BENCHMARKING STUDY

Resource Efficiency in Red Meat Abattoirs in South Africa

IN PARTNERSHIP WITH

Schweizerische Eidgenossenschaft
Confédération suisse
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Confederaziun svizra

Federal Department of Economic Affairs FDEA
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Abbreviations

APRE	Agri-Processing Resource Efficiency
CO_2	Carbon Dioxide
COD	The Chemical Oxygen Demand (COD) test is used to indirectly measure the concentration of organic compounds in water. Most applications of COD determine the amount of organic material in surface water or wastewater, making COD a useful measure of water quality, expressed in milligrams per litre (mg/l), which indicates the mass of oxygen required to oxidise the chemical solutes and solids per litre of water.
COP	Coefficient of Performance
CW	Carcase Weight
DAFF	Department of Agriculture, Forestry and Fisheries (of South Africa)
EU	European Union
FAOSTAT	Food and Agriculture Organization of the United Nations – Food and Agriculture Data
GHG	Greenhouse Gas
HT	High Throughput: >20 SUs per day
IFC	International Finance Corporation
IRR	Internal Rate of Return
ISLT	Infrequently Slaughtering Low Throughput
kg	Kilogram
kl	Kilolitre
KPI	Key Performance Indicator
kWh	Kilowatt-hour
Lairage	Stock-holding pen where animals are held pre-slaughter at an abattoir.
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LT	Low Throughput: 3-20 SUs per day
MAS	Manufacturing, Agribusiness and Services
MLA	Meat & Livestock Australia
MWh	Mega Watt hour
Offal	The organs of a slaughtered animal, usually divided into: • Red offal – heart, liver, kidney, tongue • Rough offal – stomachs, intestines, other organs
Pre-breaker	Item of plant in which large pieces of condemned carcases are broken down to smaller-sized pieces, suitable for further processing, such as sterilising and rendering.
R	South African Rands
RECP	Resource Efficiency and Cleaner Production
Rendering	Cooking and sterilising of animal waste products not fit for human consumption (i.e. "condemned"), as well as evaporation of moisture to produce a proteinaceous meal. Melted fat is normally recovered for further utilisation, such as tallow production.
RMAA	Red Meat Abattoir Association
RMLA	Red Meat Levy Administration
RT	Rural Throughput: <=2 SUs per day
SECO	Swiss State Secretariat for Economic Affairs
SEV	Specific Effluent Volume is the wastewater volume generated in a particular period divided by the number of slaughter units processed during the same period.
Solar PV	Solar Photovoltaic
SPL	Specific Pollutant Load is the pollutant mass load for a period (in terms of any parameter, e.g. COD, TKN) arising from an industrial unit process divided by the number of SUs used in production during the same period.
SS	Suspended Solids are small, solid particles which remain in suspension and are not dissolved in water. Suspended solids are important, as pollutants and pathogens are carried on the surface of particles. The smaller the particle size, the greater the total surface area per unit mass of particle, and so the higher the pollutant load that is likely to be carried.
Sticking	The slitting of an animal's throat after stunning, allowing the carcase to bleed.
Stunning	Mechanical, electrical or other means of rendering an animal unconscious before slaughtering, in an approved and humane manner.
SU	Slaughter Unit is the number of non-bovine species considered equivalent to one bovine animal for abattoir purposes, and is based on the South African standard whereby: • One cattle animal equals one SU • Two pigs equal one SU • Six sheep equal one SU • Six goats equal one SU • Six small-stock (mixed species) equal one SU.
SWI	Specific Water Intake is the water intake for a particular period divided by the number of SUs during the same period.
SWU	Specific Water Use is the water used in an industrial unit process divided by the number of SUs processed.
Tonnes CW (tCW)	Carcase Weight – the volume (metric tonnes) of carcase weight processed.
TDS	Total Dissolved Solids
tHSCW	Tonne Hot Standard Carcase Weight
TKN	Total Kjeldahl Nitrogen
UAE	United Arab Emirates
UK	United Kingdom
USA	United States of America
WBG	World Bank Group

Acknowledgments

The *Benchmarking Study: Resource Efficiency in Red Meat Abattoirs in South Africa* was produced as part of a broader International Finance Corporation (IFC) Agri-Processing Resource Efficiency (APRE) project in South Africa, aimed to assist companies engaged in agricultural processing to transition to better water and resource efficiency practices. The project is expected to help mitigate water supply risks in the sector, resulting from the water scarcity challenge in South Africa and throughout the region. The project is implemented in partnership with the Swiss State Secretariat for Economic Affairs (SECO) and the Netherlands.

A Practical Guide for Improving Resource Efficiency in Red Meat Abattoirs in South Africa was developed in conjunction with the Benchmarking Study. The Study involved benchmarking of the water and energy usage of 21 abattoirs across the country against local and international best practices. The team would like to acknowledge the contribution of the red meat abattoir owners, managers and other stakeholders who participated in the Benchmarking Study and provided input into the *Practical Guide for Improving Resource Efficiency*.

The Study was managed by Raymond Greig and Rong Chen (IFC). IFC commissioned Resource Innovations Africa (Pty) Ltd and ProAnd Associates Australia (Pty) Ltd to support the collection of information and the analysis, and to provide technical recommendations. We appreciate the effort of the key experts, Darrin McComb (Director, Resource Innovations Africa) and Jon Marlow (Director, ProAnd Associates Australia) and their teams. IFC has partnered with the Red Meat Abattoir Association (RMAA) to facilitate implementation of the project and is grateful to Gerhard Neethling (General Manager, RMAA) for coordinating stakeholder engagements and for providing inputs to the report.

The team is also grateful to World Bank Group (WBG) colleagues for support of the assessment, as well as feedback provided on the report. We would like to thank Alexander Larionov, Ivan Ivanov, Jerrard Müller, Nonhlanhla Halimana and Robert Peck. Also, many thanks to Bonny Jennings and the full team at ITL Communication and Design for the excellent production of the report.

1

Executive Summary

Resource efficiency benchmarking provides the ability for enterprises to examine and understand their own resource efficiency performance. The results can be used to compare resource efficiency performance against other enterprises at both local and international levels. They can also be used as a guide on what to measure to determine overall resource efficiency metrics. Comparing resource efficiency performance with peers provides an understanding of where efficiencies may be different and thereby assists enterprise management in any sector to identify areas of focus to increase efficiencies, reduce resource consumption and reduce operating costs.

IFC and South Africa's RMAA have partnered to conduct a resource efficiency benchmarking study of red meat abattoirs in South Africa and assess the gaps in the efficiency of the use of resources, with particular focus on water, and identify areas for improvement in performance and sustainability.

A key conclusion that can be drawn from this study, the savings achieved over time in other international red meat sectors, and the results of the individual plant resource efficiency assessments conducted under this project is that a 20-28% reduction in water consumption is estimated to be possible across the sector and that this would reduce overall water utilisation by approximately 178-245 l/slaughter unit (SU), or around 0.91-1.25 million cubic metres (a million kl) nationally per annum, with savings of around R27-R37 million.

The prediction of water savings potential for South African abattoirs is provided in Figure 1.

The water efficiency measures identified include:

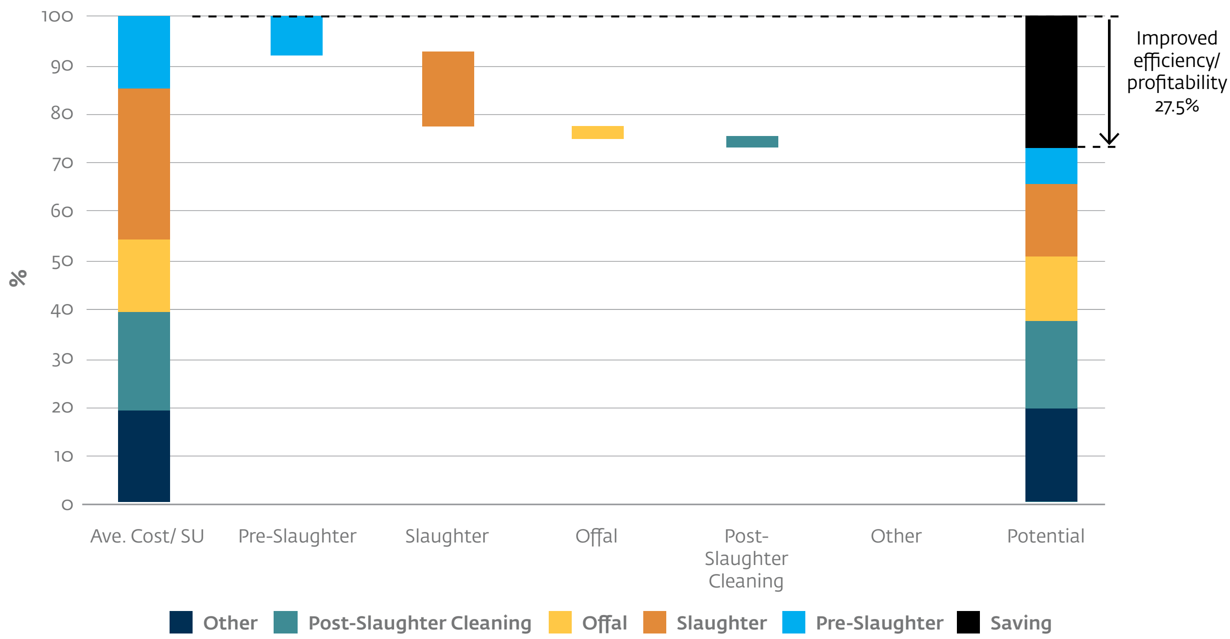
- Implement a ground water strategy
- Rainwater recovery
- Optimise manual cleaning/rinse systems
- Dry cleaning techniques
- Optimise knife and hook sanitation systems
- Optimise boot and hand washing
- Water re-use opportunities

