An assessment of V2X for commercial car parks: a case study for East Midlands Airport

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Background and motivations

Growing electric vehicles (EVs) [1]:

Table 1: EV number projection (SMMT,2021).

Year	Low scenario		Central scenario		High scenario	
	Total BEV (x1000)	%BEV	Total BEV (x1000)	%BEV	Total BEV (x1000)	%BEV
2022	537	1.6	611	1.8	795	2.3
2023	740	2.2	953	2.8	1,449	4.2
2024	1,002	2.9	1,392	4.0	2,286	6.6
2025	1,335	3.9	1,951	5.6	3,342	9.5
2026	1,739	5.1	2,628	7.6	4,624	13.0
2027	2,229	6.6	3,447	9.9	5,973	16.7
2028	2,801	8.4	4,406	12.7	7,456	20.8
2029	3,484	10.6	5,553	16.0	9,072	25.3
2030	4,293	13.4	6,909	20.1	10,817	30.2

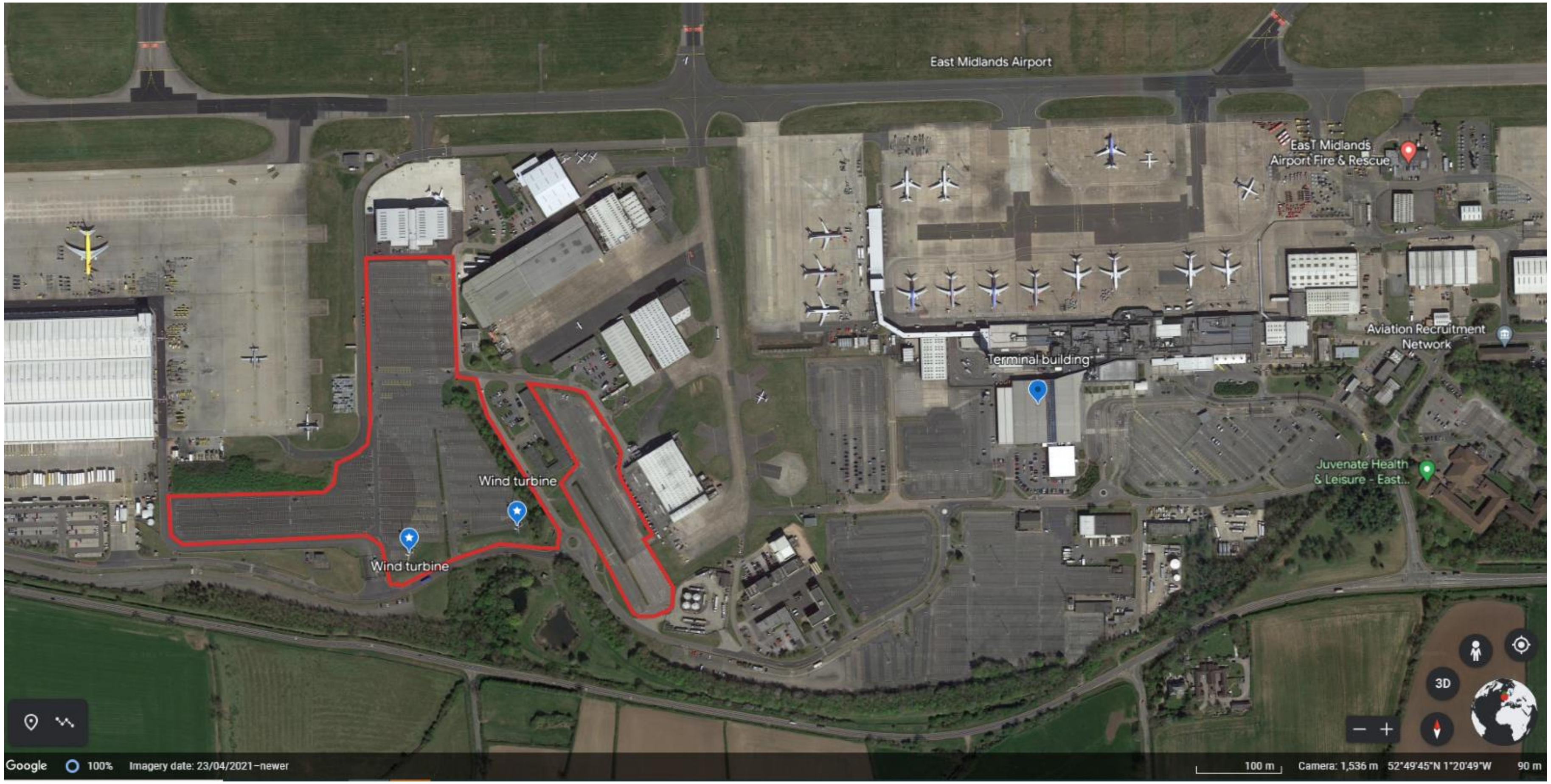
Six essentials for mainstream EV adoption identified by government[2]:

