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A2Dominion

Elmsbrook monitoring report 2022/23

Data on water, energy, heat, transport and waste use on site

Version 1

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Executive summary

This report forms the fifth in a series of monitoring reports to track the real-life performance of the UK's first ecotown. Known as Elmsbrook, the development is part of the NW Bicester masterplan and was designed to meet the original Ecotown Planning Policy Statement – PPS. Elmsbrook is one of the most comprehensively monitored developments with data on travel, energy, water, waste, and a range of other sustainability indicators collected as part of the planning requirements.

Approximately 306 homes are now occupied over phases 1-4, marking for the largest dataset we have had since reporting started. However, there are continued issues around data collection, with older monitoring equipment providing incomplete or unreliable data. 'Clean' data was only available for 205 households for this monitoring report, marking an increase when compared to the last monitoring report which used data from a total of 151 households. Consequently, this report reviews data from an additional 54 households. However, it should be noted that the data that is provided is becoming more robust, as the development is now well established, and people are embracing greener, more sustainable lifestyles.

The monitoring and data collection processes have been continuing to benefit from improvements (monitoring infrastructure and analytics). All later phases are fitted with higher specification meters and more robust equipment. App development has allowed stakeholders to view their energy and water data more readily (in real-time), assisting behaviour change and helping to highlight out of range readings. These systems are helping households and landlords to become 'smarter' over time but do require engagement with the technology so other modes of feedback are important too.

Energy and carbon performance is a highly dynamic process. This year, based on the monitoring data, the development has not achieved its true zero carbon aspirations. Elmsbrook does however still provide large energy and carbon savings compared to existing UK housing. This year's carbon balance has been impacted by a range of factors, some data related, others operational. Whilst no lockdowns caused by the COVID-19 pandemic occurred during the monitoring period, the pandemic has caused changes in behaviour that could have impacted the net zero balance. For this monitoring period, the average Elmsbrook home emitted 1,506 $kgCO_2$ compared to 894 $kgCO_2$ in the previous monitoring period. However, it should be noted that this report uses the latest SAP 10.2 figures, which introduces a variation from the last report, using a comparable methodology to the previous reports (SAP 2012 factors), the average Elmsbrook home would have emitted 712 $kgCO_2$, a 20% reduction.

Encouraging sustainability performance has been observed for electricity and water use. Annual average electricity use per household in 2022/3 stands at 3,062kWh, with 60% of homes meeting the design stage target, this represents a ~20% saving compared with the Bicester wide average (2019 figure). Water use on Elmsbrook was 6% below the design target of 80 litres per person per day, averaging 75 litres per person per day (compared to UK average of 146 litres per person per day). Total waste generated per household has increased in 2022-23 by 11% compared to 2020-21 from 591kg to 658kg. The recycling rate stands at 41.91%, compared to 53% for the district (2023), 44.6% for the county, and 44.1% for England (2021 figures). This could be representative of the larger number of detached homes that have been built in phases 3 and 4, potentially increasing the population per household.

The heat and hot water demand at Elmsbrook was slightly lower than in previous years. On average Elmsbrook residents used ~ 16% less energy for heating and hot water than previous years and on average, Elmsbrook residents used ~1%% less energy for heating and hot water than the design stage estimations. However, Elmsbrook residents used ~63% less heat than their neighbours in Bicester, 65% less than the UK average, and ~49% less than the average post-2017 new build home.

Feedback from the annual resident survey continues to be encouraging. Residents of Elmsbrook rate their health and happiness highly (64% rate their health as good to very good; however, 54% indicated since moving to Elmsbrook their happiness levels have increased), and many indicate a strong sense of community, as well as many reporting that they value the environmental friendliness of the development. Demand for these new homes is continuing to be very high, demonstrating that a more sustainable, healthy lifestyle within a fair share of the earth's resources is both viable and desirable.

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Ongoing monitoring ensures that this learning (from design, construction to occupation) finds its way back to the decision makers and stakeholders at all levels. Feedback can influence lifestyle choices (i.e. residents), construction processes (i.e. the delivery team), and planning considerations. Effects can ripple out further to inform how other developments are designed and built, both nearby in the same local planning context more widely across the UK. In this decisive decade, for climate action to stabilise global temperatures, Elmsbrook continues to show that net zero carbon developments are not only viable and important, but they are also popular.

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1 Introduction

This report has been prepared for A2Dominion by Bioregional and consists of the fifth set of monitoring results from the Elmsbrook Ecotown development in Bicester. Ongoing monitoring is now being conducted every two years. This report covers a period of 12 months (April 2022 to March 2023) and includes data from 306 occupied dwellings, 87 from the first phase of development, 71 from the second phase, 90 from the third and 58 from the fourth phase.

Information was collated from two main data sources, a survey questionnaire providing qualitative data, and from monitoring equipment (e.g. the shimmy) providing quantitative data. Other supplementary data sources complete the picture around waste and communal energy. While the total number of data sets has been increasing and the development is now well established, monitoring equipment issues have again impacted on the total number of dwellings reporting via the inbuilt shimmy system (205 of 306 plots reporting).

Technical issues around the meters and PV system on phase 1 has meant that some data was not collected correctly, even though a full year should have been available. The flat blocks share a communal roof, and their PV arrays are still not sub metered. As in the previous years, some PV inverters were, and others switched off at the isolator (unknown reason) resulting in generation failure. Additionally, the installation of a new monitoring system required several Shimmy monitors to be disconnected. For this reason, the total electricity figure (as derived from a formula of generation, export, and import) cannot be accurately reported for plots affected by these issues, reducing the available (and accurate) data set.

Whilst there were no direct impacts from the COVID-19 pandemic during this reporting period, such as national and local lockdowns, secondary impacts (long-term) from cultural changes such as remote working, shopping, fitness, eating and travel are affecting these latest results. A further and more noted effect has been from the energy and affordability crisis which has impacted energy use, consumer spending, and travel.

Data in this report is presented by theme, with a summary paragraph outlining headline figures in bullet point format, with further information on the data and analysis in the section below followed by results in graphical form. Conclusions and recommendations tie chapters together, providing a summary of the headline findings and making recommendations for improvement.

2 Overview of the site

2.1 Environmental standards

Elmsbrook is the first phase of North West Bicester, the UK's first eco-town, and will eventually include 393 homes, a primary school, community centre, an eco-business centre and local neighbourhood shops. The development included the following environmental features or standards:

- All homes built to Code for Sustainable Homes level 5, incorporating triple glazing, mechanical ventilation (MEV or MVHR) and rainwater harvesting,
- PV solar panels on every home,
- Energy centre featuring combined heat and power (CHP) plant providing space heating and hot water via district heating to all buildings on site,
- Cycle and pedestrian routes, a bus stop within 400 metres of every home, live timetable updates in each home, charging point for electric vehicles and an electric car club,
- 40% of the site is open space, with a net biodiversity gain targeted,
- Water efficiency target of 80 litres/person/day,
- One Planet Living framework & action plan.

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2.2 House types, tenure and phasing

Elmsbrook consists of a mix of 1-5 bed detached, terraced, semi-detached properties and flats. The development is made up of four phases, of which the first phase has been occupied for over five years, the second phase has been occupied for over 3 years and parts of the third phase for around 1-2 years (some part occupied) with initial data from phase four being included in this report. Further detail of the housing type and tenure for phases 1 to 3 is outlined below in table 1.

Table 1- House types and tenures by phase.

Phase /tenure.	Detached	Bungalow units	Terraced	Flat	Semi-detached
Phase 1 – 87 dwellings occupied (Fully occupied, only 7 dwellings reporting due to monitoring equipment issues)					
Private	12	26	0	4	0
Affordable	0	9	18	4	3
Shared ownership	0	7	6	5	0
Phase 2 – 71 dwellings occupied (Fully occupied, only 54 dwellings reporting due to monitoring equipment issues)					
Private	12	47	0	4	0
Affordable	0	0	4	0	4
Shared ownership	0	0	0	0	0
Phase 3 – 90 dwellings occupied (only 86 dwellings reporting due to monitoring equipment issues)					
Private	36	30	0	0	0
Affordable	0	19	0	0	0
Shared ownership	0	5	0	0	0
Phase 4 – 138 dwellings of which 58 dwellings occupied (all reporting)					
Private	38	75	0	0	0
Affordable	0	35	0	0	0
Shared ownership	0	0	0	0	0
Total dwellings - 403	98	253	28	17	7

3 Overview of the Shimmy data

This report has been collated as part of a desk-based study with a small component of on-site data collection (e.g. meter readings taken on site) by Bioregional.

3.1 Sources of information

All data sources featured in this report were provided by A2Dominion and their partners for the purposes of monitoring agreed planning conditions. These include:

- In house residential monitoring – 'shimmy' data (Carnego)
- Waste data (Cherwell District Council)
- Resident survey (A2Dominion)
- Energy centre data from Scottish Southern Electric (SSE)
- Gagle Brook Primary School meter readings (White Horse Federation)
- Eco business centre (TownSq)

3.2 Data analysis

The shimmy dataset comprises the primary information source of this study. Prior to submission, Carnego undertook an initial quality check to remove obvious data issues. Bioregional then undertook a more detailed

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secondary analysis to detect further anomalies using statistical methods (standard deviations) in combination with conditional formatting. Severe data outliers were replaced with series averages in excel, to avoid skewing effects when producing annual averages. Naturally, this introduced some error into a small percentage of results.

Where an estimate of total development level energy and carbon balances were required, missing plots (mainly on phase 1) were reconstructed using data series averages. 101 plots were recreated in this way with obvious effects on error margins, hence these results are heavily caveated.

Equipment issues remain unresolved on a majority of phase 1 properties. These are through a combination of equipment failure over time and un-plugging by a -party data provider/s. While a much smaller number of phase 2 and 3 plots were affected by data outages, these had more data anomalies such as spikes (very high or very low readings) or duplicates, where readings appear stuck in a range. We estimate that these issues are a result of loose connections, re-booting of devices/ servers and induced current or other interference.

Only after the data screening and patching exercise was completed, a detailed analysis was carried out in Microsoft Excel to produce a range of graphs and summary tables using pivot functions.

3.3 Data quality and limitations

Several important points should be noted when reviewing the data.

1. Shimmy data (water, heat, PV, electric export, electric import) was submitted as daily figures, hourly or even minute-by-minute readings are available on request from Carnego.
2. The flats share a communal roof space and PV array which is not sub metered (landlord supply). Therefore, only data on water, electrical import and heat can currently be collected for these types remotely.
3. As with the flats, the school and Eco business centre are not metered via the shimmy system and so electricity and PV estimates are derived from manual meter readings. These manual readings are less accurate as they don't cover the exact monitoring period.
4. Suspected technical issues on PV inverters and some metering equipment have caused data loss and anomalies which have impacted the quality and cover of data. A large proportion of the older meter equipment in phase 1 seems to be affected.
5. We have attempted to reconstruct missing data through extrapolation and patching (using series averages to answer the net zero carbon question), this affects the accuracy of results.
6. Problems with unplugged shimmy monitoring systems have impacted rented properties on site. A2Dominion head office arranged for a third-party provider to set up remote Feed In Tariff reporting which resulted in some meters being unplugged accidentally. Bioregional did not get provided with this third-party data in time for this year's reporting.
7. Phase 4 data nominally covers 58 properties (out of 138), however due to late (or part) occupation with staggered move-in dates quite a few of these are less than a year in occupation.
8. For this reason and due to the limited availability of data on phase 1, phase wide averages are limited and should be treated with caution.
9. Because of data protection issues (GDPR), no exact information was available on the number of persons per household, so an estimation was required to determine water consumption per person. Designed occupancy numbers were taken from the A2D schedule of housing and adjusted using statistical occupancy information by tenure.

4 Detailed results – 'shimmy' system

This section outlines the detailed results collected from the 'shimmy' system installed to households, the primary data source of this post occupancy study. For each reporting category, results have been set out in summary form (or the headline findings) followed by further information (containing specific details) and graphs. Results are expressed in both absolute terms and normalised by per square meter (or per person), to allow for easier comparison between house type etc.

4.1 Water

Buildings on Elmsbrook are designed to be water efficient through use of low flow taps, smaller baths, low flush toilets and rainwater harvesting.

Summary:

- **The average daily household water consumption figure over the latest monitoring period was 224 litres per day (all phases).**
- This compares to 246 litres in 2020/21, 227 litres in 2018-19, 375 litres in 2017/18 and 192 litres in 2016/17. (Period average: 2016-21 = 253 litres per person).
- **The estimated average per person water consumption over the monitoring period was 75 litres per day. This is 6% below the design target of 80 litres. The average water use in the UK is currently 146[1] litres per person per day.**
- This compares to the average daily water use per person of 83 litres in 2020/21, 84 litres in 2018-19, 151 litres in 2017-18 and 76 litres in 2016-17 (Period average: 2016-23 =94 litres per person).
- On average over this monitoring period, 61% of households on Elmsbrook meet their water use targets of 80 litres per person per day.
- For an average household (2.4 people), water savings equate to roughly 161 litres every day as a result of water efficient design measures and behaviour choices.

Table 2 – Elmsbrook water consumption, year-on-year comparison.

Monitoring period	Average daily per person water consumption (*litres/ day*)	Average Household water consumption (litres/day)
2022 - 2023	75	224
2020 - 2021	83	246
2018 - 2019	84	227
2017 - 2018	151	375
2016 - 2017	76	192
Average 2016-23	94	253
Design target	80	Na
UK average	146	Na

Further information:

From an estimated 306 occupied households on Elmsbrook (at the time of writing), 205 households had their water use logged consistently through the shimmy system.

[1] https://www.statista.com/statistics/1211708/liters-per-day-per-person-water-usage-united-kingdom-uk/

- Of these 205, 7 were in phase 1, 54 in phase 2, 86 in phase 3 and 58 in phase 4.
- 35 were without full data sets, i.e. likely part occupied (recent move-ins with partial data).
- 66 dwellings suffered other forms of monitoring issues, with most of those outages in phase 1 properties.
- Per person water usage has remained stable (~10% less) compared to the previous period. Usage likely affected in part by a Thames Water hosepipe ban ending November 2022.
- We estimate that 61% of monitored plots met their water target of 80 litres per person per day.
- As in previous years, no detailed information was available on the number of persons per household (required to calculate per person use), so designed occupancy numbers were taken from the A2D schedule of housing and statistical occupancy information was applied (e.g. average number of empty bedrooms by tenure) summarised in table 3.
- Household water use has decreased slightly (~9%) from the last monitoring report. In part this is possibly explained by changes to housing mix and the already mentioned hosepipe ban.
- The school's water data is unavailable because the BMS system is still not set up correctly. The school uses rainwater harvesting to flush its WC's, so water use is expected to be below average.
- The first four graphs below show the average daily household and per person water use (all phases), categorised by house type (Figure 1 and 2).
- Figure 3 shows the same results for per person water use by development phase collated and sorted, to capture the entire range of data.
- The last graph shows the percentage of homes meeting the water target of 80 litres per person by dwelling floor area (Figure 4).
- Table 2 provides a summary of water use over previous monitoring periods and compares that to the UK average.
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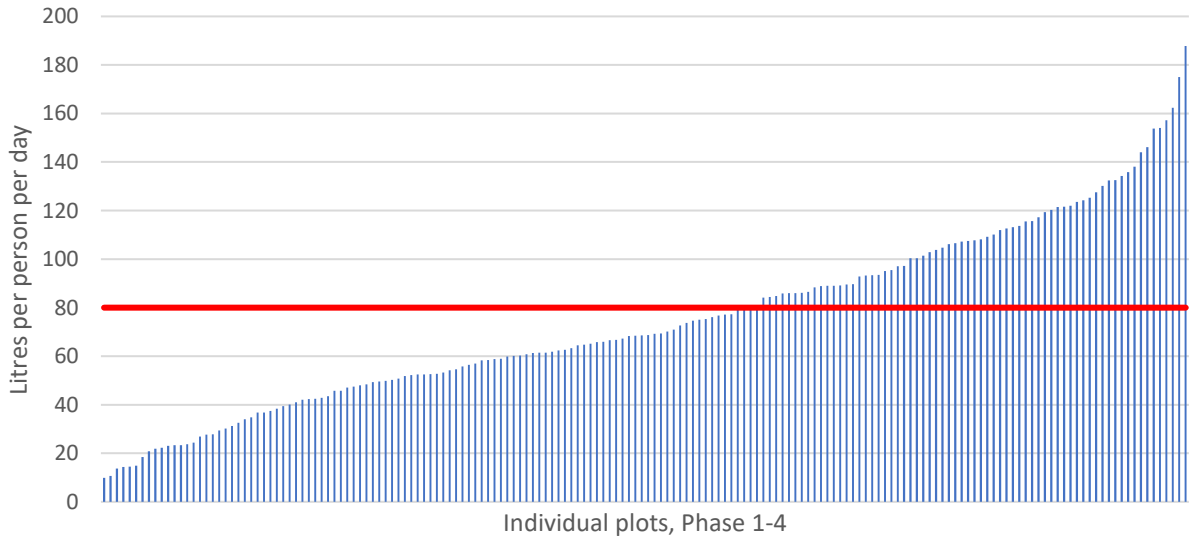

Figure 1- Average daily per person water use. Blue bars = per person water use. Red line = target.

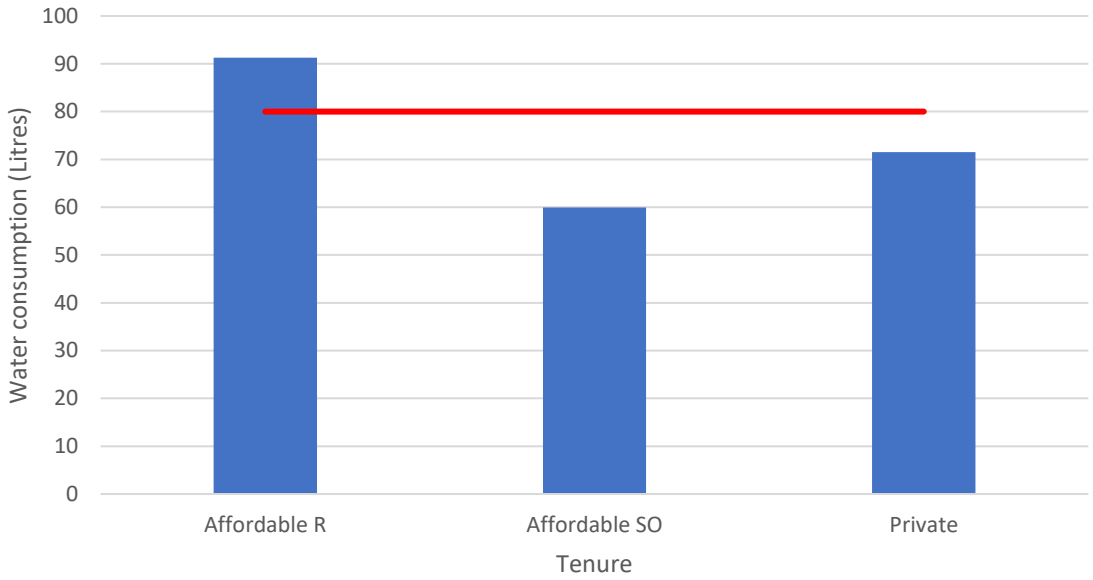

Figure 2 - Average daily per person water use, by tenure. Blue bars = per person water use. Red line = target.