POTENTIAL SAVINGS FOR THE RED MEAT ABATTOIR INDUSTRY IN SOUTH AFRICA

WATER consumption can potentially be reduced by up to 28% resulting in national savings of 1.25 million cubic meters and R37 million per annum

ENERGY consumption can potentially be reduced by up to 24% resulting in national savings of 92,000 MWh and R105 million per annum

FIGURE 1 – WATER SAVINGS POTENTIAL FOR A TYPICAL ABATTOIR[1]



THE THERMAL EFFICIENCY AND RELATED COST-SAVING MEASURES IDENTIFIED INCLUDE:

- Renewables and waste heat recovery
- Optimise steam system generation efficiency
- Insulate steam lines, valves and flanges
- Condensate recovery

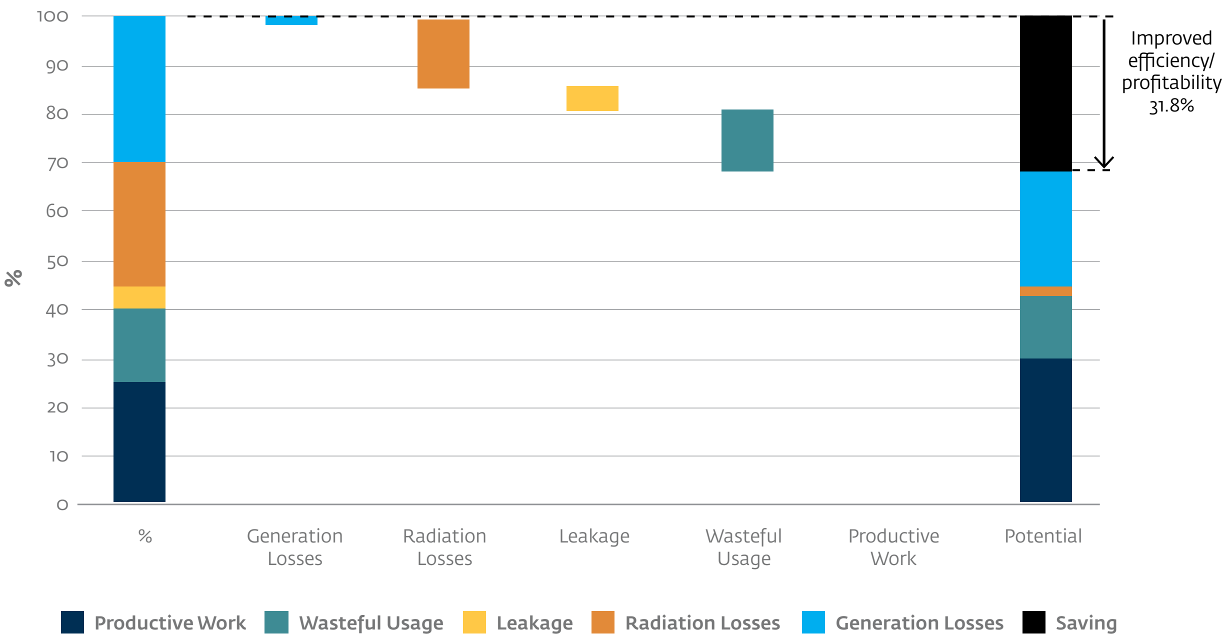
While it is more difficult to be precise because of the complexity of energy utilisation, a 12-24% reduction in total energy consumption is considered possible, which would reduce overall energy utilisation by 9-18 kWh/SU, and result in national savings of 47-92 million kWh and industry savings in the order of R54-R105 million per annum.

Larger plants with on-site rendering would typically have steam systems utilising coal boilers. Smaller abattoirs without rendering capability would utilise either electrical heating elements or small liquid fuel-driven steam systems (flash steam generators). The fuel cost per kilowatt-hour (kWh) is relatively high in the smaller plants; however, their system efficiencies are significantly better, especially for point-of-use heating applications (heating elements at the sterilisers). There is significant scope for improving costs and efficiencies in the thermal heating systems, especially in the smaller plants that have relatively high heating costs per kWh. A typical abattoir could reduce its thermal energy consumed by an estimated 32% by implementing thermal energy efficiency measures.

The prediction of thermal energy savings potential for South African abattoirs is provided in Figure 2.

[1] Extracted from "Practical Guide for Improving Resource Efficiency in Red Meat Abattoirs in South Africa", prepared as a component of this project.

FIGURE 2 – THERMAL ENERGY SAVINGS POTENTIAL FOR A TYPICAL ABATTOIR



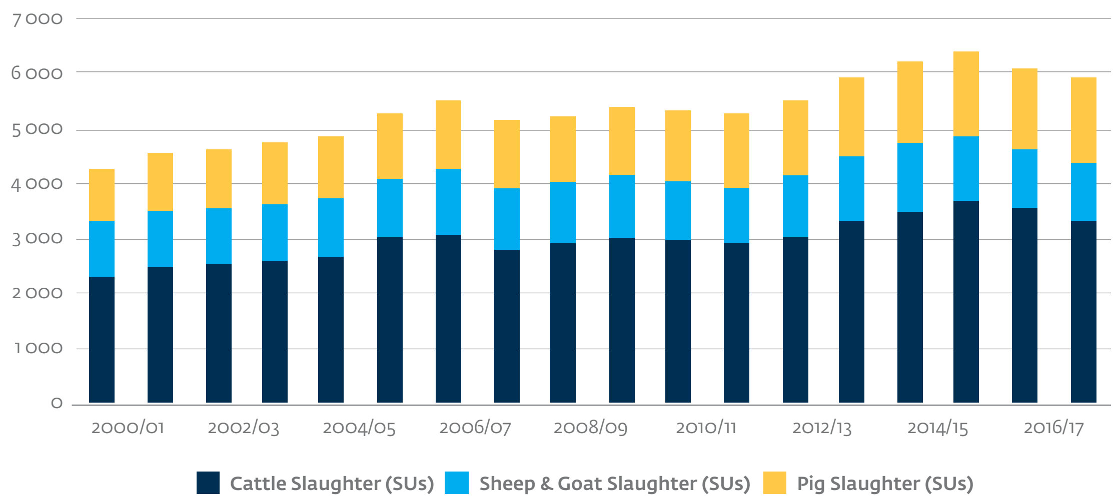
Refrigeration and chiller plants typically account for up to 45% of the electrical demand of an abattoir and therefore offer the greatest electrical savings opportunities. A typical abattoir could reduce its electrical energy consumption by an estimated 12% by implementing energy-efficiency measures.

The red meat sector in South Africa is a dynamic, growing industry that makes a significant contribution to domestic food supply and generates vital export revenue. The past two decades have seen significant changes across South Africa's livestock and meat sector, with domestic livestock populations decreasing from approximately 40 million head in 2001 to around 35 million head in 2018. While the livestock population has been decreasing, the production volumes have been increasing (see Figure 3), because the sector has substantially improved its productivity through the adoption of feed finishing practices, higher slaughter rates across all species, and heavier average carcase weights for cattle, sheep and pigs (less so for goats).

THE ELECTRICAL ENERGY EFFICIENCY AND RELATED COST-SAVING MEASURES IDENTIFIED INCLUDE:

- Review electrical tariffs
- Reduce peak electrical demand
- Pump system optimisation
- Chiller system coefficient of performance (COP) management and optimisation
- Compressed air system optimisation
- Solar photovoltaic (PV)

FIGURE 3 - LIVESTOCK SLAUGHTERING IN SOUTH AFRICA (SU)



The industry has also been impacted by the destocking of farms due to drought and disease outbreaks. Sustained drought conditions since 2018 throughout South Africa have intensified the need to find water-saving opportunities in the processing sector without compromising food safety standards. The results of this benchmarking report bring into sharper focus the fact that South African meat companies are already responding to the challenge through more careful water management on-site and measurement of all resources used. Its results are drawn from international references and the performance of 21 enterprises to give a clearer snapshot of resource utilisation across the larger industry of 423 facilities (see Table 1).