- resilient supply chains and vital raw materials
- clean and green power production
- accessible charging infrastructure
- the integration of EVs with smart grid technology
- digital platforms and mobile applications to optimise EV charging
- finding and training the next-generation workforce

[1] SMMT report (2021). Available at: https://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-new-car-market-and-parc-outlook-to-2035-by-powertrain-type-11-06-21.pdf (Accessed: 14 August 2023).
[2] EY (2023). UK-EV-success-hinges-on-six-essentials | EY UK. Available at: https://www.ey.com/en_uk/news/2023/04/uk-s-ev-success-hinges-on-six-essentials (Accessed: 14 August 2023).

Why East Midlands Airport (EMA):

- Large local energy demand
- Long-stay car parks
- Predictable dwell times



Background and motivations

Why East Midlands Airport (EMA):

- Existing car parks infrastructure

- Renewable energy generation
  Solar panels, wind turbines

- Data availability:
  half-hourly electricity data from 2022.01.01-2022.12.31

Aim: assess V2X by using the collective battery capacity of parked EVs at the airport

Illustration of energy demand and energy tariff in EMA:

Energy demand:

High from 3am to 3pm, with a steep increase from 6am onwards,
Reaching the peak demand at around 7:30am, the demand gradually decreases.
A small increase in the evening at 8pm

Energy tariff:

