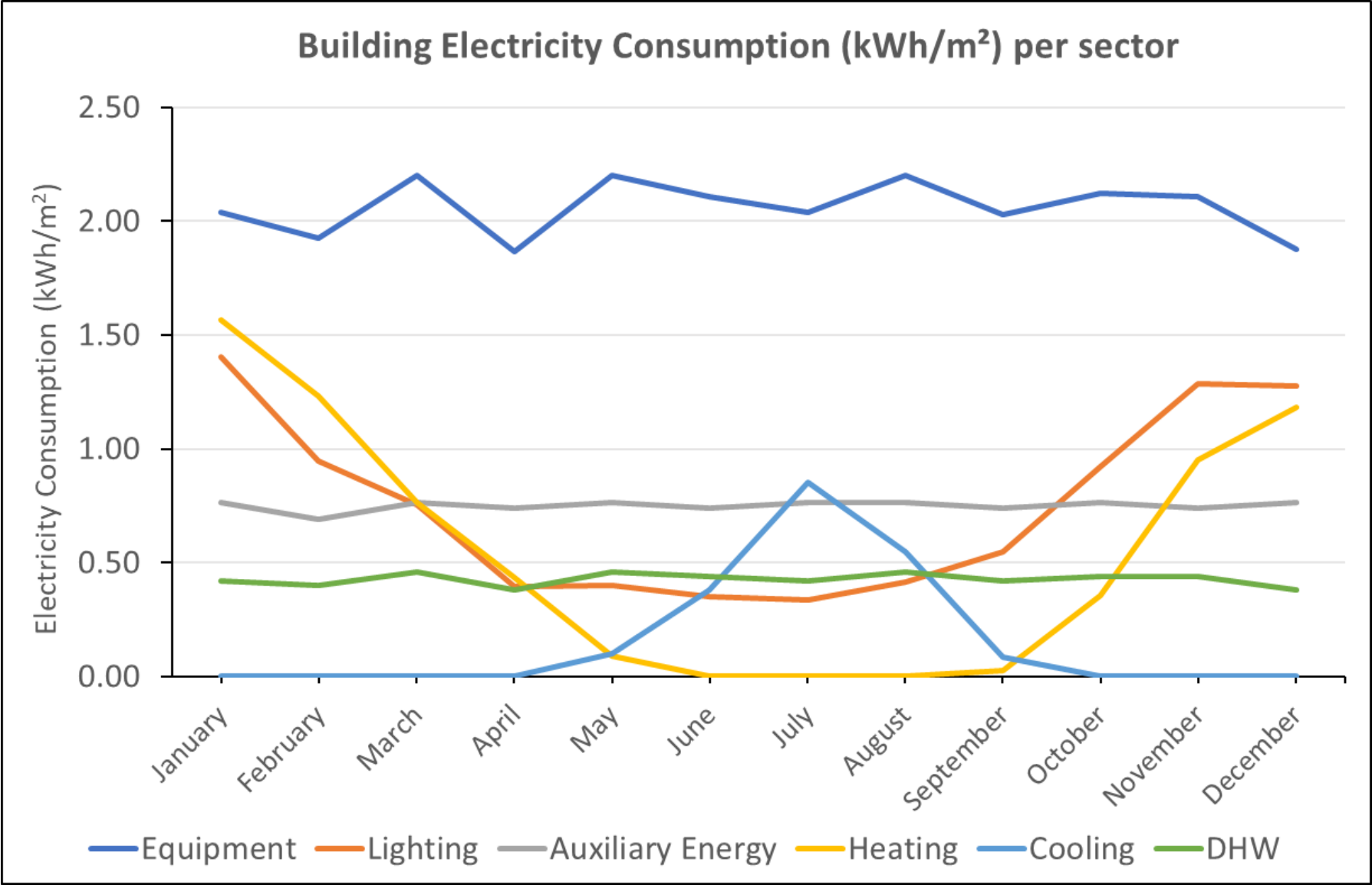