TABLE 1 – ABATTOIRS BY PROVINCE

TOTAL ABATTOIRS PER PROVINCE	
Province	**Total Number**
Eastern Cape	67
Free State	80
Gauteng	40
KZN	50
Limpopo	34
Mpumalanga	33
North West	35
Northern Cape	38
Western Cape	46
Total	**423**

To overcome the carcase weight differences between different species that would inadvertently skew benchmarking results, expressed on the basis of per livestock head slaughtered, the Benchmarking Study uses the RMAA's SU conversion rate whereby six goats/sheep are equivalent to one cattle animal, and two pigs are equivalent to one cattle animal. This enables far better interpretation of per-head usage of resources.

The benchmark comparisons took into account that the South African industry has several differences at an overall operational level from international counterparts. These include, for example, that livestock in South Africa are not washed prior to slaughter, hides and skins are sent off-site without absorbing much in the way of energy or water resources, red offal undergoes minimal processing before despatch to the domestic market, and deboning operations are almost always focused on hindquarter production which uses markedly less energy. In addition, there are clear differences in water, energy and fuel consumption between fully integrated works and those that only undertake slaughter, chill and boning tasks.

As a basis for comparison, the Benchmarking Study looked at data across three categories of plants:

i. Fully Integrated plants, which typically include full boning rooms as well as freezing, rendering and blood processing, and use steam for water heating.

ii. Slaughter, Chill and Bone plants, which include boning activity but no freezing or value-adding.

iii. Slaughter and Chill plants, which focus on despatching bone-in product to the marketplace and have minimal activity in other departments.

A profile of the 21 enterprises involved in the benchmark study is provided in Table 2.

TABLE 2 - PARTICIPATING PLANT PROFILE

PLANT PROFILES								
Facility	Slaughter & Chill	50%	Slaughter, Chill & Bone	36%	Fully Integrated	14%		
Shifts	Single Shift	93%	Double Shift	7%				
Offal Processing	Trim & Rinse	79%	Pack & Freeze	14%	Combination	7%		
Water Heating	Steam	50%	Electricity	50%				
Refrigeration	Hydrocarbon	79%	Ammonia	21%				
Blood Disposal	Wastewater	57%	Compost	21%	Dried	14%	Land	7%
Wastewater Disposal	Irrigation	50%	Sewer	43%	Surface water	7%		

The water source and usage results for the three plant categories on a per-SU basis are presented in Figure 4, and the water consumption and cost benchmark results are presented in Figure 5.

FIGURE 4 - WATER SOURCE AND USAGE BENCHMARKS

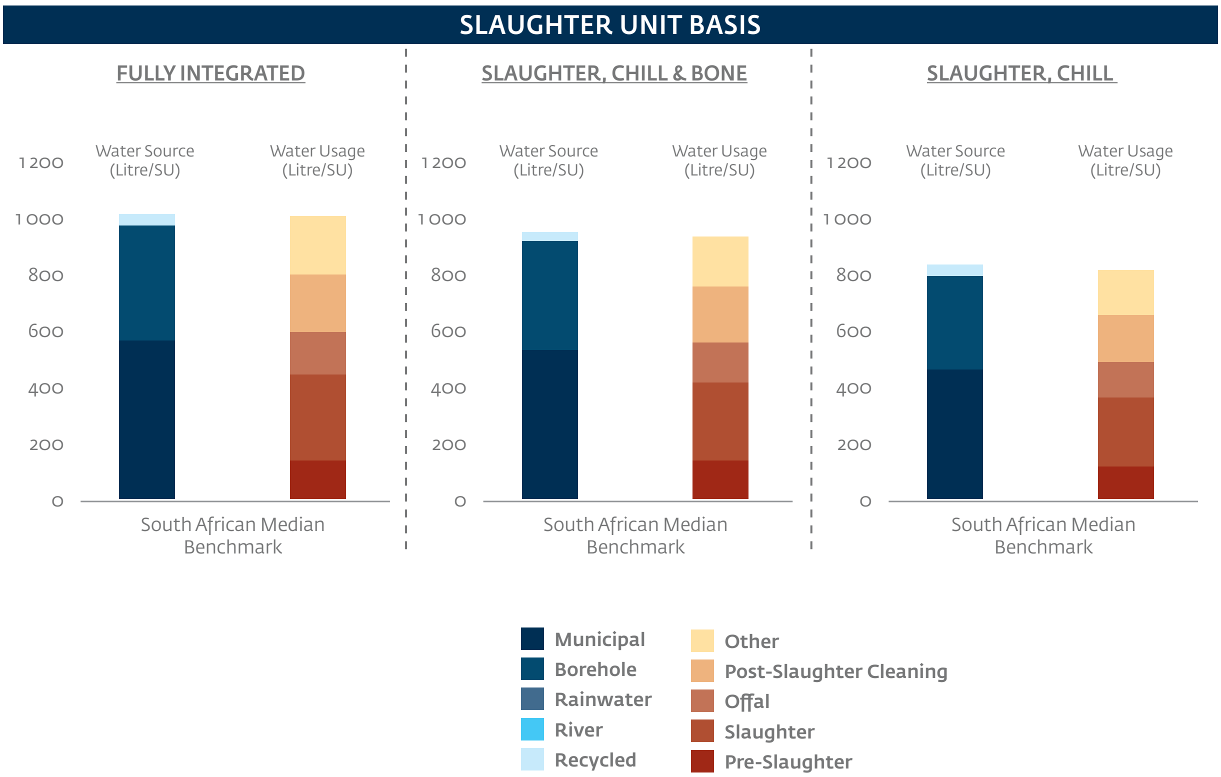
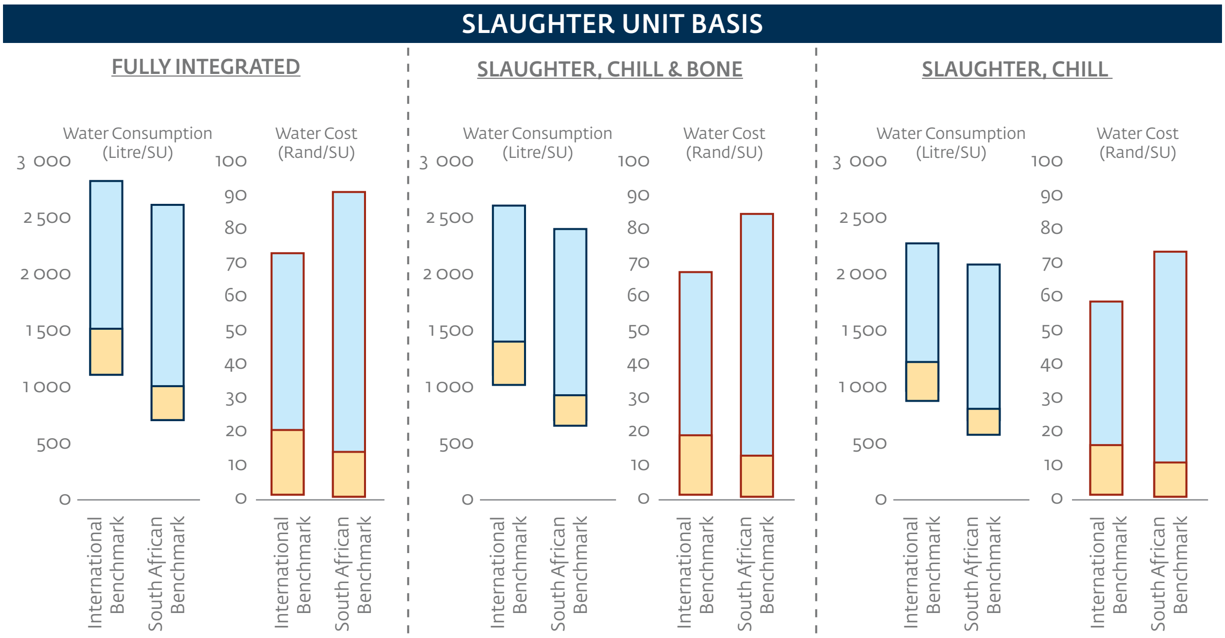