Average two peaks during the day
Morning: 6am-9am
Afternoon: 3pm-6pm

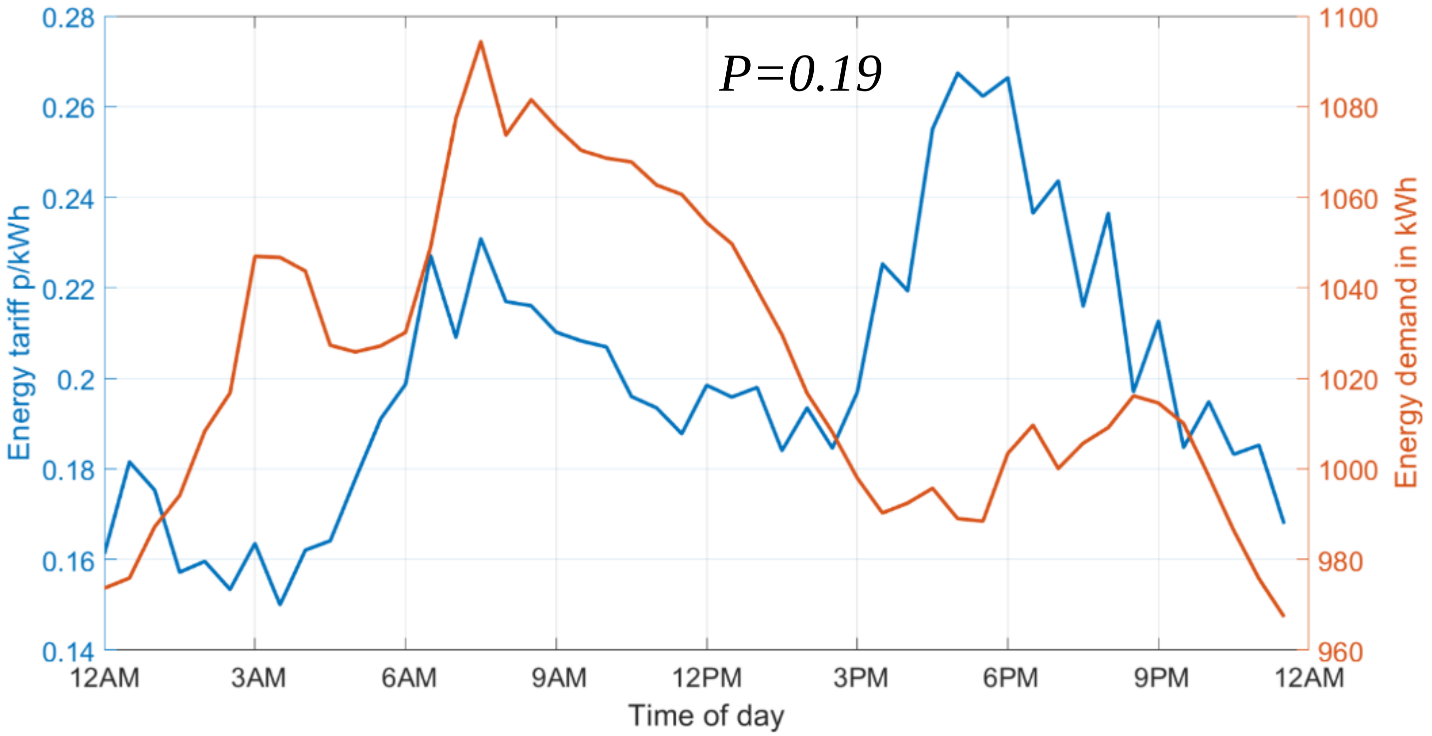


Figure 1: yearly-average half-hourly energy demand and tariff in the baseline year 2022

Assumption 1: estimated EV parking capacity

Long-stay car parking facility at EMA: up to 2500 cars

EVSE: assumed to operate at a constant power of 22kW for the entire time frame

Table 2: Estimated EV parking capacity at EMA.

Year	EV capacity scenarios at the airport			Weighted average battery size in kWh
	Low	Central	High	
2022 *(baseline)*	10 - 50	20 - 50	30 - 50	50
2023	10 - 50	45 - 75	80 - 100	53
2024	35 - 75	70 - 100	155 - 175	56
2025	60 - 100	95 - 125	205 - 225	60
2026	85 - 125	145 - 175	305 - 325	64
2027	135 - 175	195 - 225	405 - 425	68
2028	160 - 200	270 - 300	505 - 525	72
2029	235 - 275	370 - 400	605 - 625	76
2030	285 - 325	470 - 500	730 - 750	80

[1] International Energy Agency (2020). Available at: https://www.iea.org/reports/global-ev-outlook-2020 (Accessed: 14 August 2023).

Assumption 2: estimated energy demand and energy tariff up to 2030

- A growth of 1.06 was observed in the energy demand between the year 2021 and 2022, which was consequently applied for calculating building demand up to 2030.

- Energy tariff at any time was derived by calculating the mean tariff of the corresponding times from the past two years.