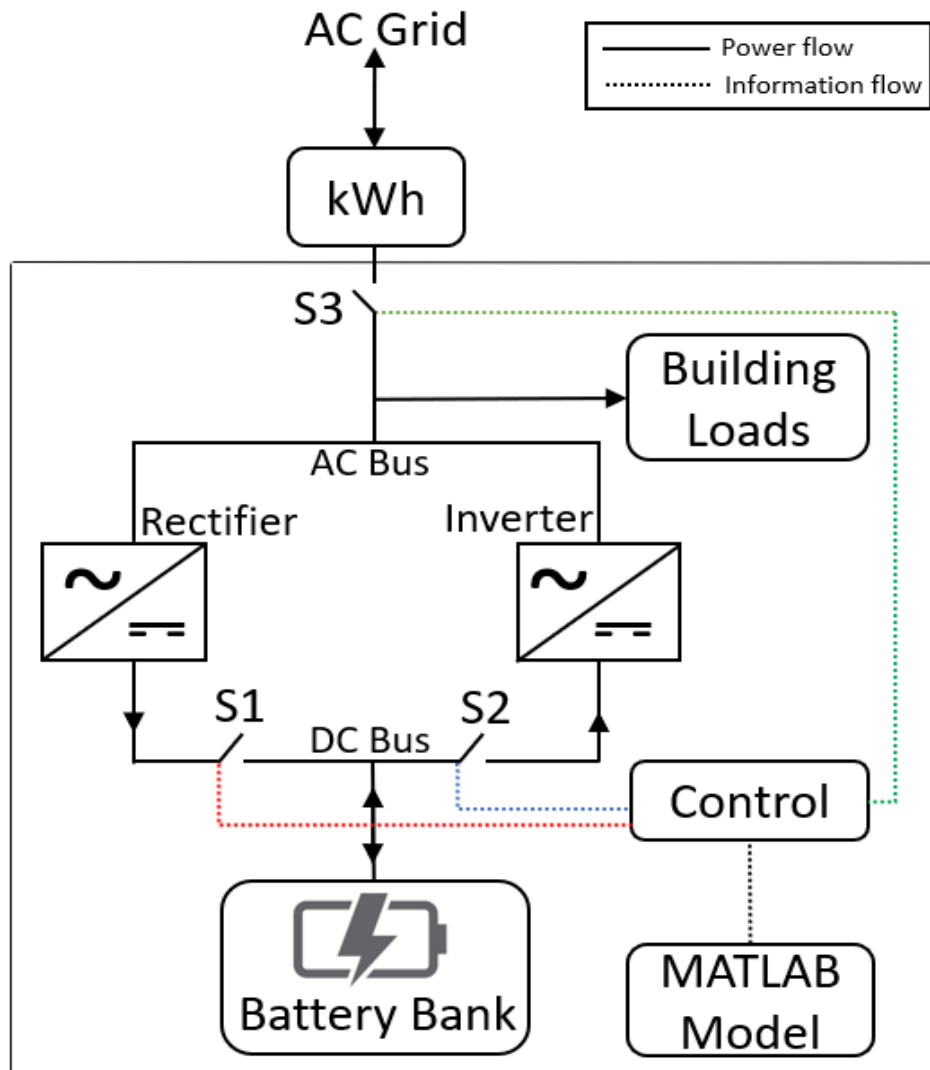


