Packhouse Action Group Water and Energy Project

2021 Energy Benchmark Results

February 2023

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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 (2020 data). This report is the second round of electricity benchmarks (2021 data). The objectives of the second phase were to:

- replicate the electricity use benchmark study undertaken in Phase 1 (2020 data);
- provide a year-on-year comparison of electricity use in the packhouse and cold storage operations;
- 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 2021** and summarises the different energy management methodologies applied at the packhouses.

2 Methodology

Outreach was done to potential new participants via phone call or email, offering the details of the project and a virtual onboarding session if they showed interest in participating. Packhouses that participated in the previous phases of the project were offered a training session in the latest version of the data collection tool if they deemed it necessary.

2.1 Development of the data collection tool

Data was collected via the 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.

Phase 2 followed a similar approach as the previous phase, but included the following updates and changes to the data collection tool:

- Additional data capture fields for generator electricity use and fuel cost.
- Additional data capture fields for renewable energy financing cost.

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 plants, compressors, condensers, fans, cooling towers, etc.)

2.3 Participation

Twenty-one packhouses were contacted, of which nine packhouses provided data.

- Eight of these nine packhouses also participated in phase 1;
- Three more packhouses did not provide data for Phase 2, but showed interest in participating in future data collection rounds.

2.4 Notes on the data

- All data sets refer to the 2021 calendar year (January to December).
- All kWh figures include grid, PV and generator electricity.
- Packhouses are anonymised in the report (named A to M). Packhouse F could only provide data on their total grid electricity consumption. Packhouse K could only provide data on the total energy consumption and cost.
- Caveats apply to some data points and, where applicable, they are acknowledged in this report under "Notes".

- Regarding the figures displayed in section 3, 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 benchmark for electricity consumption by packhouse operations 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 the results of packhouses that provided data are shown in the figure below.

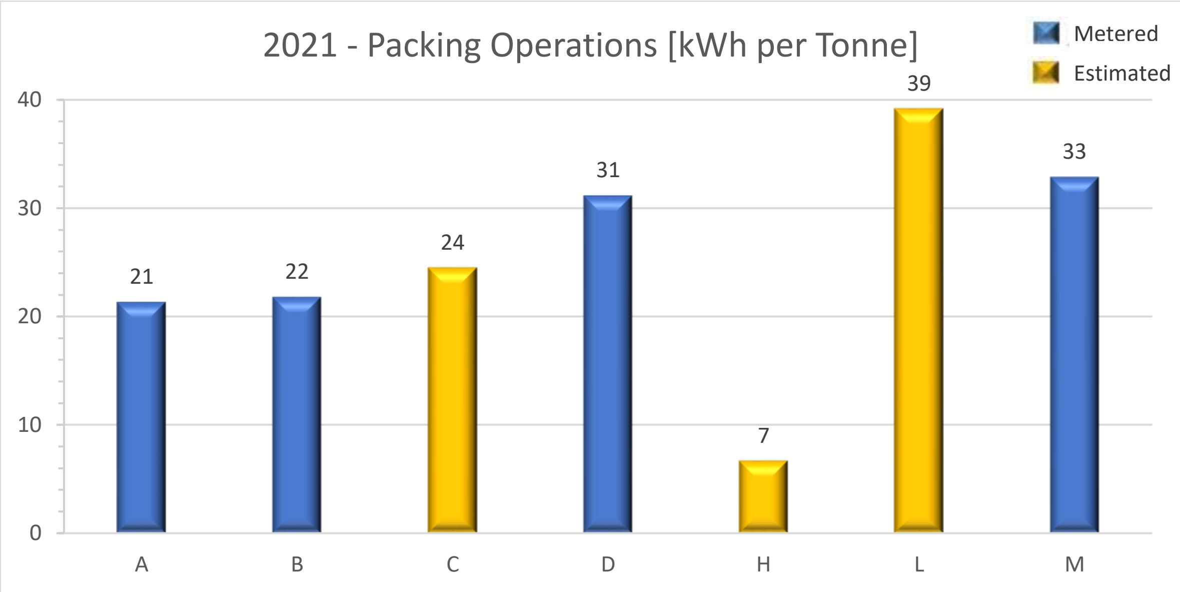

Figure 1: Packhouse operations benchmarks

<u>Figure 1 notes:</u>

Electricity consumption of Packhouse C and L was estimated due to insufficient metering.

Packhouse F & K – The packing operations' electricity use is not recorded and could not be estimated.

Packhouse H – The benchmark is low as the data sense checking is still in progress.

Taking only quality data (metered) into consideration, electricity consumption for packhouse operations ranged from 21-33 kWh per tonne of fruit. This figure aligns with the benchmark of 15-44 kWh/ton found for fruit packhouses (all commodities) in a similar study done by Bouwer (2011)[1].

The variation in packing operations benchmarks may be ascribed to the differences in energy management practices applied by the packhouses as described below.

- Packhouse A switches off the majority of the lights in its packing operations during tea and lunch breaks in both day and night shifts.
- Packhouse B uses energy-efficient motors and LED lighting in its packing operations.
- Packhouse C has low-consumption LED lighting deployed throughout its packing operations, as well as phase-balancing systems to limit unnecessary electricity consumption.
- Packhouse H uses LED lighting in the packhouse, has trained all its workers on being alert about energy saving and it has skylight panels inserted into the roof to let natural light help with energy savings.
- Packhouse M has soft starters and energy-saving lights installed in its packing operations.
- Packhouse D and Packhouse L did not indicate any energy-saving practices in their packing operations.

3.2 CA operations

3.2.1 Calculation

The benchmark for electricity consumption by CA operations 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 only be based on tonnes of fruit stored, as cold storage protocols vary widely from one operation to the next. Some packhouses store pome fruit for short periods (days or weeks), while others 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:

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

[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.

