# 2024 Energy Usage Report – Phase 5

Client: Hortgro - Packhouse Action Group

11 March 2026

BLUE NORTH

THINKING. FUTURE

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## List of Abbreviations

| | |
|---|---|
| CA: | Controlled Atmosphere |
| CAPEX: | Capital Expenditure |
| GWh: | Gigawatt-hours |
| kWh: | Kilowatt-hours |
| LED: | Light-Emitting Diode |
| OPEX: | Operational Expenditure |
| PLC: | Programmable Logic Controller |
| PPA: | Power Purchase Agreement |
| RA: | Regulated Atmosphere |
| VSD: | Variable Speed Drive |

## Definitions

**Energy use intensity (EUI):** This metric reflects how much energy is used to produce one output unit e.g., a unit of economic output (Gross Domestic Product) or a specific product or service. For instance, in the fruit industry, this is typically expressed as the number of kilowatt-hours required to pack one tonne of fruit. A lower EUI indicates that less energy is required to produce that output. EUI encompasses all forms of energy, including electricity, fossil fuels, and renewable sources.

**Electricity use intensity:** This metric focuses solely on the amount of electricity used to produce one output unit. It's a more specialised measure, highlighting the specific role of electricity in production output.

**Energy Consumption:** This refers to the overall use of energy resources (including fuels like diesel, natural gas, and even electricity itself) required to power a process.

**Electricity Consumption:** This specifically refers to the amount of electrical energy used to power devices or equipment. It focuses on the final form of energy, which is electricity.

# Executive Summary

The Packhouse Action Group (PAG) electricity benchmarking project was established to quantify operational efficiency and identify best practices for energy management within the Western Cape of South Africa's pome fruit sector The 2024 reporting cycle demonstrates a strategic shift toward energy resilience and cost optimisation, as evidenced by a growth in renewable energy integration among participants.

The results from the 2024 project indicate that the participating packhouses with metered data (A and B) operated at an average electricity intensity of approximately 243vkWh per tonne packed. While Packhouses A and B provided fully metered data for the calculation of average electricity intensity, figures for the remaining participants rely on estimated allocations. Therefore, Packhouses A and B should be used as the primary benchmarks for comparison in terms of energy use intensity, as comparisons against the estimated figures in this report may lack the necessary precision and should be approached with caution. Packhouse S (71 kWh/tonne) and Packhouse G (77 kWh/tonne) recorded the lowest intensities, suggesting that performance well below the 100 kWh/tonne threshold may be attainable. However, because the intensities for Packhouses S and G were calculated based on estimated allocations, these figures should be treated as preliminary. Multiple years of accurately metered data are required to confirm these trends and establish them as reliable benchmarks. Concurrent with these results, the project observed a substantial shift in energy sourcing, with renewable energy contributing 20% to the total group energy mix, a notable increase since the project's inception in 2020 when it was 7%.

The 2024 financial analysis underscores a significant disparity in operating costs among the participating packhouses, driven largely by their energy mix. Regarding resilience, while the necessity for generator usage declined due to alleviated load shedding, diesel generation remained the costliest energy source, peaking at R28.99 per kWh for Packhouse H. Consequently, previous participants who maximised renewable energy consumption were able to significantly lower their total electricity cost rate per kWh, effectively shielding themselves from the high-cost liability of generator fuel and grid tariffs.

To maintain competitiveness in a high-cost environment, Blue North recommends a strategic focus on data integrity and cost-effective optimisation. With 11 out of 13 participants currently relying on estimated data, the immediate priority is transitioning to sub-metering across all energy-intensive operations, including refrigeration plants and packing lines, to eliminate allocation uncertainty. Once a reliable baseline is established, packhouses should target long-term cost reductions by optimising renewable energy infrastructure. Finally, regarding thermal efficiency, management should prioritise low hanging fruits such as the rigorous inspection of existing door seals and enforcing strict door-management protocols to reduce infiltration loads, before commissioning capital-intensive thermal integrity audits or infrastructure upgrades.

# 1. Introduction:

In 2021, Blue North Sustainability (Pty) Ltd. (Blue North) was commissioned by the Packhouse Action Group (PAG) to initiate a comprehensive study on electricity consumption within the Western Cape's pome fruit packhouse and cold storage operations. What began as an analysis of 2020 data (Phase 1) has now evolved into a critical longitudinal study, with subsequent phases reflecting efficiency and performance of packhouses.

This report marks the fifth phase of the project, presenting electricity use results for the 2024 calendar year. It builds upon the findings of the 2023 report (Phase 4), which documented a shifting energy landscape characterised by rising costs and a dramatic increase in load-shedding intensity.

**Project Objectives**

The core objectives of this phase remain consistent with our commitment to supporting a drive towards energy efficiency in the industry:

- **Longitudinal Benchmarking:** Replicate the electricity use studies of previous years to identify long-term trends.
- **Intensity Comparisons:** Conduct year-on-year electricity use intensity (EUI) comparisons for both packhouse and cold storage (CA and RA) operations.
- **Financial Analysis:** Collect and analyse data regarding energy costs and the diverse sources of electricity, including grid, renewable, and generator power.
- **Best Practice Identification:** Summarise categorised data on energy management and saving practices implemented across participating packhouses.
- **Data Optimisation:** Continue to simplify and validate data collection methods to improve the accuracy of industry benchmarks.

**Context and Progress**

This report presents the 2024 (January to December) findings while drawing direct comparisons to the results of the previous four phases. As the South African energy crisis intensified through 2023, reaching record levels of power outages, the industry has seen a strategic shift toward renewable energy and battery storage sources to enhance operational resilience. By analysing the latest data from both returning and new participants, this report provides the foundation for informed management decisions and a maturing commitment to efficiency within the pome fruit sector.

# 2. Methodology:

The methodology for this phase (Phase 5) remains consistent with the rigorous approach established in previous years to ensure data comparability and integrity. The study focuses on quantifying electricity consumption and costs across specific functional areas of pome fruit operations.

## 2.1 Development of the Data Collection Tool

Data was collected using the established Excel-based collection tool. The Phase 5 tool incorporated refinements to support the evolving needs of the project:

- **Historical Data Integration**: 2023 data was pre-populated where available to reduce entry errors and support immediate data validation.
- **Electricity Management Quantification**: The electricity management section was upgraded to transition from general practice descriptions to measurable data points. The tool now utilizes conditional logic; when a packhouse selects a specific energy-saving technology additional fields are triggered to capture the estimated energy reduction (kWh).

## 2.2 Participation

Previous participants were re-engaged, and outreach done to packhouses not yet part of the project via phone call, email and WhatsApp. A total of 36 of packhouses were contacted about participating in Phase 5. Out of the total contacted, 11 packhouses returned to participate and two new packhouses joined. The primary reasons for packhouse non-participation include a limited capacity for data collection, a lack of sufficient record-keeping, such as the absence of metering or sub-metering, and constrained time and human resources for data capturing.

## 2.3 Data Collection and Validation

Electricity consumption, cost, and source data were collected through a standardised data collection tool. To ensure high data quality, the following steps were taken:

- **New participant onboarding:** New participants received training to ensure they understood the data collection tool functionality and the data requirements.

- **Data collection tool sharing:** The data collection tools were shared with each participating packhouse via email. Each packhouse would then capture their respective data into the data collection tool.

- **Sense Checking:** The project team evaluated the submitted data to identify and rectify anomalies or inconsistencies. 2023 data was pre-populated in the data collection tool where available to reduce entry errors and support immediate data validation.

- **Data Validation:** Historical data from previous phases and ongoing participants were used to support year-on-year validation and analysis.
- **Cost Accuracy:** Specific data fields were utilised to capture renewable energy installation details and operational expenditure (OPEX) for cost-per-kWh calculations.

## 2.4 Scope of Data Collection

To provide granular insights, energy use was investigated across three distinct areas within pome fruit packhouses:

1. **Packhouse Operations:** This encompasses all electricity used for pre-sorting, packing lines, ablutions, canteens, and administrative offices.
2. **Controlled Atmosphere (CA) Operations:** This includes electricity dedicated to CA storage, including refrigeration plants, compressors, condensers, fans, and cooling towers.
3. **Regular Atmosphere (RA) Operations:** This covers electricity for RA cold storage, including refrigeration plants, compressors, condensers, fans, and cooling towers.

## 2.5 Key Metrics

The primary metric used to evaluate efficiency is Electricity Use Intensity (EUI). This is defined as:

- **Packing EUI:** Kilowatt-hours (kWh) used per tonne of fruit packed.
- **Cold Storage EUI:** Kilowatt-hours (kWh) used per "tonne.days"[1] of storage.

## 2.6 Data Quality and Anonymisation

As per the convention of previous phases, all packhouse data is anonymised. The reliability of the 2024 energy intensity metrics is directly linked to the method of data collection at each facility. Data is categorised into three levels of quality: 1) Metered (high confidence via sub-metering), 2) Estimated (calculated based on technical specifications or management allocations), and 3) No data (unallocated or missing, however we could still calculate the packhouse's total EUI and electricity management practices). For the anonymised participants of this phase, Table 1 presents the data quality at each of their operations.

[1] **Note on tonne.days:** This unit accounts for both the volume of fruit and the duration it is stored, allowing for a fair comparison between packhouses with different storage protocols.

