BLUE NORTH

THINKING. FUTURE

Packhouse Action Group Water and Energy Project

2020 Energy Benchmark Results

February 2022

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1 Introduction

In 2021, Blue North Sustainability was contracted by the Packhouse Action Group (PAG) to benchmark the electricity consumption in pome fruit packhouse and cold storage operations. This was the first round of electricity benchmarks, compared to the fourth round of water benchmarks that have just been completed. The objectives of the project were to:

- conduct an electricity consumption benchmark study to highlight areas where packhouses can save energy;
- identify and compare energy management practices applied; and
- encourage industry knowledge sharing.

This report presents the results of electricity use benchmarks from **January to December 2020** and summarises the different energy management methodologies applied at the packhouses.

2 Methodology

Packhouses were onboarded with a virtual call to introduce them to the project and provide them with training on how to complete the data collection tool. A guidance video on the data collection tool was also sent to all participating packhouses.

2.1 Data collection

Data was collected via an excel based data collection tool and sense checked by the project team. Data anomalies were discussed with participants and, where applicable, rectified or reasons for the anomalies were recorded.

2.2 Scope of the data collection

The following three areas in pome fruit packhouses were benchmarked in terms of electricity consumption:

- **Packhouse operations** – This includes all operational electricity consumption in the packhouse (pre-sort, packing lines, ablutions, canteens, and offices).
- **Controlled Atmosphere (CA) operations** – This includes all electricity consumption relevant only to CA operations (refrigeration plant, compressors, condensers, fans, cooling towers, etc.)
- **Regulated Atmosphere (RA) operations** – This includes all electricity consumption relevant only to RA operations (refrigeration plant, compressors, condensers, fans, cooling towers, etc.)

2.3 Participation

Twenty-one packhouses were contacted of which 11 packhouses provided data. In addition, one packhouse committed to providing data, but no further response was received after multiple follow-ups. Four more packhouses did not provide data but committed to participating in future data collection rounds.

2.4 Notes on the data

- All data sets refer to the 2020 calendar year (January to December).
- Packhouses are anonymised in the report (named A to N). Packhouse A could only provide data on electricity cost.
- Caveats apply to some data points and where applicable, they are acknowledged in this report under "Notes".
- In graphs, blue bars always indicate accurate/metered data, whereas the yellow bars indicate calculated or estimated data.

3 Electricity benchmarks

3.1 Packhouse operations

3.1.1 Calculation

The packhouse operations benchmark is calculated as follows:

Packhouse operations electricity consumption (kWh) / Tonnes of pome fruit packed

The benchmark's Unit of Measure is: Kilowatt-Hour per Tonne of pome fruit packed.

3.1.2 Results

Only packhouses who provided data are shown.