Simulation model 1: unmanaged charging

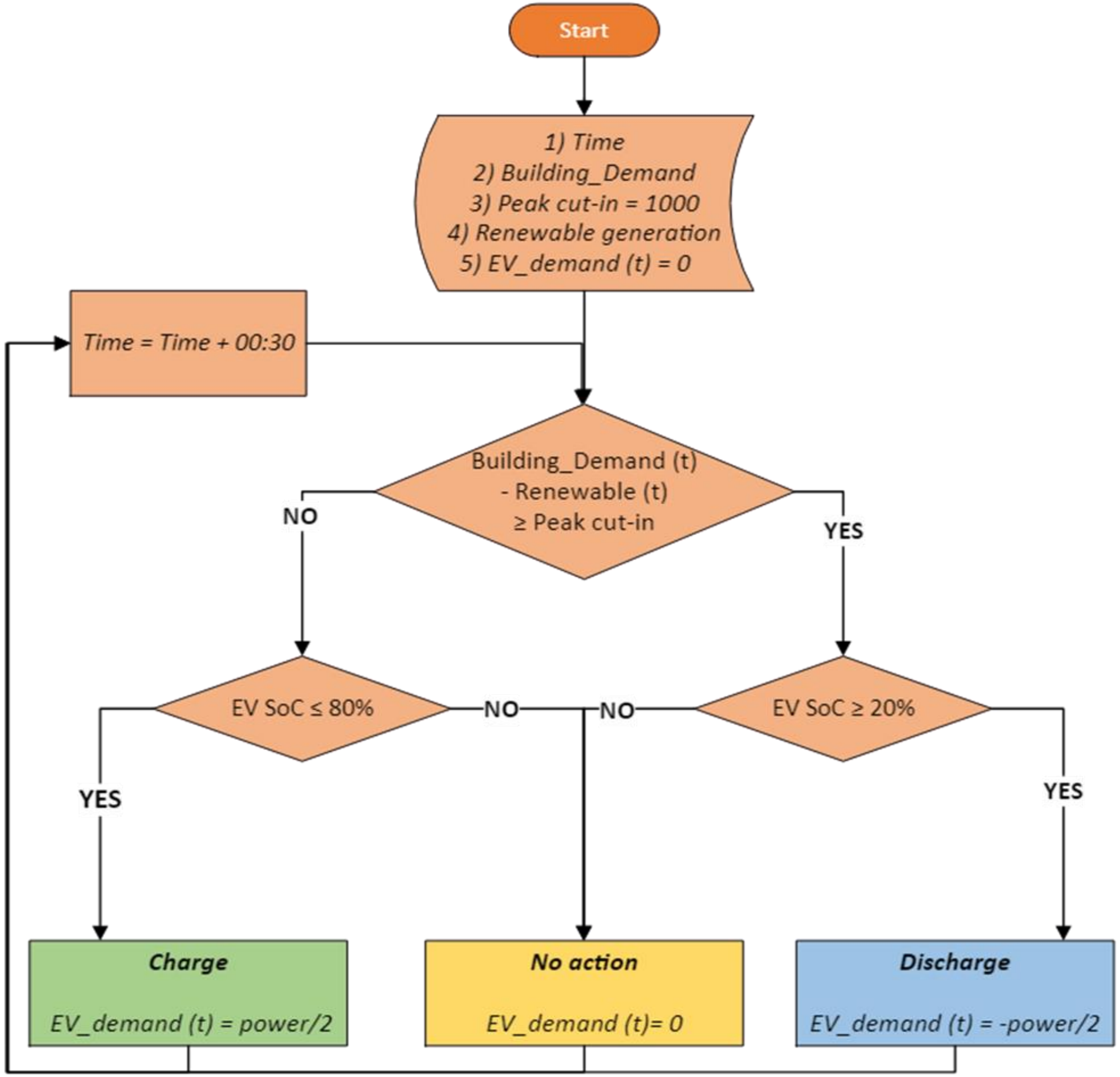
(the baseline model for comparison)

- Generate an annual EV parking dataset
- Iterate the algorithm through each time step (half hour) and charge the vehicle up to 80%
- Introduce new EVs into the parking lot at 10am, which is the busiest time at the airport