*Table 1: Data Quality*

| Packhouse | Packing operations | CA operations | RA operations | Previously Participated |
|---|---|---|---|---|
| A | Metered | Metered | Metered | Yes |
| B | Metered | Metered | Metered | Yes |
| C | Estimated | Estimated | Estimated | Yes |
| F | No Data | No Data | No Data | Yes |
| G | Estimated | No Data | Estimated | Yes |
| H | Estimated | Estimated | No Data | Yes |
| K | Estimated | Estimated | Estimated | Yes |
| L | Estimated | Estimated | Estimated | Yes |
| M | Estimated | Estimated | Estimated | Yes |
| P | Metered | No Data | No Data | Yes |
| Q | No Data | No Data | No Data | Yes |
| R | Estimated | Estimated | Estimated | No |
| S | Estimated | No Data | Estimated | No |

# 3. Electricity Use Intensity Results

This section presents the electricity use intensity results for each packhouse operation.

## 3.1 Packing Operations

The energy efficiency of packing lines remains a core benchmark for operational success, representing the electrical load required to move fruit through all packing stages. For 2024, we continue to utilise 'kWh per tonne' as the primary metric to normalise energy use against varying production volumes.

### 3.1.1 Calculations

The metric for electricity consumption by packing operations is expressed in kilowatt-hours (kWh) per tonne of fruit packed (tonnes). It is calculated by dividing the total electricity consumed by the packing line infrastructure, including pre-sorting machinery, sizing equipment, and associated administrative support, by the total volume of pome successfully packed during the 2024 calendar year.

$$\frac{Packing\ Operations\ Electricity\ (kWh)}{Pome\ Fruit\ Packed\ (Tonnes)}$$

### 3.1.2 Results

Figure 2 below illustrates the packing EUI results for this phase.

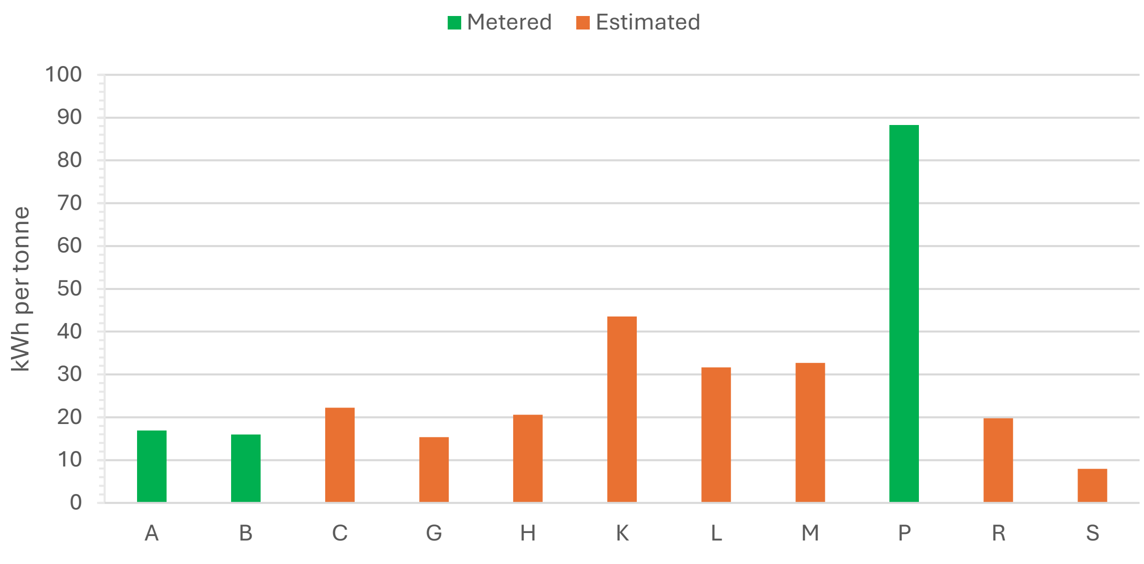


*Figure 2: Packing Operations Electricity Use Intensity results [Total kWh per tonne packed] for phase 5's participants.*

When focusing exclusively on packhouses with verified metered data, the benchmark range for packing operations has narrowed significantly to 16–17 kWh/tonne, from 12-114 kWh/tonne in the previous phase. Packhouse A achieved an especially impressively low intensity of 16.36 kWh/tonne, a marked improvement from previous cycles (22 kWh/tonne), while Packhouse B reported a slightly higher intensity of 17.72 kWh/tonne compared to 12 kWh/tonne in 2023.

Among participants relying on estimated allocations, Packhouse S, a new packhouse to the study, reported the lowest intensity at 7.99 kWh/tonne. However, given that this figure is derived from estimates rather than sub-metering, it should be viewed as an indicative target rather than a confirmed industry baseline.

Packhouse P reported a reduction in intensity to 88.22 kWh/tonne (down from 114 kWh/tonne in 2023). While this 22.6% decrease is positive, the intensity remains disproportionately high compared to the group average. This persistence suggests that the underlying data allocation issue identified in Phase 4, where electricity consumption covers all fruit commodities packed while production tonnes only reflect pome fruit, may still be present. This necessitates further validation to isolate the specific pome fruit electricity load. Meanwhile, the mid-tier group (K, L, and M) remains stable in the 30–45 kWh/tonne range (similarly to the previous phase), representing a clear opportunity for future efficiency interventions.

## 3.2 Cold Storage Operations

Cold storage remains the most energy-intensive component of packhouse operations, driving the majority of electricity demand. For 2024, 'kWh per tonne.day' is again used as the primary metric, which normalises energy use by accounting for both fruit volume and storage duration.

### 3.2.1 Calculation

The metric is calculated by dividing the specific electricity consumption of the storage operations by the total "tonne.days".

This section presents a "Combined Cold Storage" analysis (aggregating CA and RA operational data). This approach is necessary to benchmark packhouses that do not currently possess the sub-metering infrastructure required to distinguish between their CA and RA electricity loads.

$$\frac{Cold\ (CA\ +\ RA)\ Storage\ Operations\ Electricity\ \ (kWh)}{Cold\ (CA\ +\ RA)\ Storage\ \ (Tonne.Days)}$$

### 3.2.2 Results

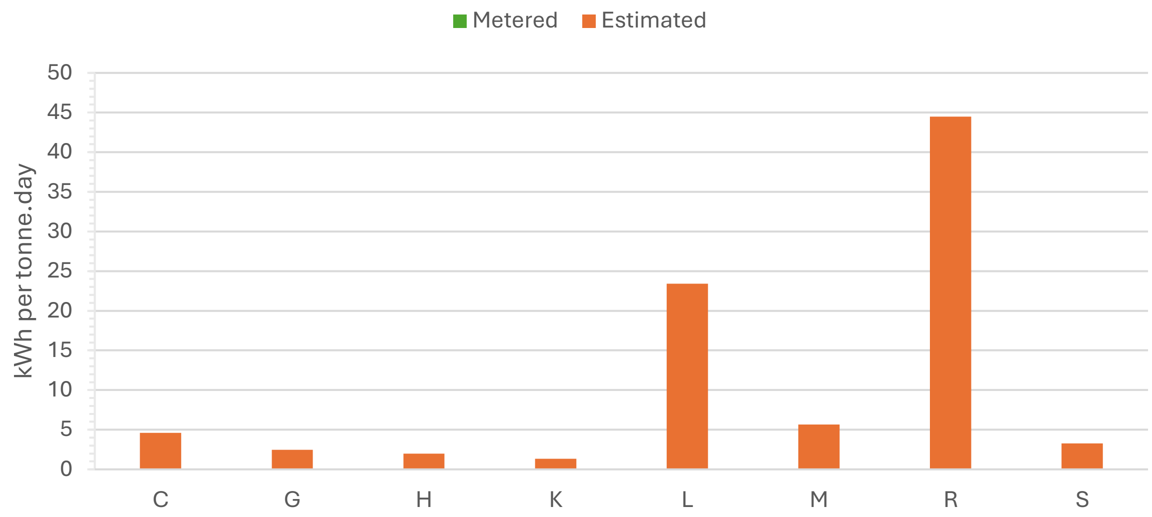


*Figure 3: Cold Storage (CA + RA) Electricity Use Intensity [CA + RA kWh per tonne packed] for phase 5's participants.*

The data displays wide fluctuations. Packhouse K (1.35) and Packhouse H (1.98) indicate potential high efficiency, while extreme outliers such as Packhouse R (44.48) and Packhouse L (23.40) likely reflect data allocation errors or extremely short storage cycles (low tonne.days) that skew the intensity metric.

### 3.2.3 Key Observations

- **Data Gaps:** The invalid results for Packhouses F, P, and Q highlight the critical need for accurate storage logs; without tracking "storage days," electricity data cannot be effectively benchmarked.
- **Sub-metering for Cold Storage:** Current data provides a broad indication of energy usage in CA and RA facilities; we recommend the installation of dedicated meters for these cooling types. This will allow management to isolate "problem areas".

## 3.3 Controlled Atmosphere (CA) Operations

Controlled Atmosphere (CA) storage is a specialised refrigeration process that manages oxygen and carbon dioxide levels to extend the shelf life of pome fruit. This section isolates the electricity intensity of CA-specific infrastructure. Only Packhouse A and B could provide accurately metered data for CA Operations.