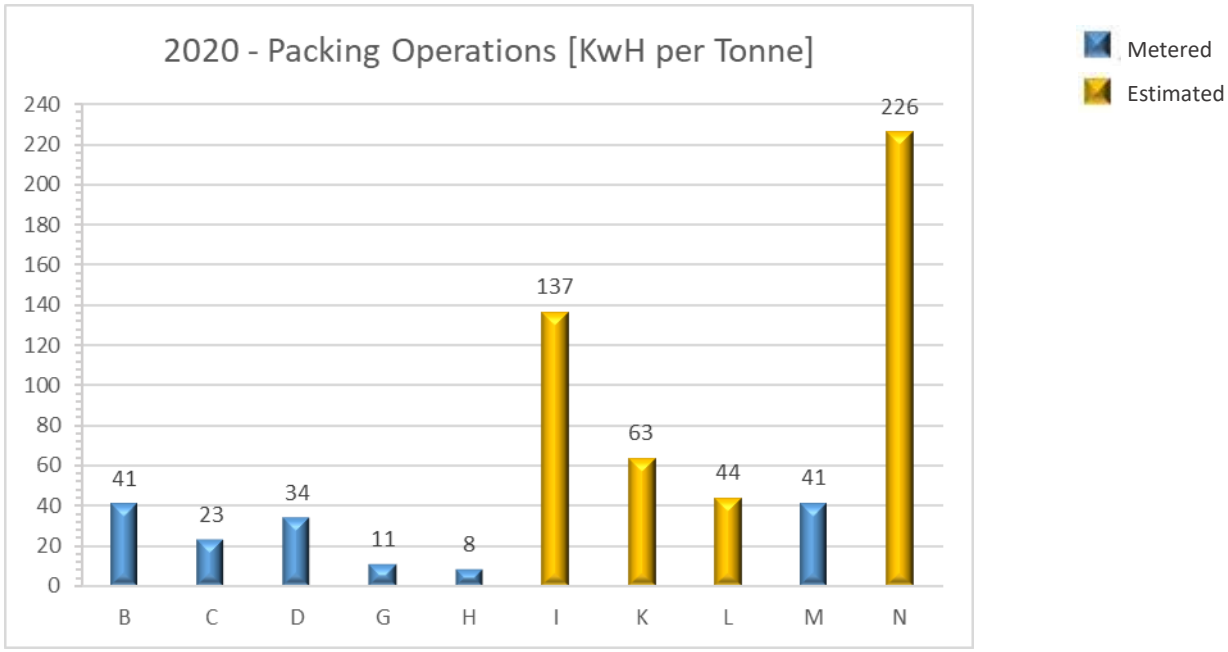

Figure 1: Packhouse operations benchmark results

Figure 11 notes:

Electricity consumption of Packhouses K and L were estimated due to insufficient metering.

Packhouse I – This benchmark includes RA operations consumption use.
Packhouse N – This benchmark includes CA and RA storage electricity consumption as allocation between the different areas in the packhouse was not possible.

Taking only metered/accurate data into consideration, electricity consumption for packhouse operations ranged from 8 kWh to 41 kWh per tonne of fruit. This figure is slightly lower than the benchmark of 15-44 kWh/ton found in a similar study done by Bouwer (2011)[1], which could indicate increased energy efficiency over time.

Packhouse G and Packhouse H used up to five times less electricity per tonne of fruit in packhouse operations than the other packhouses. This may be due to specific energy management practices applied described below.

Packhouse G have Sonoff switches installed to switch off any unnecessary lights off-site, have replaced all the lights in the packing operations with LEDs and installed solar energy system to produce electricity to the ablutions, canteens and offices.

Packhouse H uses LED lighting and have sky light panels inserted into the roof to let natural light help with energy savings.

3.2 CA operations

3.2.1 Calculation

The CA operations benchmark is calculated as follows:

CA operations electricity consumption (kWh) / CA Tonne.Days

The benchmark's Unit of Measure is: Kilowatt-Hour per Tonne.Day of fruit stored. Tonne.Days is not an intuitive unit of measure and is explained in more detail below.

The cold storage benchmark cannot be based on tonnes stored only, as cold storage protocols vary widely from one operation to the next. Some packhouses store pome fruit for short periods (days or weeks), while other store fruit for long periods (several months to almost a year). Tonne.Days deals with this neatly as it calculates the amount of electricity used to store one tonne of pome fruit for one day. An example is:

[1] Bouwer, J.J., 2011, August. Using a benchmarking approach to improve energy efficiency in fruit packhouses and cold stores. In 2011 Proceedings of the 8th Conference on the Industrial and Commercial Use of Energy (pp. 30-33). IEEE.

200 Tonnes stored for 1 day = 200 Tonne.Days
200 Tonnes stored for 3 days = 600 Tonne.Days

3.2.2 Results

Only packhouses who provided data are shown.