Figure 5 – Building’s Electricity Consumption

# Battery Storage - Arbitrage Modelling



**Figure 6** - Power and information flow between system components

- The algorithm uses as an input year-ahead hourly electricity prices, trying to optimise the charge-discharge pairs on a daily basis.
- Battery is charged at the cheapest prices (pump operation) and is discharged when electricity reaches its most expensive values.
- Operational bottlenecks apply to avoid exceeding the maximum state of charge (SOC) and to make sure the energy added or removed from the ESS are in accordance with the system's charging and discharging capacities.
- Charging when building loads are significant is not allowed.
- Discharging when building loads are insignificant is not allowed.



..... Real-time Price -- Loads without storage \* Exported Electricity - - - - Battery Charge/Discharge — Loads using Storage

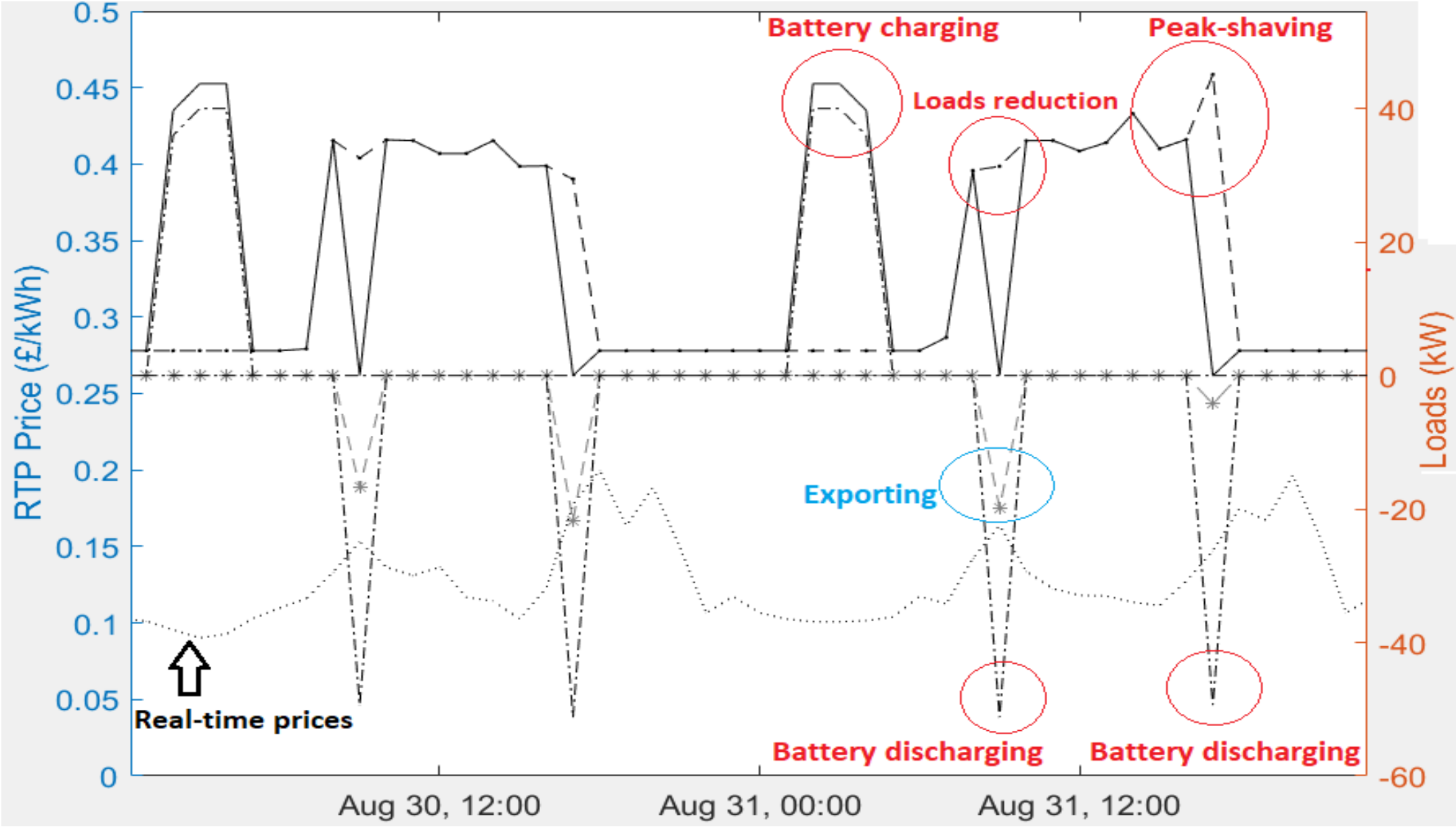
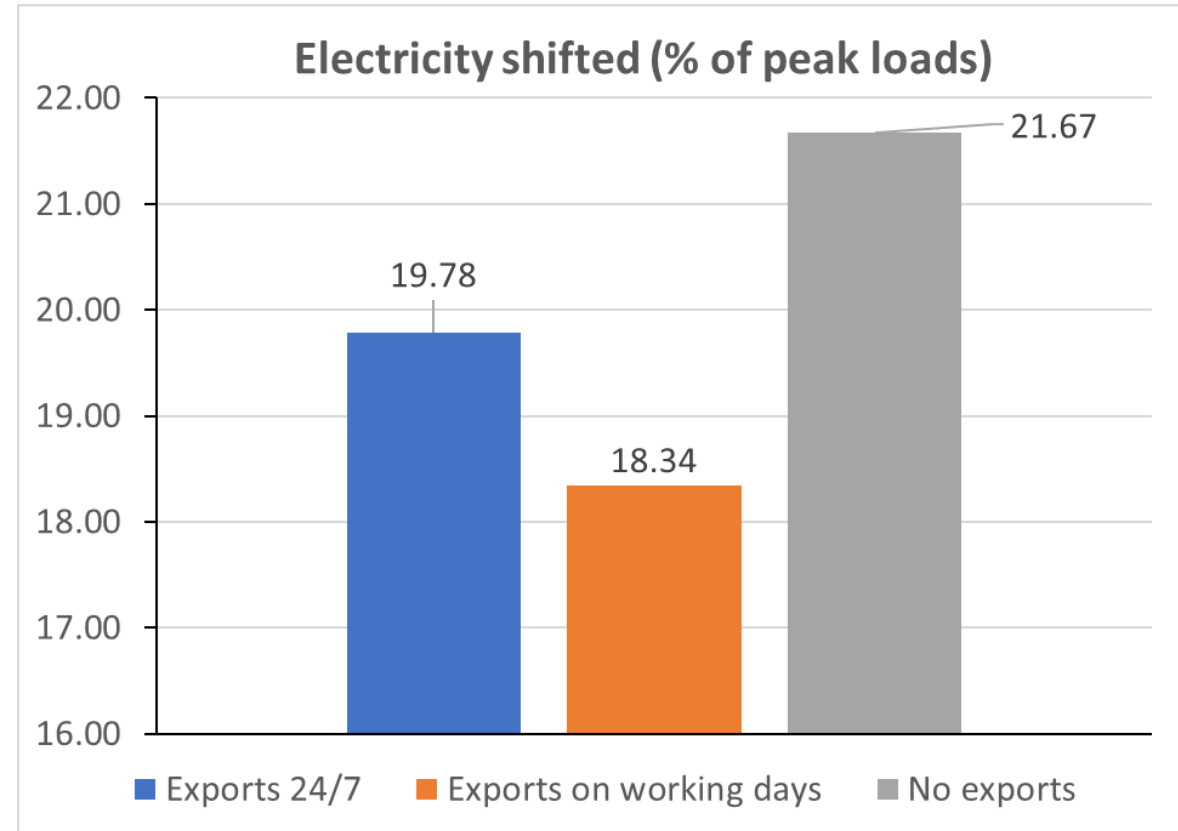
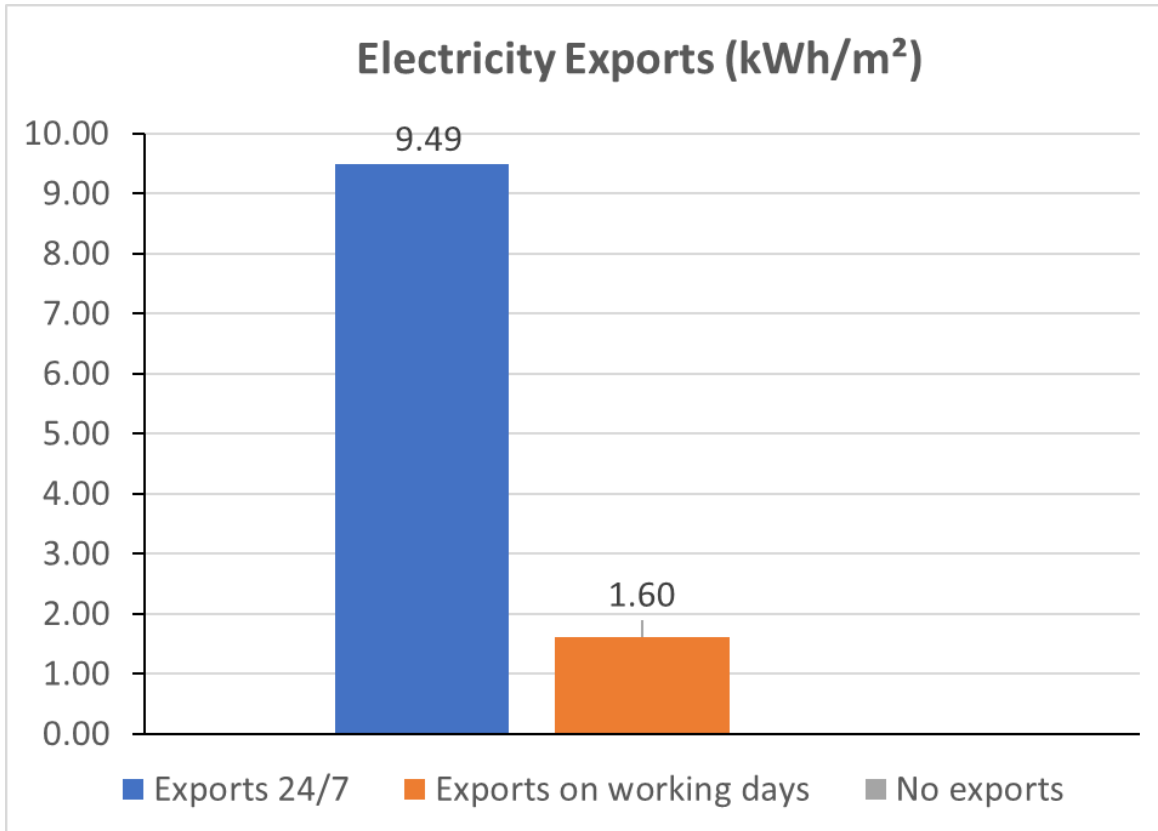