FIGURE 5 - WATER CONSUMPTION AND WATER COST BENCHMARKS

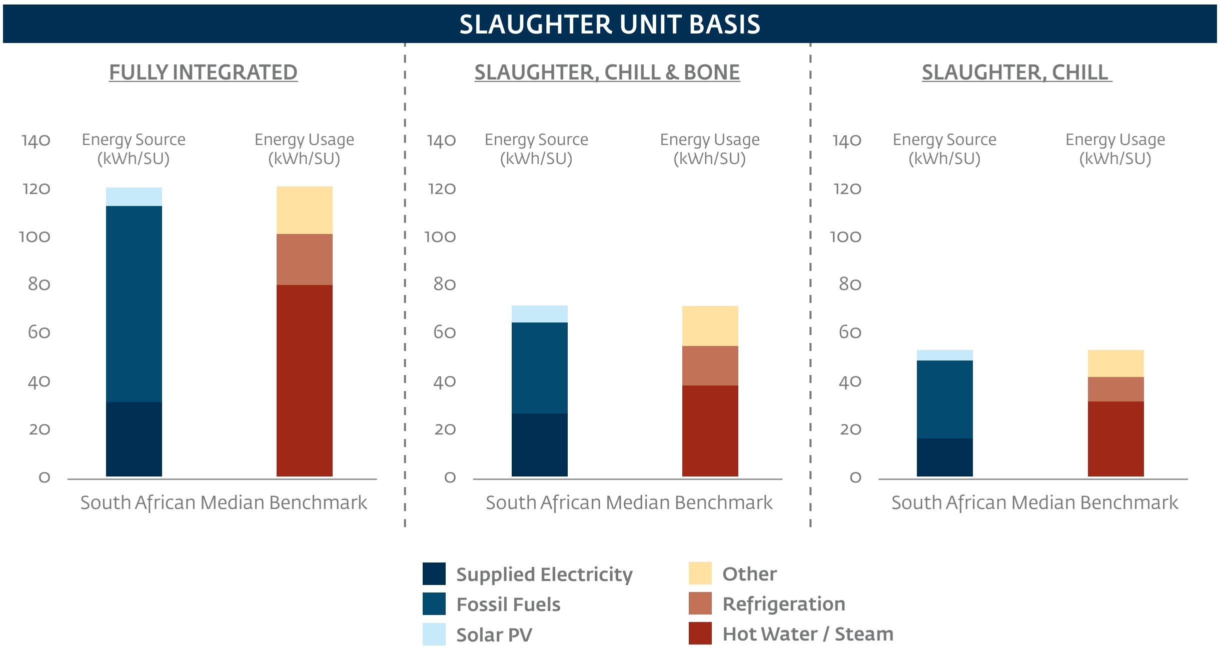


On this basis, South African plants across all three categories used a lesser volume of water per SU compared to the international benchmark cohort, but paid similar costs for this resource, mainly due to higher volume charges stemming from municipal supply and disposal charges. The low-cost plants utilise borehole water with low or no costs, and dispose wastewater to irrigation.

The total energy source and usage results for the three plant categories on a per-SU basis are presented in Figure 6, and the total energy consumption and cost benchmark results are presented in Figure 7.

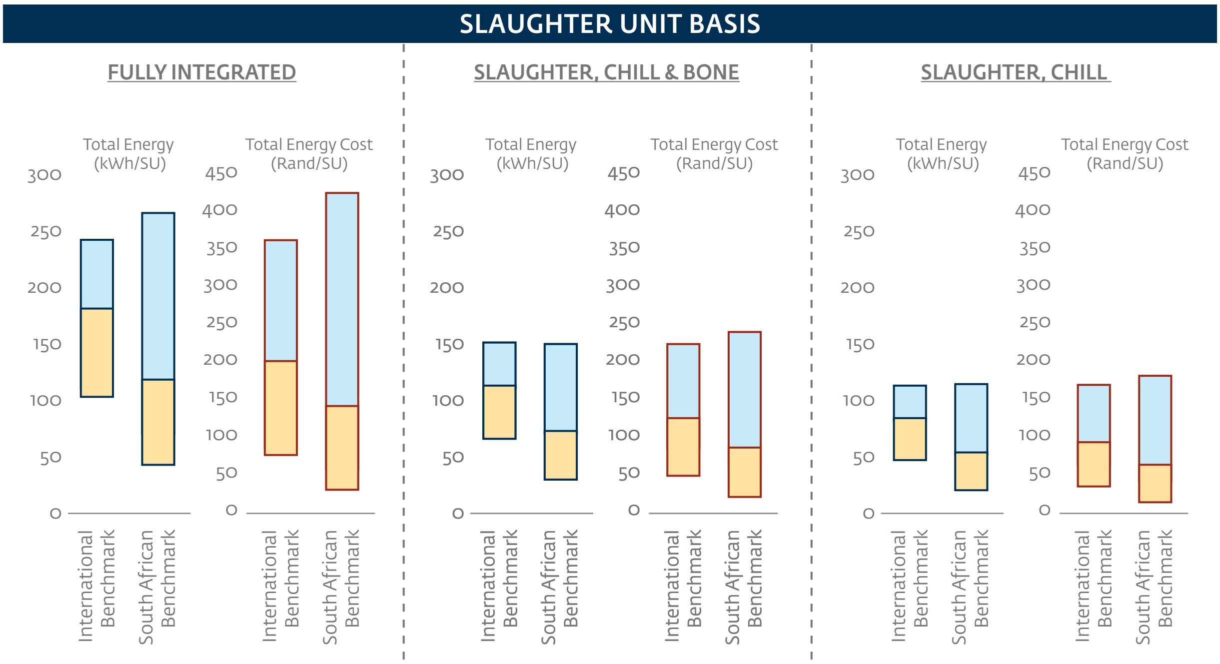
The results of the study with regards to energy source and energy usage were insightful. First, it is clear that fossil fuels supply about 60% of energy supply at plant level, particularly in the Fully Integrated category, and electricity supplies around 30% of the energy requirements. There is an emerging interest in solar PV usage by facility operators. A Fully Integrated enterprise uses 120 kWh per SU, which is more than twice the requirement of enterprises in the Slaughter and Chill category.

FIGURE 6 – TOTAL ENERGY SOURCE AND USAGE BENCHMARKS



The results of international comparisons for energy contrasted with South African facilities (see Figure 7) show South African enterprises using less energy on an SU basis. The study attributes this to the thermal heat load in South African plants being different to Australian and New Zealand examples, due to the use of electrical energy and heating elements to generate hot water, or the use of coal to produce steam (which results in high energy use and boiler losses). Liquefied Petroleum Gas (LPG) is also frequently used in the South African industry for pig singeing, although it is up to five times more costly than coal on a per kWh basis.

FIGURE 7 – TOTAL ENERGY USAGE (KWH) AND COST BENCHMARKS



The study points out the likelihood that South African companies will continue to be reliant on coal and direct-point electrical-based heating systems for the next decade or so; however, the establishment of natural gas reserves and heavy CO_2-equivalent taxes on coal-based systems may start to move industry towards other systems in the longer term.

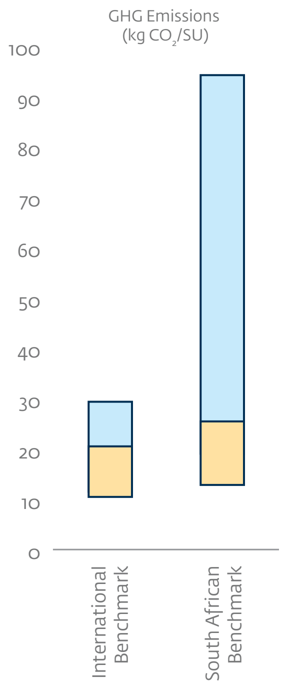
TABLE 3 - ENERGY AND WATER UNIT COSTS

FINANCIAL	INTERNATIONAL BENCHMARKS	SOUTH AFRICAN BENCHMARKS
	Median	Median
Cost / kWh Electrical including demand charges (R/kWh)	R2.90	R1.30
Cost / kWh Thermal (R/kWh)	R0.34	R1.13
Cost of water purchase (R/kl)	R5.45	R14.00
Cost of water discharge including penalties (R/kl)	R9.73	R7.50

Cost comparisons between the two energy inputs provided some contrasts: South African enterprises were found to be paying around R1.30/kWh for electrical energy and 1.13/kWh for thermal energy, compared to the equivalent of R2.90/kWh and R0.34/kWh, respectively in the international benchmark cohort. This disparity in unit price in part explains the higher use of electricity for water heating in South Africa.

Estimates of Greenhouse Gas (GHG) emissions have been calculated from the energy data obtained from the plants, and Figure 8 provides the median and range of GHG emissions.