3.2.2 Results

Only the results of packhouses who provided data are shown in the figure below.

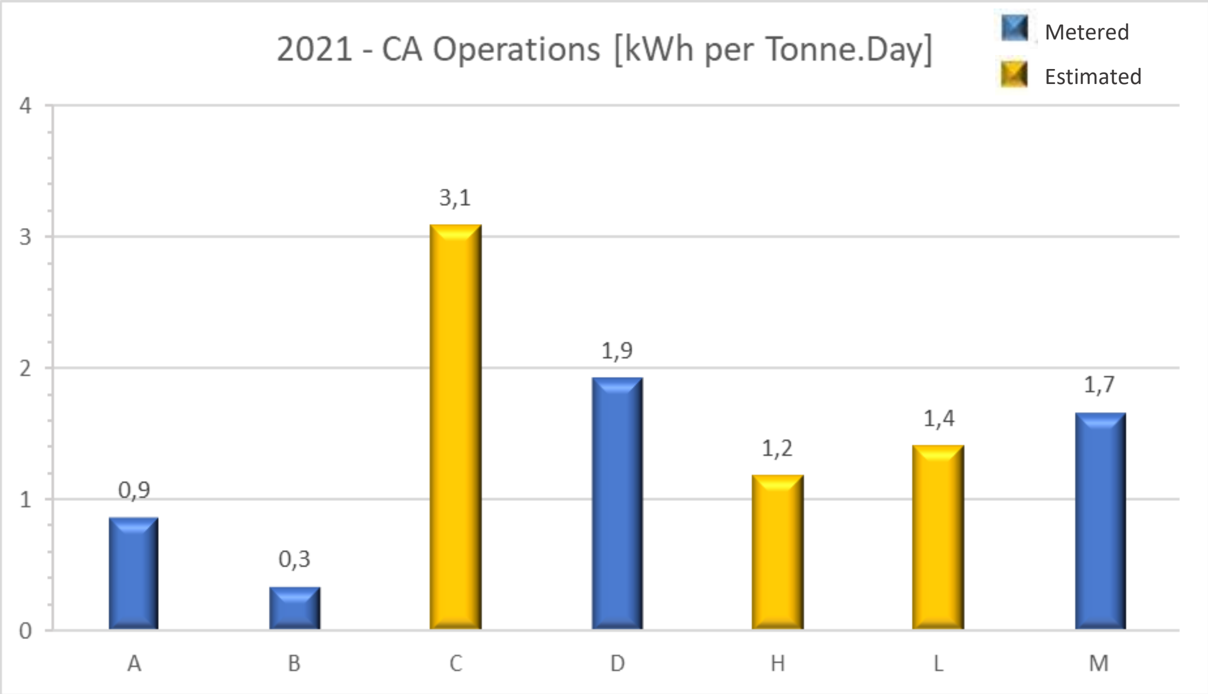

Figure 2: CA operations electricity benchmarks

Figure 2 notes:

Electricity consumption of Packhouses C, H and L was estimated due to insufficient metering.

Packhouse F & K – The CA operations' electricity use is not recorded and could not be estimated.

When only considering metered or accurate data, the CA operations' electricity benchmarks ranged from 0.3 to 1.9 kWh per Tonne.Day. These results align with a similar study by Bouwer[2], where the electricity use benchmark for the CA storage of apples was less than 1 kWh per Tonne.Day.

Packhouse D and Packhouse M used six times as many kilowatt-hours per tonne of fruit in comparison to Packhouse B, while Packhouse A used three times as many kilowatt-hours per tonne of fruit as Packhouse B. These differences may be attributed to different energy management practices applied as described below or due to assumptions made on tonne days that is not calculated from primary data.

- Packhouse A has Variable Speed Drives (VSDs) installed on the majority of their CA and RA fans, and their condensers, fans and cold store lights are controlled by a Programmable Logic Controller (PLC) programme.

[2] https://postharvestinnovation.org.za/wp-content/uploads/2017/06/Energy-well-spent-PHI-Project-2014.pdf

- Packhouse A automatically switches off its lights during every lunch and tea break.
- Packhouse B has solar panels installed for its refrigeration. The solar energy use is included in the cold storage kWh.
- Packhouse C have VSDs installed on all major compressors to limit current surges during start-up.
- Packhouse D's refrigeration plant room does auto-scheduling based on RURAFLEX peak tariff periods, where the plant switches to lower energy consumption during certain times per day and year, as well as energy management on cold stores where the rooms switch off at certain periods during the day.
- Packhouse M manages its underutilised cold rooms by combining them to save energy.

3.3 RA operations

3.3.1 Calculation

The benchmark for electricity consumption by RA operations 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 the results of packhouses who provided data are shown in the figure below.