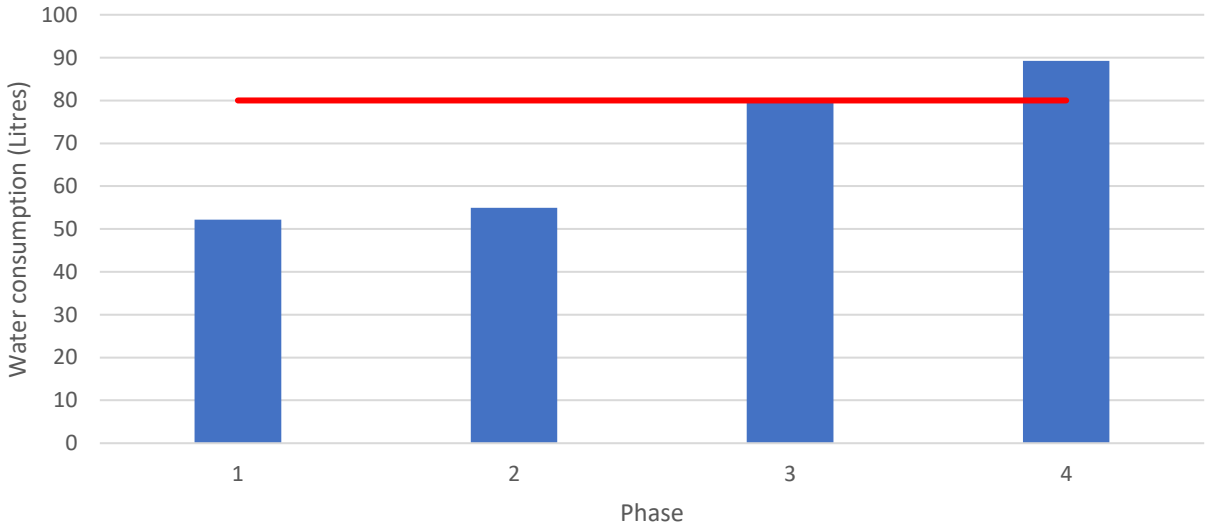

Figure 3 – Average per person water use by phases. Blue bars = per person water use. Red line = target.

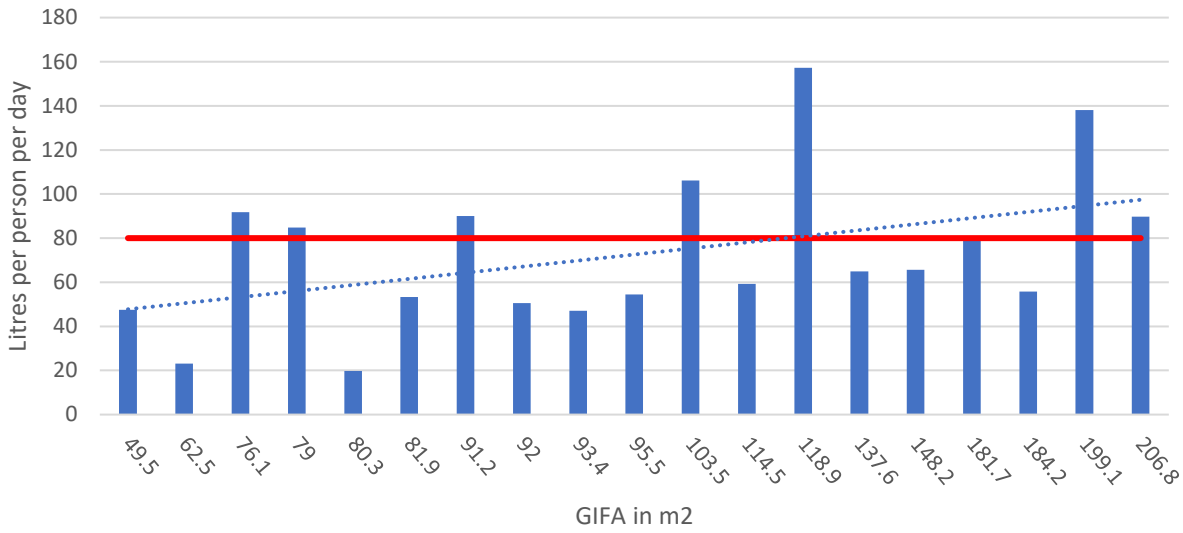

Figure 4 – Average per person water use by dwelling floor area. Blue bars = per person water use. Dotted line = trend. Red line = target.

Table 3 – Assumed occupancy average for per person water usage.

	Flats	2B	3B	4B	5B	Bungalow
Designed occupancy	3	4	3	6	9	3
Assumed occupancy	1.7	2.4	3	3.8	3.8	3

4.2 Electricity

Buildings on Elmsbrook are designed to use less electricity, which is achieved by maximising natural light, energy efficient lighting and efficient electrical appliances. On top of that, each house utilises its roof space carefully to generate electricity from photovoltaics (PV). Sub metered energy data from PV generation, import and export can then be used to calculate the electricity consumption for each dwelling.

Summary:

- Over the latest monitoring period the average annual household electricity use at Elmsbrook was calculated as 3,062kWh.
- This compares to 2,964kWh in 2020-2021, 2,631kWh in 2018-19, 2,550kWh in 2017-18 and 3,122kWh in 2016-17 in the previous monitoring periods (Period average: 2016-23 = 2,866 kWh/a).
- Electricity consumption increased by 3% from the last report.
- The design stage benchmark figures for average electricity consumption were calculated as 2,932kWh annually (or 30.79kWh/m^2).
- On average Elmsbrook homes matched the design stage electricity targets closely, with a 4% increase identified in 2022/23. 60% of households remained within this design target.

- Bicester's annual household electricity average as of 2019 is 3,835kWh[2] (4,311kWh in 2015), meaning that Elmsbrook residents used ~20% less electricity than their neighbours in Bicester. The UK average is 3,545KWh.
- In the same period Gagle Brook school used 43,972 kWh up from 35,167 kWh in the last monitoring period. This is likely down to increased occupancy and use of the building.

Table 4 - Electricity use summarised by monitoring period.

Average energy consumption per household *(kWh)*	
2022 - 2023	3,062
2020 – 2021	2,964
2018 - 2019	2,631
2017 - 2018	2,550
2016 – 2017	3,122
Average 2016 - 2023	2,866
Design target	2,932
Bicester average 2019	3,835
Bicester average 2015	4,311
UK average	3,545

Further information:

- Please note, electricity use has been calculated from sub metered shimmy data using the formula PV + import – export = total electricity used.
- When one of those sub metered data sets is missing, electricity use cannot be calculated accurately, and estimates incur a margin of error.
- PV on communal roofs (e.g. the flat blocks) usually only covers the landlords supply and requires meter readings which is less accurate than the shimmy. Flats electricity usage is therefore only generated from import readings.
- From an estimated 306 occupied households on Elmsbrook (at time of writing), 199 households had their electricity usage logged consistently through the shimmy system – 6 in phase 1, 51 in phase 2, 86 in phase 3 and 56 in phase 4.
- 107 dwellings suffered monitoring issues, with a majority of those outages in phase 1 properties.
- The school used 43,972 kWh of electricity over the monitoring period, of that only 23,688 kWh was imported from the grid, 68,177 kWh generated, and 47,893 kWh exported.
- The Eco business centre used 31,522 kWh of electricity over the monitoring period, of that only 15,267 kWh was imported from the grid, 41,501 kWh generated, and 25,245 kWh exported.

[2] Calculation based on data from: 2021, (BEIS). Postcode level electricity statistics: 2019 (experimental). (Online). Available from: https://www.gov.uk/government/statistics/postcode-levelhttps://www.gov.uk/government/statistics/postcode-level-electricity-statistics-2019-experimentalelectricity-statistics-2019-experimental. Date accessed: 20/09/2021.

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- Table four provides a summary of electricity consumption over previous monitoring periods and compares that to Bicester and UK averages.
- Note that as with previous years, electricity use for EV charger points at homes is included in household figures. Actual average household electricity use is probably lower than reported.

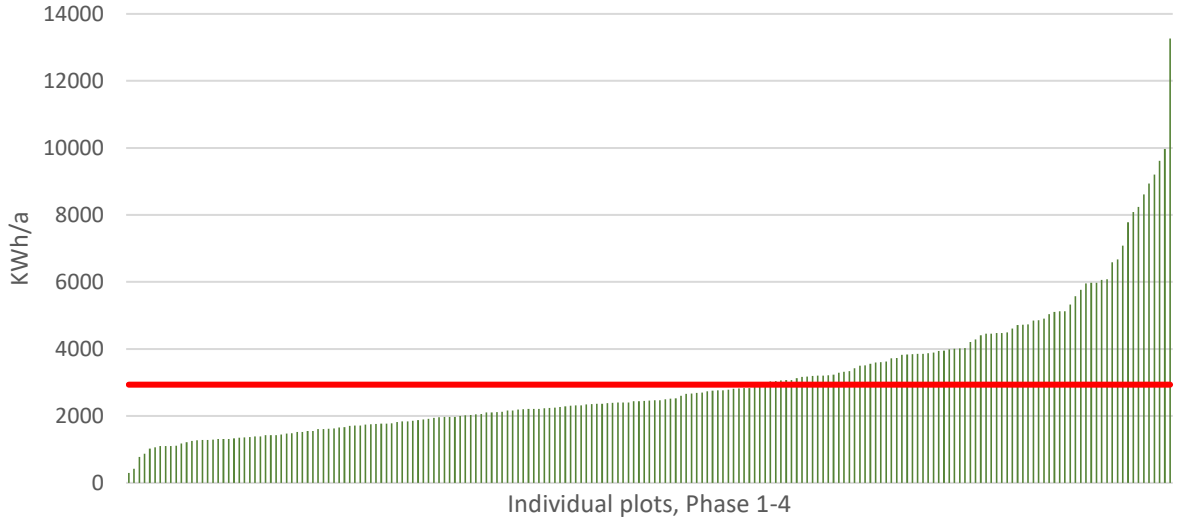


Figure 5 – Total annual electricity consumption per household. Green bars = individual dwellings. Red line = target.

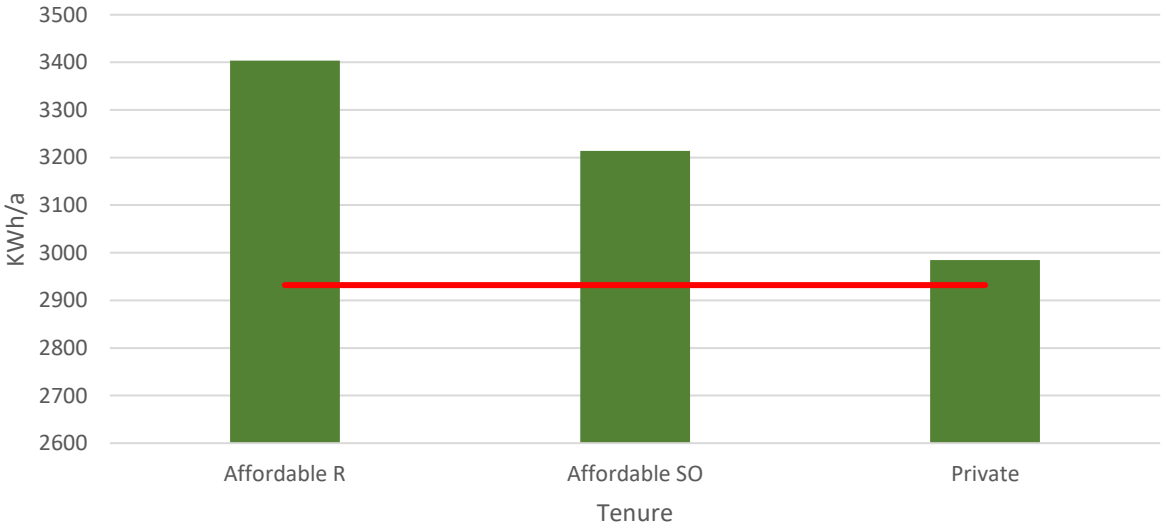
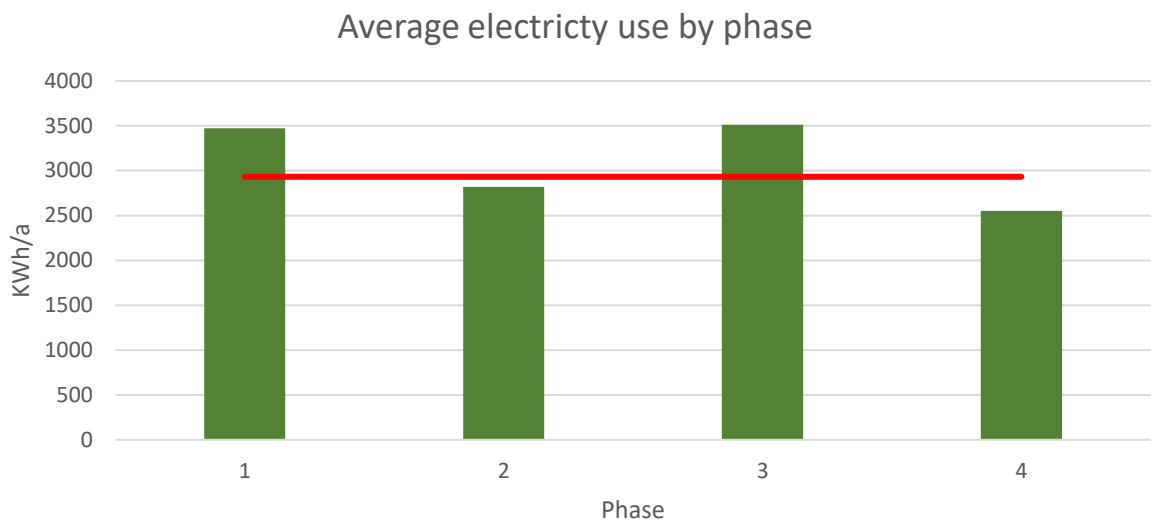


Figure 6 - Average electricity use by tenure. Green bars = individual dwellings. Red line = target.

Figure 7 –



Average annual electricity by phase. Red line = target.

4.3 Heat

Elmsbrook is served by an energy centre supplying heat to all buildings to cover space heating and hot water demand via a conventional district heating system. Data is collected at the point of use in the household for dwellings (via a heat meter at the heat interface unit reporting by the shimmy) and is centrally reported by SSE for Gagle Brook school and Eco Business Centre.

Summary:

- Over the latest monitoring period, the average household heat usage at Elmsbrook (all phases) was estimated at 4,709 kWh (Heat = hot water + space heating).
- This compares to 5,580 kWh in 2020-21, 4,924 kWh in 2019-20, 5,473 kWh in 2018-19 and 4,023 kWh per household in 2017-18 in the previous monitoring periods (Period average: 2016-23 = 4,942 kWh/a).
- **While heat usage reduced by ~ 16% from the last reported usage, some of that will be due to seasonal affects and the affordability and energy crisis.**
- The cost-of-living crisis hit UK consumers hard in 2022 with the average annual grocery bill rising by more than £450, petrol and diesel fuel prices reaching record highs and energy bills soaring. As wholesale gas prices increasing, energy cost was being passed onto the consumer, with energy bills rising by £500 per consumer in January 2022 and the Ofgem energy price cap reaching £3,850 in January 2023[3].
- Design stage annual heat use (all phases) was estimated at 4,269 kWh, for an average dwelling on site. This design figure converts to 44.83 kWh/m^{2}a on a per area basis (i.e. an intensity) and compares to 44.65 kWh/ m^{2}a for the measured average. **On average Elmsbrook residents used ~1%% less energy for heating and hot water than the design stage estimations.**
- KWh/m^2 is a more useful metric for comparison of heat usage, as the housing mix changes from phase to phase. Hot water usage is strongly correlated to occupation and space heating usage can be further influenced by tenure.

[3] https://www.cision.co.uk/resources/articles/how-uk-consumers-responding-energy-bills-crisis/

- The average annual Bicester household heat consumption based on 2019 data is 12,645[4] kWh, increasing from 12,373 kWh in 2018 (derived from gas use data only)[5]. This compares to the UK average of about 13,532 kWh[5] (gas only data).
- **Elmsbrook residents used around 63% less heat than their neighbours in Bicester, around 65% less than the UK average, and around 49% less than the 9,300 kWh average for new builds since 2017[6] in England and Wales (comparing all with gas use only).**
- In the same period, the Eco Business Centre used 56,428 kWh and Gagle Brook school 109,795 kWh, which is 4% and 7% of the total heat sold on site.

Table 5 - Heat usage summarised by monitoring period Average annual heat usage per household (kWh.	
2022 - 2023	4,709
2020 - 2021	5,580
2018 - 2019	4,924
2017 - 2018	5,473
2016 - 2017	4,023
Average 2016-23	4,942
Design target	4,269
Bicester average 2022	10,561
Bicester average 2019	12,645
Bicester average 2018	12,373
Bicester average 2015	12,755
UK average (Typical gas consumption, 2023)	12,000
Average for 2017 new build England and Wales[6] (gas consumption)	9,300

Further information:

- This analysis was derived from a dataset of 205 plots of which 38 were removed for part occupation (recent move in) or extremely low usage (dwelling likely unoccupied). This left us with 167 good quality heat use data points (or plots).
- The breakdown of heat use data by phase is as follows: 5 were from phase 1, 47 from phase 2, 67 from phase 3 and 48 from phase 4.
- As before, data with less than 360 days' worth of readings was excluded in this analysis.
- Phase 1 data was severely impacted by data and equipment issues, with older less reliable data capture technology failing or data capture or transfer issues.
- 53% of sampled homes are currently meeting the design heat target of 44.83 kWh/m^2 (space heating and hot water).
- The first two graphs overleaf show the average annual heat usage (all phases), absolute and normalised by area (Figure 8 and 9).