FIGURE 8 - ESTIMATE OF GHG EMISSIONS

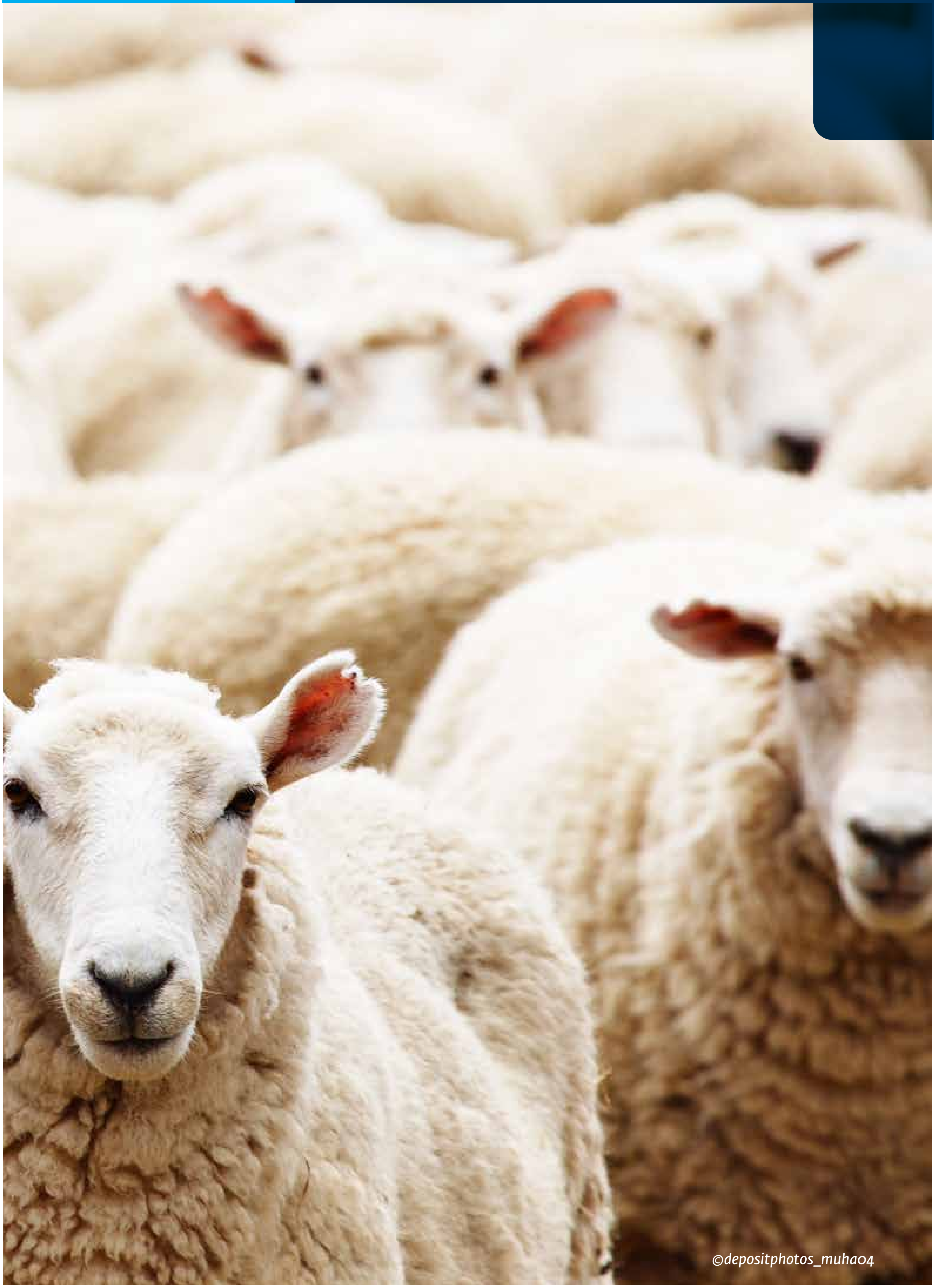


While the median level of emissions is similar for both South Africa (27 kgCO_2/SU) and internationally (22 kgCO_2/SU), the South African data shows some high levels of GHG emissions. This is essentially due to the impact of the direct utilisation of electricity for hot water heating where the electricity is primarily generated from thermal fuel at a centralised generation facility. South Africa is still heavily reliant on coal power stations, resulting in comparatively high CO_2 emissions per kWh electricity.

Emerging from this study is the development of a set of 18 key performance indicators (KPIs) for the processing sector, with particular focus on water consumption, wastewater generation and energy use. These KPIs in turn have produced a detailed profile of individual plants' performance as well as findings about the industry on a national level.

A key output of the study is a self-assessment tool that can be used by other enterprises in South Africa to benchmark themselves. The self-assessment "Benchmark Tool" produces a "Resource Efficiency Benchmark Report" tailored to the participant plant.

A "*Practical Guide for Improving Resource Efficiency in Red Meat Abattoirs in South Africa*" has also been produced and the opportunities and recommendations in this guide have been incorporated into "Resource Efficiency Assessment Reports", tailored to the circumstances of each enterprise participating in the study. The Practical Guide for Improving Resource Efficiency details specific, practical solutions that abattoirs can adopt to improve their resource efficiency and competitiveness, and ultimately their sustainability.



2

Introduction

Background to the Project

Water scarcity, greater water demand and changes in water supplies due to climate change are severely affecting large parts of Southern Africa, including South Africa, posing a significant risk to the region. Coupled with the increasing cost of energy and underdeveloped practices of handling agricultural waste, the availability of resources in general presents a significant risk for companies engaged in agribusiness.

It has been estimated that South Africa's red meat production sub-sector, including beef, pork, sheep and goat meat processing, takes up to 10% of the total water consumption and slightly less of the energy consumption in the agricultural processing space (excluding pulp and paper). The sector possesses significant potential to reduce the use of water and other resources, which would improve its cost base and environmental footprint, and increase the competitiveness and sustainability of abattoirs and integrated operators, as well as enhance their export potential.

SOUTH AFRICA'S red meat production sub-sector, including beef, pork, sheep and goat meat processing, takes up to 10% of the total water consumption and slightly less of the energy consumption in the agricultural processing space (excluding pulp and paper).

The IFC, a member of WBG, is the largest global development institution focused exclusively on the private sector in developing countries. IFC's Manufacturing, Agribusiness and Services (MAS) Advisory team offers a diverse array of services to private sector companies, assisting to improve productivity and mitigate risks associated with environmental factors and climate change. In agribusiness, MAS Advisory assists with the integration of smallholder farmers into food supply chains, improving agricultural productivity and food safety, optimising the use of resources, saving energy and water, and reducing waste.

In 2019, IFC and the SECO launched the APRE programme in South Africa. The programme aims to assist the agri-processing sector in South Africa to improve sustainability and competitiveness by emphasising reductions in water use, along with related reductions in energy and fuel consumption (or usage). Red meat processing has been identified as one of the priority sub-sectors, offering significant potential to reduce resource consumption.

Red meat processing has been identified as one of the priority sub-sectors, offering significant potential to reduce resource consumption.

The RMAA is the leading industry association in South Africa that aims to improve the competitiveness of domestic producers, promoting good operational practices, facilitating linkages between sector players, and advocating for policy measures to create a conducive enabling environment.

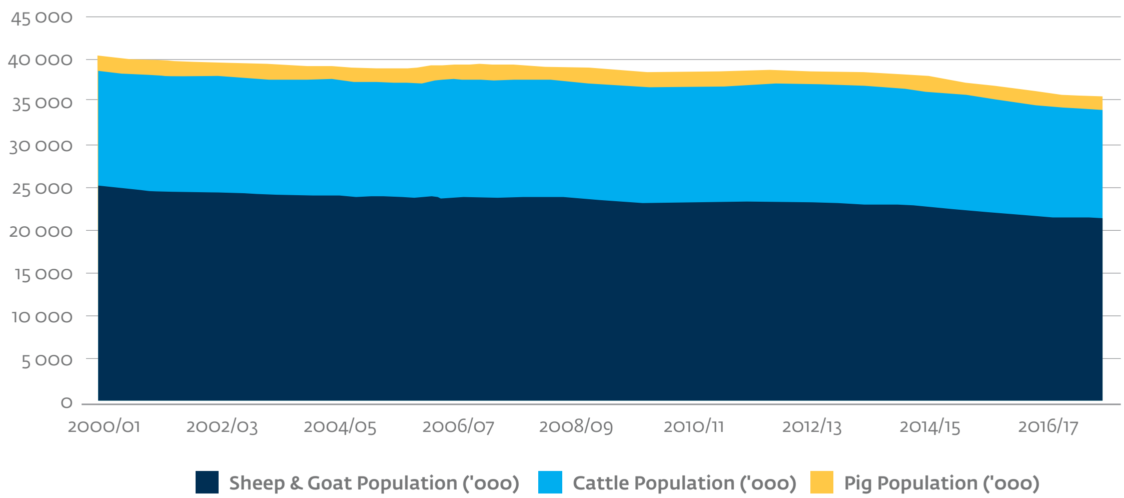
IFC and RMAA partnered to conduct the resource efficiency benchmarking of red meat abattoirs in South Africa to assess gaps in the efficient use of resources with a focus on water, and identify areas for improvements in performance and sustainability.

The following pages are a summary of the South African meat processing industry's performance against domestic (South African) and international benchmarks.