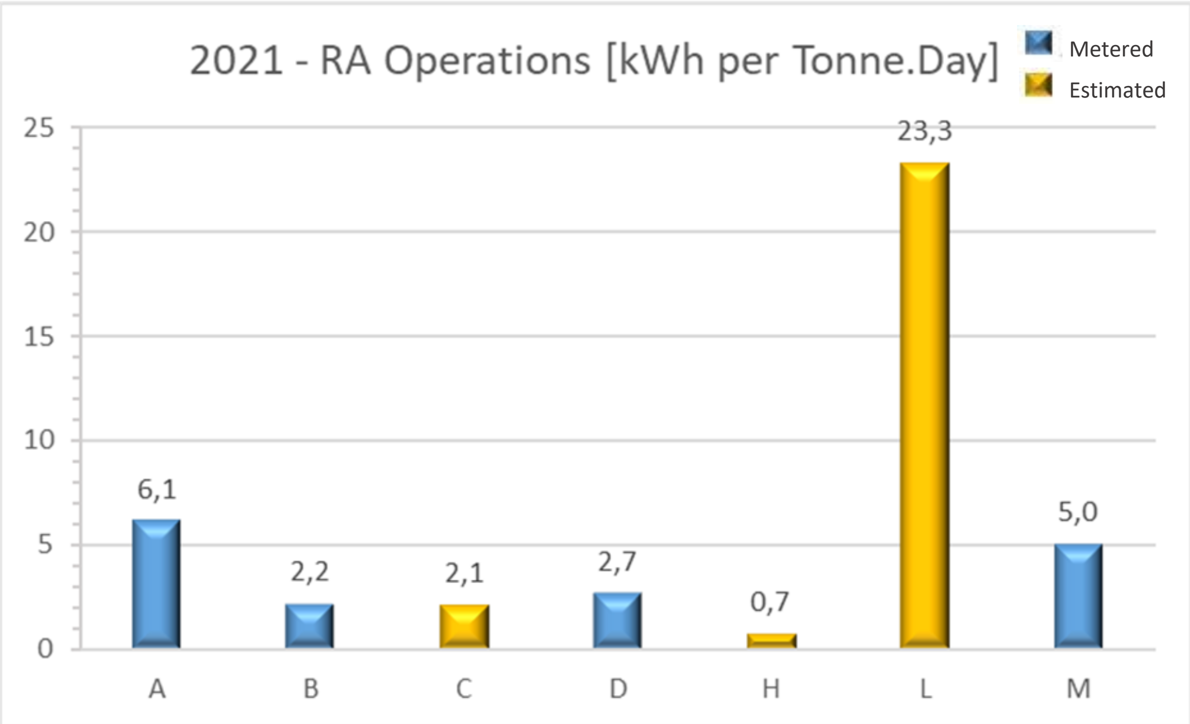

Figure 3: RA operations electricity benchmarks

Figure 3 notes:

Electricity consumption of Packhouses C, H and L was estimated due to insufficient metering.

Packhouse F & K – The RA operations' electricity use is not recorded and could not be estimated.

When only considering quality data (metered), the RA operations electricity benchmark is between 3.0 and 6.1 kWh per Tonne.Day. This figure is lower than the electricity benchmark of 8 kWh found for apples in a similar study by Bouwer[2].

The variation in RA operation benchmarks can also be ascribed to the different energy management practices applied by the packhouses as described in section 3.2.2.

4 Overall Packhouse electricity consumption index

The overall index for each packhouse incorporates electricity use for all sections of the packhouse, excluding electricity consumption allocated as "other". This is treated as an index rather than a benchmark as cold storage protocols vary widely from one operation to the next, which affects the overall packhouse results. Some packhouses store pome fruit for short periods (days or weeks), while others store fruit for long periods (several months to almost a year). The unit of measure for this index is kilowatt-hour per tonne of pome fruit packed. The indexes for January to December 2021 are presented in Figure 4.

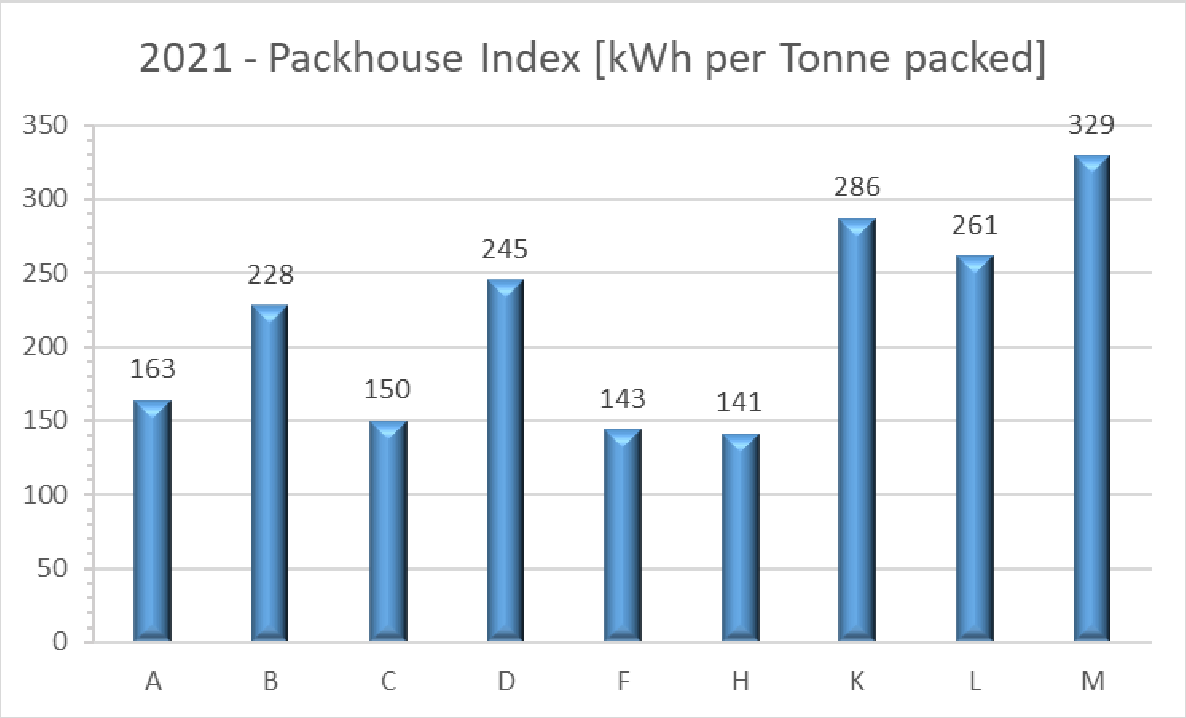

Figure 4: Overall packhouse energy use indexes

The large variation in the overall electricity indexes could 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. It could also be that some packhouses are storing their fruit for longer periods of time than others. The majority of packhouses consumed 150 - 250 kWh electricity per tonne of fruit packed in 2021.