Assumptions and models

Simulation model 2: peak shaving

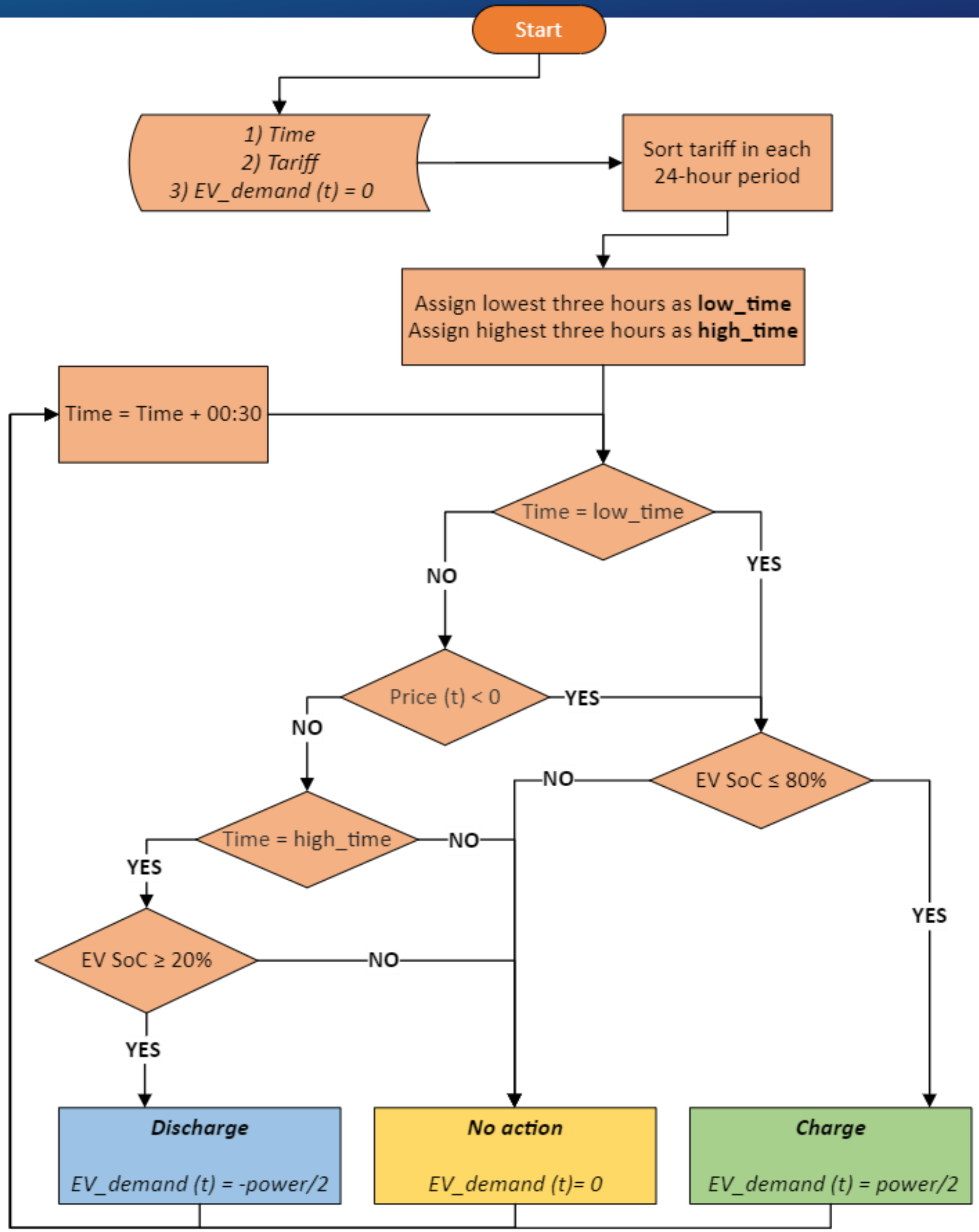
- Generate an annual EV parking dataset
- Check if the current time step is the peak time
- If peak time, discharge EVs
- If off-peak time, charge EVs



Assumptions and models

Simulation model 3: grid arbitrage

- Generate an annual EV parking dataset
- Sort the energy tariff for each 24-hour period
- Assign the lowest six tariff times for charging
- Assign the highest six tariff times for discharging
- Iterate the algorithm through each time step (half-hour)
- Introduce new EVs at the lowest tariff rate each day



Results and discussion

Net costs due to charging:

Capital costs of infrastructure and EVSE is not considered nor is ongoing maintenance and refresh.

Assume there are no constraints with regards to the number of available EVSE at any given time.

Simulation results in 2022:

Both peak shaving and grid arbitrage modes offer potential benefits in terms of cost saving for EV operation in the baseline year.