The South African Meat Processing Industry

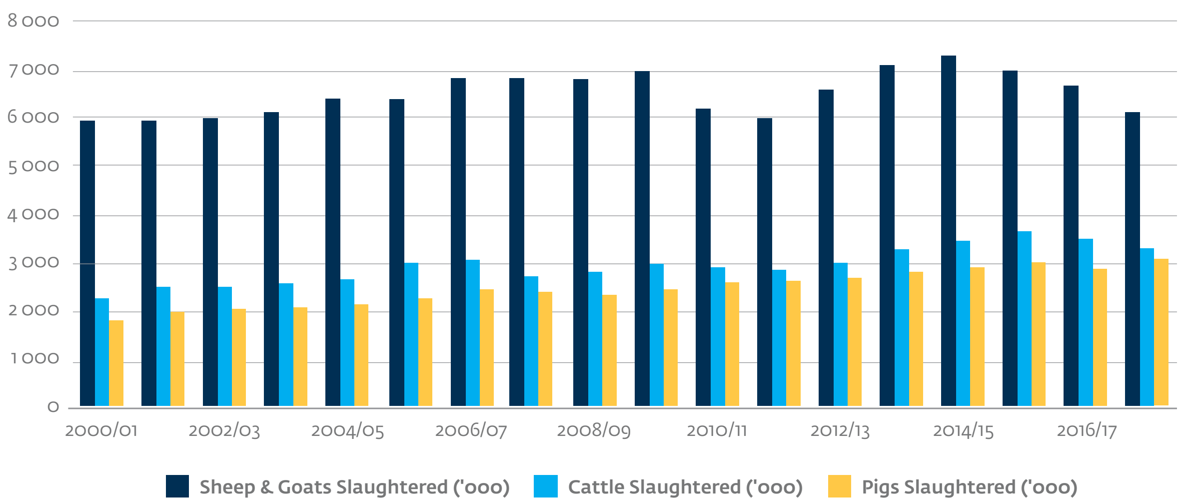
The South African meat processing industry produces animal products for consumption in the South African domestic market and a number of export markets.

FIGURE 9 – LIVESTOCK POPULATION IN SOUTH AFRICA[2]



The red meat livestock population has decreased from 40 million head in 2001 to around 35 million head in 2018 (see Figure 9). While the population has been decreasing, production volumes have been increasing as the sector has improved production efficiency, particularly through the adoption of feed finishing practices, but has also been impacted by destocking of production properties due to drought and disease outbreaks.

FIGURE 10 – LIVESTOCK SLAUGHTERING IN SOUTH AFRICA (HEAD)[2]



[2] Department of Agriculture, Forestry and Fisheries, 2019

According to the Department of Agriculture, Forestry and Fisheries (DAFF), the number of livestock processed per annum in South Africa between 2000 and 2018 (see Figure 10):

- Increased from 2.3 million to 3.3 million cattle
- Increased from 1.9 million to 3.1 million pigs
- Was stable at around six million sheep/goats.

The South African Red Meat Levy Admin (RMLA) reported that 2.7 million cattle, 4.9 million sheep, 722 goats and 3.2 million pigs were processed in 2019[3].

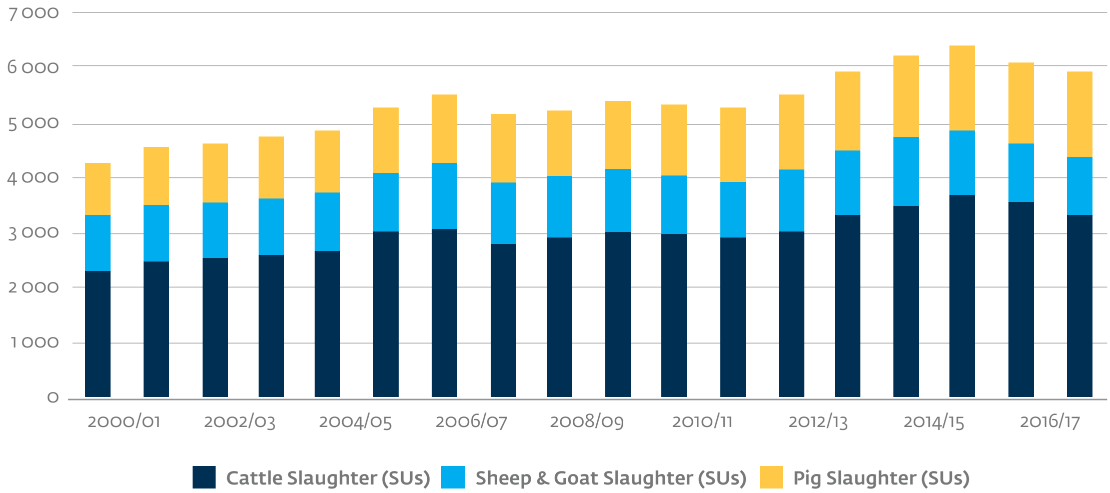
South Africa utilises a measure referred to as SUs to provide an overall indicator of the total volume of red meat processed in the country.

Figure 11 provides the progression between 2000 and 2018 of livestock slaughtering in South Africa based on SUs.

SUs ARE BASED ON THE FOLLOWING CONVERSIONS:

- One cattle animal equals one SU
- Two pigs equal one SU
- Six sheep equal one SU
- Six goats equal one SU
- Six small-stock (mixed species) equal one SU.

FIGURE 11 - LIVESTOCK SLAUGHTERING IN SOUTH AFRICA (SU)[4]



The number of SUs slaughtered increased from 4.2 million SUs in 2000 to 5.9 million in 2018. This is a growth of 40% over 18 years and demonstrates the successful growth rate of the sector.

In the 12 months from November 2018 to October 2019, the RMLA recorded 5.1 million SUs processed (see Table 4). The difference between the Department of Agriculture, Forestry and Fisheries (DAFF) Statistics and the RMLA data could be due to the DAFF data including an estimate for home kill.

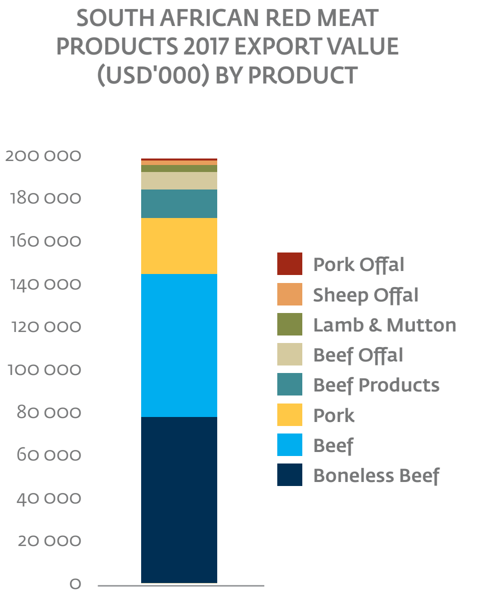
3 Red Meat Levy Admin, 2020

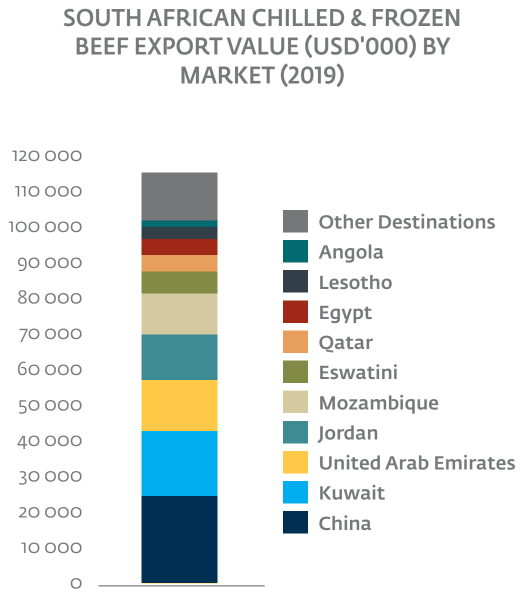
4 Department of Agriculture, Forestry and Fisheries, 2019

TABLE 4 – RMLA SLAUGHTER STATISTICS[5]

SLAUGHTER STATISTICS (HEAD) - RED MEAT LEVY AUTHORITY 12 MONTHS - NOVEMBER 2018 TO OCTOBER 2019				
Province	**Cattle**	**Sheep**	**Goats**	**Pigs**
Eastern Cape	216 174	431 849	125	192 076
Free State	505 986	815 258	-	218 161
Gauteng	456 237	595 718	6	1 310 626
KwaZulu-Natal	234 728	121 352	-	448 058
Limpopo	150 054	19 581	179	59 411
Mpumalanga	537 131	88 039	86	156 041
North West	181 690	1 706 248	70	109 707
Northern Cape	254 849	39 754	143	85 524
Western Cape	119 963	1 117 512	113	645 237
TOTAL HEAD	**2 656 812**	**4 935 311**	**722**	**3 224 841**
TOTAL SU	**2 656 812**	**822 552**	**120**	**1 612 421**
TOTAL SU	**5 091 905**			

FIGURE 12 - SOUTH AFRICAN RED MEAT EXPORTS[6]





[5] Red Meat Levy Admin, 2020

[6] Food and Agriculture Organization of the United Nations, 2020

Red meat exports are important to the South African economy and in 2017, exports were worth an estimated US$200 million. These exports were dominated by beef products which made up over 80% of red meat exports.