5 Electricity sources

The sources of electricity that contribute to the total kWh per packhouse is displayed in Figure 5. More than 80% of the electricity used in the packhouses is supplied by the grid (e.g. Eskom). It is positive to note that five of the packhouses also make use of solar (PV) energy to supply part of their electricity.

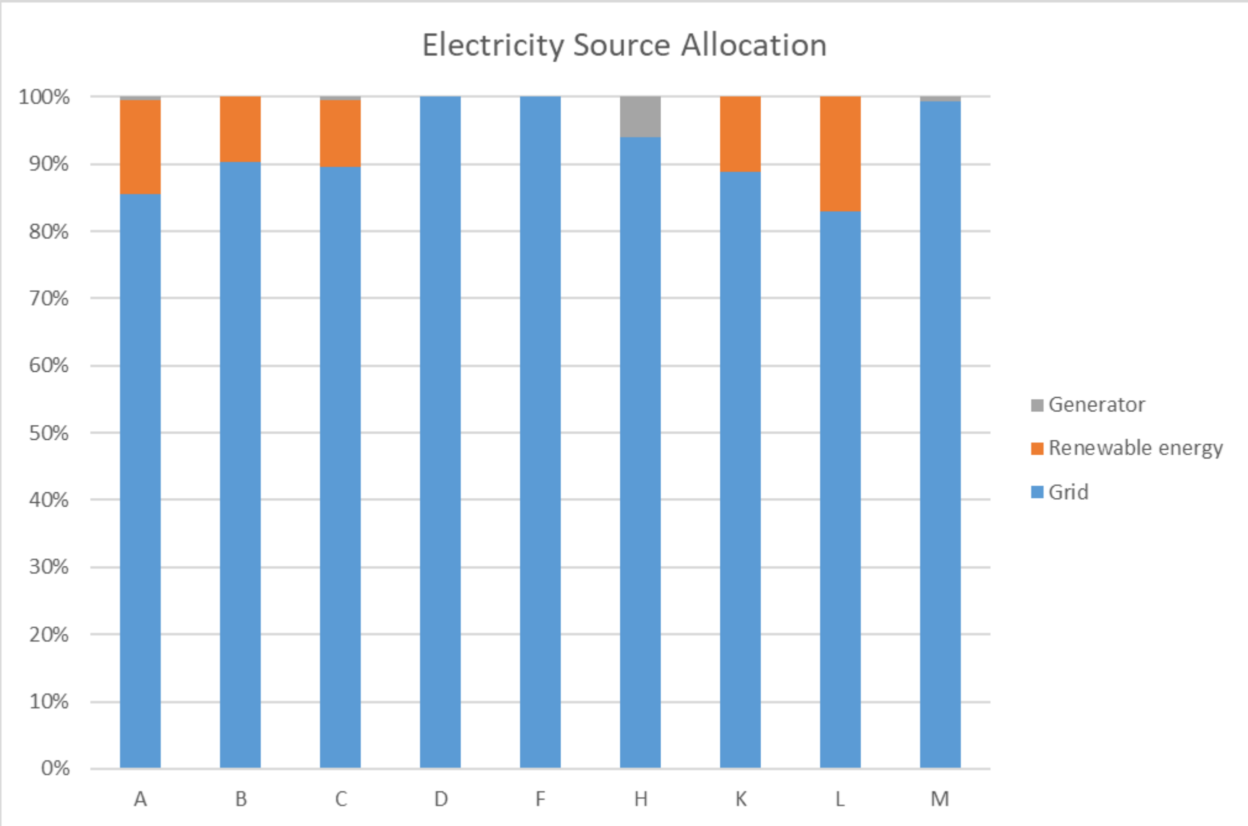

Figure 5: Electricity sources per packhouse

6 Electricity usage profile

It is useful to compare the electricity use profiles of different packhouses. Figure 6 below displays the percentage of electricity consumed for different areas/activities in each of the participating packhouses, excluding electricity use allocated as "other".