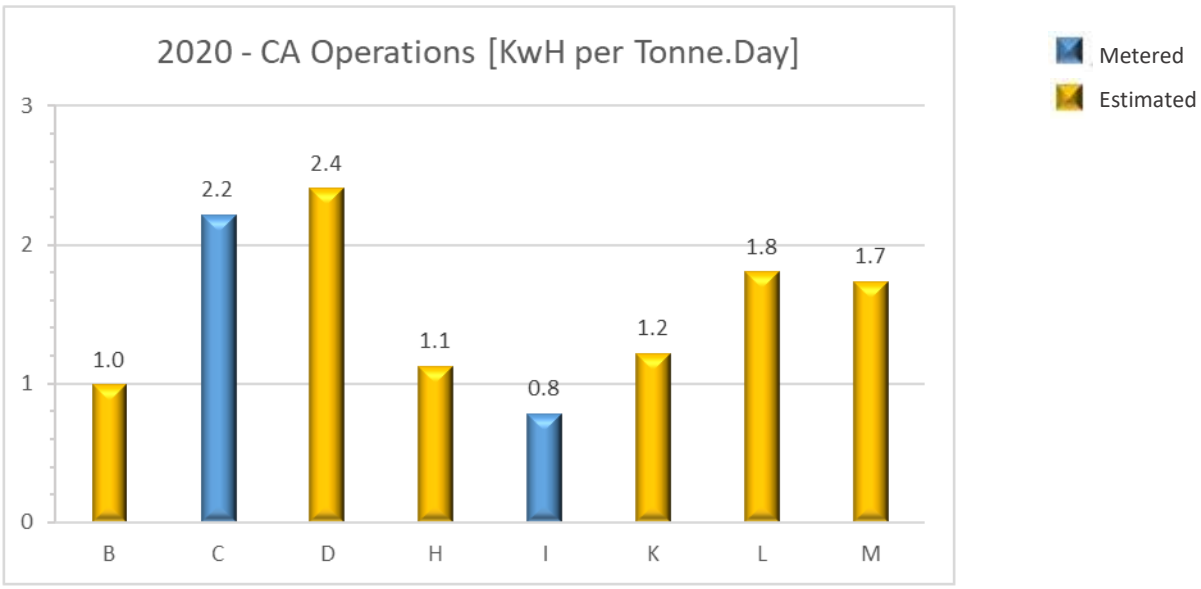

Figure 2: CA operations electricity benchmarks

Figure 12 notes:

Electricity consumption of Packhouses B, D, K, L, H and M were estimated due to insufficient metering

When only considering metered/accurate data, the CA operations electricity benchmarks ranged from 0.8 to 2.2 kWh per Tonne.Day. This figure is significantly lower than the benchmark of 5.5 -9.5 kWh/Ton.Day found by Bouwer (2011)[2].

Packhouse C used nearly three times as many kilowatt-hours per tonne of fruit in comparison to packhouse I. These differences may be attributed to different energy management practices applied.

Packhouse C uses LED lighting, Power Factor Correction, variable speed drives and solar energy to reduce electricity consumption.

At Packhouse I the cold rooms are set on timers, programmed so they only run when necessary overnight. In the daytime solar energy is used. Packhouse I also uses a

[2] Bouwer, J.J., 2011, August. Using a benchmarking approach to improve energy efficiency in fruit packhouses and cold stores. In 2011 Proceedings of the 8th Conference on the Industrial and Commercial Use of Energy (pp. 30-33). IEEE.

supervisory control and data acquisition (SCADA) system to manage cold room settings and timers to save energy.

3.3 RA operations

3.3.1 Calculation

The RA operations benchmark is calculated as follows:

RA operations electricity consumption (kWh) / RA Tonne.Days

The benchmark's Unit of Measure is: Kilowatt-Hour per Tonne.Day of fruit stored. Tonne.Days are explained in more detail in Section 3.2.1 of this report.

3.3.2 Results

Only packhouses who provided data are shown.