[4] https://www.gov.uk/government/statistics/postcode-level-gas-statistics-2022
[5] https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained
[6] https://www.gov.uk/government/statistics/energy-consumption-in-new-domestic

- It appears that overall heat use (see heat use by ventilation type graph, Figure 10) is significantly lower for those plots on site utilising MVHR's. This suggests that the heat recovery helps to reduce energy use compared to passive, DMEV or MEV systems. Please note that all social rented dwellings properties are fitted with MVHR while private households are fitted with MEV and the Ventive system. This will impact heat usage on those tenures.
- The remaining two graphs show the percentage of homes meeting the heat target of 44.83 kWh/m^2 in two different categories by number of bedrooms and house types (Figure 11 and 12).
- Table four provides a summary of heat usage over previous monitoring periods and compares that to Bicester and UK averages.

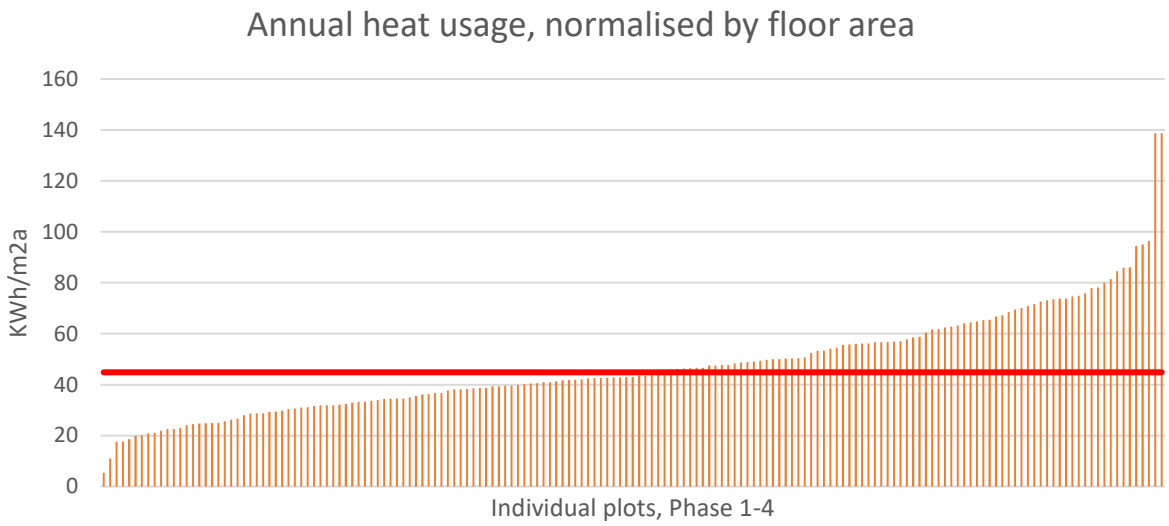


Figure 8 – Total annual heat use by metre squared. Orange bars = individual dwellings. Red line = target.

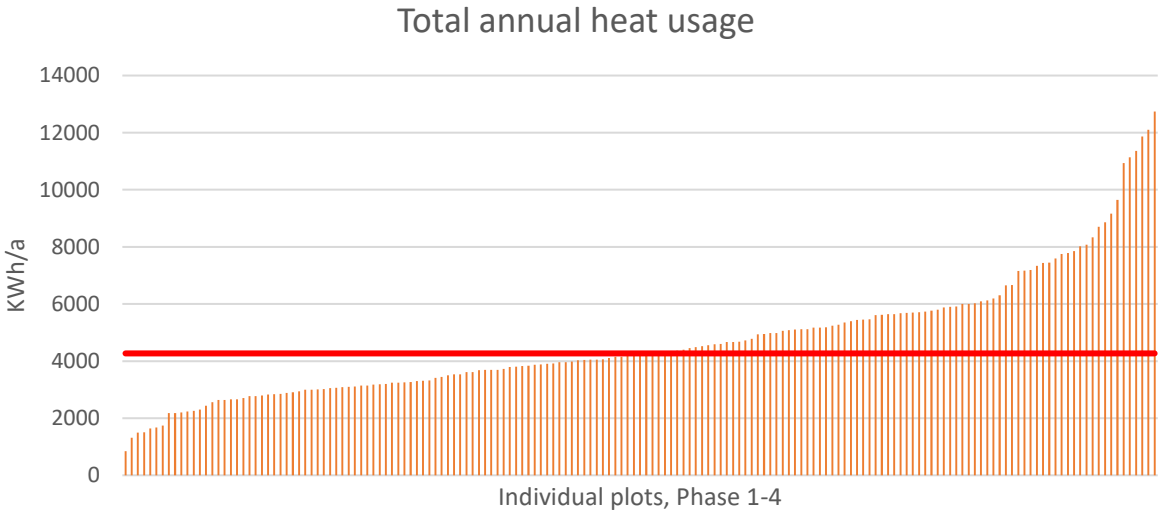


Figure 9 – Total annual heat use per dwelling, over the latest monitoring period. Orange bars = individual dwellings. Red line = target.

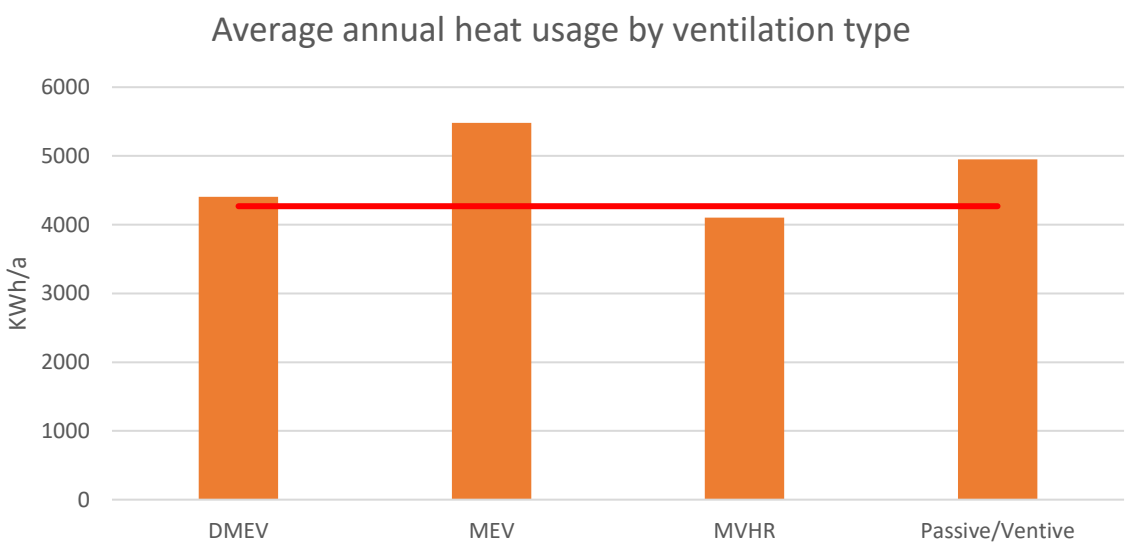


Figure 10 – Average annual heat use over the latest monitoring period, categorised by ventilation types/systems. Red line = target.

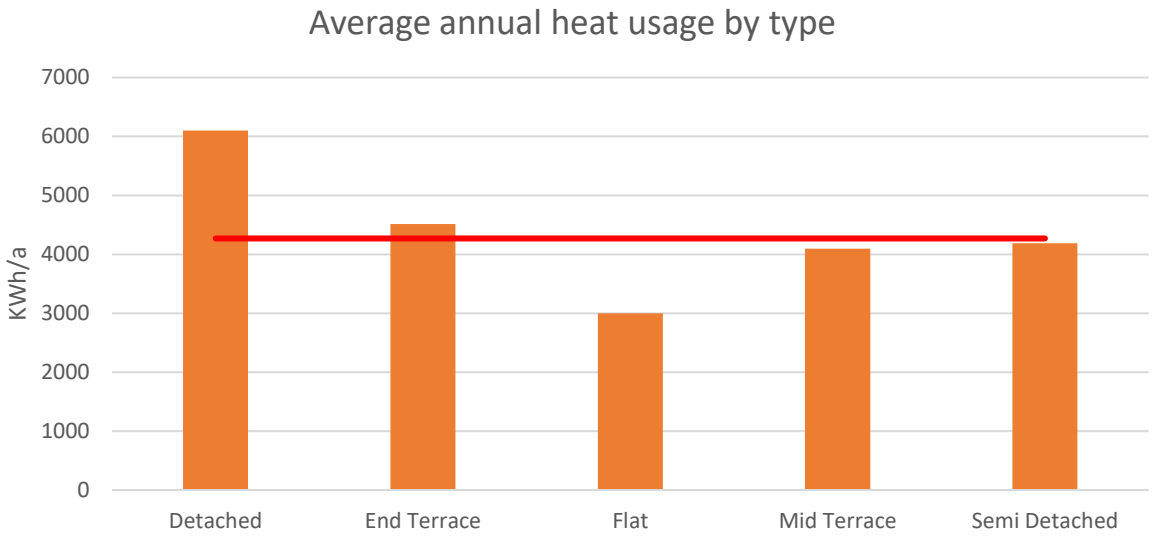


Figure 11 – Average annual heat use, categorised by house type types. Red line = target.

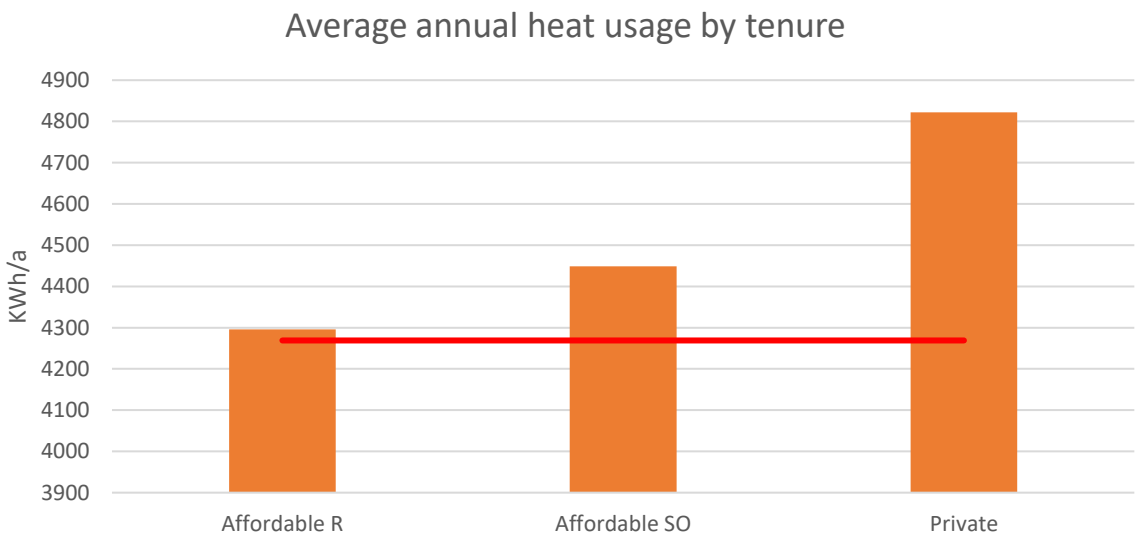


Figure 12 – Average annual heat use by tenure. Red line = target.

4.4 Photovoltaics (PV)

Buildings on Elmsbrook are fitted with roof mounted PV, an important sustainability feature that contributes renewable energy and offsets operational carbon emissions elsewhere. The combined generation of all systems on site makes it one of the largest residential PV arrays in the country. The data below summarises the electricity output from all buildings on site.

Summary:

- **Over the latest monitoring period, the average PV generation (per household; all phases) was estimated at 3,114 kWh.**
- This compares to 3,113 kWh in the previous period (2020-2021), an almost identical quantum (Period average: 2017-21 = 3,023 kWh/a).
- PV yield is dynamic and affected by climatic and weather patterns as well as building design (orientation, shading, pitch and area). Since the last report further dwellings have been built and occupied affecting the average, so comparison between years/ phases is less useful.
- A large proportion of dwellings in phase 1 were affected by monitoring issues or inverter failure (e.g. some of the flat blocks on phases 1 and 2).
- The Eco Business Centre had an estimated PV generation of 41,0501 kWh over the latest monitoring period, the latest meter reading, and the length of the monitoring period in days (previous period estimate 56,076 kWh).
- Gagle Brook school had an estimated PV generation of 68,177 kWh, proportionally calculated based on the time periods between previous meter reading, the latest meter reading and the length of the monitoring period in days (previous period estimate 94,079 kWh).
- The PV array on the energy centre roof generated a further 25,173 kWh over the monitoring period (based on sub metering (previous period estimate 23,506 kWh).
- The site wide total generation from PV was estimated as 1,042,986 kWh in the latest monitoring period, a majority of this (908,136 kWh) has been generated by dwellings on site (the previous period estimate was 923,924 kWh, of which 750,263 kWh generated by dwellings on site).

Table 6 – PV generation summarised by monitoring period.

Average annual PV generation per household *(kWh)*	
2022 - 2023	3,114
2020 - 2021	3,113
2018 - 2019	3,361
2017 - 2018	2,505
2016 - 2017	N/a
Average 2017-21	2,993
Design target	N/a

Further information:

- Generation figures are based on data from 206 dwellings. Of these 26 were removed for part occupation (recent move in) or extremely low usage (data or generation issue). That left 180 useable PV data sets with more than 360 days. 28 flats were not sub metered (manual readings were taken), of which some had inverter issues.
- Missing PV data was affected by a range of factors this year, some a result of monitoring equipment failure (mainly phase 1), some inverter outages and others still a result from connection loss through equipment being exchanged previously (by other data providers without coordination with Carnego), which does not appear resolved yet.
- Due to the large amount of missing data (on phase 1), a design vs measured comparison is not possible for phase 1 during this monitoring period.
- The design stage estimates for phase 2 were 200,135 kWh per year based on MCS calculations. The measured total for Phase 2 was calculated at 143,580 kWh for 55 dwellings, which is 185,349 kWh extrapolated from 71 (the previous estimate was 198,136 kWh for 66 dwellings, 213,146 kWh extrapolated).
- The measured total for Phase 3 was calculated at 269,597 kWh for 86 dwellings, unfortunately, no design comparison data is available (the previous estimate was 189,755 kWh for 79 dwellings).
- The measured total for Phase 4 was calculated at 159,295 kWh for 58 dwellings, unfortunately, no design comparison data is available.
- The flat blocks are still not sub metered (i.e. monitored via the shimmy) so they require manual meter readings. This affects 24 plots on Phase 1 and four on Phase 2.
- A manual reading of the export meters suggested part or full-generation failure on a number of these blocks from tripped inverters. We therefore recommend that the maintenance teams undertake status checks of all inverters on regular intervals.
- A manual meter reading for Gagle Brook school was taken and compared with the last available reading to calculate proportional usage within the monitoring period. This doesn't allow for year-to-year fluctuations from weather effects, so it could be under or overstating this year's PV generation.
- Figure 15 displays the average annual PV generation by phase in kWh's and shows a decrease in energy generation from phase 4. Whilst it is assumed that the PV panels will be more efficient on phase 4 than phase 1 the energy generation disparity could result from a difference in size, orientation, or housing mix of phase 4.

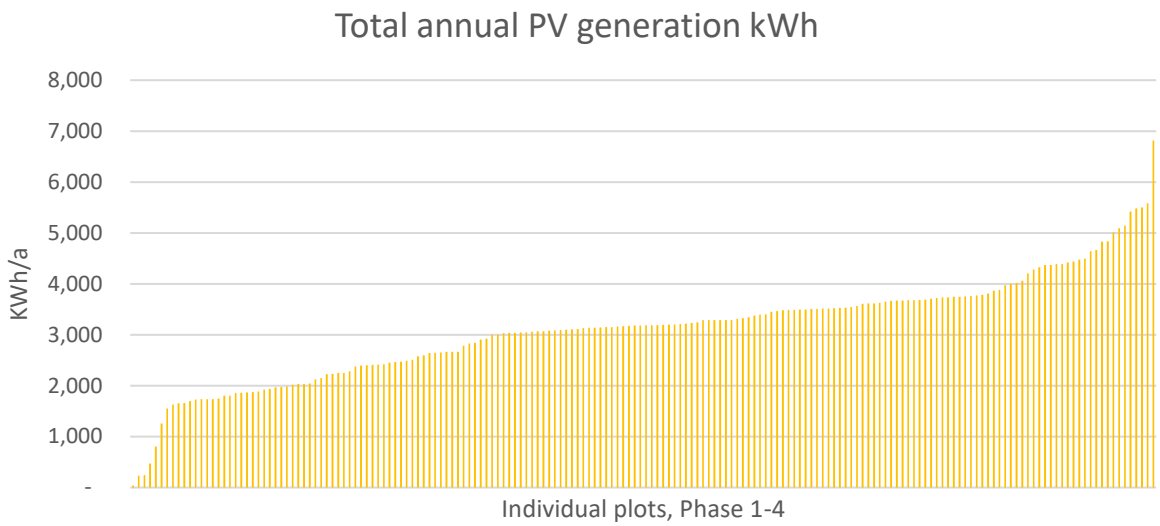


Figure 13 - Average PV generation per household, phase 1-4 (average 3,114 kWh).

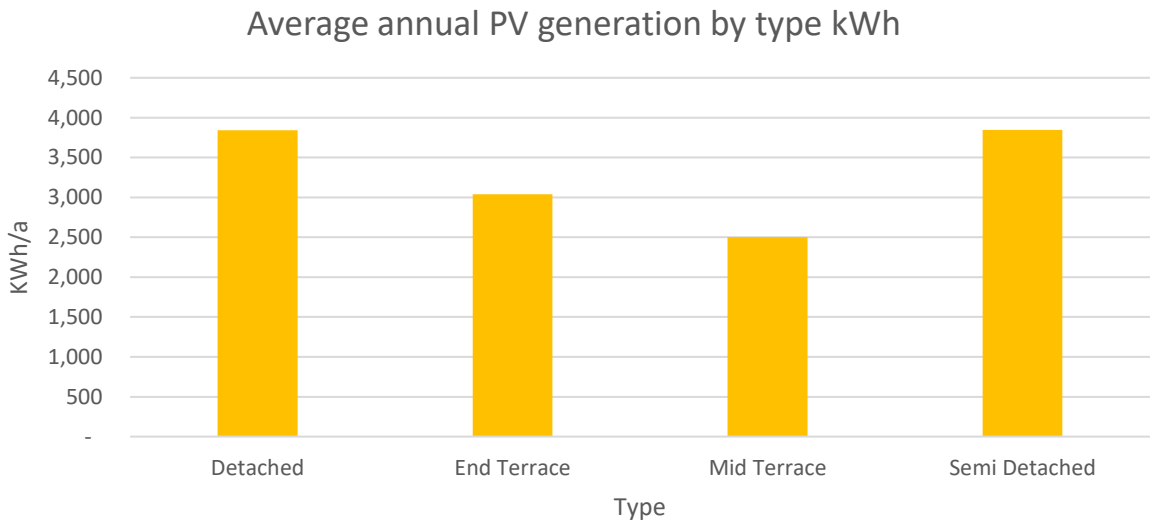


Figure 14 - Average PV generation per household by house type (site wide average 3,114 kWh).