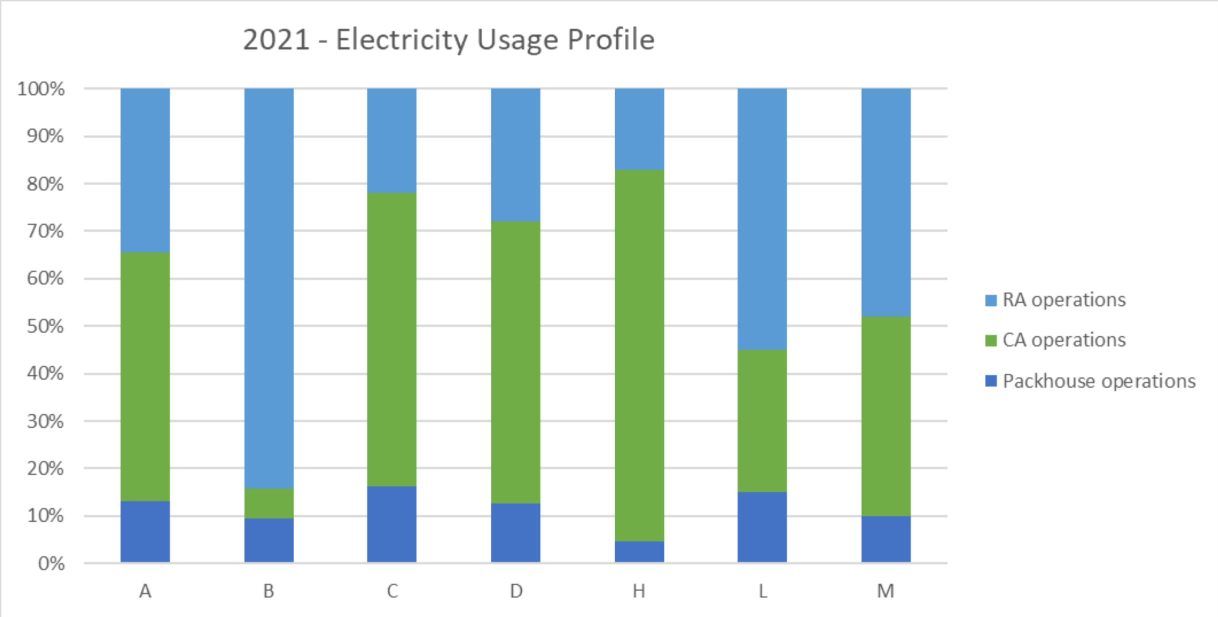

Figure 6: Electricity use profiles of the packhouses

<u>Figure 6 notes:</u>

Packhouses A, B, D and M provided accurate data and these profiles can be used for comparison.

Packhouse B – This packhouses has more RA cold rooms than CA cold rooms.

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	Metered	Metered	Metered
B	Metered	Metered	Metered
C	Estimated	Estimated	Estimated
D	Metered	Metered	Metered
E	Did not participate in Phase 2		
F	No data	No data	No data
G	Did not participate in Phase 2		
H	Metered	Estimated	Estimated
I	Did not participate in Phase 2		
J	Did not participate in Phase 2		
K	No data	No data	No data
L	Estimated	Estimated	Estimated
M	Metered	Metered	Metered
N	Did not participate in Phase 2		

6.1 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/activities).
- Errors in electricity consumption records.
- The application of different types of energy management practices.
- The application of different CA storage capacities and strategies.

7 Electricity cost

Figure 7 below depicts the total cost of electricity in Rand per kWh for each packhouse.

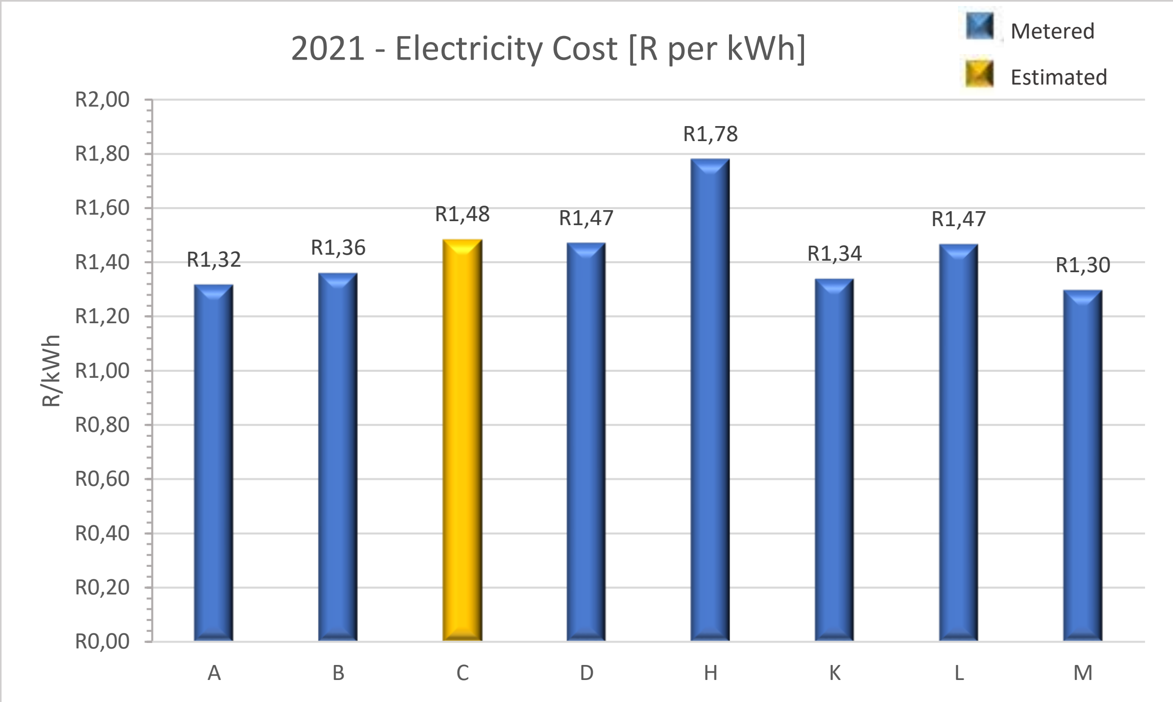

Figure 7: Rand per kWh electricity cost benchmarks

Packhouse C's grid electricity cost was metered, but its renewable electricity cost was estimated and therefore this packhouse appears as yellow in the graph above.

Figure 8 below depicts the costs in Rand per kWh for the electricity sources that supply each packhouse. Renewable electricity, which only consisted of PV, had the lowest cost and generator electricity had the highest cost. Generators are increasingly relied upon as an alternative electricity source due to the increased levels of load shedding in South Africa and this adds significantly to electricity costs. It is therefore recommended that packhouses further explore renewable energy and battery solutions to offset load shedding and achieve cost savings in the long term despite the high initial investment required.