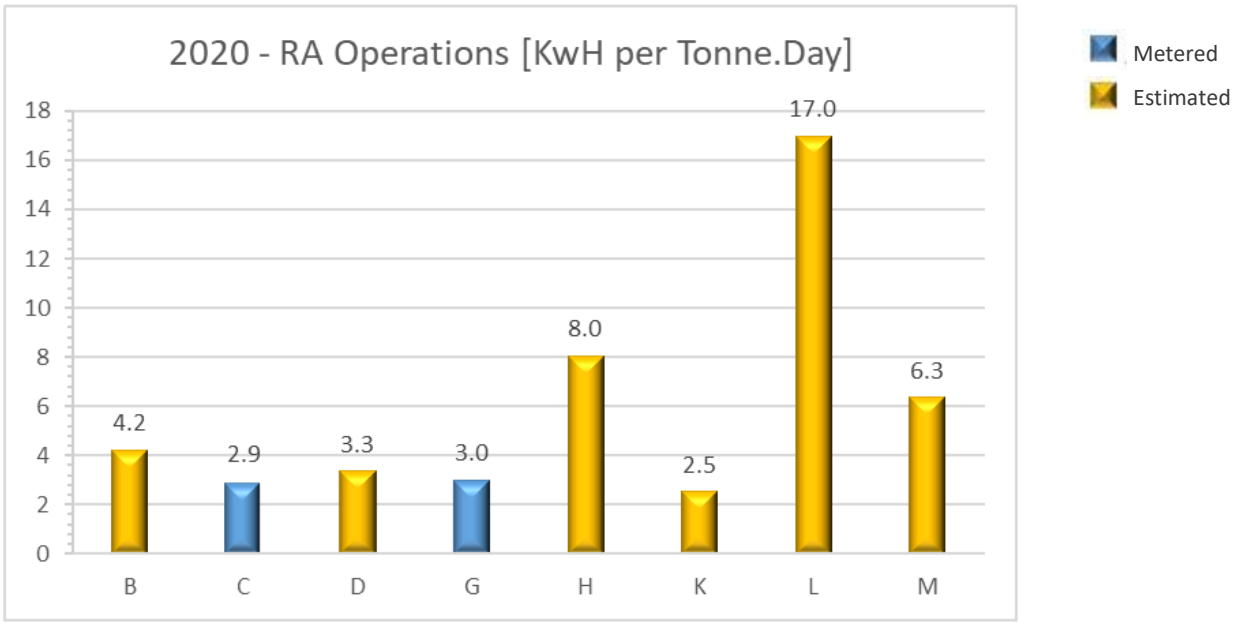

Figure 3: RA operations electricity bechmarks

Figure 13 notes:

Electricity consumption of Packhouses B, D, H, K, L and M were estimated due to insufficient metering.

When only considering metered/accurate data, the RA operations electricity benchmark is 3 kWh per Tonne.Day. This figure is also significantly lower than that found by Bouwer (2011)[3].

4 Overall Packhouse electricity consumption benchmark

The overall benchmark for each packhouse incorporates electricity use for all sections of the packhouse, excluding electricity consumption allocated as "other". The unit of measure for this benchmark is kWh per tonne of pome fruit packed. The January to December 2020 benchmarks are presented in Figure 4.