### 3.3.1 Calculation

The metric for CA operations is expressed in "kWh per tonne.days". This is calculated by dividing the electricity consumption dedicated to CA rooms by the total "tonne.days" of fruit held under CA protocols.

$$\frac{CA\ Operations\ Electricity\ \ (kWh)}{CA\ Operations\ \ (Tonne.Days)}$$

### 3.3.2 Results

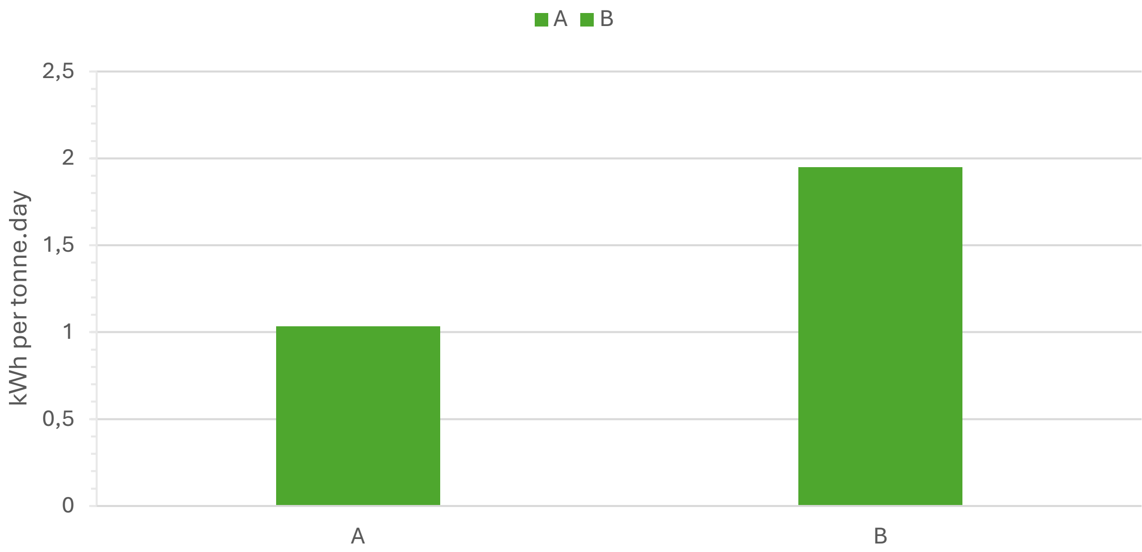


*Figure 4: CA Operations Electricity Use Intensity [CA kWh per tonne.day] for phase 5's participants.*

The 2024 results provide a clearer picture of operational efficiency thanks to the expansion of verified data points. Focusing exclusively on packhouses with metered electricity data, the industry benchmark for Controlled Atmosphere (CA) storage has established a verifiable performance range of 1.0 to 2.0 kWh/tonne.day.

Although a slight increase since 2023 (0.7 kWh/Tonne.day), Packhouse A continues to lead the metered group with an CA energy use intensity of 1.03 kWh/tonne.day, aligning closely with that from a similar study by by Bouwer[2], where the electricity use benchmark for the CA storage of apples was less than 1 kWh per Tonne.Day. A significant development in this cycle is the inclusion of metered data from Packhouse B, which reported an intensity of 1.94 kWh/tonne.day.

### 3.3.3 Key Observations

- **Benchmark Alignment:** The metered results from Packhouses A and B confirm that modern CA facilities can realistically operate within the 1.0 – 2.0 kWh/tonne.day range.
- **Technological Drivers:** Packhouses achieving lower intensities typically utilise Variable Speed Drives (VSDs) on fans and compressors to optimise energy use during the long-term maintenance phase of CA storage.

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

- **Efficiency Opportunities:** Through improved insulation management and automated system optimisation, rather than costly infrastructure overhauls, packhouses can potentially move towards the 1 kWh benchmark for CA storage EUI.

## 3.4 Regular Atmosphere (RA) Operations

Regular Atmosphere (RA) operations involve standard cold storage where temperature is the primary control variable.

### 3.4.1 Calculation

The RA electricity use intensity is expressed in kWh per tonne.days. This metric is calculated by dividing the total electricity consumed by RA-specific refrigeration by the total "tonne.days" of fruit stored in these rooms.

$$\frac{RA\ Operations\ Electricity\ \ (kWh)}{RA\ Operations\ \ (Tonne.Days)}$$

### 3.4.2 Results

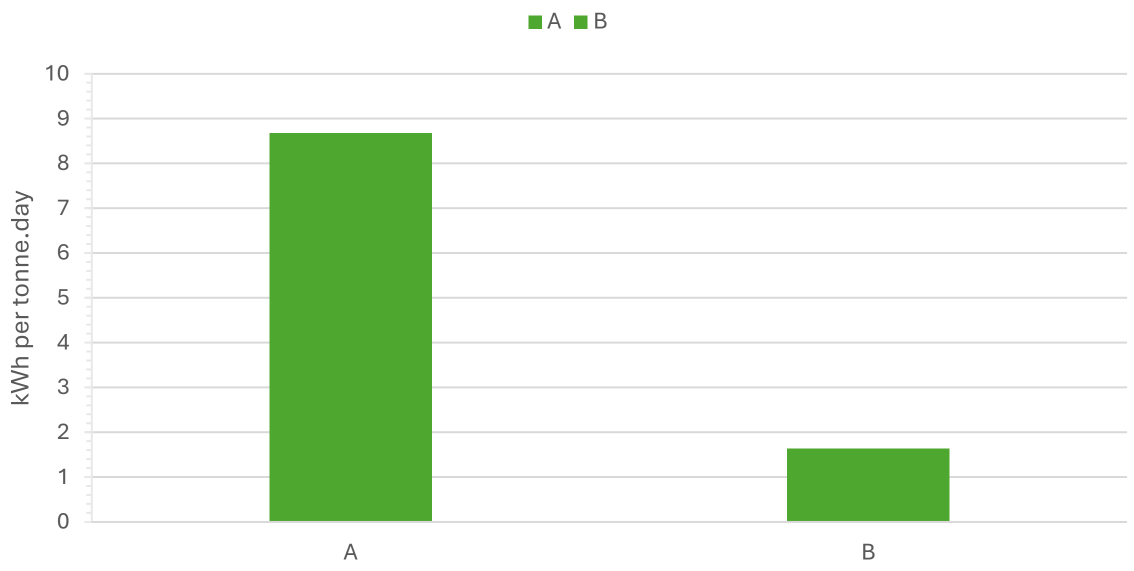


*Figure 5: RA Operations Electricity Use Intensity [RA kWh per tonne.day] for phase 5's participants.*

The 2024 results for RA storage reveal a broad performance spectrum, heavily influenced by the specific operational role of the cold room (e.g., rapid cooling versus holding). Focusing on metered data, Packhouse B achieved a remarkably efficient intensity of 1.63 kWh/tonne.day.

In contrast, Packhouse A, also a metered facility, recorded an intensity of 8.67 kWh/tonne.day. This higher figure is consistent with the energy profile of rapid initial cooling (removing field heat from harvested fruit), a process identified by Bouwer (2014)[3] as significantly more energy-intensive than steady-state storage

### 3.4.3 Key Observations

- **Operational Context Matters:** The disparity between the metered results of Packhouse B (1.63) and Packhouse A (8.67) highlights that "RA Storage" covers two distinct functions: energy-intensive rapid cooling (removing field heat) and lower-energy staging (holding fruit before packing), which could be the reason why the data for Packhouse A and B differ.
- **Data Availability:** The lack of data availability for Packhouses F, H, P, and Q highlights the persistent industry challenge of isolating RA-specific loads from the broader packhouse electrical supply.
- **Sub-metering for Cold Storage:** For packhouses that does not have metered RA Storage data we recommend the installation of dedicated meters for these cooling types. This will allow management to isolate "problem areas".

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

# 4. Overall Packhouse Electricity Use Intensity Results

The overall electricity intensity metric, expressed in kilowatt-hours (kWh) per tonne of fruit packed, provides a high-level view of the energy efficiency of the entire facility. This metric combines all measured electricity use, including packing, refrigeration (CA and RA), and administrative support, normalised against the total volume of pome fruit packed. This calculation excludes non-core consumption categorised as "Other" (such as on-site staff housing or external infrastructure) to ensure the benchmark reflects only the direct operational performance of the packhouse.

The overall packhouse electricity use intensity results provide a general indication of energy use per unit of pome fruit packed. However, the results in Figure 6 should not be directly compared between individual packhouses due to disparities in practices.

## 4.1 Results

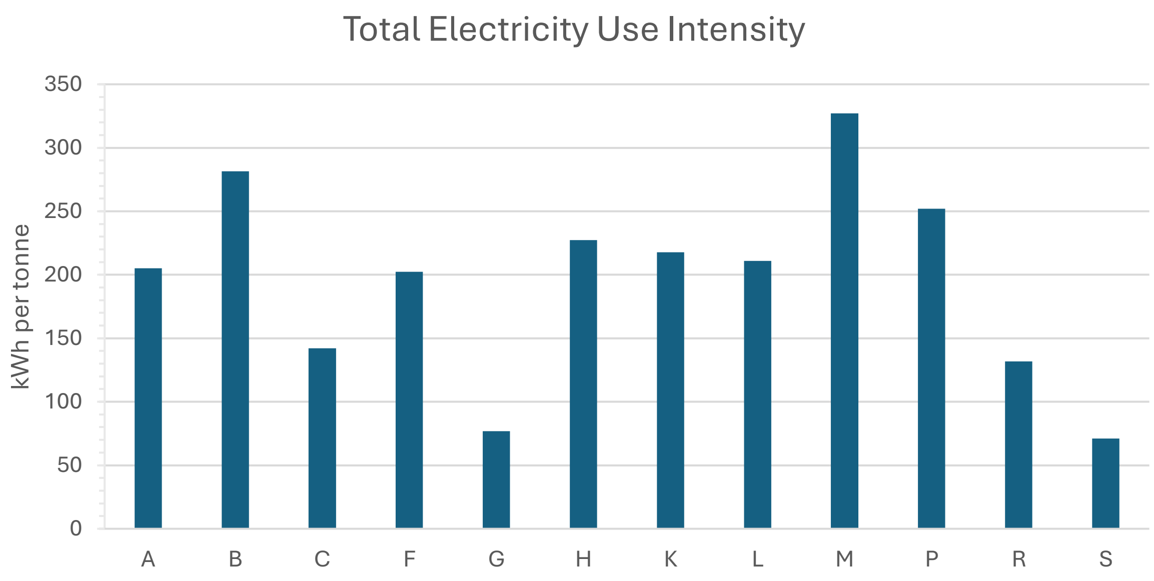


*Figure 6: Total Electricity Use Intensity [EUI kWh per tonne pome fruit packed] for phase 5's participants.*

The results reflect a diverse energy landscape, with total intensities ranging from 71 kWh/tonne to 327 kWh/tonne. When considering only the packhouses with metered data, Packhouse A and B, the overall EUI ranged from 205 to 282 kWh/tonne of fruit packed. Please note that data from the rest of the packhouses was calculated based on estimates and caution should be applied when considering these figures.