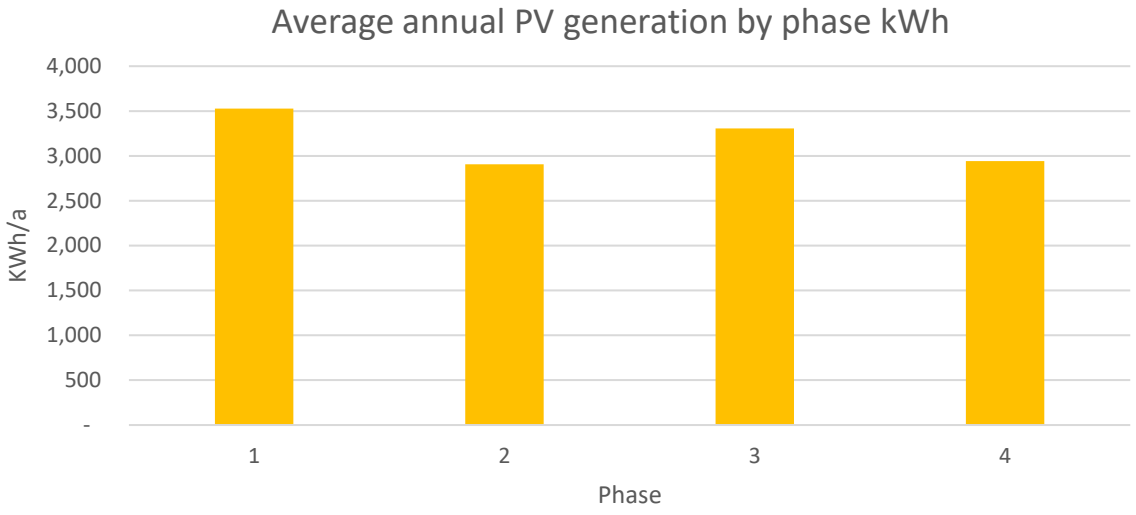


Figure 15 - Average PV generation by phase (site wide average 3,114 kWh).

4.5 Waste

Waste data is provided by Cherwell District Council (CDC) and is collected by weighing the waste collection trucks leaving Elmsbrook. The data includes recycling, refuse and garden & food (compost), between 5th of April 2022 to the 28th of March 2023. Note that CDC data was not provided on glass collected from bottle banks for recycling, and therefore this is not included in the figures. **The headline figures:**

- **The total waste generated has increased significantly since the last monitoring period with total waste in Kg increasing by ~29% from 142,530kg in 2020/21 to 201,400kg in 2022/23. This increase partially reflects the ~21% increase in housing occupancy from 241 occupied households in 2020-21 to an estimated 306 occupied households.** The additional 8% increase could be representative of the larger number of detached homes that have been built in phases 3 and 4, potentially increasing the population size per household.
- **Total waste generated per household during 2022-23 increased by 11% compared to 2020-21 from 591kg to 658kg.**
- Refuse (general waste) per household in 2022-23 was 382kg per household (based on 306 occupied households in 2022/23). This is an increase of 82% from the 2020-21 average of 210kg per household (based on 241 households).
- Recycling totals at Elmsbrook were logged at 276kg per household over the monitoring period. This compares to the CDC average recycled waste for 2020/21 of 215kg per household.
- Compost waste was 80kg per Elmsbrook household on average in 2022-23, down from 168kg in 2020-21. The CDC 2020/21 average was 332kg, that's 4 times more compost produced outside the development. This could be explained by residents using garden compost as opposed to a compost collection.
- The average recycling rate in Elmsbrook dropped significantly for this monitoring period, (2022 – 2023) falling to 41.91%, from 64.44%. This is significantly lower than the Cherwell District average for 2022-23 of 53%[7]. This might be explained in part by the increased use of garden composting and glass recycling points. It is unclear if these bulk recycling points are captured in the development weights.

[7] https://www.cherwell.gov.uk/downloads/file/11199/annual-report-2022-2023-print-version

Further information:

- County wide comparison figures were not provided by Cherwell District Council for this monitoring period. The CDC annual report captured the percentage change and recycling rates.
- The waste stream patterns over the course of the monitoring period are outlined in the graphs below (Figure 16). It can be seen that there are considerable spikes in refuse.
- Refuse was the largest waste stream in 2022/23, accounting for nearly double the amount of waste as recycling, the next largest waste stream. Finally, garden and food waste were, again, the smallest waste stream.
- Residual waste increased significantly from 36% in 2020/21 to 58.1% in 2022/23, as a percentage of total waste produced at Elmsbrook.
- Within Elmsbrook, the proportion of dry recycling has decreased by 7.8% from 36% in 2020/21 to 28.2% in 2022/23 whilst the proportion of organic waste decreased even more from 28% in 2020/21 to 12.1% (table 6). In contrast, refuse waste increased from 36% to 58.1%.
- Figure 18 shows the average percentage breakdown of waste for the 2020/21 and 2022/23 monitoring periods, and figures 19, 20 and 21 show the average weight of each waste stream per household for 2020/21 and 2022/23. As can be seen in Figure 22, the average household annual waste has increased year-on-year for refuse with both recycling and food waste decreasing.
- Per household recycling decreased from 213kg in 2020/21 to 198.8kg in 2022/23, and food and garden decreased from 168kg in 2020/21 to 80.6kg in 2022/23. In contract, refuse peaked at 387.4 kg per household in 2022/23, compared to 210 kg in 2020/21.
- During this monitoring period There have been significant changes in the waste levels compared to previous monitoring periods. Whilst a drop in food and garden waste could be seen as a positive the spike in refuse waste suggests that more compostable waste was collected as refuse during this monitoring period.
- It should be noted that from March 22nd, 2022, Cherwell District Council began collecting food waste separately. Whilst the data provided shows only a small amount of food waste (0.01% of all waste) this could be a reason for the significant drop in food waste.

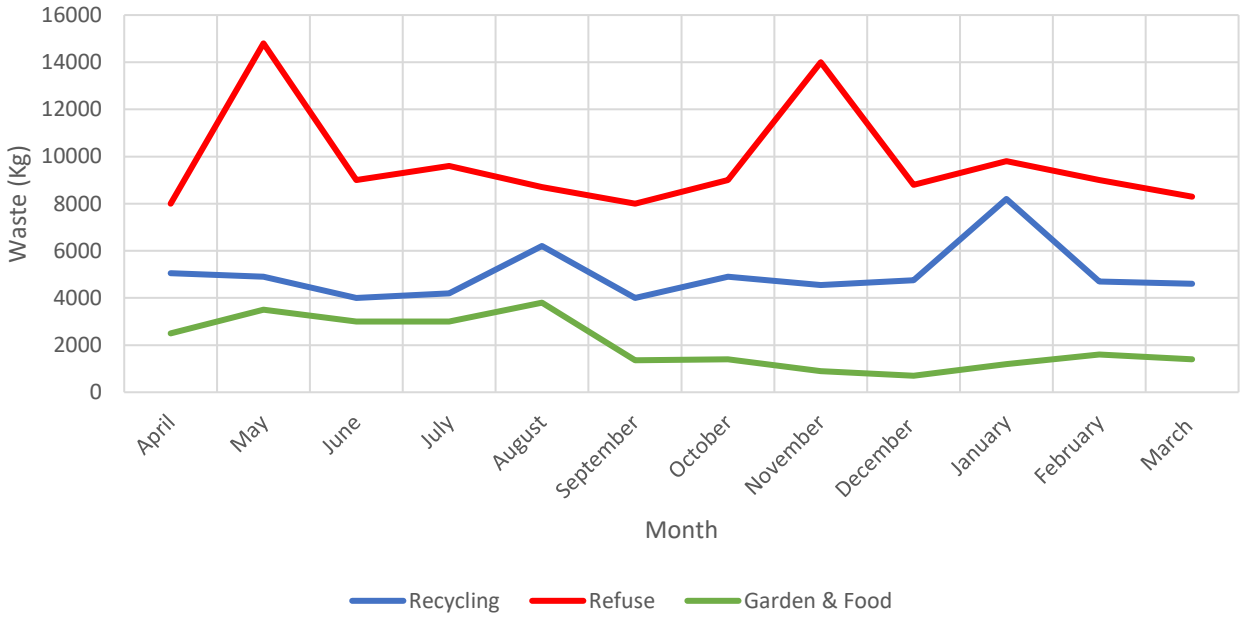


Figure 16 - Weight of monthly waste (kg) by stream over the monitoring period (April 2022 - March 2023)

Table 7 - Average annual household waste treatment - Elmsbrook and CDC total (%)

	2017/18		2018/19		2019/20		2020/21		2022/23	
	Elmsbrook	CDC	Elmsbrook	CDC	Elmsbrook	CDC	Elmsbrook	CDC	Elmsbrook	CDC
Dry Recycling	20%	20 %	24%	19 %	32%	22 %	36%	22 %	29.8%	53%
Organics	25%	34 %	21%	40 %	28%	34 %	28%	34 %	12.1%	
Residual	55%	45 %	55%	40 %	40%	45 %	36%	44 %	58.1%	44%

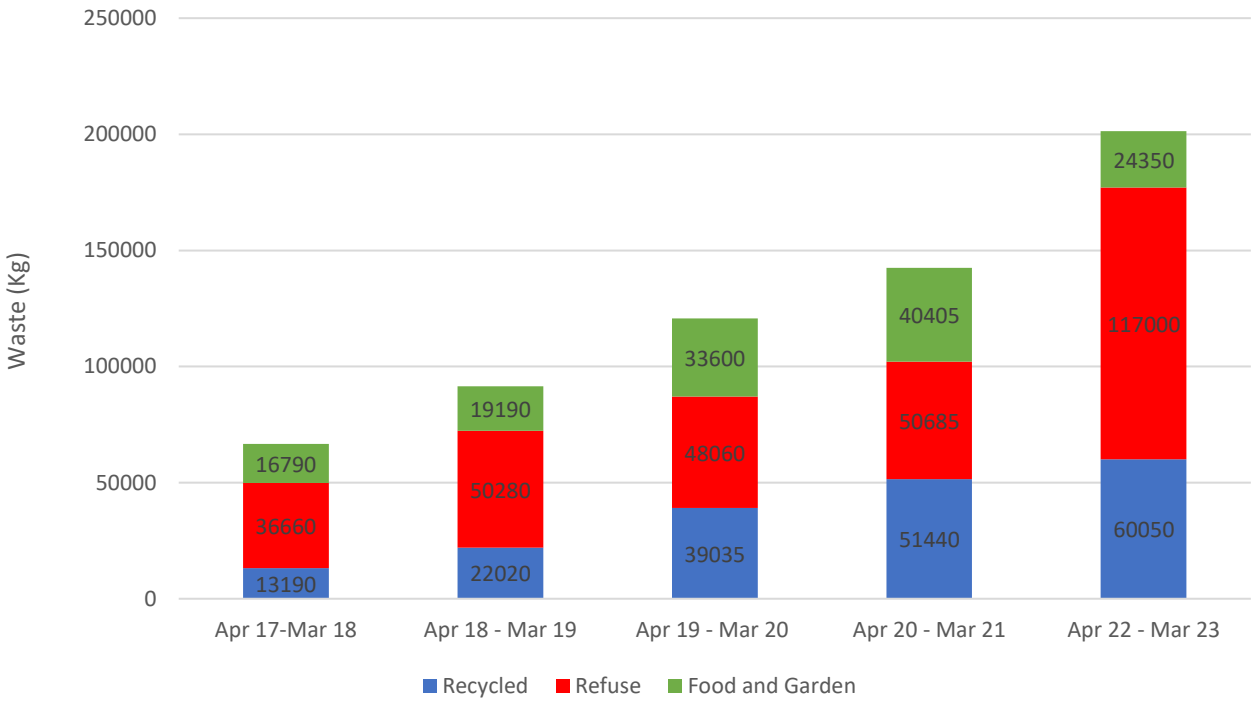


Figure 17 - Weight of annual waste (kg) by stream between April 2017 - March 2023, covering five monitoring periods.

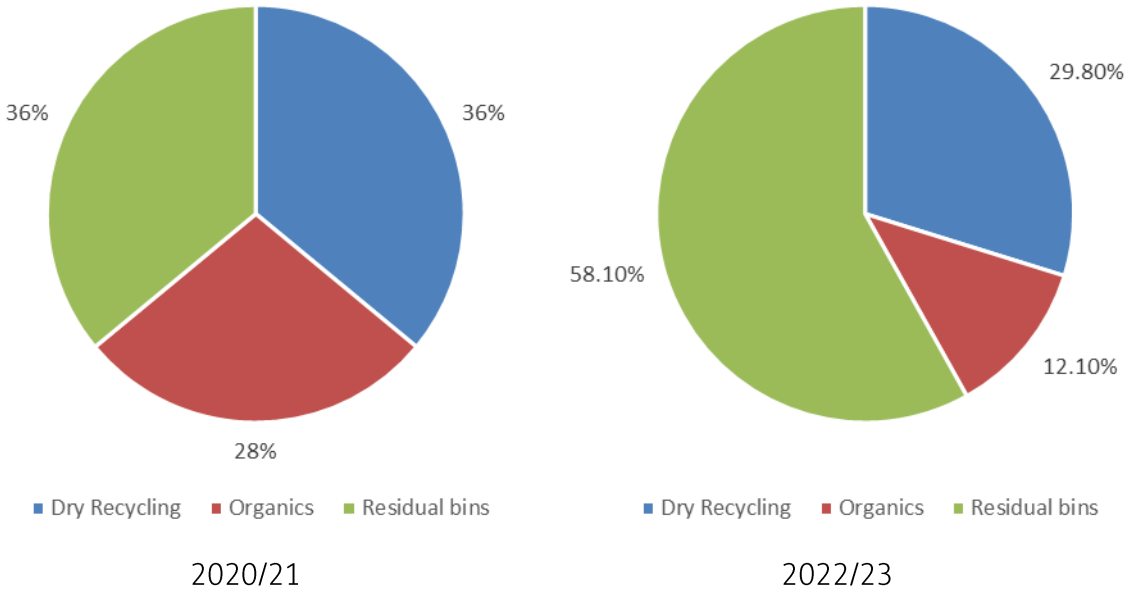


Figure 18 - Comparison in waste stream by % between 2020/21 and 2022/23.

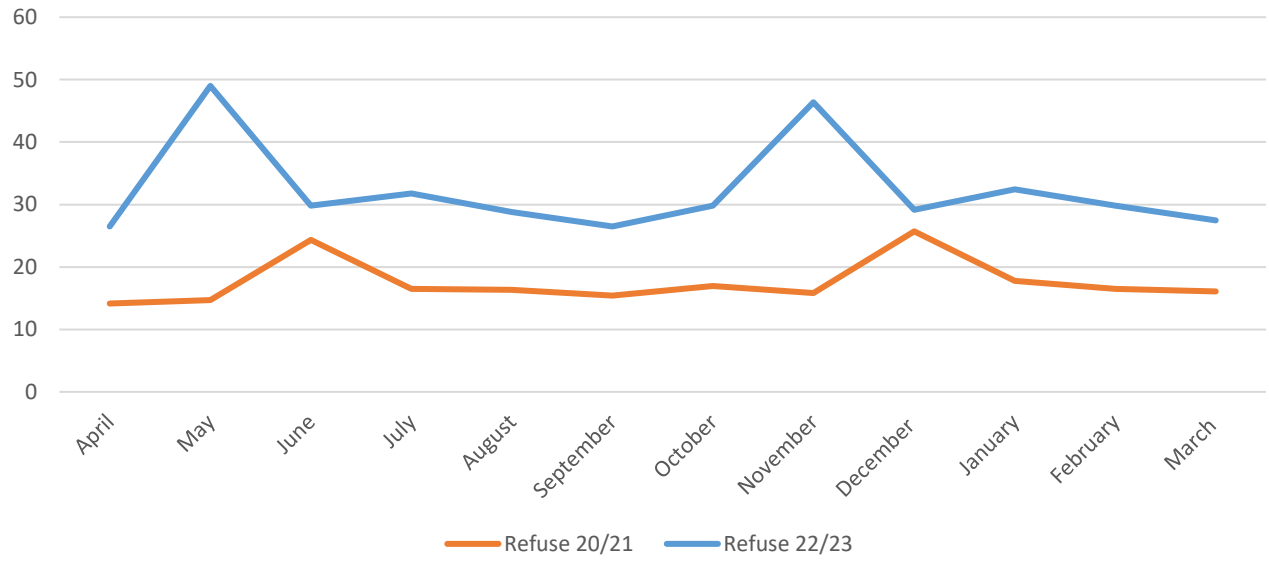


Figure 19 - Average monthly refuse waste per household over 2020/21 and 2022/23, site wide