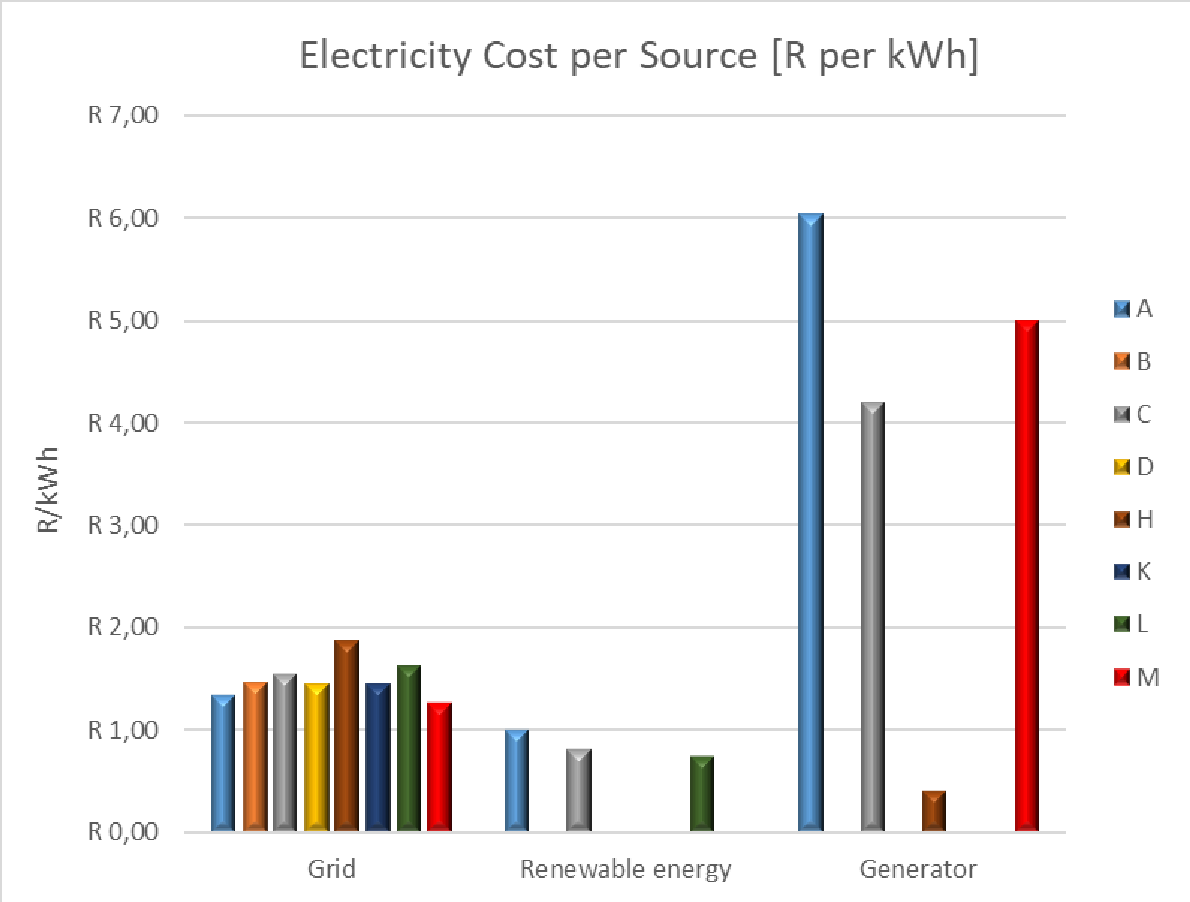

Figure 8: Cost per electricity source for each packhouse

Table 2 below summarises the quality (metered or estimated) of the cost data (Rands) per electricity source supplying each packhouse.

Table 2: Quality of cost data (Rands) per electricity source supplied by each packhouse

Packhouse	Grid	Renewable	Generator	Financing of renewable energy
A	Eskom invoice - Megaflex	Own meter reading	Own meter reading	N/A
B	Municipal invoice	N/A	Municipal invoice	N/A
C	Estimate	Estimate	Estimate	Estimate
D	Own meter reading	N/A	Own meter reading	N/A
E	Did not participate in Phase 2			
F	No data			
G	Did not participate in Phase 2			
H	Municipal invoice	N/A	Own meter reading	N/A
I	Did not participate in Phase 2			
J	Did not participate in Phase 2			
K	Eskom invoice - Ruraflex	N/A	Own meter reading	Own meter reading
L	Municipal invoice	Own meter reading	N/A	N/A
M	Eskom invoice - Ruraflex	N/A	Own meter reading	N/A
N	Did not participate in Phase 2			

The grid electricity cost per kWh for 2021 ranged from R 1.30/kWh to R 1.80/kWh; an increase from the 2020 benchmark of R 1.00/kWh to R1.70/kWh. The higher cost per kWh for 2021 can mostly be attributed to the 15% tariff increase issued by Eskom in 2021[3].

[3] https://www.eskom.co.za/distribution/wp-content/uploads/2022/04/Tariff-Booklet-final.pdf

8 Year-on-Year Energy Comparison

Only packhouses who participated in both Phase 1 and Phase 2 are shown on the figures below.

The energy consumption per ton of fruit packed of 2021 showed a decrease for all areas of activity since 2020 for the majority of the packhouses. It is encouraging to see a reduction in energy consumption benchmarks, and another year's benchmarking would confirm if this is a trend.