- **Top Performers**: Packhouse S (71 kWh/tonne) and Packhouse G (77 kWh/tonne) emerged as the most efficient operations in this cycle. For Packhouse G, this represents an improvement from its 85 kWh/tonne result in the previous phase.
- **Historical Benchmarks**: Several packhouses, including Packhouses A, F, K, and L, are measured around the 200–225 kWh/tonne range. This alignment is

significant, as it falls close to the 2023 average of 206 kWh/tonne reported for participants in Phase 4.

- **High-Intensity Operations**: Packhouse M (327 kWh/tonne) and Packhouse B (282 kWh/tonne) reported the highest overall intensities. For Packhouse B, this is a notable increase from its previous result of 228 kWh/tonne, which may be attributed to longer storage durations or shifts in throughput volume.
- **Corrective Trends**: Packhouse P (252 kWh/tonne) has shown a dramatic improvement from its 443 kWh/tonne outlier status in 2023. This 43% reduction supports the hypothesis that previous data was affected by metering errors and reflects a move toward more accurate reporting.

## 4.2 Key Observations

The 2024 results for overall electricity intensity reveal a maturing energy landscape where strategic investments and operational refinements are yielding measurable results.

- **Emergence of High-Efficiency Benchmarks**: Packhouse S (70.97 kWh/tonne) and Packhouse G (76.75 kWh/tonne) have set a new performance standard for the project. These low intensities are significantly below (±35%) the group average of 195.48 kWh/tonne.
- **Industry Mean**: Participating packhouses (A, F, K, L, and H) are now operating within a stable band of 200–227 kWh/tonne.
- **Correction of Historical Outliers**: A notable success in the 2024 cycle is the performance of Packhouse P. After reporting a high intensity of 442.93 kWh/tonne in 2023, it has decreased to 252.06 kWh/tonne this year. This 43% reduction highlights the value of the PAG project in identifying and rectifying metering errors.
- **Throughput Sensitivity**: The high intensity observed at Packhouse M (327.01 kWh/tonne) underscores how sensitive the kWh/tonne metric is to packing volume. In years with lower throughput, "fixed" electricity loads (like base refrigeration and security lighting) are spread across fewer tonnes, driving the intensity upward.

Please note that more years of accurately metered data is required to confirm above observations and trends.

# 5. Packhouse Electricity Sources

The energy landscape for packhouses in 2024 continues to evolve as packhouses balance cost, reliability, and sustainability. This section analyses the breakdown of electricity sourced from the national grid, renewable installations, and diesel generators.

## 5.1 Results

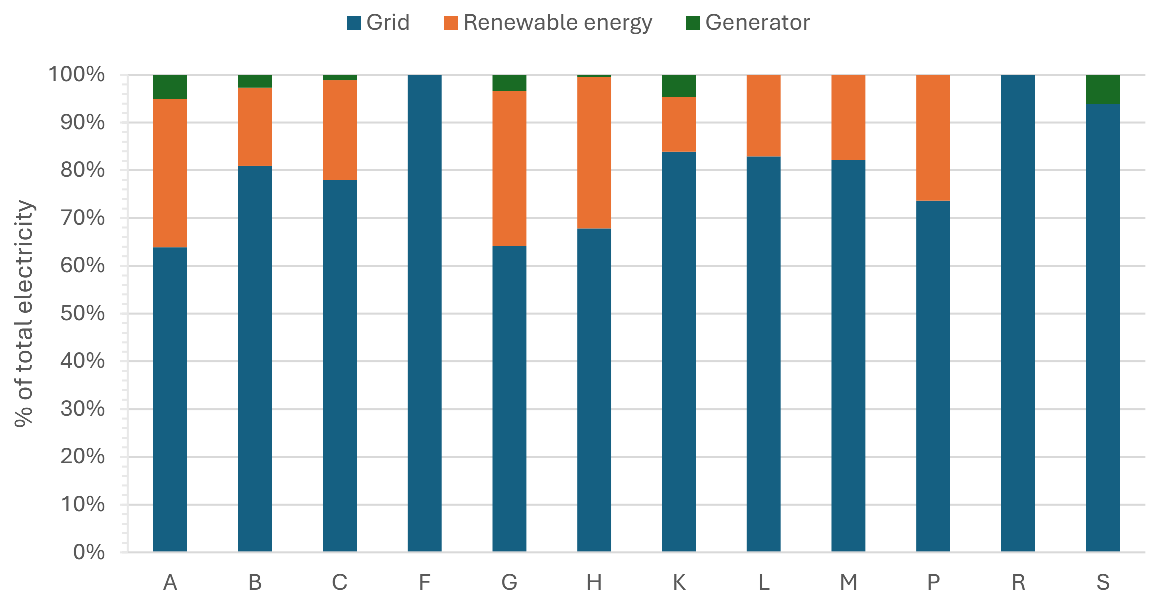


*Figure 7: Electricity Source Allocation [% of total electricity] for phase 5's participants.*

The 2024 data highlight a significant shift toward mixed energy models, with a growing percentage of total consumption being met by on-site renewable generation.

- **Grid Dominance**: The national grid remains the primary power source for all participants. Based on the reported data, Packhouse B (a fully metered packhouse) recorded the highest consumption at 32.1 GWh. Packhouse M followed with a reported, though estimated, consumption of 19.7 GWh.

- **Renewable Integration**: Eight out of the thirteen analysed packhouses now show significant renewable energy usage. Packhouse A leads in total renewable volume with 9.2 GWh, followed by Packhouse B at 6.4 GWh. For Packhouse G, renewables now account for approximately 32% of their total energy mix compared to the previous phase's 25%.

- **Generator Reliance**: While load-shedding risk mitigation remains a priority, several packhouses, including L, M, P, and R, reported zero generator usage for this period. This may indicate either a lower incidence of power interruptions or successful "bridging" using battery storage and solar during daylight hours. In contrast, Packhouse A recorded the highest generator backup at 1.5 GWh.

## 5.2 Key Observations

- **The Rise of Solar**: The widespread adoption of renewable energy across eight of the thirteen participants demonstrates that solar PV has moved from a "pilot" phase to a core operational strategy.
- **Resilience Planning**: The high grid-to-renewable ratio in packhouses like Packhouse A suggests a sophisticated energy management approach where renewables offset peak costs while the grid provides base-load stability.
- **Cost Implications**: As grid tariffs and diesel prices continue to fluctuate, those with high renewable use as demonstrated in their electricity source allocation (such as G, H, and P) are better positioned to maintain stable electricity costs per kWh.

# 6. Distribution of Packhouse Electricity Consumption

Analysing the distribution of electricity consumption across different operational areas provides vital insights for targeting energy reduction strategies. This section breaks down the 2024 usage into four primary categories: Packhouse Operations, CA Operations, RA Operations, and Other (non-production, e.g. housing) uses.

## 6.1 Results

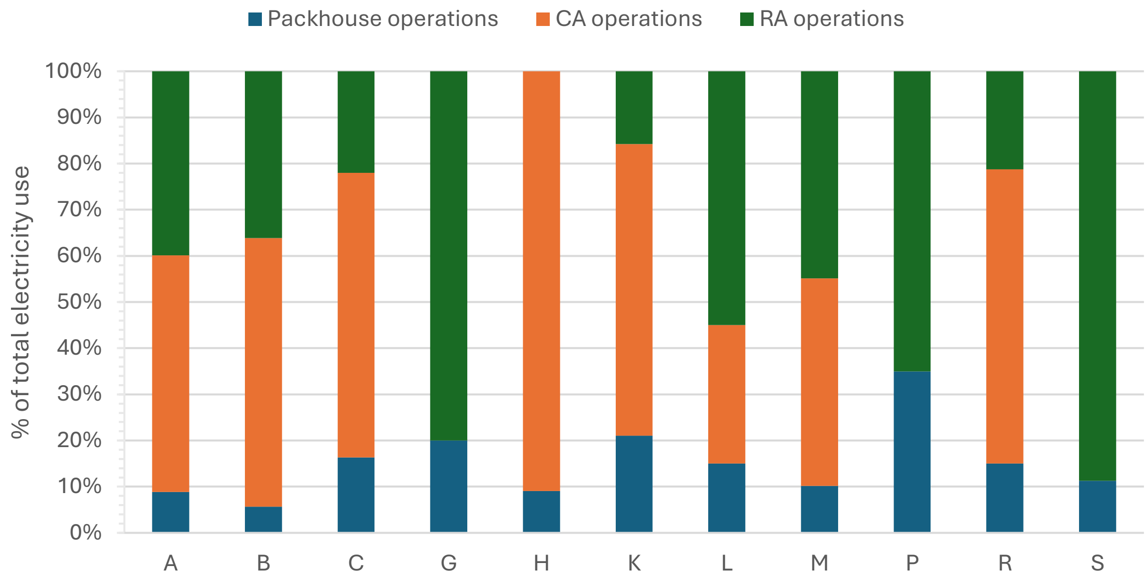


*Figure 8: Electricity Use Profile [% of total electricity use] for phase 5's participants.*

The 2024 data confirms that refrigeration (CA and RA) remains the dominant energy consumer across almost all participating packhouses.