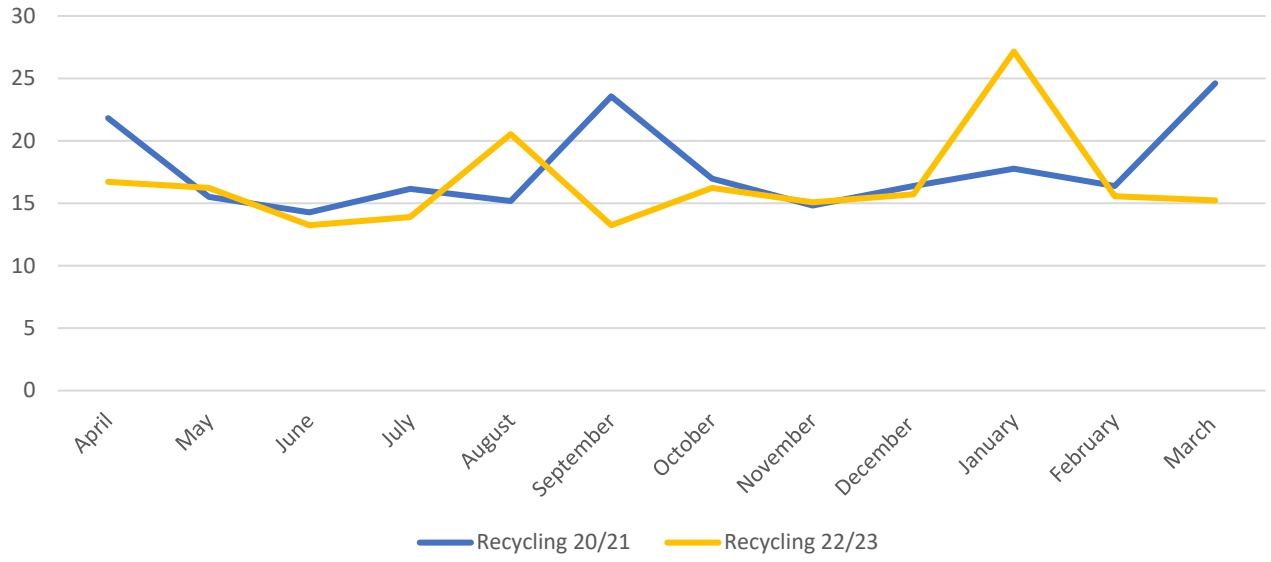


Figure 20 - Average monthly dry recycling per household over 2020/21 and 2022/23 periods, site wide

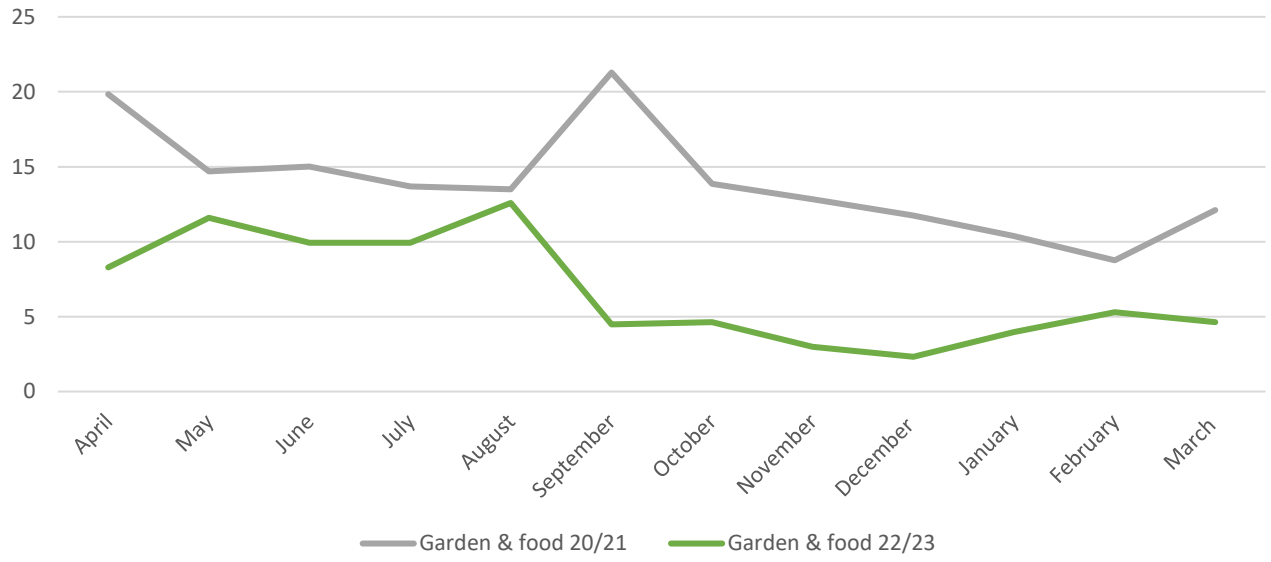


Figure 21 - Average monthly garden and food recycling per household over 2020/21 and 2022/23 periods, site wide

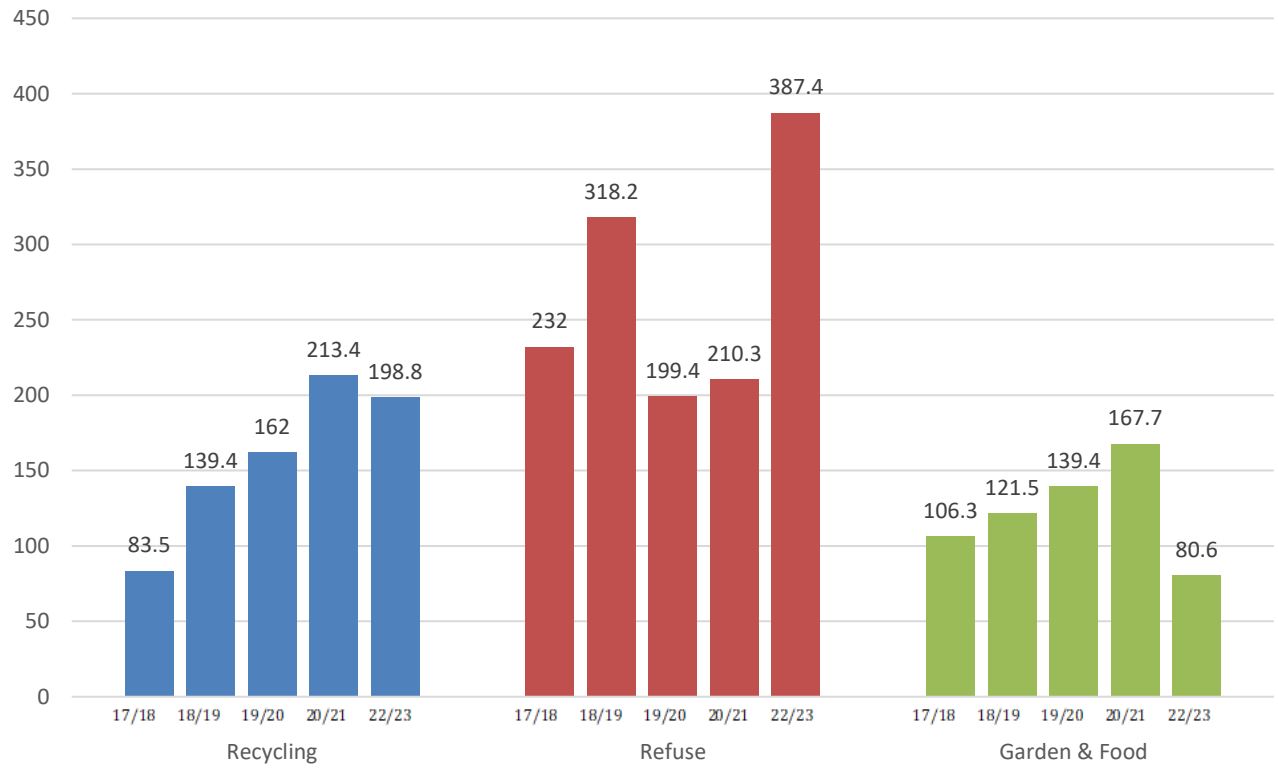


Figure 22 - Average annual waste per household by type, year-on-year comparison from 2017/18 to 2020/21.

4.6 Energy centre

The Elmsbrook energy centre provides the development with heat via a district heating network. Heat is generated from a gas-powered combined heat and power (CHP) unit with backup gas boilers. A roof mounted PV array provides further renewable energy to offset equipment loads. Energy data was provided by the energy centre provider Scottish Southern Electric (SSE) from automated meter readings (AMR) and some manual meter readings.

Summary:

- The majority of the heat generated in the energy centre, over the latest monitoring period, was supplied by CHP (62%) a slight increase from the previous monitoring period where 58% of heat was supplied by CHP.
- The remaining 38% was generated by gas boilers, well short of the design split of 90:10 (CHP: Boiler) and increasing the carbon intensity of the operation. The CHP is supposed to meet most of the heat demand by the end of phase 2 but continues to be significantly off the expected trajectory.
- Total heat generated was 2,880,600 kWh, up by ~10% from the last monitoring period (2,617,400 kWh last period).
- Approximately 47% of heat energy generated is currently being lost through either storage, distribution or commissioning loads. The designed distribution loss was 28%. Calculated by subtracting the heat sold from the heat generated. The exact split between storage, commissioning and distribution losses is not known.

- The CHP delivered a monitored efficiency of 73% during 2022-23, as compared with a design stage assumption of 78% and a monitored efficiency of 73% in 2017-18, 62% in 2018-19, and 76% in 2020 - 21.
- The boilers delivered a monitored efficiency of 90% in 2022-23, Above the design stage assumption of 87%.
- Solar PV electricity generated on the energy centre rooftop over the latest monitoring period was 25,173 kWh (23,506 kWh in the previous monitoring period). Figures are dependent on climate and weather conditions and have fluctuated between a low of 13,295 kWh in 2017-18 to a high of 26,182 kWh in 2019-20.

Table 8 - Energy centre data summarised from 2017-21

	2017-18	2018-19	2019-20	2020-21	2022 - 23
CHP					
Electricity generated (kWh/year)	304,600	661,900	1,249,800	1,400,000	1,569,280
Heat output (kWh/year)	317,200	741,200	1,387,300	1,522,300	1,771,600
Gas consumption (kWh/year)	944,206	1,866,069	3,562,459	3,903,626	4,572,553
Boiler					
Heat output (kWh/year)	904,100	866,400	843,800	1,095,100	1,109,000
Gas consumption (kWh/year)	1,029,940	995,997	866,996	1,215,852	998,927
PV					
Electricity generated	13,295	22,952	26,182	23,506	25,173

Further information:

- The energy centre generated (2,880,600 kWh of heat (CHP and boiler) in 2022-23 to meet the space heating and hot water demand on site (2,617,400 kWh in the previous monitoring period). The breakdown is as follows: Residential (estimated from shimmy and extrapolation of missing data) = 1,361,195 kWh (1,344,733 kWh previously), Gagle Brook school = 109,795 kWh (161,644 kWh previously), from billed data, Eco Business Centre = 56,428 kWh (previously 57,151 kWh), also from billed data.
- The CHP ran 1,824 hrs (1,610 hrs previously) over the monitoring period, the gas boiler ran for 1,669 hrs (2,065 hrs previously).
- Operationally, the CHP ran 93% of the time (96% previously), the CHP was not operational for 27 days (likely scheduled maintenance) throughout the monitoring period with an average of ~5.3hrs per day (~7 hrs per day previously). Longer running hours for the CHP would improve the carbon balance.
- Figure 24 shows the electricity generated against heat output over the monitoring period by generation mode. CHP electricity generated, and heat output are aligned for most of the year, with the boiler providing additional assistance during the colder months and remaining mostly off during the summer.

- During Autumn and Winter, the CHP gas consumption gradually increases from September through until a peak usually in January reaching a peak across the years of ~800,000 kWh in January 2023. Consumption then gradually decreases as months get warmer.
- CHP gas consumption was greater than boiler consumption in most months except from November to December, when there was high heat demand.

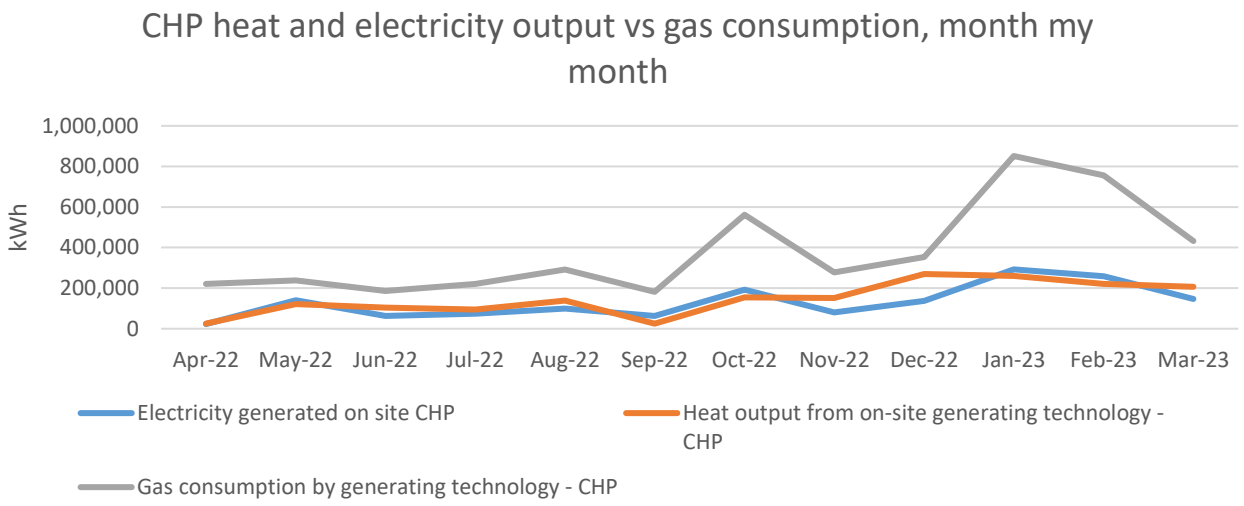


Figure 23 - Electricity generated vs. heat output from HP and boiler.

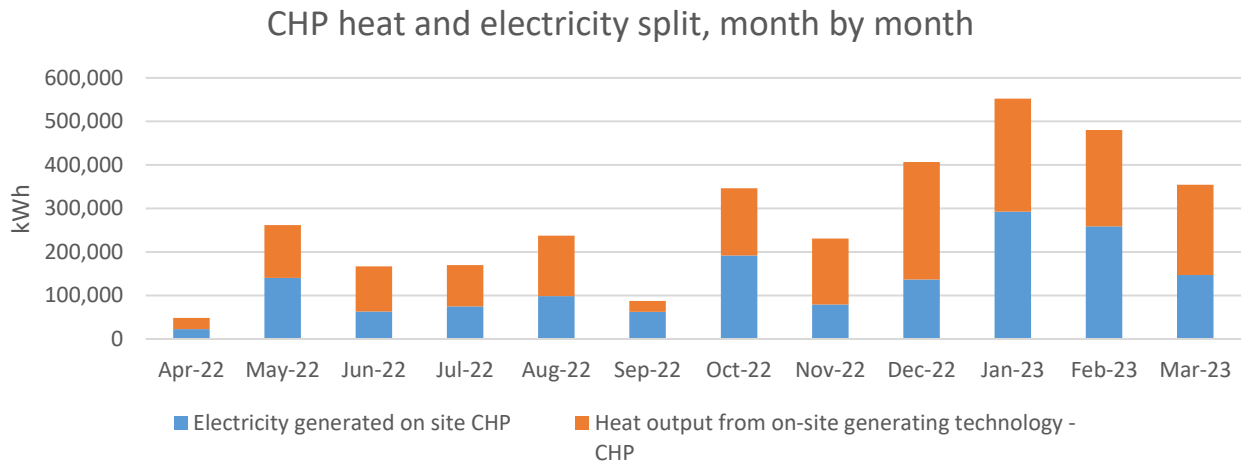


Figure 24 - Electricity generated vs. heat output from CHP.

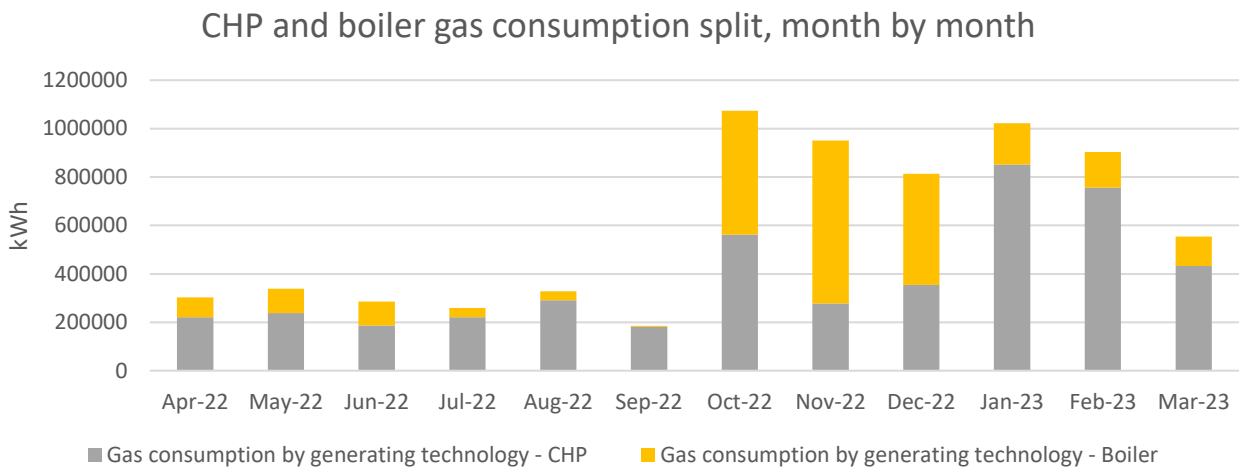


Figure 25 – Gas consumption by heat generating technology (energy centre).

4.7 Net zero carbon

Elmsbrook was designed to be a 'true' net zero carbon development, meaning all energy uses are accounted for in the carbon balance, including those from regulated (heating, hot water, lights, pumps & fans) and unregulated uses (appliances, cooking).

The development was devised to achieve this over the course of a full year, meaning offsets from energy generation balance the carbon emissions on the demand side. As the energy strategy further relies on a certain demand utilisation for the energy centre to run efficiently and economically (e.g. CHP to boiler contribution and split), reporting against its target ahead of final completion and occupation of all buildings on site is difficult.

With changes in the rate of development of the wider masterplan, it is unclear whether the energy centre will be at capacity before the heat source (the CHP engine) might require changing or replacing. A further factor in the yearly carbon balance is the highly dynamic environment. e.g. external temperatures, sun hours, user behaviour and electrical grid carbon intensity are very variable (year on year). Ahead of the energy centre reaching its full (designed) capacity, the results are unlikely to meet the set targets fully, but hopefully, provide a useful glimpse of its trajectory and any useful feedback and learning for this particular strategy.