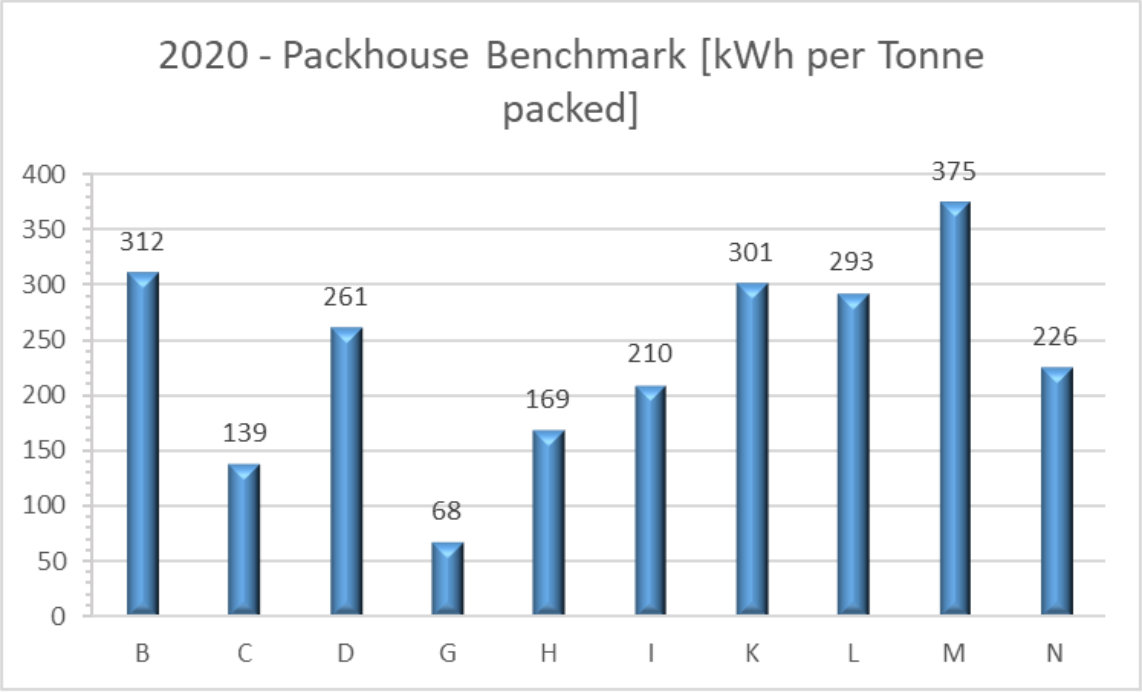

Figure 4: Overall electricity benchmarks

The large variation in the overall electricity consumption benchmarks can be ascribed to the unique combination of facilities at the packhouse (for example packhouses have varying CA storage capacities and strategies) and the different energy management practices applied. Regardless, the general consensus seems to be that approximately 100 - 300 kWh of electricity was consumed per tonne of fruit packed.

5 Electricity usage profile

It is useful to compare the electricity use profiles of different packhouses. Figure 5 below displays the percentage of electricity consumed for different areas/activities in each of the participating packhouses.

[3] Bouwer, J.J., 2011, August. Using a benchmarking approach to improve energy efficiency in fruit packhouses and cold stores. In 2011 Proceedings of the 8th Conference on the Industrial and Commercial Use of Energy (pp. 30-33). IEEE.

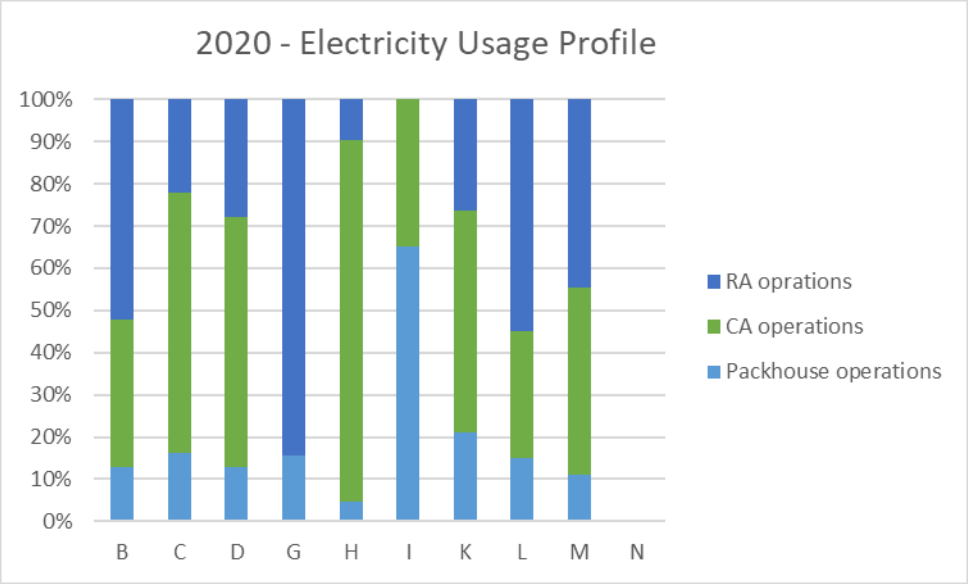

Figure 5: Electricity use profiles

Figure 15 notes:

Packhouse C – Provided accurate data and this profile can be used for comparison.

Table 1 below summarises the quality of the data received from each of the participating packhouses, for each area/activity.

Table 1: Summary of packhouse data quality for the different areas/activities

Packhouse	Packing operations	CA operations	RA operations
A	No data	No data	No data
B	Metered	Estimated	Estimated
C	Metered	Metered	Metered
D	Metered	Estimated	Estimated
G	Metered	N/A	Metered
H	Metered	Estimated	Estimated
I	Estimated - allocation issue	Metered	No data - allocation issue
K	Estimated	Estimated	Estimated
L	Estimated	Estimated	Estimated
M	Metered	Estimated	Estimated
N	Estimated - allocation issue	No data - allocation issue	No data - allocation issue

5.1.1 Variation in electricity use profiles

There are large variances in the electricity use profiles of participating packhouses. This could be attributed to:

- A lack of metering (resulting in estimated data).