Figure 7 – Battery Storage (120 kWh with an inverter/rectifier capacity of 55/40 kW) altering the building’s demand

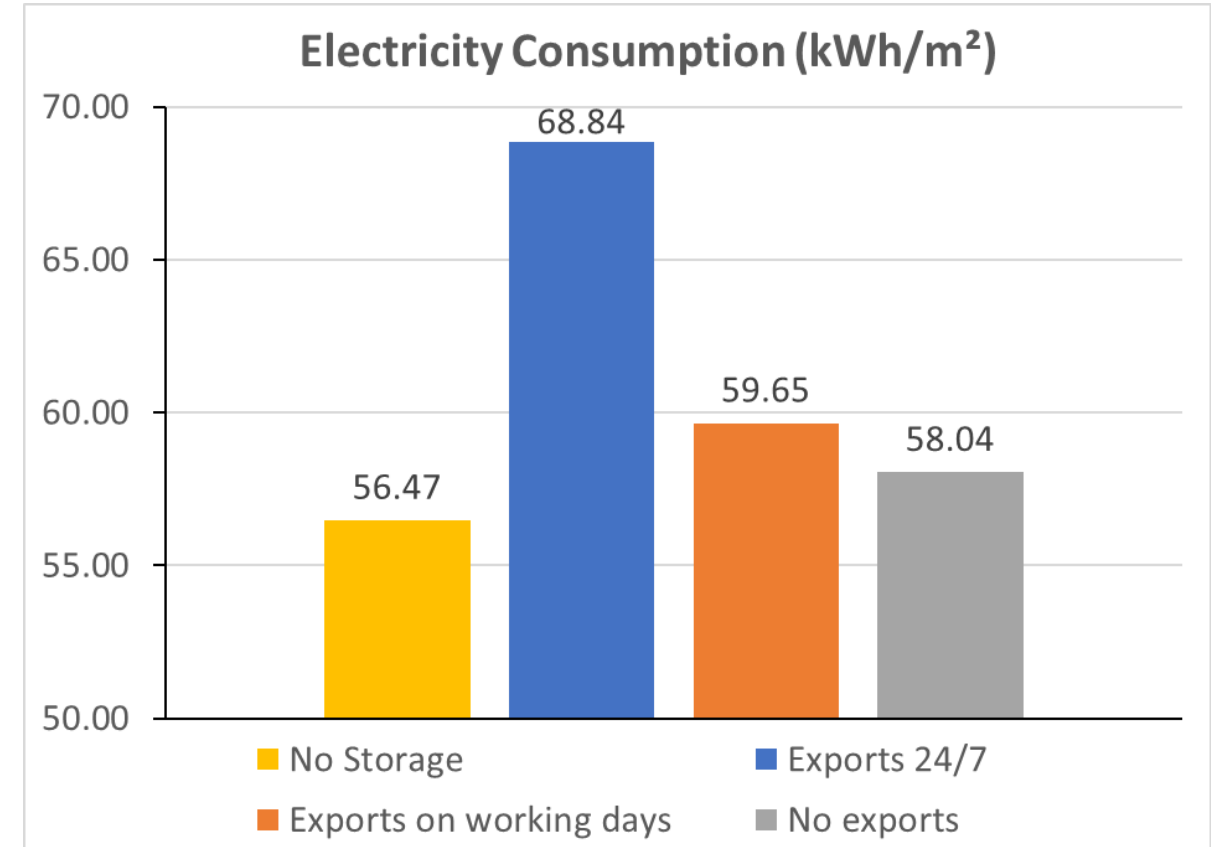
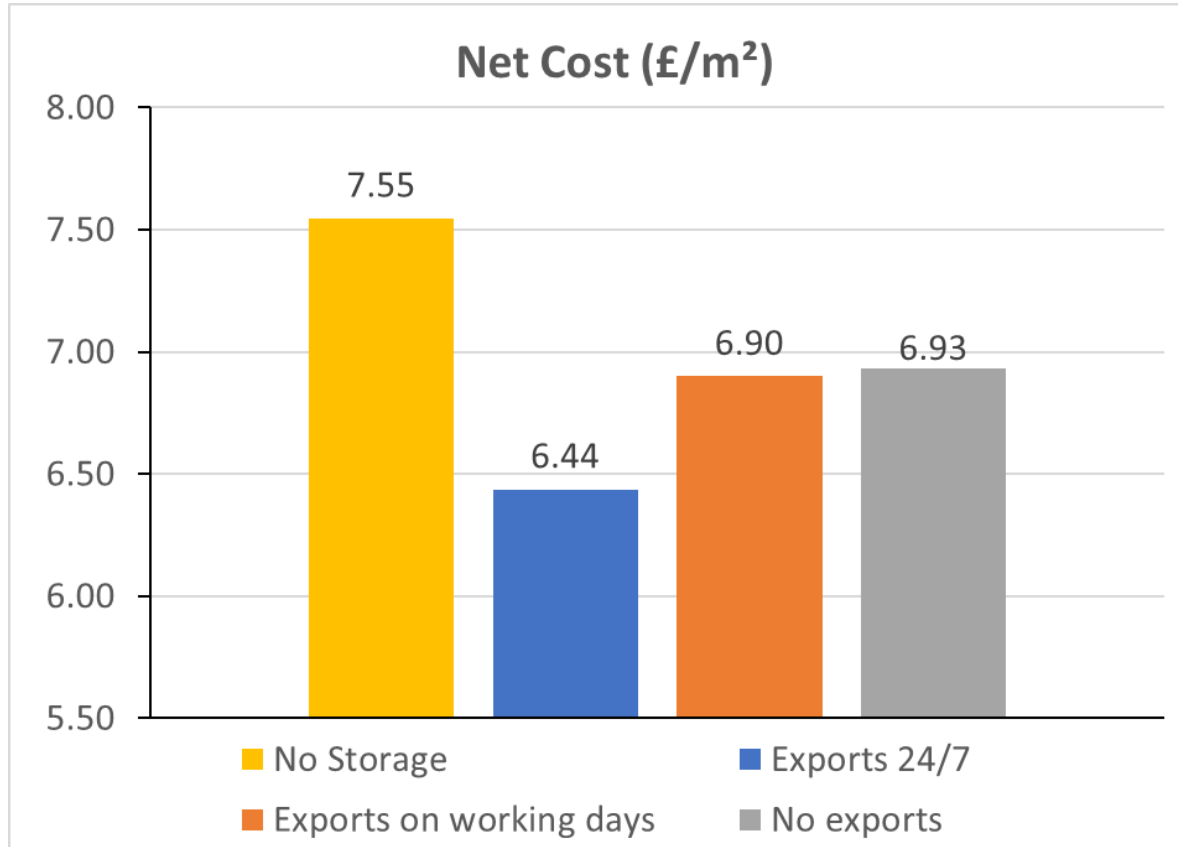
# Annual Results \*



System: 120 kWh Li-on Battery, Rectifier/Inverter (40/-55 kW), DOD 90%,

\*Capital cost of the Battery Storage system is not considered.

# Annual Results\*



\*Capital cost of the Battery Storage system is not considered.

# Conclusions

- Buildings can become energy storage vectors and provide balancing services to the grid, adapting their loads and responding to real-time electricity prices.
- Battery Storage Systems are currently expensive but their prices have been steadily decreasing.
- Arbitrage is currently more expensive than buying electricity directly from the grid when including the capital costs.
- Financial motives and a proper regulatory framework are needed for SGOBs in order to construct a feasible and cost-effective scheme as the capital costs can be significant.
- Simulation of different building designs and a sensitivity analysis of the battery storage system size can provide more clarity about SGOB characteristics.

# THANK YOU FOR LISTENING ANY QUESTIONS?



We shape our buildings; thereafter they shape  
US.

(Winston Churchill)