Summary:

- We estimate that in 2022-23 the average home at Elmsbrook emitted 1,506 $kgCO_2$ (from regulated and unregulated energy uses) Using the latest SAP 10.2 carbon factors. This is a significant increase from the previous monitoring reports figure of 894 $kgCO_2$. However, in the previous reporting period the carbon emission factors were calculated using SAP 2012, these have now been updated in SAP 10.2, introduced with the latest revision of the UK Building Regulation Part L. The latest SAP 10.2 carbon factors more accurately represent the current UK electricity grid mix and therefore carbon emissions from electricity use.
- Whilst the figure of 1506 $kgCO_2$ reflects Elmsbrook's current emissions, **using the previous SAP 2012 factors, carbon emissions would amount to 712 $kgCO_2$ per dwelling, a reduction of 20 % (from 894 $kgCO_2$ in the previous reporting period).**
- Our per dwelling figure (1,506 kg CO_2, using SAP 10.2 factors) compares to ~3,600 $kgCO_2$ (or 3.6 tonnes CO_2) for an average *existing* UK dwelling, around 58% less. It compares to ~1,400 $kgCO_2$ (or 1.4 tonnes CO_2) for an average *new build* UK dwelling, about comparable performance (~8% worse) based on a carbon and energy strategy devised over a decade ago. Note the data source

for the comparison figures (existing and new dwellings) has been updated since the last report and can be found in the footnote 8.

- **The development as a whole (energy centre, business centre, school and residential) did not manage to achieve zero carbon over this reporting period with 966 tonnes CO_2 net emissions using the latest SAP 10.2 emissions factors.**
- However, applying the SAP 2012 emissions factors, the development produced 425 tonnes CO_2 of net emissions which compares to 383 tonnes CO_2 net emissions for the 2020/21 monitoring period. Even using the historic emission factors, at the time the strategy was written (SAP 2009), yields 328 tonnes CO_2 net emissions for this reporting period.
- Continued monitoring data problems and some operational issues have meant that the level of confidence in the accuracy of the carbon balance is estimated at medium to low, likely understating actual best-case performance. Influencing factors include district heating commissioning heat load for Phase 4, system losses and year to year fluctuations in weather and occupancy/ usage and the energy centre not yet being at capacity.
- While the homes energy and carbon performance are now about comparable with the latest new builds, the development is still likely emitting significantly less carbon emissions than an equivalent new build development once the school and eco business centre are factored in, which heavily contribute to the overall carbon balance. The Eco business centre is a Passivhaus plus building with the school designed with Passive design features and having a vast solar PV array.

Further information:

- We estimate that in 2022-23 the average home on Elmsbrook emitted 1,506 kgCO_2 per year (894 kgCO_2 per year in the previous reporting period). This figure is likely an overstatement (i.e. less favourable) than actual performance.
- The reason for that is commissioning the heat load for the phase 4 is still under construction, which can account for as much as 20-30% of total heat use. Commissioning heat loads are hot water being circulated in the mains ring and sub-rings to prevent the pipes from clogging up.
- Commissioning heat use and network distribution and storage losses are hard to segregate and remove from the dataset so are currently featured in the result, we estimate the combined effect to be about 47% of total heat generated.
- Other sources of error arise from missing data (data logging issues), which resulted in the extrapolation of ~100 data sets (mainly on phase 1).
- Four flat blocks on Phase 1 (24 flats) and one block on phase 2 (4 flats) have experienced some level of PV inverter outages. The resultant generation loss is hard to estimate as the data is collected through manual meter readings on site. A proportion of that data will be missing and will have adversely affected the site wide carbon balance.
- **By the end of phase two, the proportion of heat supplied by CHP as compared with gas boiler split was intended to be 90:10 but this is currently not the case. In reality, the ratio is 62:38 a slight increase from 58:42 in the last monitoring period.**
- **Re-running the site wide carbon emissions calculations, with the intended 90% CHP utilisation the development would likely achieve its true zero carbon status.**
- It is difficult to find robust (UK) household carbon footprint data (to be used as an emission comparison) that purely looks at energy consumed in the dwellings. Previous reports estimated a figure of 5.42 tonnes CO2e (last updated in 2016), which was calculated from total reported household emissions divided by the number of households (as per the office for national statistics). For this year's reporting we've used figures[8] published by the Home Builders Federation (from underlying DHLUCs statistics), having the advantage of being more recent (2023 data) and reporting both existing and new build homes energy use. This information has been included here for comparative purposes; more accurate data sources might exist.

[8] https://www.hbf.co.uk/documents/12662/Watt_Energy_Efficiency_New_Homes_finalv2.pdf

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- The site-wide carbon balance was calculated using the current SAP 10.2 carbon factors of 0.210 and 0.136 kgCO2/ kWh for gas and electricity respectively. The UK electricity grid has steadily decarbonised since Elmsbrook's energy strategy was written. The original (SAP 2009) carbon factors would give a more favourable carbon balance, even the previous (SAP 2012) would be quite advantageous for the carbon balance but potentially expose the development to criticism. Reporting the carbon emissions using SAP 2012 carbon factors would produce a net carbon balance of 638 tonnes less than Elmsbrook's performance using SAP 10.2. As such, SAP 2012 figures would greatly oversell Elmsbrook's performance and not accurately reflect its carbon emissions, opening the development up to criticism.
- The energy and carbon balance remains highly dynamic, and figures will change from year to year based on climate, electricity grid mix/carbon factors, people's behaviour, energy costs etc. Adding more homes/ switching new parts of the development online improves energy centre utilisation which influences the energy balance.
- Again, it is possible that commercial considerations (by the energy centre operator) could have influenced the boiler to CHP split for heat generation. Running the CHP outside peak time export tariffs might incur higher operational costs than using the boiler (better thermal efficiency) for the same gas consumption and might be less viable in the long term.

Table 9 – Energy balance over the monitoring period 2022/23.

Element	Exported Electricity (kWh)	Imported Electricity (kWh)	Gas imported (kWh)	Comments
Dwellings (all phases) – sub-metered data, 360+ days data	463,841	469,259	Na	205 properties or data sets
Dwellings (all phases) - data reconstructed	242,013	233,126	Na	Meter issues resulted in extrapolation and data reconstruction of 101 properties
Eco Business Centre - manual meter readings	25,245	15,267	Na	Apportioned based on monitoring period (meter readings for time period >365 days)
Gagle Brook school - manual meter	47,893	23,688	Na	Now mostly occupied
Energy centre - sub metered	1,533,402	71,868	5,571,480	Includes distribution and commissioning heat loss
Total	2,312,393	813,207	5,571,480	kWh

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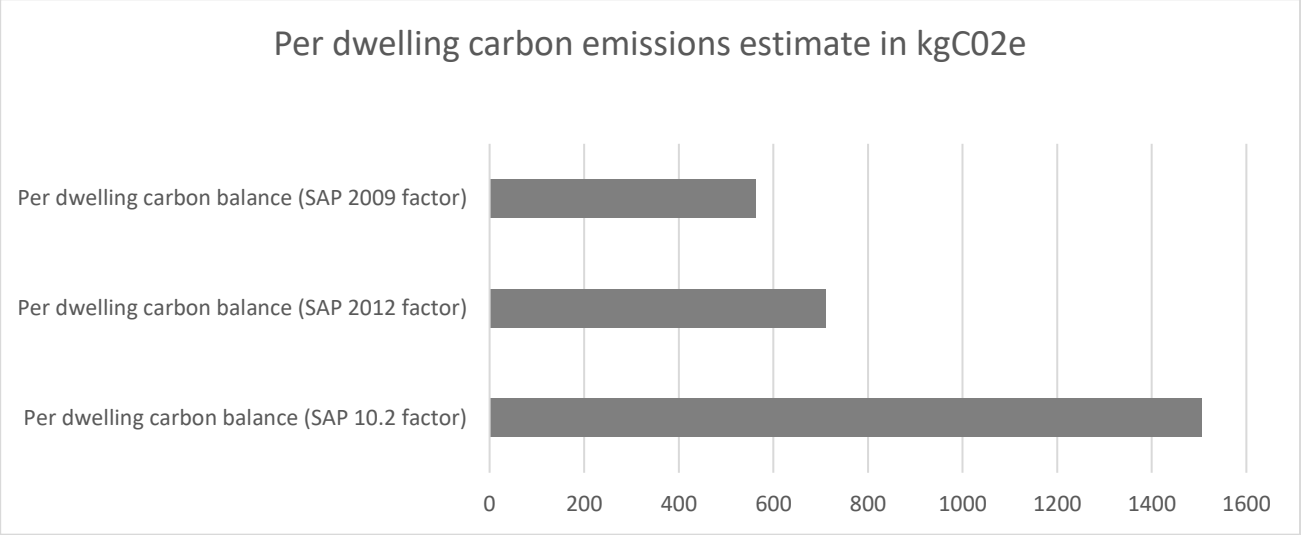

Figure 26 - Impact of changing carbon factors: SAP 2009 factors at time of application, SAP 2012 previous factors, SAP 10.2 current carbon factors (UK Building Regulations Part L).

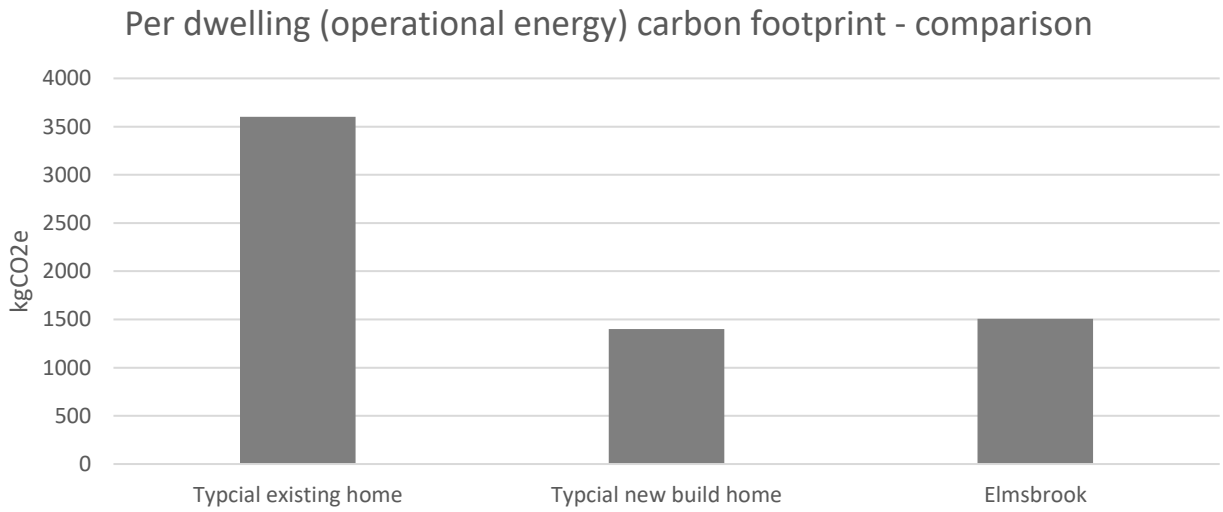

Figure 27 - Comparison of Elmsbrook per dwelling carbon footprint with typical existing and new build.

Item		Carbon factor	Resultant carbon emission	Notes:
Electricity exported	- 2,312,393 kWh	0.136 kgCO_2/kWh	- 314.485 TonnesCO_2	Favourable to balance
Electricity imported	+ 813,207 kWh	0.136 kgCO2/kWh	+ 110.596 TonnesCO_2	Unfavourable to balance
Gas imported	+ 5,571,480 kWh	0.210 kgCO2/kWh	+ 1,170.011 TonnesCO_2	Unfavourable to balance
Resultant site wide carbon balance			+ 966.121 TonnesCO_2	Net emissions

Table 10 - 2022/23 carbon balance (Energy use in kWh x SAP 10.2 Carbon factor = Resultant carbon emissions).

4.8 Resident survey

The Elmsbrook survey was advertised through email, a letter to residents, on the shimmy device and with help of the Elmsbrook Community Organisation (ECO). The survey was hosted electronically on the Survey Monkey site over a period of 6 weeks. A total of 81 responses were received.

Summary:

- 26% of household responded to the survey and provided data (30% of households in the previous reporting period). Most responses were received in the first few weeks of the survey going live.
- 66% of respondents indicated their health is good (34) to very good (19). In the previous reporting period this was 83% with 41 'good', 20 'very good'). 24 of the remainder answered "fair" and 4 "bad", with none stating, "very bad" (81 responses total), displayed in figure 30.
- Considering respondents' happiness levels since residents moved to Elmsbrook, (on a scale of 1-10, where 0 is "not at all" and 10 is "completely" happy) 54% indicated their happiness had increased since moving to Elmsbrook (above neutral, 5 or above). In the previous reporting period 71% of residents indicated they were happy the day before taking the survey.
- Surveying the sense of community belonging, 64% felt that they strongly belong in their immediate neighbourhood (27% very strongly, 37% fairly strongly). In the previous reporting period, this was 62%. 29% did not feel a very strong sense of belonging (7% not strongly at all).
- Household use of greenspace by type (multiple choice question) (Figure 29, question 5) is predominantly open countryside and nature reserves, comprising 55 and 35 households respectively. Country parks (34) and play parks (30) are the next used types of greenspace. This is followed by sports greens, grow beds and allotments (elsewhere in Bicester) with 7,5 and 1 household respectively using these greenspaces. 12 respondents indicated their households do not use any of these green spaces. The frequency to which households use green spaces varies, with the majority indicating, 29 weekly, 12 daily and 22 ad hoc. 11 households used these spaces fortnightly, and 3 monthly.
- Since COVID-19 pandemic and lockdowns, homeworking has increased dramatically. Now 54 out of 81 respondents work from home at least once a week. A majority of respondents work from home every day (37% or 20 respondents), 10 twice per week (19%), 8 three times a week (15%) and 4 four times a week (7%).
- Considering the support that can be provided to help people with more home-based working, 19% (15 responses) felt that co-working space would be beneficial (up from 13% in the last survey), with 18% feeling occasional use of such space would be beneficial, and 63% feeling they would not benefit.

Further information:

- 41% of respondents (33) answered that they are using delivery companies for their shopping more since to the pandemic. 37% (30) said about the same and 22% didn't note any increase. This trend in online purchases is reflected in national statistics[9] (online as a percentage of total) that saw a rise through the pandemic (peaking at 31% in 2021), followed by a small reduction, currently sitting at 27% (in 2022 latest full year of reporting).
- Considering sustainable household waste management behaviours and practices, 51% answered that their household composts their green and/or food waste (60% previously), while 12% only do sometimes (previously 4%), and 37% do not at all (36% before). This is a significant area to improve in terms of sustainable living of residents across the eco-development, and public engagement may help to improve the rate of green and food waste composting.

[9] https://www.ons.gov.uk/businessindustryandtrade/retailindustry/timeseries/j4mc/drsi

- While 75% of respondents answered that they understand how to operate the heating system effectively in their homes (78% previously), there is scope for improvement through additional support to the 25% (20 respondents) that answered "no".
- 72 written (open-ended) responses about what residents value the most about living at Elmsbrook (question 17) were converted into a word cloud (see Figure 28).
- 58% of respondents (47) know 6 or more neighbours by name, and 12% (or 10 respondents) know 4-5. The UK average was estimated in 2019 by this study[10] as knowing 4 of your neighbours.
- The full table of answers can be found in the appendix.

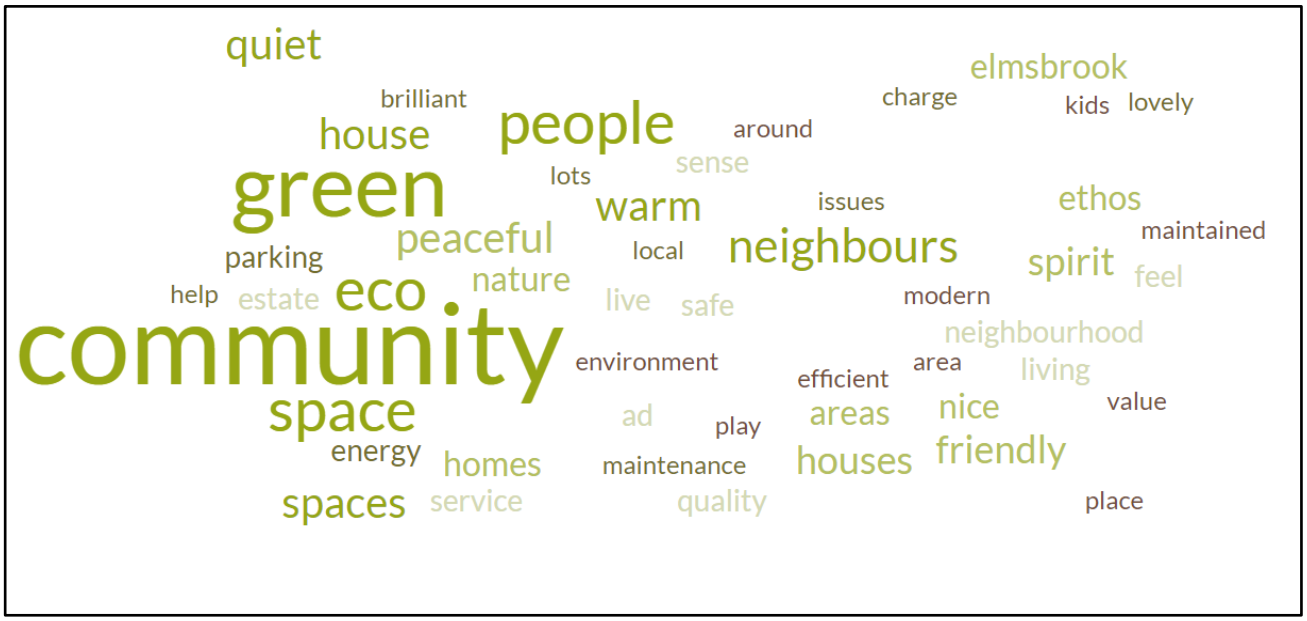

Figure 28 – What do residents value most about Elmsbrook 'word cloud'.