- Electricity consumption that is metered, but that cannot be clearly allocated to the specific areas of the packhouse (one meter measuring electricity use for multiple areas).
- Errors in electricity consumption records.
- Different types of energy management practices applied.
- Different CA storage capacities and strategies applied.

6 Electricity cost

Figure 6 below depicts the cost of electricity in Rand per kWh for each packhouse.

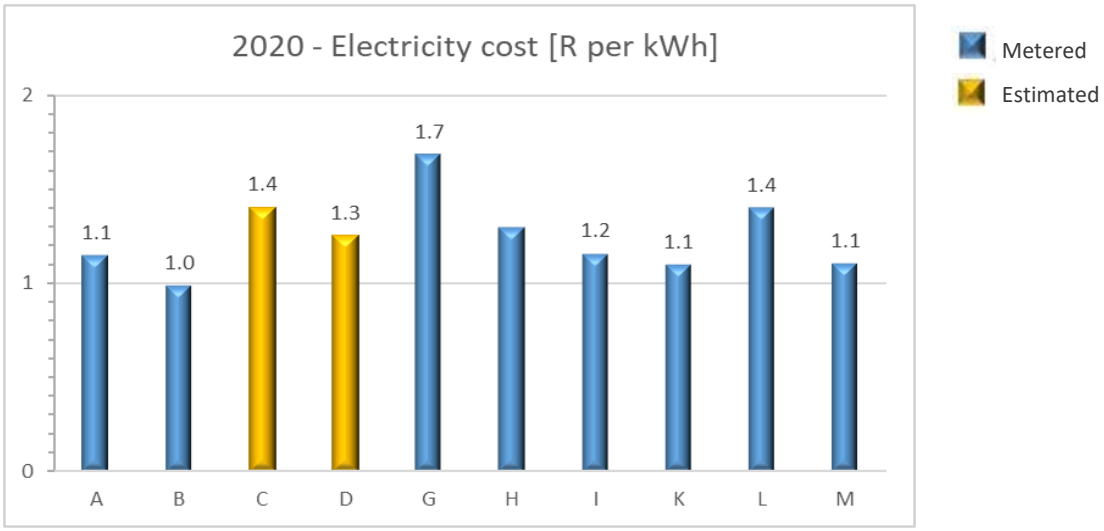

Figure 6: Rand per kWh electricity cost benchmarks

Figure 16 notes:

Table 2 below summarises the source of each packhouse's **total** electricity cost data.

Packhouse C's grid electricity cost was metered, but their renewable electricity cost was estimated and thus this packhouse appears as yellow on the graph.

Table 2: Source of electricity cost data per packhouse

Packhouse	Grid	Renewable
A	Eskom invoice - Megaflex	Bought in at R1/kWh
B	Municipal invoice	Own meter reading
C	Municipal invoice	Estimated
D	Estimated	N/A
G	Own meter reading	N/A
H	Eskom invoice - Ruraflex	N/A
I	Eskom invoice - Ruraflex	Own meter reading
K	Eskom invoice - Ruraflex	N/A
L	Municipal invoice	Municipal invoice
M	Own meter reading	N/A
N	No data	No data

The cost per kWh, ranged from R 1 /kWh to R 1.70 /kWh.

7 Energy Management Practices

Packhouses were asked a series of qualitative questions around energy management practices applied in the different areas of activity in the packhouse. A summary of these results is shown below.

7.1 Pre-sort/packing line

Seven packhouses apply energy management practices in their pre-sort and packing lines.

- One packhouse switches off the majority of their lights during tea and lunch breaks in both the day and night shifts
- One packhouse uses Power Factor Correction.
- Two of the seven packhouses have soft starters installed.
- Three of the seven packhouses have variable speed drives installed in the electronic motors of their pre-sort and packing lines (such as those in the water pumps), which control the frequency of the electric current and thus the speed at which the motors function to save energy.
- One packhouse have Sonoff switches installed to switch any unnecessary lights off.
- One packhouse does not use the machinery in the offseason during peak tariff time phases.
- Three of the seven packhouses make use of LED lights.
- Two packhouses make use of solar energy.