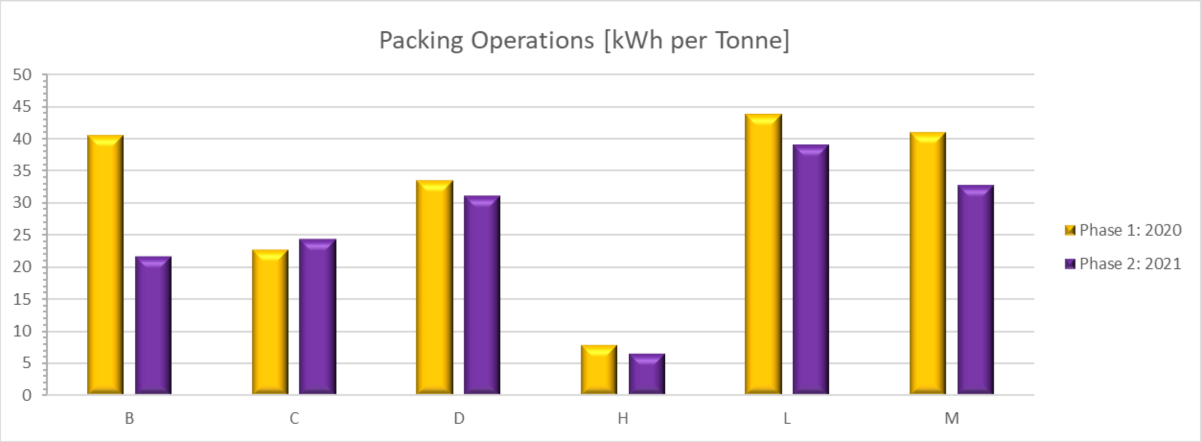

Figure 9: Year on year comparison of packhouse operation benchmarks

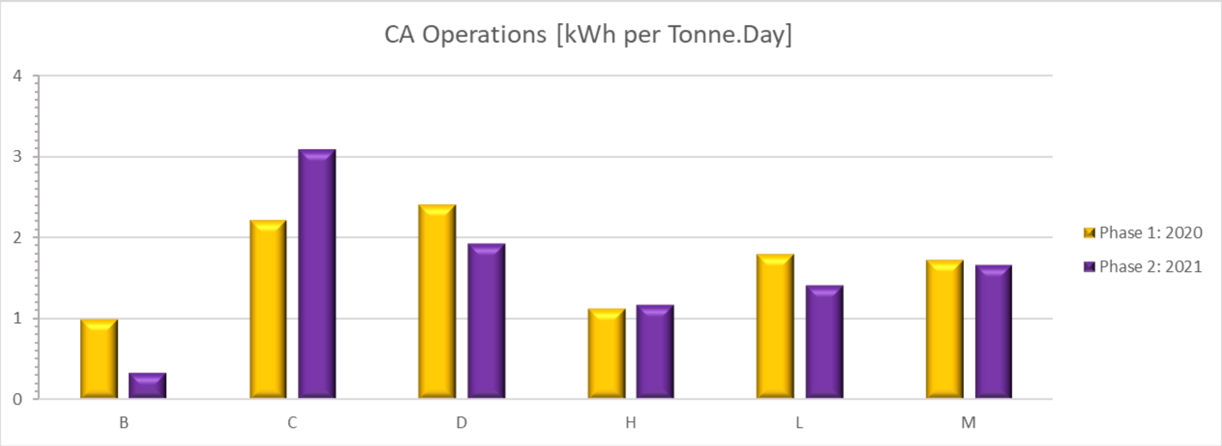

Figure 10: Year on year comparison of CA operation benchmarks

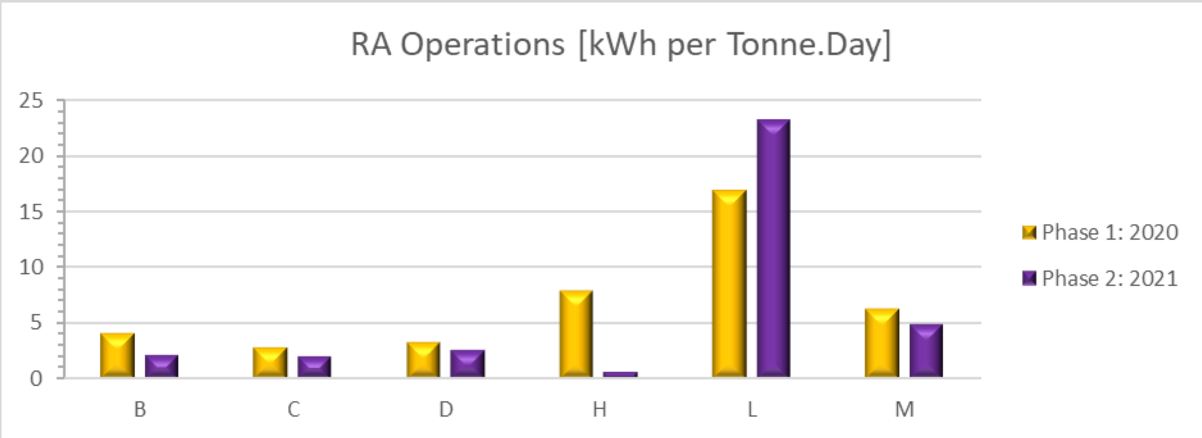

Figure 11: Year on year comparison of RA operation benchmarks

The overall packhouse index results (Figure 12) shows that all the packhouses besides Packhouse C showed a decrease in kWh per tonne of pome fruit packed since 2020.