- **Refrigeration Dominance**: For large-scale operations like Packhouse B, refrigeration accounts for the vast majority of load, with 20.7 million kWh dedicated to CA and 12.9 GWh to RA. Packhouse A shows a similar profile, utilising over 23 GWh for combined cold storage compared to 2.2 GWh for packing line operations.
- **Operational Variability**: The profile of Packhouse M shows a perfectly balanced split between CA and RA operations (10.5 GWh each), suggesting a highly standardised storage protocol across their facility. In contrast, Packhouse G utilise no electricity for CA, focusing entirely on RA storage and packing.
- **Packhouse Operations**: Packing lines, while less intensive than cooling, still represent significant loads for packhouses, like Packhouse M (2.39 GWh) and Packhouse A (2.24 GWh).

- **Other (Non-Production) Loads**: Several packhouses reported significant "Other" energy use, which includes housing, canteens, and administrative offices. Packhouse A reported the highest in this category at 2 GWh.

## 6.2 Key Observations

- **Refrigeration as the Primary "Hotspot"**: In packhouses with cold storage capabilities, refrigeration accounted for between 65% and 94% of total energy use in the 2024 reporting period.
- **The RA-Only Profile**: For packhouses like G, P, and S, the electricity profile is simplified by the absence of CA infrastructure, allowing for a more direct focus on RA cooling efficiency and packing line optimisation.
- **Strategic Opportunity**: Packhouses with high "Other" usage, such as Packhouses A and K, may find significant, low-cost savings by implementing simple office-based measures like motion sensors and hot water boiler timers.

# 7. Financial Impact

The financial impact of electricity consumption is a primary concern for packhouse management, especially given the persistent upward trend in national utility tariffs. This section analyses the cost per kilowatt-hour (kWh) across the three primary energy streams utilised in 2024: 1) Grid (Eskom/Municipal), 2) Renewable Energy, and 3) Diesel Generators.

$$(Grid\ electricity\ cost\ (ZAR) + \ Generator\ fuel\ cost\ (ZAR) + \ Renewable\ (PV) OPEX\ cost\ (ZAR) + \ Interest\ on\ renewable\ energy\ CAPEX\ (ZAR))\ /\ Total\ electricity\ consumption\ (kWh)$$

## 7.1 Results

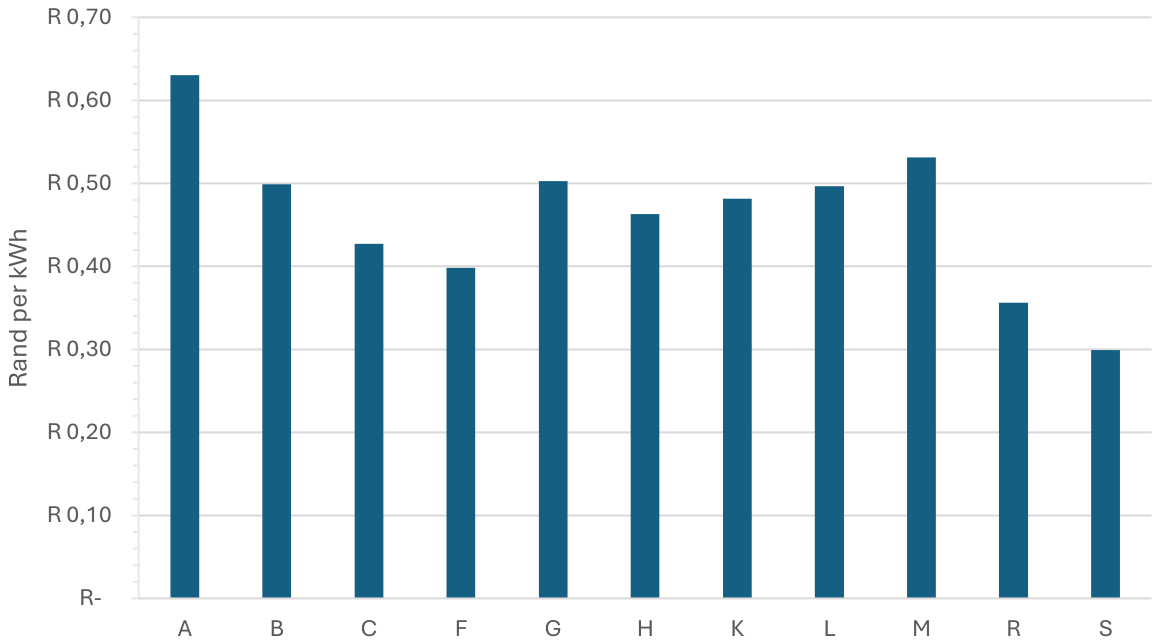


*Figure 9: Electricity Cost per kWh [Rand per kWh] for phase 5's participants.*

The total electricity cost comprises the cost of grid electricity, renewable energy, and diesel used in generators.

- **Grid Electricity Costs:** The average cost for grid electricity (Eskom and Municipal) has seen a continued increase since 2023 (average of R2.25 per kWh), with most packhouses paying between R1.96 and R2.67 per kWh. Packhouse S reported the highest grid cost at R3.10 per kWh.
- **Renewable Energy Savings:** Renewable energy remains the most cost-effective source by a significant margin.

- **Generator Expenditure:** Diesel-powered generation remains the most expensive stream. While costs reached as high as R28.99 per kWh at Packhouse H, due to low utilisation the overall group dependency on generators fell sharply in 2024.
- **Data Incompleteness:** Entries for Packhouses P and Q reflect zero values, indicating specific financial allocations were unavailable for this reporting cycle.

## 7.2 Key Observations

- **Renewable Return on investment**: The data indicate that once initial capital expenditure is managed, renewable energy provides a near-zero marginal cost of power, offering a vital hedge against grid inflation.
- **Grid Inflation**: The average grid cost of approximately R2.38 per kWh (excluding outliers) reflects the impact of the 2023/2024 tariff hikes sanctioned by Eskom.
- **Impact of Reduced Load Shedding:** A defining feature of 2024 was the significant reduction in load-shedding intensity compared to 2023. This resulted in a substantially lower requirement for diesel-powered generator energy. Because diesel is the most expensive energy source, this reduction directly contributed to a decrease in the overall blended cost per kWh for participating packhouses.
- **The "Generator Trap"**: The high cost of generator power (averaging over R6.00 per kWh for several participants) highlights the financial strain placed on operations that lack sufficient battery or solar capacity to bridge power outages.
- **Strategic Shift**: The disparity between R0.01 (Renewable) and R2.38 (Grid) provides a powerful financial incentive for packhouses to continue expanding their renewable footprint to secure long-term operational resilience.

## 7.3 Cost of Electricity per Source

To understand the drivers behind the cost of electricity per source it is necessary to analyse the individual rates of the three primary energy streams. The 2024 data highlight the massive price variance between utility-provided power, self-generation via renewables, and emergency diesel backup.

### 7.3.1 Analysis of 2024 Results

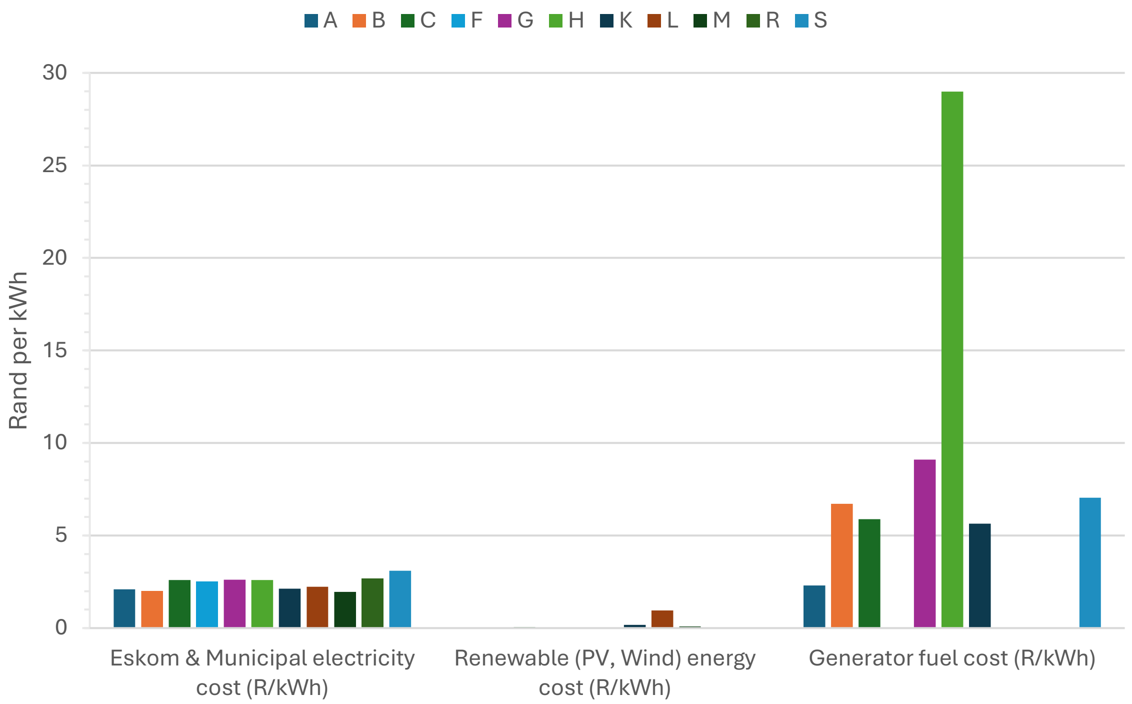


*Figure 10: Electricity Cost per Source [Rand per kWh] for phase 5's participants.*

The unit costs for each source demonstrate why energy procurement strategy has become as important as operational efficiency for packhouse profitability.