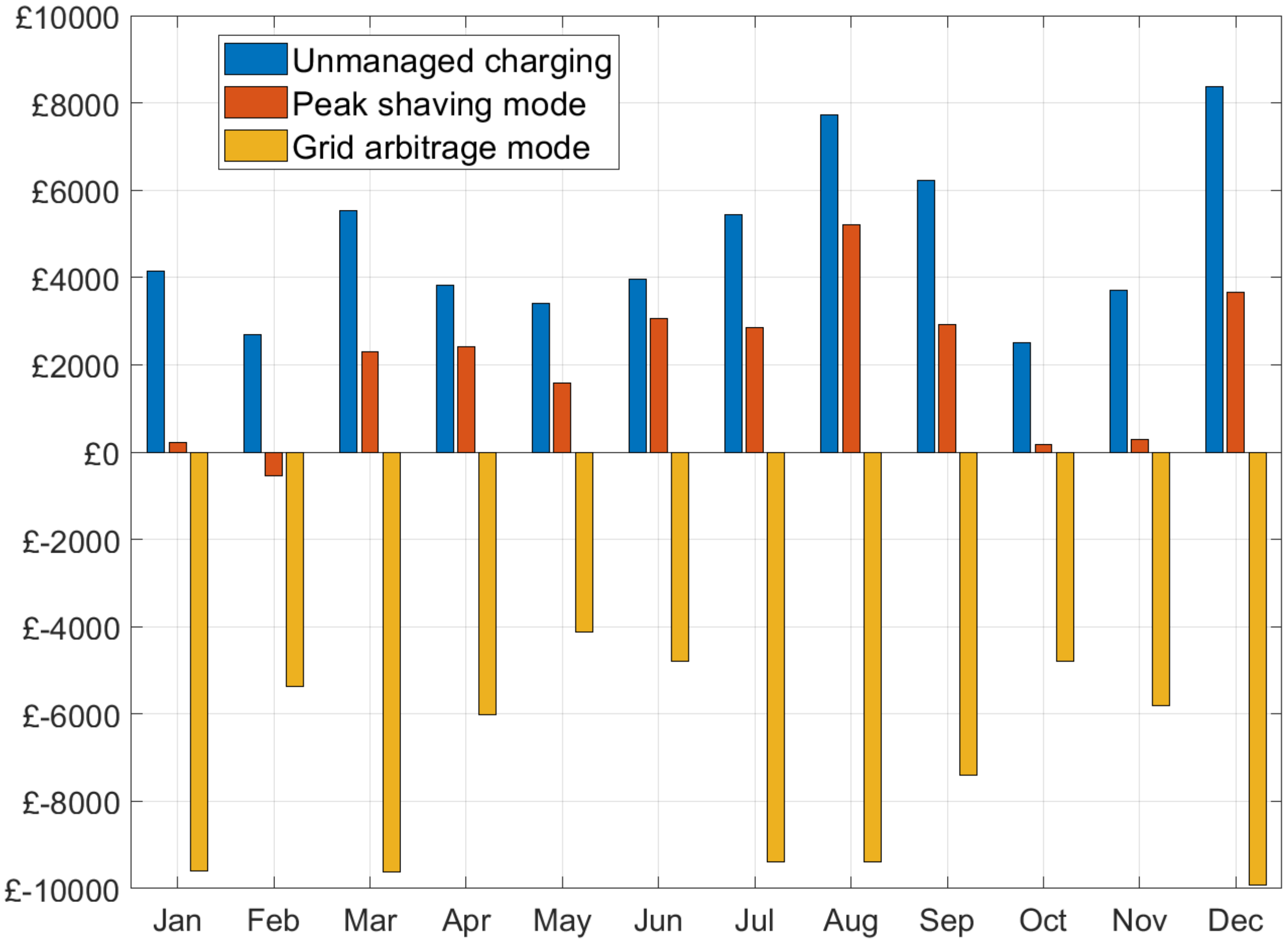


Figure 2: results of different simulation models during the baseline year (central scenario)

Results and discussion

Simulation results in 2022-2030:

Both peak shaving and grid arbitrage modes offer potential benefits in terms of cost saving for EV operation in the future landscape.

Grid arbitrage consistently demonstrates a pronounced superiority over both unmanaged charging and peak shaving throughout all years.