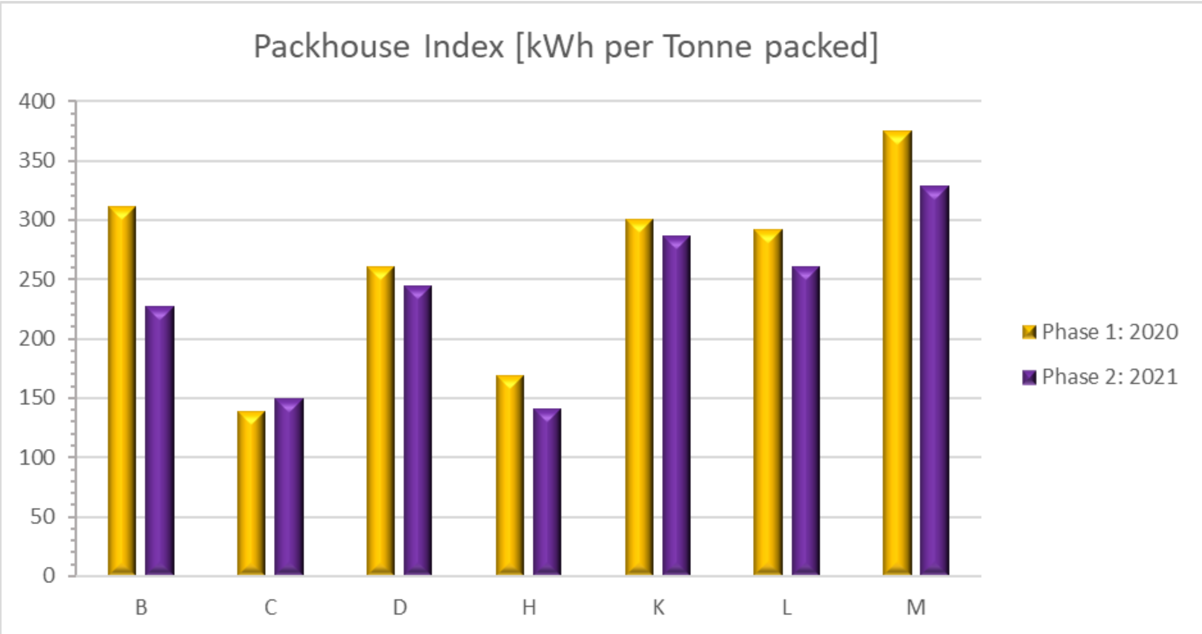

Figure 12: Year-on-year comparison of overall packhouse energy use indexes

9 Energy Management Practices

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

9.1 Pre-sort/packing line

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

- One packhouse switches off the majority of its lights during tea and lunch breaks on both the day and night shifts. Besides saving electricity, it raises awareness and reinforces a culture of efficient resource use.
- Three of the six packhouses have LED lights installed.
- One of the six packhouses also uses phase balancing systems to limit unnecessary energy consumption.
- One of the six packhouses also makes use of Variable Speed Drives (VSD) and has PLCs installed in its packing operations. A VSD is an electronic control instrument that manipulates the frequency of the electrical current and in so doing speeds up or slows down an electrical motor. VSDs save electricity and have an attractive payback period.
- Two of the six packhouses have soft starters installed.

9.2 Refrigeration

Seven packhouses apply energy management practices in their refrigeration plants.

- Three of the five packhouses have VSD motors installed on compressors and fans in their cold storage, and two of these use a PLC program to manage their condensers, which allows only the necessary compressors to operate.
- One of the above packhouses also uses a SCADA system for the semi-automatic control of its refrigeration, have soft starters installed on all its condensers and use the high pressure generated from compressors for the pumping of cooling liquid by its pumper drum system.
- One of the five packhouses makes use of solar energy for its cold storage.
- One packhouse's refrigeration plant room does auto-scheduling based on RURAFLEX peak tariff periods, where the plant switches to lower energy consumption during certain times per day and year, as well as energy management on cold stores where the rooms switch off at certain periods during the day.
- One of the five packhouses uses a SCADA system to manage energy use during peak and off-peak periods.
- One of the five packhouses has high-speed doors installed on all their RA rooms. High-speed doors reduce energy losses by reducing the time an opening between cold rooms is exposed to direct airflow and hereby minimizing heat lost from the premises or gained from outside.
- The above packhouse also manages its poorly utilized cold rooms by combining them.

9.3 Ablutions, canteens and offices

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

- One packhouse switches off its hot water boilers at the close of business on a Friday and only restarts them again on Mondays.
- Two of the seven packhouses make use of LED lights in their staff facilities.
- One packhouse makes use of motion sensors on its office lights.

9.4 Additional energy-saving practices

Five packhouses indicated additional energy management practices applied.

- One packhouse switches off its glue machines over weekends.
- One packhouse uses 500 kVA solar panels to supply its packhouses and cooling facilities with electricity. They are busy with a project to expand their solar capabilities.
- One packhouse has changed the batteries in their forklifts to lithium-ion, which is more energy efficient.
- One packhouse trained all its workers on being energy-saving alert. They switch off any unnecessary lights in the packhouse and have skylight roof panels installed to let natural light help with energy savings.
- One packhouse has Power Factor Correction on its main electrical supply and a 1-megawatt solar installation in line with its electricity grid. This packhouse makes use of absolute energy monitoring in line with applicable start and stop procedures for optimum energy use. It has energy-sufficient motors and LED lighting with replacement maintenance and CAPEX installations implemented. Furthermore, this packhouse has solar power production while a backup generator is running during load shedding and power failures.
- One packhouse switches its plant room off whenever possible.

10 Conclusion

Seven of the packhouses that participated in Phase 1 returned to participate in Phase 2. This is encouraging as it indicates that the packhouses find the process valuable. If the number of participating packhouses increases in future rounds, the value of these benchmarks will also increase.

The project continues to provide 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 collection of generator electricity use, as well as generator fuel and renewable energy financing costs, has proven valuable in ensuring that participants can more accurately allocate their data and thus, the electricity use and costs benchmarks can be more accurately calculated.

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 areas of the packhouse and that some packhouses are even looking to expand their solar energy capability.

The following points are areas of concern:

- There are still some packhouses that do not meter the electricity use in specific areas and therefore they 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 a 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 energy consumption appears to be decreasing with time in the packhouses and it would be valuable to conduct this study over several more years to confirm the year-on-year trends.

11 Recommendations

The following recommendations are made:

- It is key to understand the reasons for metering issues experienced by packhouses. This data could be collected in the next rounds of data collection.
- Ask participating packhouses for further suggestions to improve the data collection tool and processes.
- Continue collecting annual data to confirm the downward energy consumption trend.
- Where possible, collect cost and kWh savings achieved information for energy management practices applied.
- Collect more detail on how renewable energy cost is determined (e.g. interest related to financing, capital repaid, repairs and maintenance etc.).