- **Grid Electricity (Eskom & Municipal):** Grid costs remain the baseline expense for most packhouses, with an average rate of approximately R2.38 per kWh (excluding outliers). Packhouse S reported the highest tariff at R3.10 per kWh, while Packhouse M secured the most competitive rate at R1.96 per kWh. These discrepancies often reflect the varying municipal markups and the impact of fixed "maximum demand" charges on the final unit price.

- **Renewable Energy:** Renewables continue to offer the lowest marginal cost of energy. Several packhouses reported near-zero operational costs, such as Packhouse G (R0.01) and Packhouse C (R0.05). Even when accounting for higher maintenance or finance-inclusive models, such as in Packhouse L (R0.95), renewables remain at least 50% cheaper than the cheapest grid electricity available.

- **Generator Fuel Cost:** Diesel generation remains a high-cost necessity. While Packhouse A achieved a relatively low rate of R2.30 per kWh, most participants faced significantly higher costs, averaging between R5.60 and R9.10 per kWh. The extreme outlier of R28.99 per kWh at Packhouse H could be because of estimated data.

### 7.3.2 Key Observations

- **The Price Gap:** The difference between the highest grid cost (R3.10) and the lowest renewable cost (R0.01) represents a huge variance in unit price. This staggering gap is the primary driver for the rapid acceleration of solar PV installations across the industry.
- **Economic Resilience:** Packhouses with high grid-unit costs (like S, R, and G) derive the highest proportional benefit from renewable energy. For these packhouses, every kWh generated on-site saves significantly more than it would for a facility on a lower municipal tariff.
- **Generator Cost Volatility:** Unlike grid or renewable costs, which are relatively predictable, generator costs are highly sensitive to global fuel prices and internal maintenance cycles. The reduction in load shedding in 2024 has mitigated this volatility, but the high unit cost remains a significant financial risk for future outages.
- **Data Gaps:** The absence of data for Packhouses P and Q suggests that while these packhouses may be consuming energy from these sources, their financial tracking systems are not yet granular enough to allocate costs per specific energy stream

# 8. Year-on-Year Analysis

Year-on-year comparisons provide critical insights into the long-term effectiveness of energy management strategies and the industry's resilience against external pressures like load shedding and tariff hikes. This section tracks the average total electricity intensity, calculated as total kWh (excluding non-production "Other" loads) per tonne of pome fruit packed, from 2020 through 2024.

## 8.1 Analysis of 5-Year Performance Trends

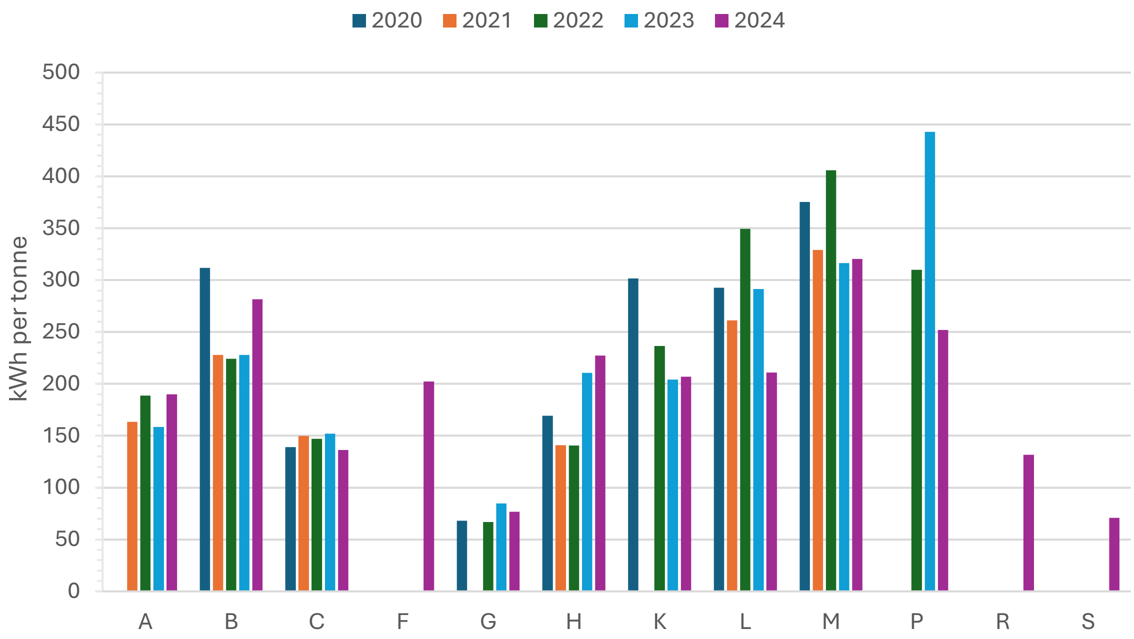


*Figure 11: Total Electricity Use Intensity [kWh per tonne pome fruit packed] for phase 5's participants.*

The five-year data horison shows a maturing energy landscape where many packhouses are successfully stabilising their consumption despite increasing operational complexities. It should be noted that gaps in the historical record for certain packhouses reflect years where they did not participate in the benchmarking study. Please note that packhouse A had metered data for all years and can be used for comparison, but the other packhouses and conclusions made from their data below should be treated with the necessary caution.

- **Long-Term Efficiency Leaders**: Packhouse C continues to demonstrate remarkable stability, maintaining an intensity between 136 and 152 kWh/tonnes over the five-year period. Packhouse G also remains a leader in efficiency, ending 2024 at 76.75 kWh/tonnes, an improvement from its 2023 peak of 84.69 kWh/tonnes.

- **Most Improved**: Packhouse P shows the most dramatic positive shift in the study. After hitting a high of 442.93 kWh/tonnes in 2023 (Phase 4), it has reduced its intensity to 252.06 kWh/tonnes in 2024.
- **Consistency and Stabilisation**: Packhouses K and L have both shown significant long-term improvements. Packhouse L has achieved a steady decline from 349.35 kWh/tonnes in 2022 to 211.02 kWh/tonnes in 2024. Packhouse K has also stabilised at 206.86 kWh/tonnes.
- **Rising Intensities**: Packhouse B saw its intensity rise to 281.52 kWh/tonnes in 2024, its highest level since 2020. This increase likely correlates with the facility expansions and construction activities undertaken during the 2024 period. Similarly, Packhouse H has seen a steady increase since 2022, reaching 227.30 kWh/tonnes this cycle. These increases are often tied to lower packing volumes or extended storage requirements during difficult harvest seasons.

## 8.2 Key Observations (2020–2024)

- **Project participation**: The onboarding of new participants in the 2024 cycle, alongside the continued commitment of long-standing members, underscores the growing value the industry places on this benchmarking initiative. This sustained engagement validates the project as a critical tool for operational insight and strategic planning.
- **Normalisation of the Industry Average**: Excluding outliers, the industry is averaging around a mean of 200–220 kWh/tonnes.
- **Electricity Source Allocation (2020–2024):** The five-year trajectory reveals a definitive structural shift in energy sourcing, characterised by the progressive displacement of grid electricity with on-site renewable generation. This upward trend in solar adoption highlights the industry's strategic commitment to self-sufficiency, ensuring greater financial resilience against rising tariffs and supply instability.
- **Grid Electricity**: In 2020, the industry was almost entirely reliant on the grid at 93%. By 2024, this has dropped significantly to 78%, despite a slight 2% uptick from the previous year. This indicates that while the grid remains the backbone of the industry, its relative importance is shrinking as alternatives become more prominent.
- **Renewable Energy Surge**: The most consistent trend is the growth of renewable energy, which has nearly tripled from 7% in 2020 to 20% in 2024. This steady

increase demonstrates that packhouses are integrating it as a core component of their base-load supply.

- **Generator Resilience**: Generator usage peaked in 2023 at 8% due to the record-breaking 332 days of load shedding experienced that year. In 2024, generator reliance dropped sharply to 2%. This decrease suggests a more stable national power supply during the period and that increased solar and battery capacity are now successfully "bridging" shorter outages without the need for diesel intervention.