7.2 Refrigeration

Nine packhouses apply energy management practices in their refrigeration plants.

- Five of the nine packhouses have variable speed drives installed in the electronic motors of the compressors and fans in their cold storage.
- Two of the nine packhouses use a Programmable Logic Controller (PLC) program to manage their condensers, which allows only the necessary compressors to operate.
- One packhouse also uses a PLC to control the lights in their CA and RA cold rooms and lights automatically switch off during lunch and tea breaks.
- Two of the nine packhouses make use of LED lights in their cold storage.
- Two of the nine packhouses make use of solar energy in their cold storage.
- One packhouse makes use of Power Factor Correction in its cold storage.
- One packhouse does auto-scheduling based on RURAFLEX peak tariff periods in its cold storage, where the plant switches to lower energy consumption during certain times per day and year
- One packhouse uses maximum demand controllers in their cold storage.
- One packhouse has timer systems installed to manage the fans in the cold rooms, switching them off during peak hours.

- One packhouse set their cold rooms on timers, programmed so they only run when necessary overnight.
- One packhouse has soft starters installed on all their compressors, cooling fans and some of their cooling towers.
- One packhouse uses a SCADA system to manage peak & off-peak periods.

7.3 Ablutions, canteen and offices

Seven packhouses apply energy management practices in their ablutions, canteens and offices.

- One packhouse switches off their hot water boilers at close of business on a Friday and only restarts them again on Mondays.
- Five of the seven packhouses make use of LED lights in their staff facilities.
- Two of the seven packhouses make use of solar energy in their staff facilities.
- Two of the seven packhouses makes use of Power Factor Correction in their staff facilities.
- One packhouse have installed Sonoff switches to switch off any unnecessary lights in their staff facilities.
- One packhouse makes use of motion sensors on their office lights.
- One packhouse applies absolute energy monitoring, with applicable start and stop procedures for optimum energy usage and vacuum breakers in their staff facilities.

7.4 Additional energy saving practices

Four packhouses indicated additional energy management practices applied.

- One packhouse switches off their glue machines over weekends.
- One packhouses changes their forklift batteries to lithium ion, which is more energy efficient and requires less charging.
- One packhouse installed a solar energy system.
- One packhouse replaces their maintenance and redundant equipment with energy efficient motors and some of their houses are fitted with solar geysers.

8 Conclusion

The project provided valuable insights into the energy consumption of pome fruit packhouses and cold stores. The quantitative results can serve as a baseline for pome fruit packhouses to improve their energy consumption in the future, while also providing a guide for improvement targets.

The large variation seen in the benchmark results indicate that there is much room for improvement, with a particular need for metering to be installed and accurate energy consumption record keeping. Differences in energy management practices applied could also explain some of the variances in the benchmarks.

The use of more efficient equipment and the application of good energy management practices can greatly improve energy use efficiency. It is positive to note that the majority of the packhouses who participated in this project already have energy management practices in place in at least some or all areas of packhouse. Determining which of these practices allows for the most efficient energy use can only be done if more accurate electricity use data is collected from more packhouses in future rounds of this project.

The following points are areas of concern:

- A large number of packhouses do not meter the electricity use in specific areas and therefore packhouses do not have an accurate picture of how and where electricity is consumed.
- In some cases, meters are not read, or the readings are not recorded. This results in poor electricity usage history and undermines the value of the data and any management decision based on the data.

It is positive to find that the electricity consumption benchmarks in this study are lower to that found for fruit packhouses previously, showcasing potentially improved energy use efficiency in the pome fruit industry. It would be valuable to conduct this study over several years to establish year on year trends.

9 Recommendations

The following recommendations are made:

- It is crucial to communicate the impact that metering, record keeping, and data issues can have on the benchmark results and to illustrate this with examples. This will be addressed in the close-out sessions with packhouses and during onboarding sessions for future data collection.
- Subsequently, it is key to understand the reasons for metering issues experienced by packhouses. This could be implemented in next rounds of data collection, if the project were to continue.
- Renewable energy financing and other cost data should be considered in future data collection rounds.
- Participating packhouses could be asked for suggestions to improve the data collection tool and processes.
- Annual continuation of this project will allow for year-on-year comparisons to be made.