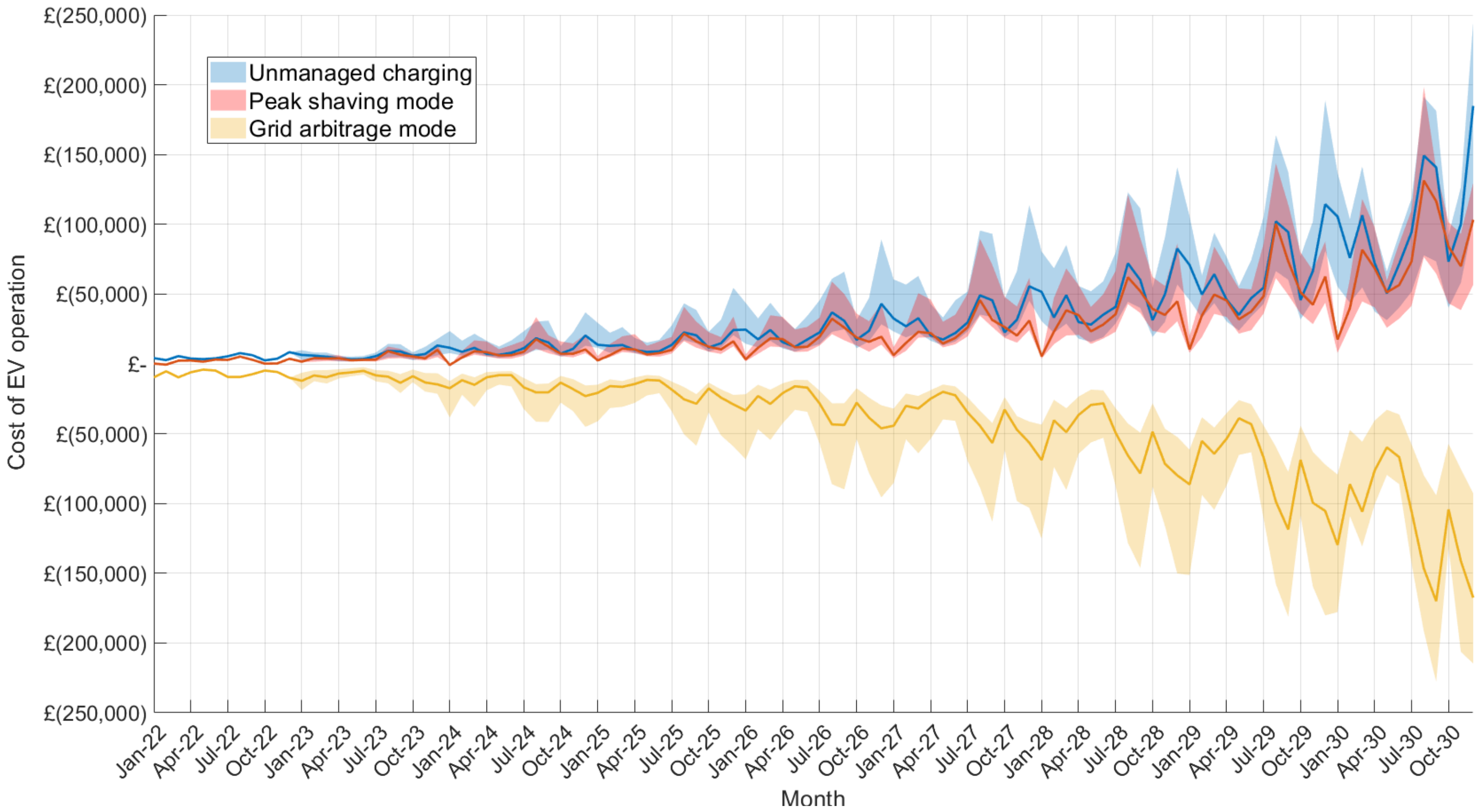


Figure 3: results of different simulation models during the period of 2022-2030

Conclusions and future work

Conclusions:

- Investigated the potential benefits of implementing different V2X strategies, namely peak shaving and grid arbitrage, within the context of East Midlands Airport. Unmanaged charging mode included as the baseline for comparison.

- Data of the energy demand and energy tariff was analysed to identify possible opportunities for V2X technologies implementation. (Weak correlation)

- The simulation results from 2022 to 2030 showed that both peak shaving and grid arbitrage charging modes can help reduce the EV charging costs, while grid arbitrage outperforms the other two strategies by generating a surplus income.

Future work:

- The proposed simulation models can be further refined and extended using data from other airport such as Manchester Airport to further validate and generalize the findings.