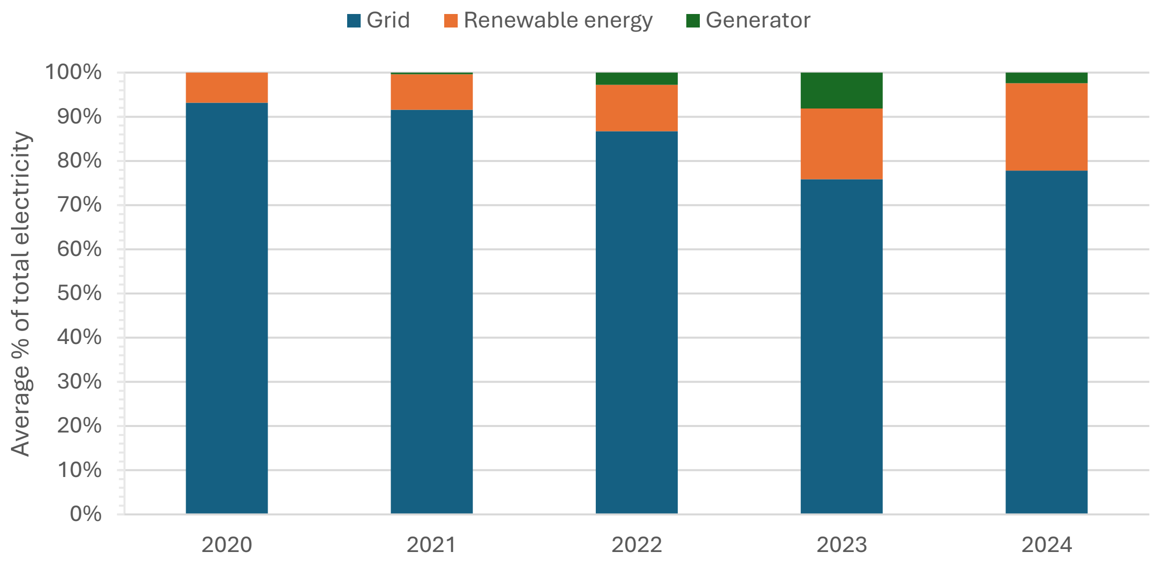


*Figure 12: Yearly Electricity Source Allocation [Average % of total electricity] for phase 5's participants.*

# 9. Energy Management Practices

It is important to move beyond simply tracking consumption to understanding the specific operational behaviours and technologies driving these results. All participating packhouses now consistently employ energy-saving practices across their operations, reflecting a maturing commitment to efficiency within the industry.

## 9.1 Pre-sort/Packing Line

The pre-sorting and packing lines represent a significant portion of the electricity use of a packhouse. Fundamentally, these energy management practices are implemented with the specific objective of driving and improving operational efficiency within packhouse environments.

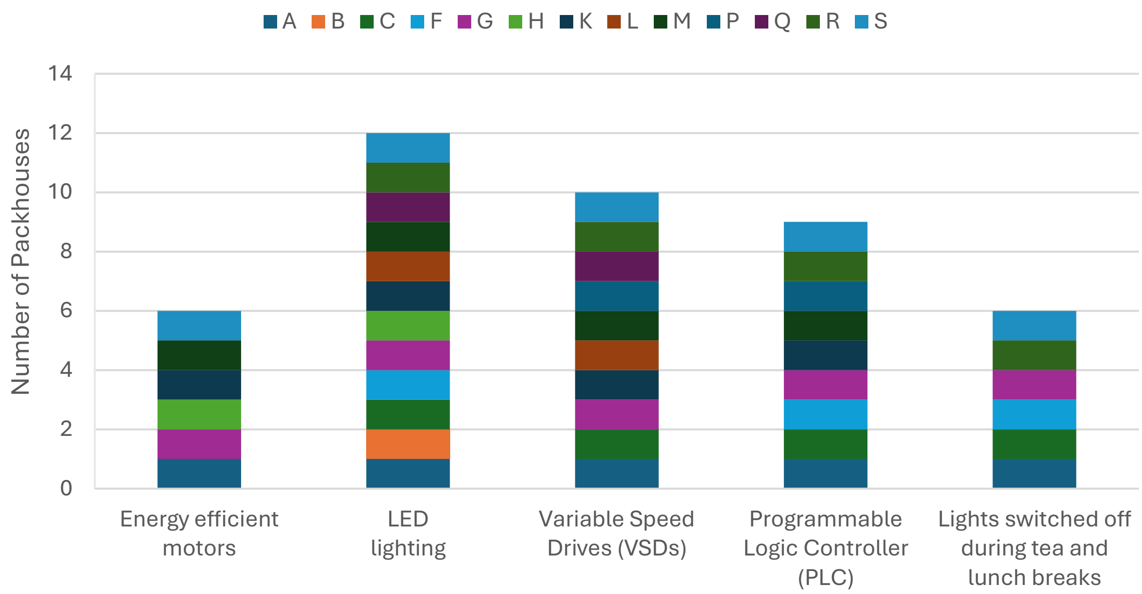


*Figure 13: Energy-saving practices in Pre-sort/Pack line [Number of Packhouses] for phase 5's participants.*

The 2024 survey data demonstrate a high adoption rate of specialised energy-saving technologies across the 13 analysed packhouses as can be seen in Figure 13:

- **LED Lighting:** This remains the most widely adopted measure, with 12 out of 13 packhouses (92%) having fully transitioned to LED systems.
- **Variable Speed Drives (VSDs):** 77% of participants utilise VSDs on their packing lines to mitigate energy surges and optimise motor performance during varying throughput speeds.
- **Programmable Logic Controllers (PLCs):** 69% of packhouses use PLCs to automate line operations, ensuring that machinery only runs when fruit is present, thereby reducing "idle" energy waste.

- **Energy Efficient Motors:** Roughly half of the participants (54%) have upgraded to high-efficiency motors, which provide long-term savings in the high-torque environments of pre-sorting lines.
- **Behavioural Savings:** 54% of packhouses, including A, C, G, R, and S, now actively switch off lights during tea and lunch breaks. This practice not only saves electricity but reinforces a culture of resource consciousness among staff.

## 9.2 Refrigeration

Refrigeration is the primary driver of electricity demand in pome fruit operations, refrigeration (combined CA and RA operations) accounted for between 65% and 94% of total energy use in the 2024 reporting period. Implementing advanced control systems and physical barriers is essential for maintaining strict cold chain protocols while managing rising energy costs.

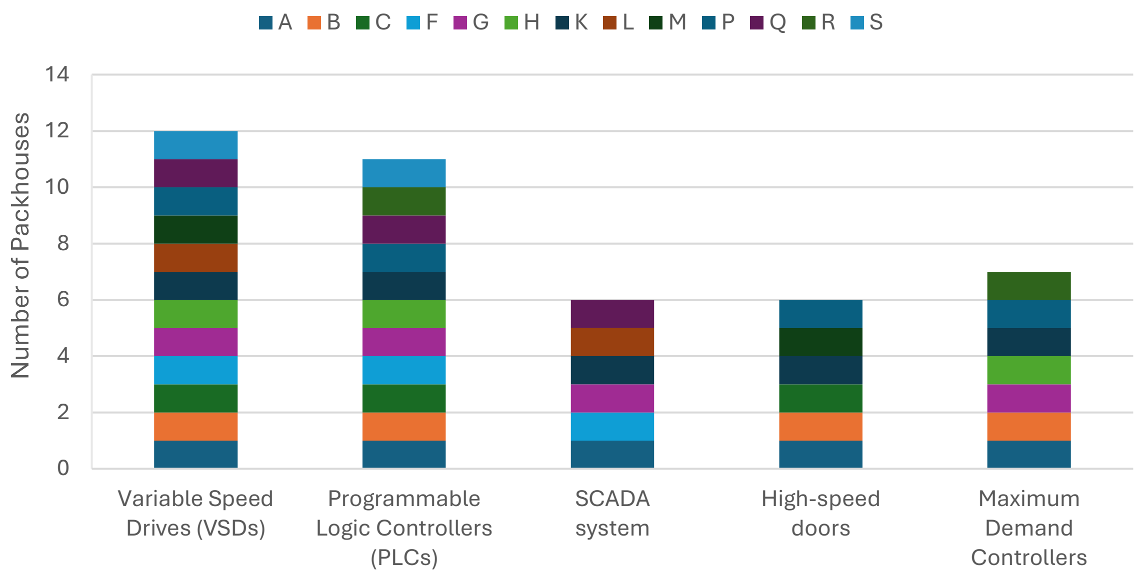


*Figure 14: Energy-Saving practices in Refrigeration [Number of Packhouses] for phase 5's participants.*

The 2024 data highlight a sophisticated approach to thermal management across the participating group, with a focus on automation and peak-load mitigation as can be seen in Figure 14:

- **Variable Speed Drives (VSDs):** Adoption is nearly universal, with 12 out of 13 packhouses (92%) utilising VSDs on compressors and fans. This technology allows motors to adjust their speed based on real-time cooling demand, preventing the energy spikes associated with traditional on/off cycles.
- **Programmable Logic Controllers (PLCs):** 77% of participants use PLC programs to manage their refrigeration plants. These systems optimise energy use by ensuring only the necessary number of compressors operate to maintain set points.

- **High-Speed Doors:** Used by 54% of packhouses, these doors are a critical physical measure to reduce "infiltration". By minimising the time a cold room is exposed to outside air, they significantly reduce the energy required to recover lost temperatures.
- **Maximum Demand Controllers:** 62% of packhouses utilise these controllers to optimise peak energy usage. This is particularly relevant for managing municipal electricity costs, where "Maximum Demand" charges can constitute a large portion of the monthly bill.
- **SCADA Systems:** 46% of the group uses Supervisory Control and Data Acquisition (SCADA) systems for high-level monitoring and energy management. These systems provide the granular data necessary for identifying refrigeration "hotspots".

## 9.3 Ablutions, Canteens, and Offices

While often categorised as secondary loads, the energy consumption in administrative and staff support areas provides a significant opportunity for "low-hanging fruit" efficiency gains. These areas—comprising offices, canteens, and ablutions—benefit from simple, low-cost behavioural and hardware interventions that contribute to the overall reduction in site intensity.