Chilled and frozen beef in 2019 (not including offal items) was exported to a wide variety of destinations, with China, Kuwait and the United Arab Emirates (UAE) accounting for 50% of export volumes, as depicted in Figure 12.

TABLE 5 – STRUCTURE OF THE SOUTH AFRICAN RED MEAT PROCESSING SECTOR[7]

TOTAL ABATTOIRS PER PROVINCE		CATTLE ABATTOIR THROUGHPUT CAPACITY			
Province	**Total Number**	**High Throughput (HT)**	**Infrequently Slaughtering Low Throughput (ISLT)**	**Low Throughput (LT)**	**Rural Throughput (RT)**
Eastern Cape	67	12	3	10	33
Free State	80	20	7	17	13
Gauteng	40	14	6	4	
KwaZulu-Natal	50	16	7	7	8
Limpopo	34	8	6	9	36
Mpumalanga	33	13	4	8	2
North West	35	11	4	8	11
Northern Cape	38	9	3	9	6
Western Cape	46	16	7	16	2
Total	**423**	**119**	**47**	**88**	**111**

The structure of the red meat processing sector in South Africa is extremely diverse and ranges from a relatively limited number of large, sophisticated enterprises servicing the demand requirements of customers worldwide at one end, to a large number of low production, simple "slaughter and chill" operations that supply red meat carcases to local butchers and markets.

Table 5 provides an analysis of the provincial structure of the South African red meat processing sector as at 2019, indicating a total of 423 enterprises.

Indicative production levels for High Throughput (HT), Low Throughput (LT) and Rural Throughput (RT) plants are:

- HT: >20 SUs per day
- LT: 3-20 SUs per day
- RT: <=2 SUs per day.

TABLE 5 ALSO PROVIDES THE NUMBER OF CATTLE ABATTOIRS BY THROUGHPUT CAPACITY; THIS DATA INDICATES THAT:

- Around one-third of cattle abattoirs are high throughput;
- Another one-third are intermediate or low throughput;
- Another one-third are rural throughput.

It needs to be recognised that while the large plants servicing sophisticated domestic and international markets usually have advanced management capabilities, this may not be the case in the smaller, low throughput and rural-based enterprises.

The development of the Benchmark Tool which can be self-populated by enterprise management is seen as an essential project component to engage management across the broad spectrum of red meat processing enterprise capabilities.

7 Red Meat Abattoir Association, 2018

BENCHMARKING – PAINTING PICTURES

It is important to recognise that benchmarks are useful in providing an indication of relative performance. The reality however, is that meat processing plants often differ in some way or another (e.g. Fully Integrated plants with rendering facilities, retail ready, or further processing operations versus simple "Slaughter and Chill" operations).

While corrections have been made to the input information where data is available, and the "Benchmark Tool" makes a number of adjustments associated with processing operation, the outputs should be interpreted while understanding that the International Benchmarks (mostly representing fully integrated facilities) may not directly compare with the Domestic Benchmarks (which, for example, tend to not process offal as thoroughly and generally do not have rendering plants). The Domestic Benchmark data at a departmental level relies on data collected when undertaking plant visits where actual metering was not available.

The benchmarking provides a rating against KPIs, and such ratings will contain some level of imprecision.

Resource Efficiency Benchmarking

Resource efficiency benchmarking provides the ability to examine and understand resource efficiency performance in relation to others. The results can be used to compare resource efficiency performance against other red meat processing enterprises at both the international and the local level. The report can also be used as a guide on what to measure, to determine resource efficiency metrics relevant to red meat processing. Comparing resource efficiency performance with peers provides an understanding of where resource efficiencies may be different and thereby helps enterprise management to identify areas of focus to increase efficiencies, reduce resource consumption, and reduce operating costs.

This report provides performance benchmarks relevant to the South African red meat processing sector, based on international references and the performance of 21 meat processing plants located throughout South Africa during the first quarter of 2020.

Data for this report has been collected from a variety of sources, including:

- Plant monitoring data
- In-plant surveys by the project team
- Accounting documentation
- Energy and material audit tools
- A desk study of international benchmarking.

The report provides resource efficiency benchmarking based on resource usage and associated costs for water (incoming and outgoing volumes and quality) and energy (electricity and fuel) in relation to the units of meat produced (SU), and carcase weight (tonnes CW).

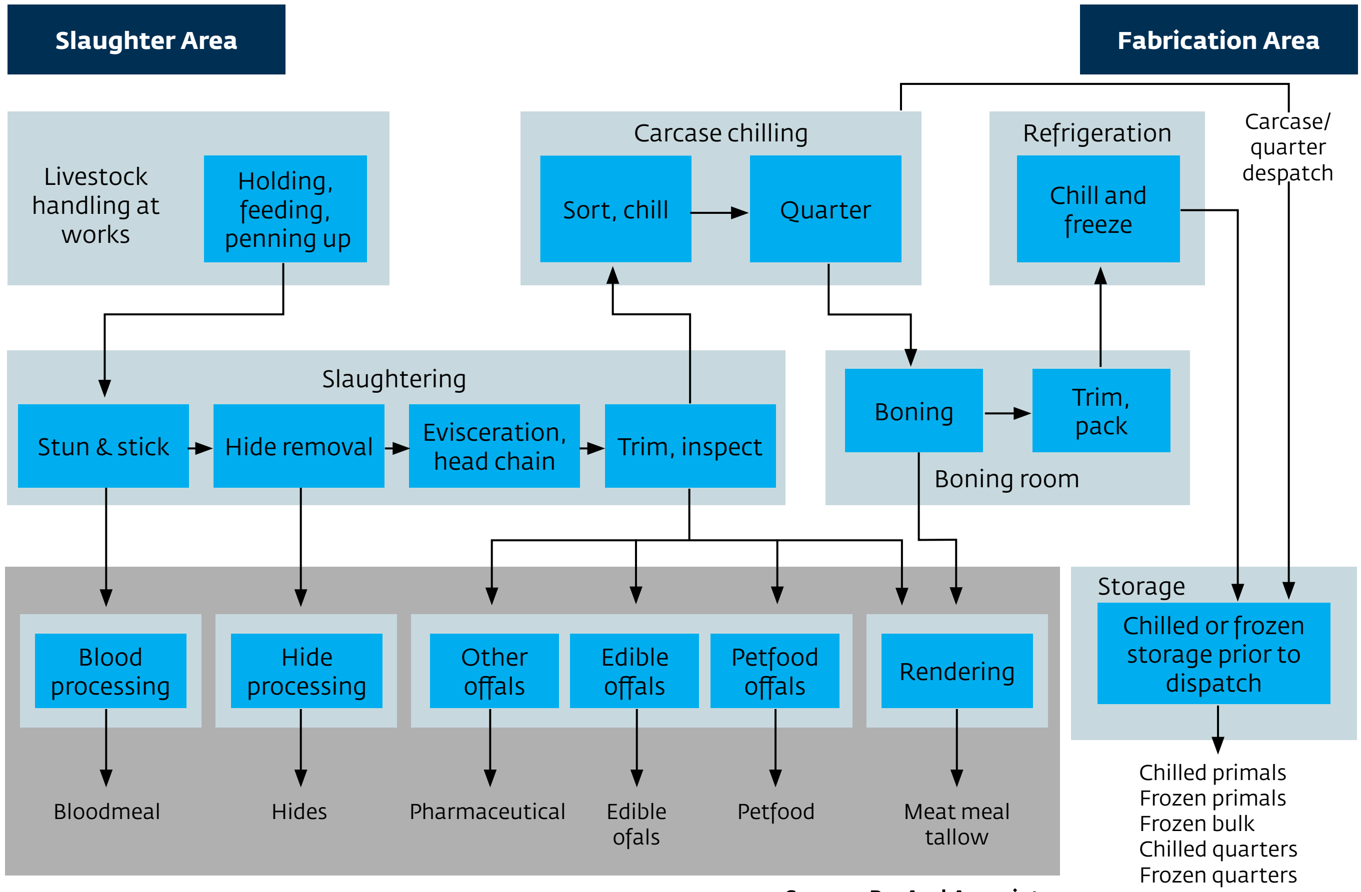
Choosing the right units for rationalising resource performance is essential for providing useful resource efficiency information. Resource efficiency measurements should not be based on the quantity or cost of resources alone. Variations in processing procedures, departmental operations and variability of finished products typically alter the quantity and overall cost of resources consumed. Rationalising resource quantity and cost against the "volume processed" provides a method to measure resource efficiency performance and it is the unit used throughout this report.

Process Variation and the Impact on Resource Utilization

A significant challenge for benchmarking in the red meat processing sector is an understanding of how the industry operates so that benchmarking can be conducted on the basis of "best endeavours".