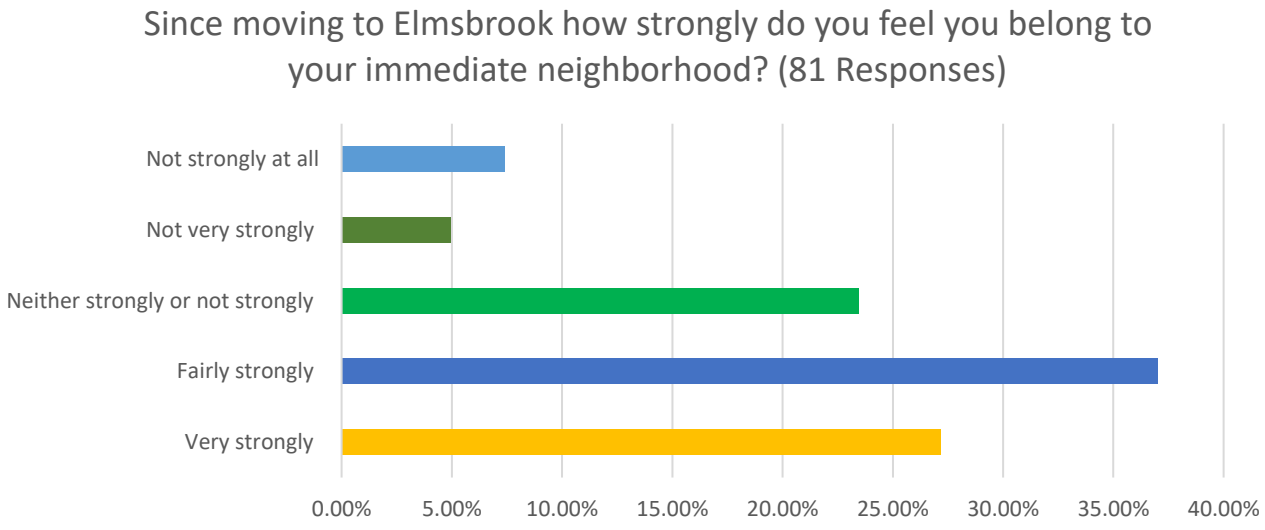

Figure 29 - Answers to question 11 about feeling belonging.

[10] https://www.aviva.com/newsroom/news-releases/2019/11/one-in-ten-uk-residents-know-none-of-their-neighbours/

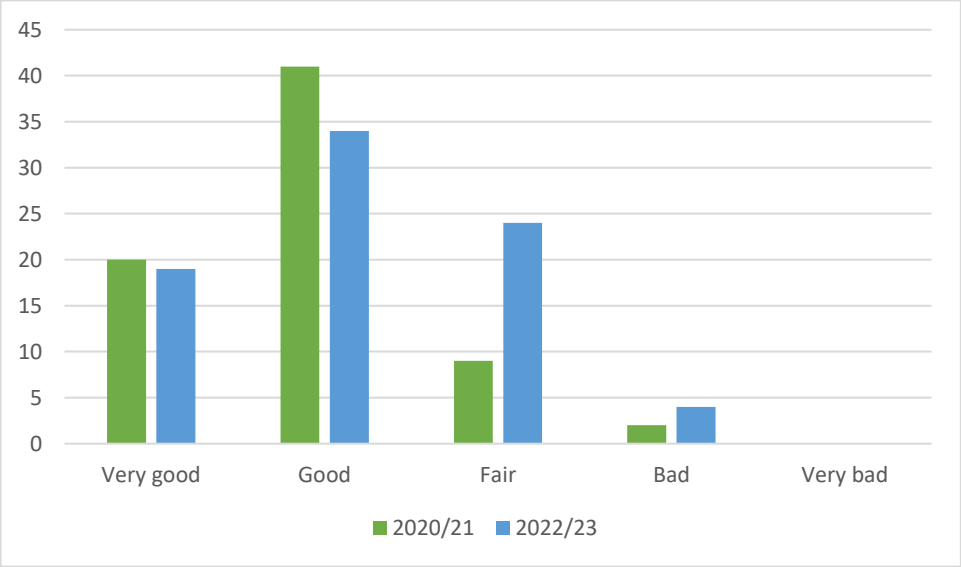

Figure 30 – comparison of resident self-reported health levels in 2020/21 vs 2022/23.

4.9 Transport

Transportation data was provided by Mode Transport consultants, the data included the number of cars, pedestrians and bicycles that entered and left the development along with information regarding bus use. The data was provided as at a monthly level. An error with the sensor collecting pedestrian and cycling numbers occurred during February and March 2023, this is currently under investigation, however, as a result of this no pedestrian or bicycle trips were recorded in February 2023 and no bicycle trips were recorded in March 2023. Additionally, there are considerable uncertainties contained within this data. These uncertainties stem from the differences between in and out vehicle count, displayed in figures 35, 36 and 37. Particularly in the case of the pedestrian count, Figure 34, where there were significant discrepancies between pedestrian in and pedestrian out figures. To address this a modal share was completed for both in count and out count with the likely true figure lying in between the values. Modal share is displayed in Figures 30 and 31. As a result of the uncertainty in this data results have not been drawn, however, comparisons to previous monitoring reports and national data have been made.

Summary:

- During the monitoring period a total of 479,322 trips were recorded, the trips have been broken down by transport method below:
    - Motorised vehicles: 394,983, (82.4% of all trips)
    - Pedestrians: 68,352 (14.3% of all trips)
    - Bicycles: 15,987 (3.3% of all trips)
- Figure 31 below, displays the modal share for vehicles entering Elmsbrook whilst Figure 32 displays the modal share using data from vehicles leaving Elmsbrook. The true modal share will lie somewhere in the range between these two figures. As can be seen below, figure 30 is skewed towards pedestrian trips as a result of a higher number of pedestrians in trips and a lower number of vehicles in compared to the data for pedestrians and vehicles out. Conversely, figure 31 displays a significantly lower modal share from pedestrians and is more in line with the previous monitoring periods modal share completed on one day in September 2021.
- Data from the E1 Bus service was provided by E1 via Mode Transport Consultants, the data was provided as a quarterly breakdown of ticket sales and revenue. The quarterly data was then divided by 3 to provide the approximate monthly and monitoring period ticket sales. From April 2022-March

2023 the approximate number of tickets sold was 39,838 with a monthly average of 3319. Bus ticket sales were mostly consistent throughout the year; however, they did fall slightly into the summer months.

- Data from resident's survey suggest that the main mode of transport remains the car as sole occupant (68% of respondents), followed by the car as passengers (9%), walking (7.5%) with train and bus tied at 6%. The main mode of transport is defined as the household's main mode (longest distance/travel time) of travel for the most frequent journey undertaken in a typical week.

Further information:

- Figure 33 displays the modal share from the previous monitoring periods' transport report completed by Mode Transport consultants. As can be seen this modal share is roughly consistent with the OUT-counter data, figure 32, with vehicular transport comprising 88.6% and 87.8% of journeys, pedestrians comprising 7% and 9.2% respectively and bicycles comprising 3.1% and 3.9% of trips respectively.
- However, Figure 31 is more consistent with national statistics for 2022, where 67.5% of trips were made in a vehicle and the remaining 32.5% of trips were made by active transportations modes. When compared to Figure 31, 39.6% of trips were made by active transportation and 60.4% of trips were made by vehicle transportation. Whilst this represents a higher percentage of active transportation than the national average.
- Figure 34 details the total number of trips made per month by vehicle type. This data demonstrates that the vast majority of trips during the monitoring period were made by car. Car trips peaked in March accounting for a total of 37,522 trips (92.2% of all trips in March), however, during this month the counter for cyclists was not working and therefore no data for cycling numbers was recorded. Despite this, cycling numbers have never made up more than 5.1% of trips. The highest percentage of car use in a month where complete data has been analysed was December with a total of 31,701 trips (91.7% of all trips in December), this may have resulted from the weather conditions with fewer hours of daylight and colder temperatures making active travel less appealing.
- As shown in Figure 37, August had both the lowest percentage of trips made by car at 69.9% and the highest percentage of trips made by pedestrians at 25.8%.
- The average number of trips made by pedestrians was significantly higher during the spring/summer months of April, May, June, July and August than it was for the rest of the monitoring period. The average number of trips made by pedestrians during the spring/summer months (listed above) was 9508. Pedestrian trips fell to 5271 in September, with the monthly average number of trips made by pedestrians from September 2022 to March 2023 (Excluding February as no data was recorded for this month) being 3469. Again, this may be attributed to weather conditions making active transportation less desirable.
- The number of trips made in and out of Elmsbrook by bike remained consistent through May 2022 – November 2022 averaging 1832 trips a month. Of the remaining months data was not collected for February and March with the average number of trips made in April, December and January being 1055.
- Figure 38 identifies the monthly average ticket sales for the E1 bus service. The monthly ticket sales were at their lowest in April 2022 at 2943, ticket sales steadily rose through May – October 2022 before peaking in the three months between November 2022 to January 2023. This may again correlate with weather conditions as a greater number of tickets were sold in the colder months. However, ticket sales remain relatively consistent throughout the monitoring period with the fewest tickets sold in a month being 2943 and the highest being 3490.

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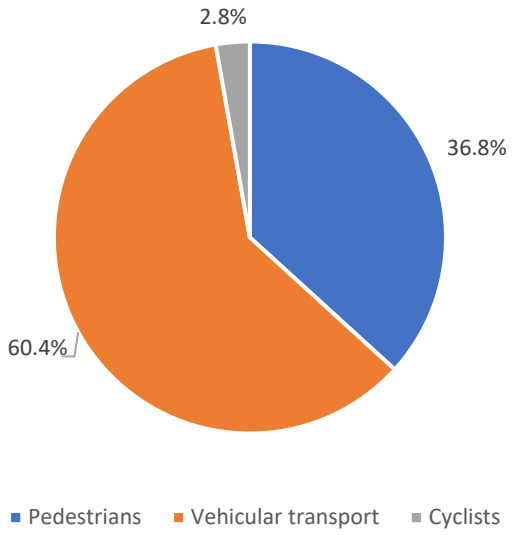

Figure 31 – IN counter modal share.

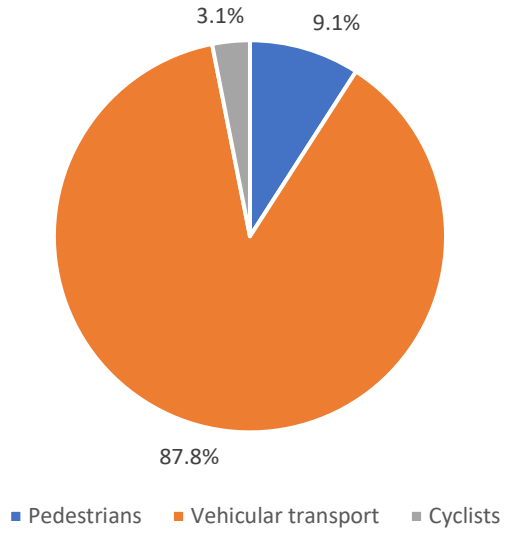

Figure 32 – OUT counter modal share

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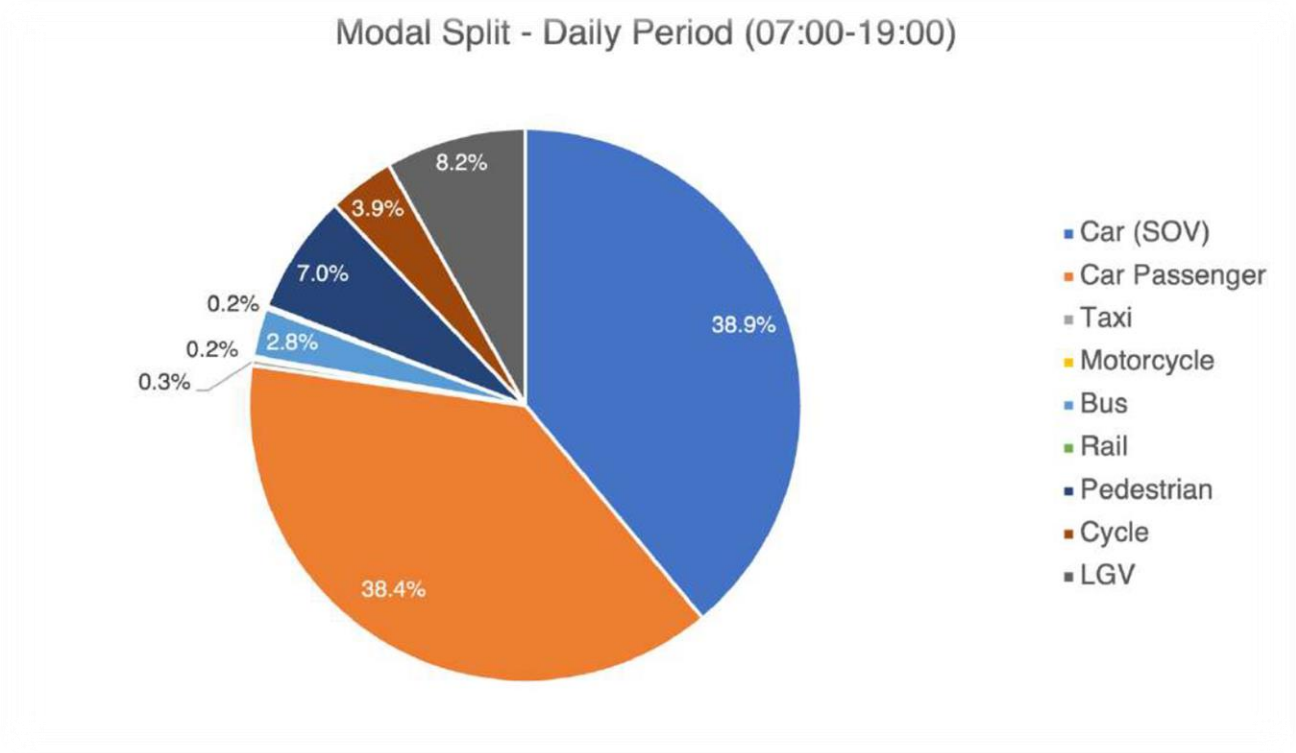

Figure 33 – Modal share completed by Mode transport in 2021 for the Elmsbrook development.[11]

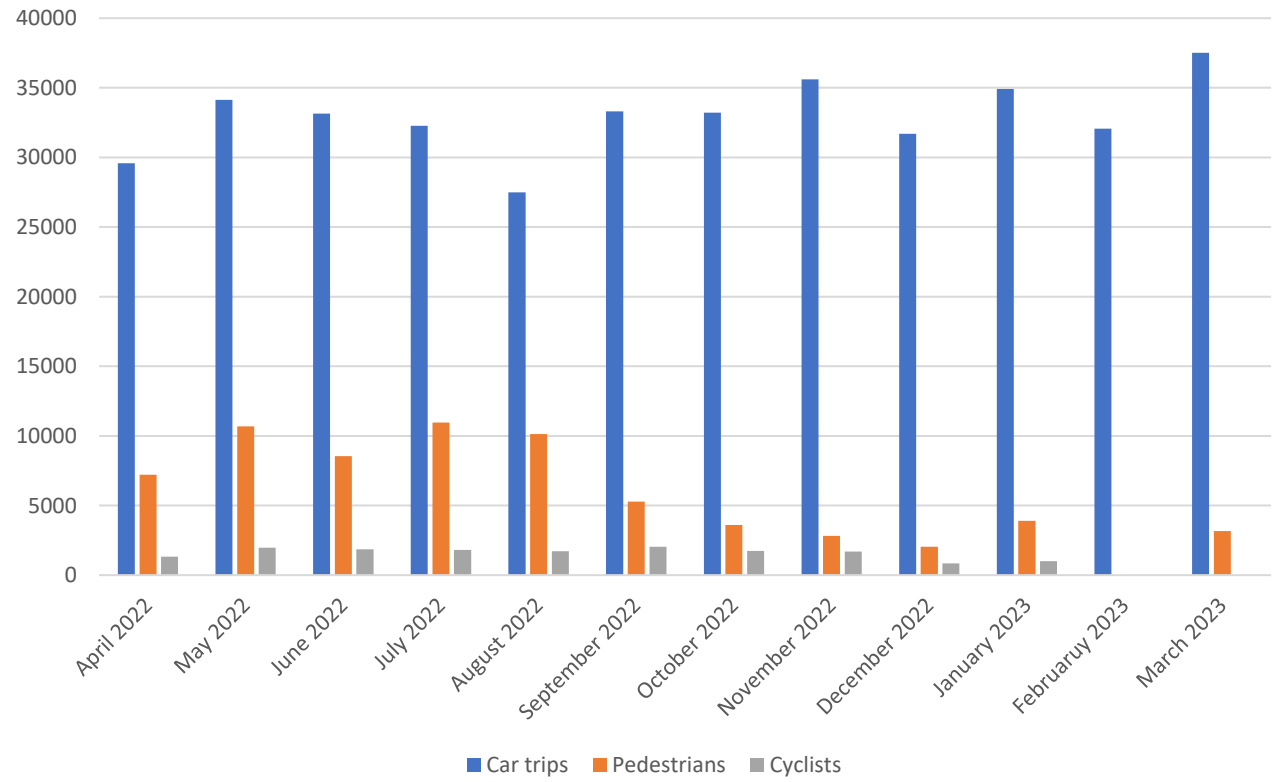

Figure 34 – Number of monthly trips (total) by transport mode.

[11] North West Bicester Exemplar Eco-Development, Elmsbrook Travel Plan Monitoring Report February 2022, provided by Mode transport consultants, available upon request.

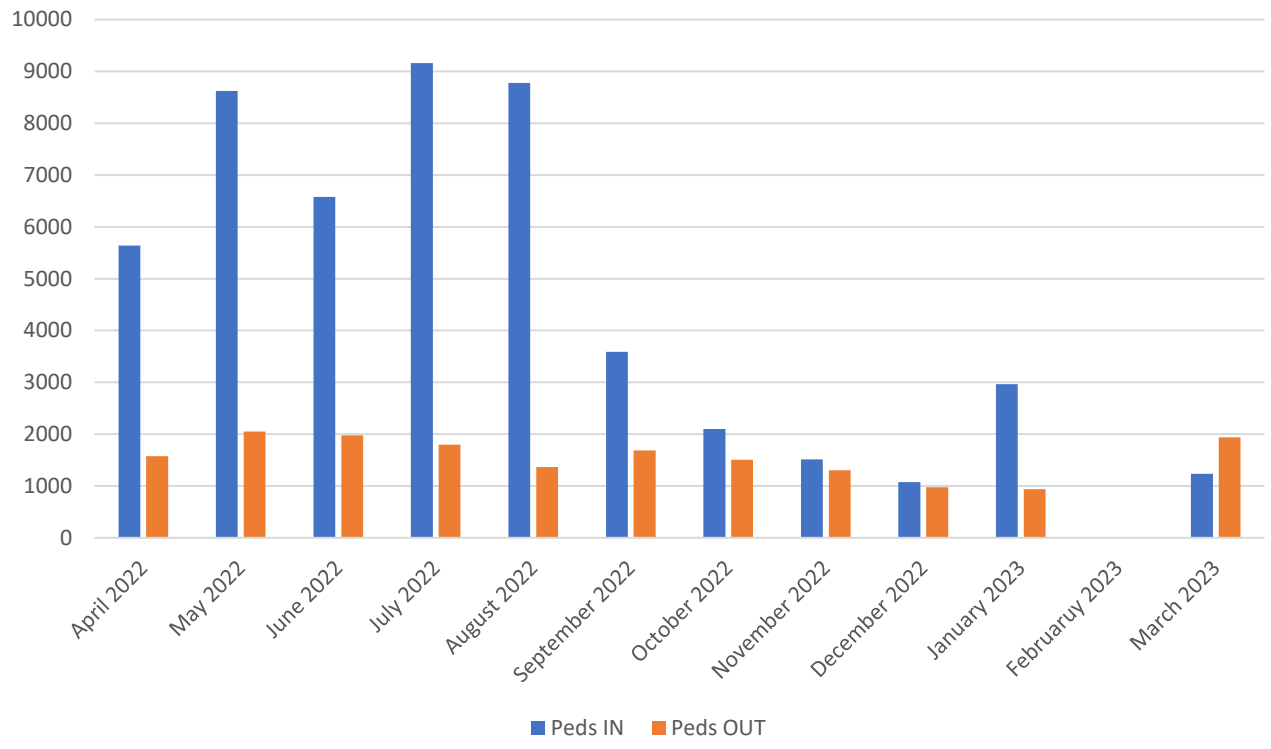

Figure 35 – Monthly pedestrian count for people leaving or entering Elmsbrook on foot.