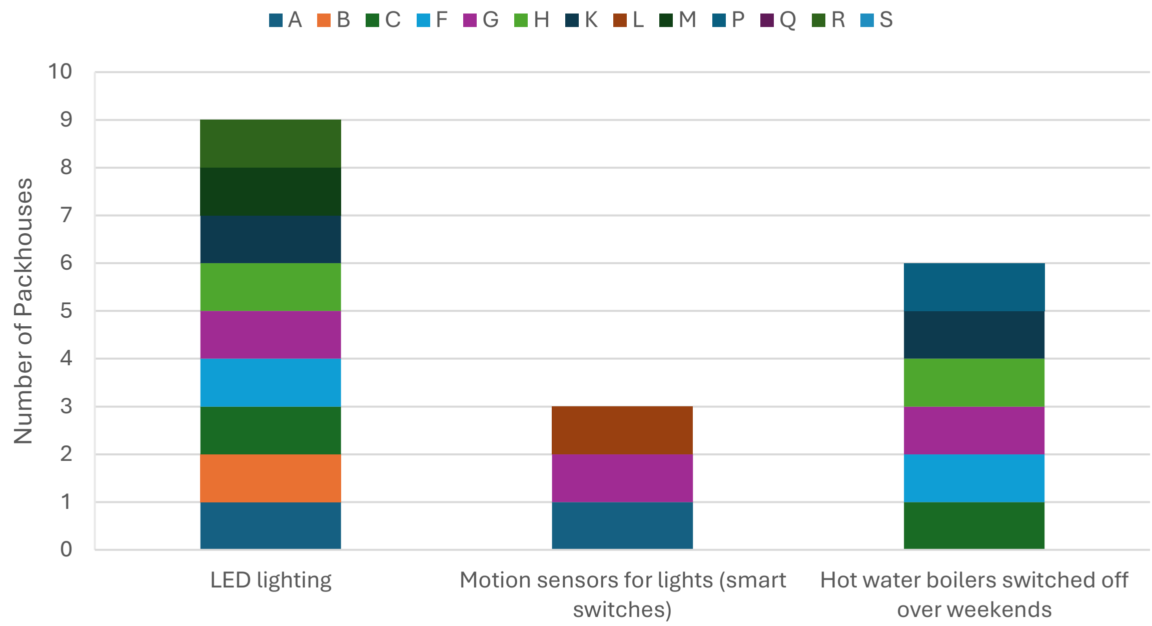


*Figure 15: Energy-saving practices in Ablutions, Canteen & Offices [Number of Packhouses] for phase 5's participants.*

The 2024 survey results indicate a varied adoption of energy-saving measures in these auxiliary areas:

- **LED Lighting**: This remains the most popular intervention, with 69% of the reporting packhouses having installed LED systems in their offices and staff packhouses.
- **Hot Water Boiler Management**: A proactive approach to reducing standing losses is evident, with 54% of packhouses, including C, F, G, H, K, and P, switching off hot water boilers over weekends. This simple practice eliminates unnecessary heating cycles during non-operational hours.
- **Motion Sensors (Smart Switches)**: This remains the least utilised technology in this category, with only 23% of participants (A, G, and L) employing motion sensors to automate lighting control in sporadically used areas. This represents a clear "level up" opportunity for the remaining packhouses.

# 10. Energy Cost Efficiency Matrix

This analysis examines the relationship between physical energy intensity (kWh per tonne packed) and financial intensity (Energy cost in ZAR per tonne packed). By mapping these two metrics, we can identify which packhouses are successfully converting efficient energy use into lower operational cost. Packhouses should therefore aim to be as left and low as possible in Figure 16.

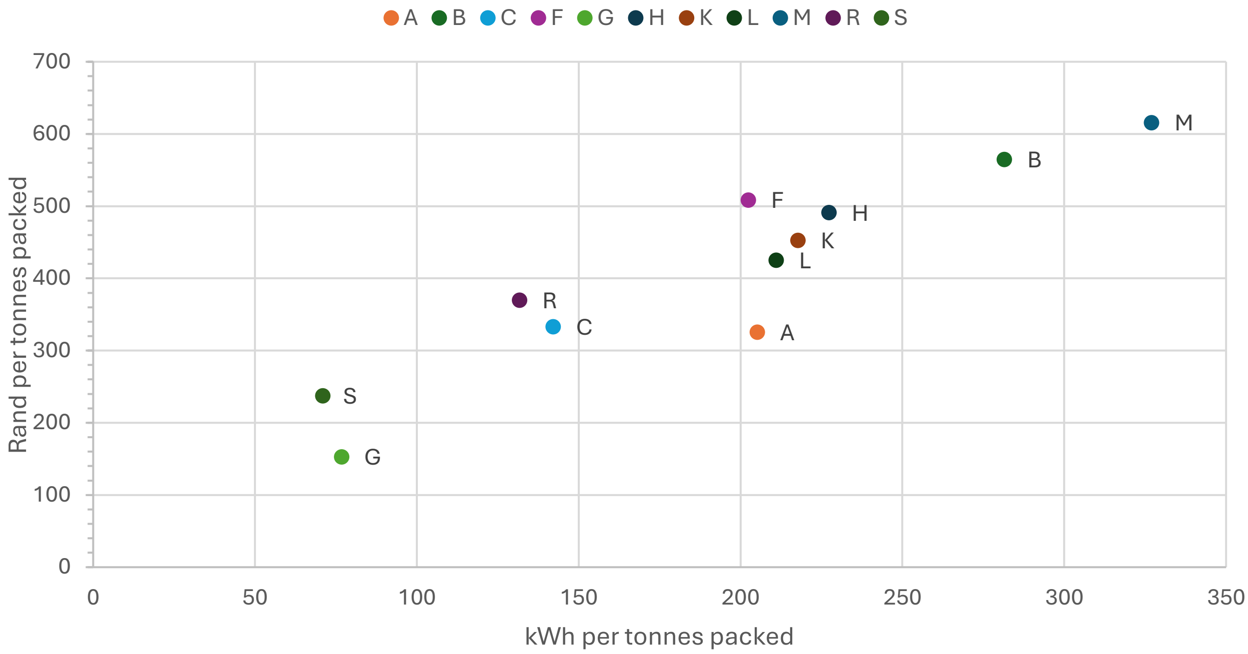


*Figure 16: Energy cost efficiency matrix [kWh per tonne packed vs cost per tonne packed] for phase 5's participants.*

- **Financial Leaders**: Packhouse G stands out as the most cost-efficient operation, spending only R152.62 per tonne while maintaining a low energy intensity of 76.75 kWh/tonne. This suggests that their high renewable energy mix (32%) is effectively shielding them from high grid tariffs.
- **The Cost of Inefficiency:** Packhouses like Packhouse B and Packhouse M face a "double burden," reporting both high energy intensity (over 300 kWh/tonne) and the highest costs per tonne (R564.40/tonne and R615.46/tonne respectively).
- **The Renewable Buffer:** Packhouse S demonstrates the power of source optimisation. Despite having a slightly lower physical efficiency than G, its cost of R237.16 per tonne remains well below this studies average of approximately R380/tonne, proving that sourcing is as critical as machinery efficiency.

# 11. Conclusion

The 2024 Energy Project analysis highlights a pivotal year for the participating packhouses. The data indicates a clear shift from reactive crisis management toward proactive, strategic energy optimisation.

Key findings from this cycle include:

- **The Normalisation of Efficiency:** The participating packhouses is coalescing around a standard intensity of 200 kWh per tonne packed. This alignment suggests a maturing operational standard where outliers are increasingly rare and often due to correctable data allocation errors rather than fundamental inefficiency.
- **The Renewable "Shield":** With renewable energy contributing on average 20% of the total supply (up from 7% in 2020), the data indicates that solar integration is increasingly serving as a buffer against rising grid tariffs.
- **Cold Storage Benchmarks:** The fully metered results from Packhouses A and B provide the most credible baseline for industry performance. By establishing a verified operational range, these packhouses demonstrate the importance of basing efficiency targets on measured data rather than theoretical estimates. This confirms that accurate sub-metering is essential to quantify the true energy demands of effective thermal management.

# 12. Recommendations

To further improve energy use performance, packhouse management should prioritise the following strategic actions:

**Infrastructure:**

- **Universal Sub-metering:** Transitioning from "Estimated" to "Metered" data for CA and RA sections is urgent. Packhouses cannot manage what they do not measure. Installing dedicated digital meters for refrigeration plants will eliminate data gaps and reveal specific "hotspots" of inefficiency.

**Financial Strategy: Source Optimisation**

- **Maximise Renewable Energy Use:** Packhouses currently sourcing <10% of their energy from renewables should actively investigate greater adoption thereof.

**Operational Culture: The Human Element**

- **Behavioural Governance:** Implement "Zero-Cost" protocols such as switching off hot water boilers on off-periods and enforcing lighting discipline during breaks. These measures require no CAPEX but directly improve the base-load profile.

**Futureproofing**

- **Carbon Reporting:** As international markets increasingly demand environmental transparency, packhouses should begin converting their kWh data into Carbon Intensity (kg $CO_2$e/tonne). This proactive step will ensure readiness for future ESG audits and retail requirements.

**Recommendations for Data Collection Tool Enhancements**

To provide deeper diagnostic insights in future project cycles, we recommend adding the following specific data fields to the collection tool:

- **Fruit Waste and Yield Analysis:** Currently, the amount of "Received" and "Packed" fruit totals are captured in the data collection tool as part of this study, however, explicitly tracking the "Total Waste Tonnage" allows us to calculate the "Energy Cost of Waste." This metric highlights the electricity consumed to cool, wash, and sort fruit that is ultimately discarded, helping management quantify the energy penalty of poor orchard quality.
- **Cold Storage Volume ($m^3$):** Incorporating the total cubic capacity of cold rooms enables the calculation of volumetric efficiency (kWh/$m^3$). This metric offers a distinct advantage by isolating the technical performance of the refrigeration plant and thermal envelope from logistical variables. By benchmarking the energy required to maintain temperature per cubic meter of space, management can

accurately assess the baseline efficiency of their infrastructure and insulation quality, irrespective of fluctuating fruit occupancy levels.

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