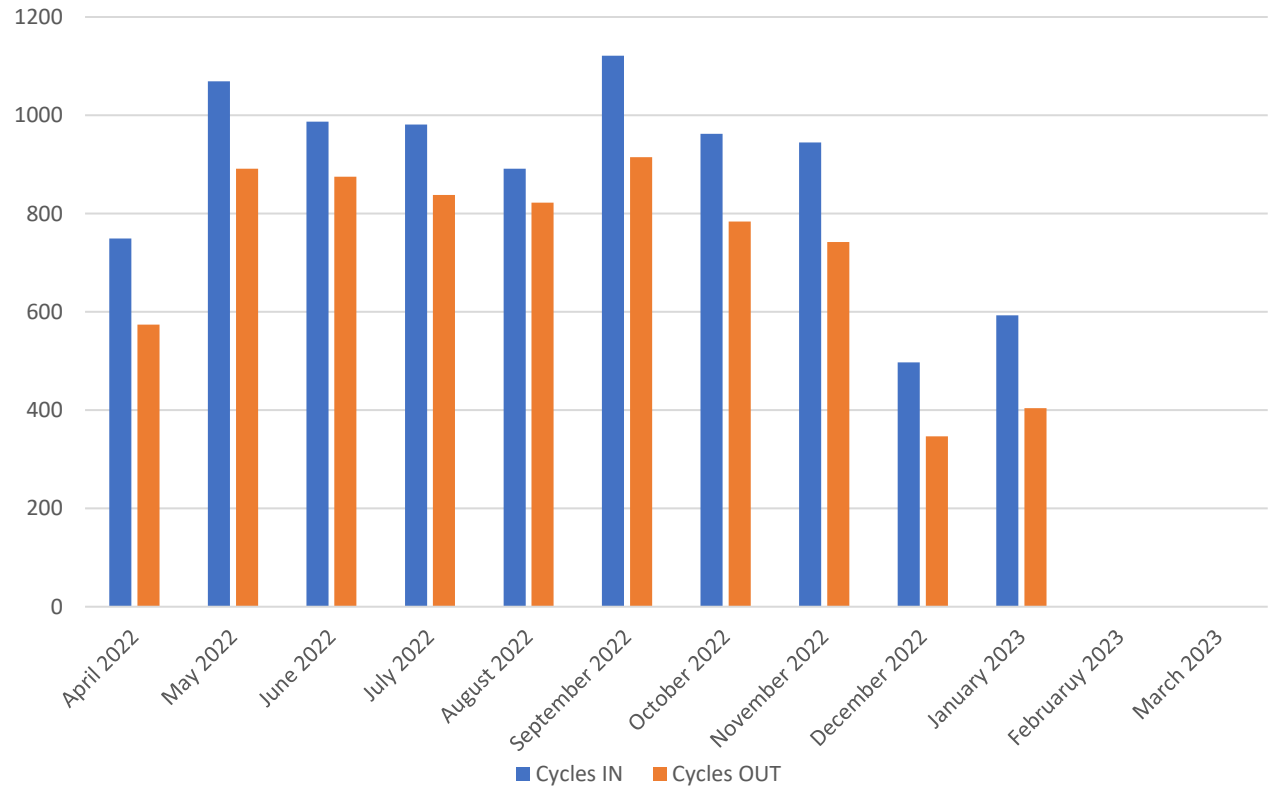

Figure 36 – Monthly cycle count for people leaving or entering Elmsbrook.

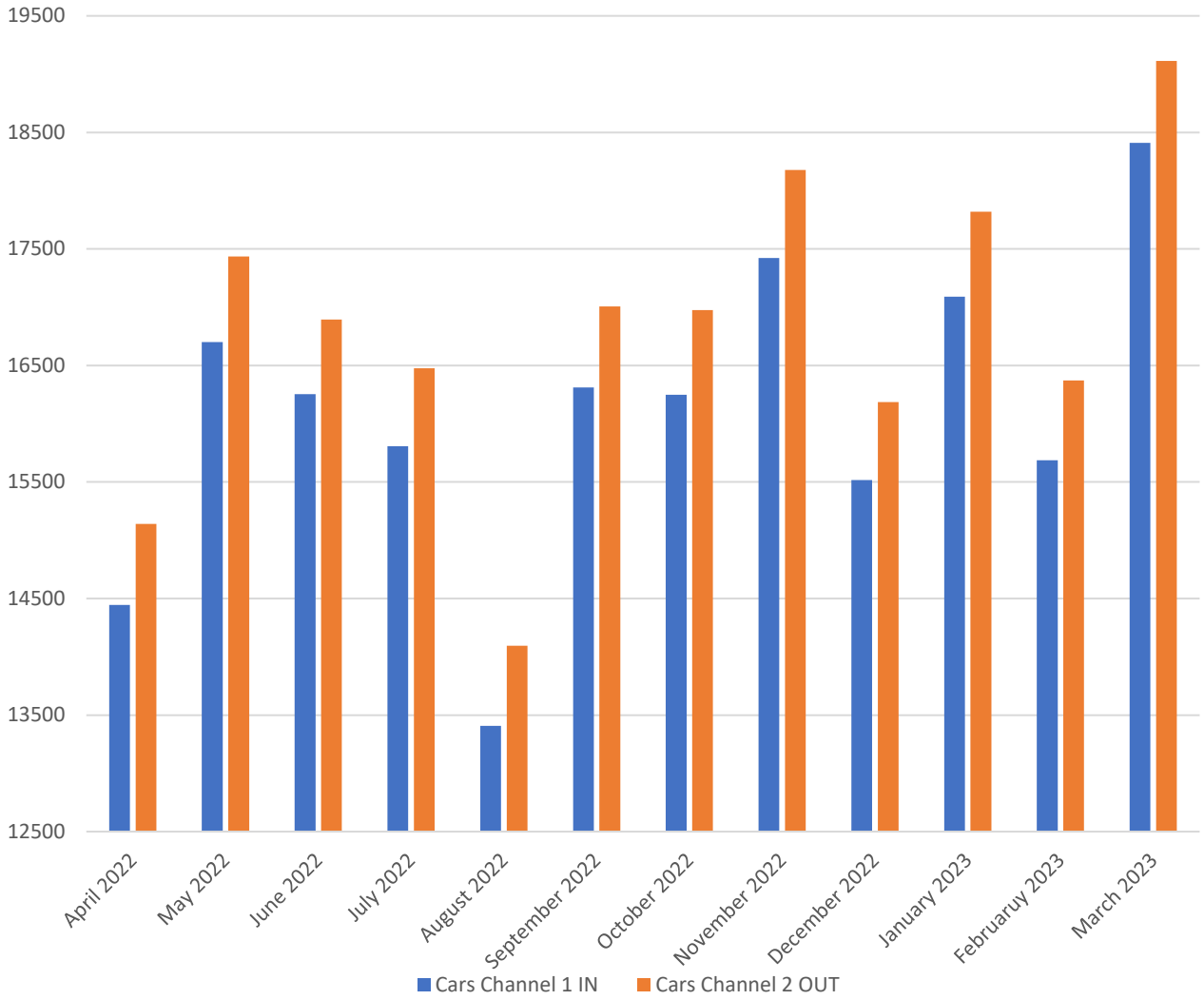

Figure 37 – Monthly car count for people leaving or entering Elmsbrook.

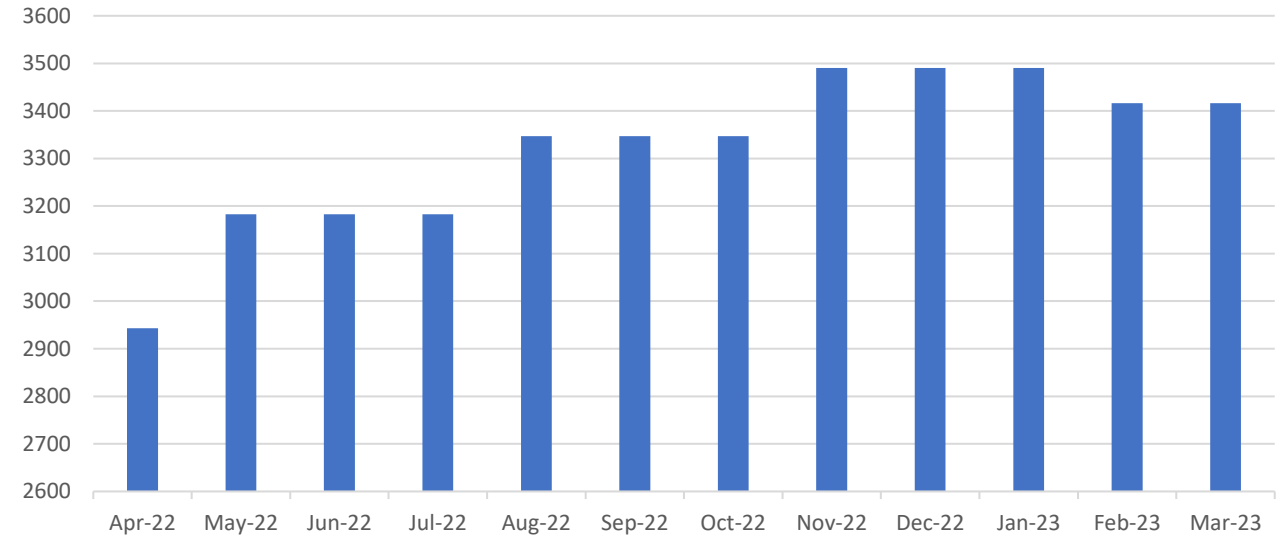

Figure 38 – Monthly average ticket sales, E1 bus service.

5 Conclusions and recommendations

5.1 Overview

This post occupancy report forms the fifth in a series undertaken at the Elmsbrook development – the UK's first Ecotown.

It has been a decade since the original Ecotown concept was published and the NW Bicester energy strategy was devised in response. Since then, technologies and thinking have moved on, yet Elmsbrook is still competitive with other state of the art new build developments when it comes to energy use and water use and with a clear edge on wider sustainability indicators such as community, health and happiness.

With the UK electricity grid now rapidly decarbonising (reflected in the latest carbon factors; SAP 10.2), strategies that are reliant (in part) on other sources of energy (other than electricity) are now at a heavy disadvantage. At Elmsbrook the carbon balance is impacted by the energy centres heat source, which is currently a gas CHP, which in the real term reduces the offsets that are now available from exporting energy and displacing the formally more carbon intensive grid electricity.

Whilst the exact carbon balance of the development (school, residential phases and energy centre), year on year is dynamic and influenced by many factors, in each subsequent reporting period the trend has been slightly, but steadily, away from realising its net zero carbon status. Contributing to these external factors are development growth and internal operational decisions which are affecting gas use at the energy centre. For example, the CHP engine has not yet reached its designed capacity because of delays and lower build out rates of the wider master plan, so engine efficiency and CHP to boiler split is affected through this part load operation (affecting energy generation and offsets).

Considering other sustainability indicators, household daily water use has decreased slightly from 246 to 224 litres, while water use per person has reduced incrementally from 83 to 75 litres a day. 61% of households are on average meeting their water use targets off 80 litres per person per day (compared to UK average of 142 litres per person per day). Annual electricity use is almost unchanged to the last reporting period (average per household: 3,062 kWh) and is currently almost meeting its design target (4% off target), and ~20% better than the average for Bicester. Waste practices still have room for improvement with recycling rates dropping to 42% (from 62% in 2020-2021), (higher than the district, county and national levels), while total waste generated also increased sharply to 382 kg per household (from 210 kg). This increase could relate to more time spent at home or changing consumer/ shopping trends (more online purchases), but future analyses should monitor whether this rise continues, and take action to help residents reduce their waste. It is also possible that the onsite bulk collection points and garden composting could affect weights logged.

In this year's household survey, 64% felt that they strongly belong in their immediate neighbourhood (with 27% indicating very strongly, and 37% fairly strongly), increasing slightly from 62% of survey respondents in the last reporting period. A majority of respondents commented that their happiness has increased since they moved here (54%), and 65% indicate their health is good to very good. New working practices since the COVID-19 pandemic and lockdowns led 67% of respondents surveyed to move to home working at least one day per week with 37% working from home very day. Considering whether residents could be supported in home-based working by having co-working space, 19% felt this would be beneficial, 18% felt occasional use of such spaces would be valuable, and 63% felt they would not benefit.

Despite technical elements of the development requiring improvement, Elmsbrook seems to be continuing to grow into a positive and happy community where residents generally consider themselves to have high levels of well-being and feel as though they belong to a community.

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5.2 Key findings

- The average home on Elmsbrook used 7,242 kWh of energy per year (heat and electricity), which works out as and energy use intensity (EUI) of 68 kWh/m2a when normalised for floor area. This compares to 9,414 kWh for an average UK new build[12], around 30% more than a house in Elmsbrook. An existing home is estimated to use 21,041 kWh/a, almost three times as much as an Elmsbrook home.

- In carbon terms, we estimate that in 2022/23 the average home at Elmsbrook emitted 1,506 kgCO_2 (or 1.5 tonnes CO_2) per year. 1,506 kg CO_2 compares to 3,600 kgCO_2 (or 3.6 tonnes CO_2) for an average existing UK dwelling, so around 58% less. A new build home is estimated to have a similar carbon impact (1,400kgCO2) to Elmsbrook, largely due to less favourable mains gas carbon factors penalising the gas combined heat and power (CHP) engine and gas boiler in the energy centre.

- For this reason, the development as a whole (energy centre, school and residential) does not appear to have achieved zero carbon emissions over this reporting period with a positive balance of 966 tonnes CO_2 (i.e. the net carbon emitted). In order to compare this figure (with previous results) we've applied the old SAP 2012 factor separately, which change the figures to 425 tonnes CO2. This figure can then be compared like for like, with the 383 tonnes CO2 net emissions in the previous reporting period. Note the development has considerably increased in size since then.

- While the development is clearly more energy efficient (in absolute usage terms) than most other new developments, the carbon balance is about comparable. This is for two reasons: 1. The UK electrical grid has decarbonised (reflected in latest carbon factors) to an extent where nonelectric solutions are penalised in carbon terms (i.e. the Elmsbrook gas CHP) 2. The latest Building Regulations (Part L 2021) have increased fabric performance to an extent that is now is almost in line with the Ecotown PPS standards set a decade ago (in the NW Bicester energy strategy).

- Clearly one aspect that impacts carbon performance is the load and operational pattern of the energy centre. Originally sized to supply a large part of the masterplan, delays in build out and other planning and commercial factors have meant that this is now no longer likely with more decentralised solutions looking more favourable. This means that for the foreseeable future the energy centre remains to operate at part load, with heavier usage on gas back up boilers than accounted for in the original energy strategy. To illustrate this point, the current CHP to gas boiler split (for heat generated) is 62:38 compared to the designed split of 90:10. Higher boiler usage can sometimes be more economical but also more carbon intensive.

- Dwellings on site are using marginally (~4%) more electricity than anticipated at design stage, however still significantly less (~20%) than an average Bicester household. For this reporting period dwellings used 10% more heat (hot water and space heating) than design estimate but 63% less than the Bicester average (65% less than UK average).

- Elmsbrook residents currently produce more residual waste than the county average. The average recycling rate for Elmsbrook has decreased from 64% in the previous period to 41.9%, compared to 53% for the county. While it is unclear what has caused this increase it is worth noting the increase of home working patterns, on site bulk recycling collection and garden composting that could have had an influence on the final numbers.

- Elmsbrook residents used 75 litres of water per person per day, 6% below the design target of 80 litres per person per day. For an average household (2.4 people), water savings equate to roughly 161 litres saved every day through water-efficient design measures.

[12] https://www.hbf.co.uk/documents/12662/Watt_Energy_Efficiency_New_Homes_finalv2.pdf

5.3 Recommendations

Bioregional recommends the following actions to improve the environmental performance of the development, efficiency of the monitoring process and quality of data:

- Elmsbrook residents waste and recycling rates have worsened since last reporting period. It is important to understand the causes behind this (e.g. home working patterns), and if education and campaigns can be delivered to improve these. As a first step we recommend reaching out via a separate waste focused survey to all households and co-ordinating these with CDC.

- The flat units remain unmetered, requiring on site manual meter readings. This affects the accuracy of electricity and PV calculations. Further equipment problems can run undetected if not hooked up to an automatic system. We recommend the installation of a PV sub metering system, similar to the other households on site.

- We suspect that commissioning heat loads still make up a proportion of the district network system losses (affecting the accuracy of the carbon intensity calculation). While construction is ongoing, we recommend that these commissioning heat loads are reported separately by the energy centre provider.

- Active monitoring of data is immensely useful to spot out-of-range values and address potential equipment failures for example water leaks or PV inverter failure. With work by Carnego already planned/ underway, Bioregional recommends that this process is tested and refined using stakeholder feedback. A2Dominion should ensure that the relevant maintenance teams have access to this data (from rented/shared ownership properties on site) and required resources to respond.

- Similar to above, Bioregional recommend that the Shimmy App provides an “out of range” warning to private households with messaging to inform them of potential equipment failure or malfunction. It is unclear to what extent this is already happening in the app’s algorithm.

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