The meat industry process flow outlined in Figure 13 represents a full set of operating departments associated with what can be described as an "Integrated Meat Processing" enterprise. International benchmarking is generally conducted on processing enterprises that have all the operating departments outlined in Figure 13.

FIGURE 13 - MEAT INDUSTRY PROCESS FLOW: FULLY INTEGRATED ENTERPRISE



Source: ProAnd Associates

There are no significant differences in technology and plant design, particularly in the slaughter and boning areas of meat plants in South Africa, compared with international plants. While the livestock handling and slaughtering operations are similar across the formal meat processing sector there are some significant operating differences in other departments compared to South African enterprises. The differences at an overall industry level are outlined in Table 6.

TABLE 6 – DIFFERENCES IN PROCESSING OPERATIONS

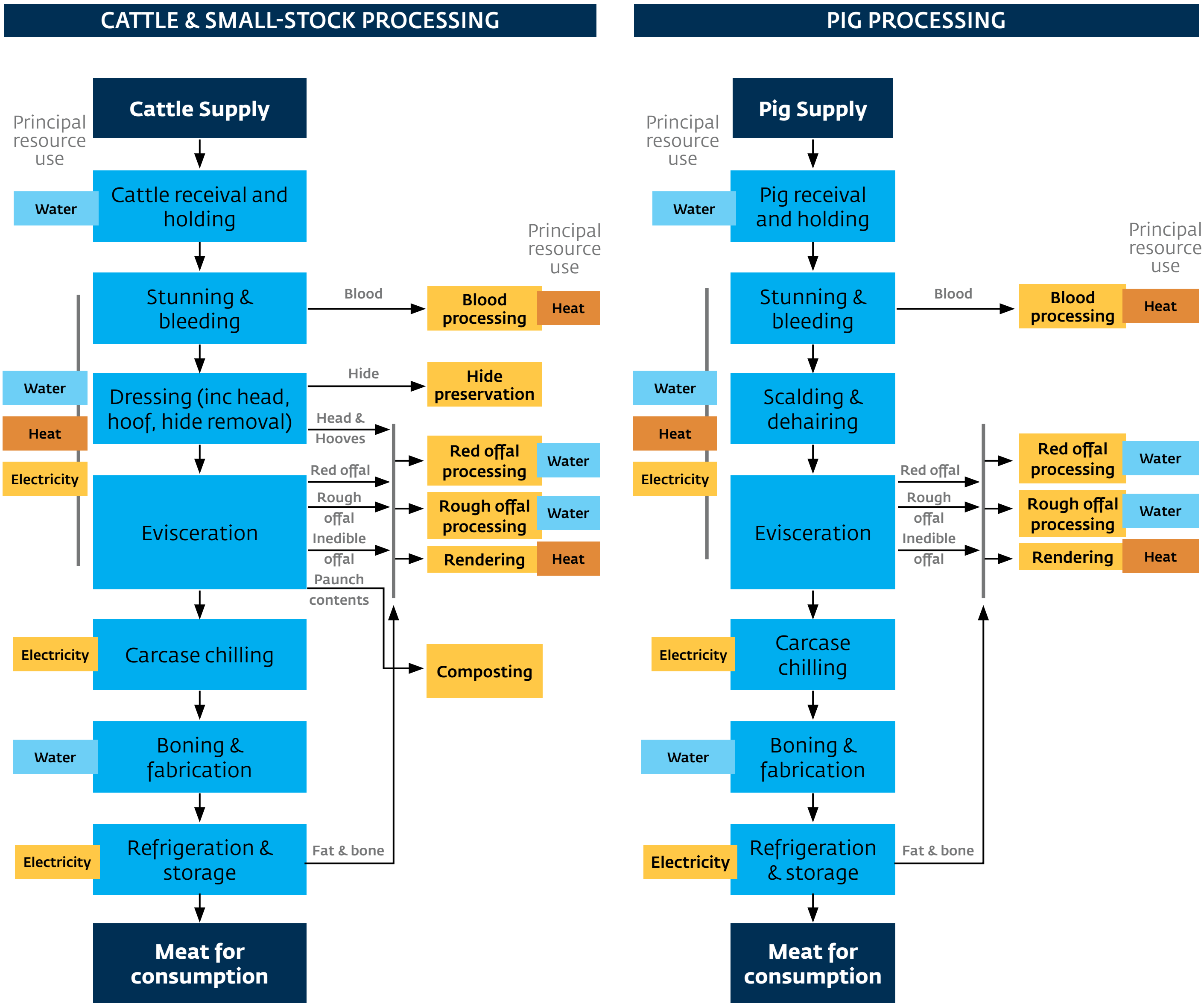
DEPARTMENT	FULLY INTEGRATED ENTERPRISES	SOUTH AFRICAN ENTERPRISES
Livestock Handling	Livestock in Australia (particularly feedlot cattle) and New Zealand are generally washed before slaughter.	Livestock in South Africa are not washed before slaughter.
Blood Processing	Blood is coagulated and dried in a pneumatic drier to produce blood-meal. The process involves heat to dry and produces highly loaded stick-water from the coagulation process.	Blood is not processed on-site and is often despatched directly to a composting operation, with little to no energy or wastewater implications.
Hides	Hides and skins are often short-term preserved using chilled water or refrigeration involving energy and water consumption, and wastewater generation. They are sometimes salted.	Hides and skins are generally sent off-site daily in a fresh condition, not requiring the use of any water or energy resources.
Offal	Red and rough offal is cleaned and processed, packed into cartons and frozen (generally for export). This requires considerable amounts of water and generates contaminated wastewater. Freezing requires additional energy compared to chilling.	Red offal is regularly processed as full sets which are rinsed and chilled prior to despatch to the domestic market in chilled form. Rough offal is rinsed, cleaned and also despatched to the domestic market in chilled form. The use of water and energy is significantly less than for the fully integrated enterprise.
Boning	While there may be a small number of fresh carcases/quarters despatched, most carcases will be fully fabricated and packed prior to despatch. More energy will be associated with longer-term chilling, product freezing and storage.	Most boning rooms process mainly hindquarters, and the majority of forequarters are despatched as chilled bone-in quarters directly into the domestic market. Less energy is needed than in fully integrated enterprises.
Refrigeration	All plants have installed more efficient centralised ammonia refrigeration. Many have replaced blast freezers with more efficient plate freezers and have recently begun to install automated, unmanned carton handling and storage systems for both frozen and chilled product.	Many enterprises in South Africa continue to have less efficient distributed hydrocarbon systems for refrigeration systems and retain blast freezing and manual cold storage systems.
Rendering	Rendering is almost universally present in the fully integrated enterprises due to significant raw material volumes from the slaughter and boning processes. Almost all have heat recovery units installed, which generate hot water from rendering waste heat; however, the net energy use is high due to the rendering process itself.	Very few enterprises operate rendering facilities, as the raw material volume is small, and most items have a domestic market demand. Items that cannot be marketed are directed to composting operations with little to no impact on resource use.

In order to make comparisons there is a need to adjust the resource consumption in accordance with the departmental operations employed by the enterprise.

Resource Utilisation

Resource utilisation at meat processing operations involves the consumption of water, thermal energy (heat) and electricity. Figure 14 provides an overview of process flow and resource consumption for cattle, small-stock and pig processing.

FIGURE 14 - MEAT PROCESSING ENTERPRISE FLOWCHARTS AND RESOURCE CONSUMPTION



Project Methodology

The project identified a series of KPIs relevant to the red meat processing sector (including beef, pork, sheep and goat), with a focus on water consumption, wastewater generation, and energy use. This was done through discussions with the Project Reference Group (a group of stakeholders including abattoir managers and industry specialists). The KPIs are summarised in Table 7.

TABLE 7 - KEY PERFORMANCE INDICATORS

	INCOMING WATER		ENERGY
1	Total abstracted water – municipal (kl)	10	Total energy used (kWh)
2	Total abstracted water – ground/surface/rainwater (kl)	11	Total energy used in refrigeration units (kWh)
3	Total re-used water (%)	12	Total thermal energy for steam and hot water systems (kWh)
4	Pre-slaughter water usage (kl)	13	GHG emissions (kg CO_2e)
5	Rough offal handling (kl)		**FINANCIAL**
6	Post- operative cleaning (kl)	14	Cost/kWh Electrical, including demand charges (R/kWh)
	EFFLUENT	15	Cost/kWh Thermal (R/kWh)
7	Total volume discharge (kl)	16	Cost of water purchase (R/kl)
8	Average chemical oxygen demand (COD) (mg/l)	17	Cost of water discharge, including penalties (R/kl)
9	Average total dissolved solids (TDS) (mg/l)	18	Required IRR for projects (%)

With the assistance of the Project Reference Group, and in particular the RMAA, 30 firms engaged in the red meat abattoir sector were identified to participate in the benchmarking (jointly with the RMAA and IFC), of which 21 facilities participated in the project.

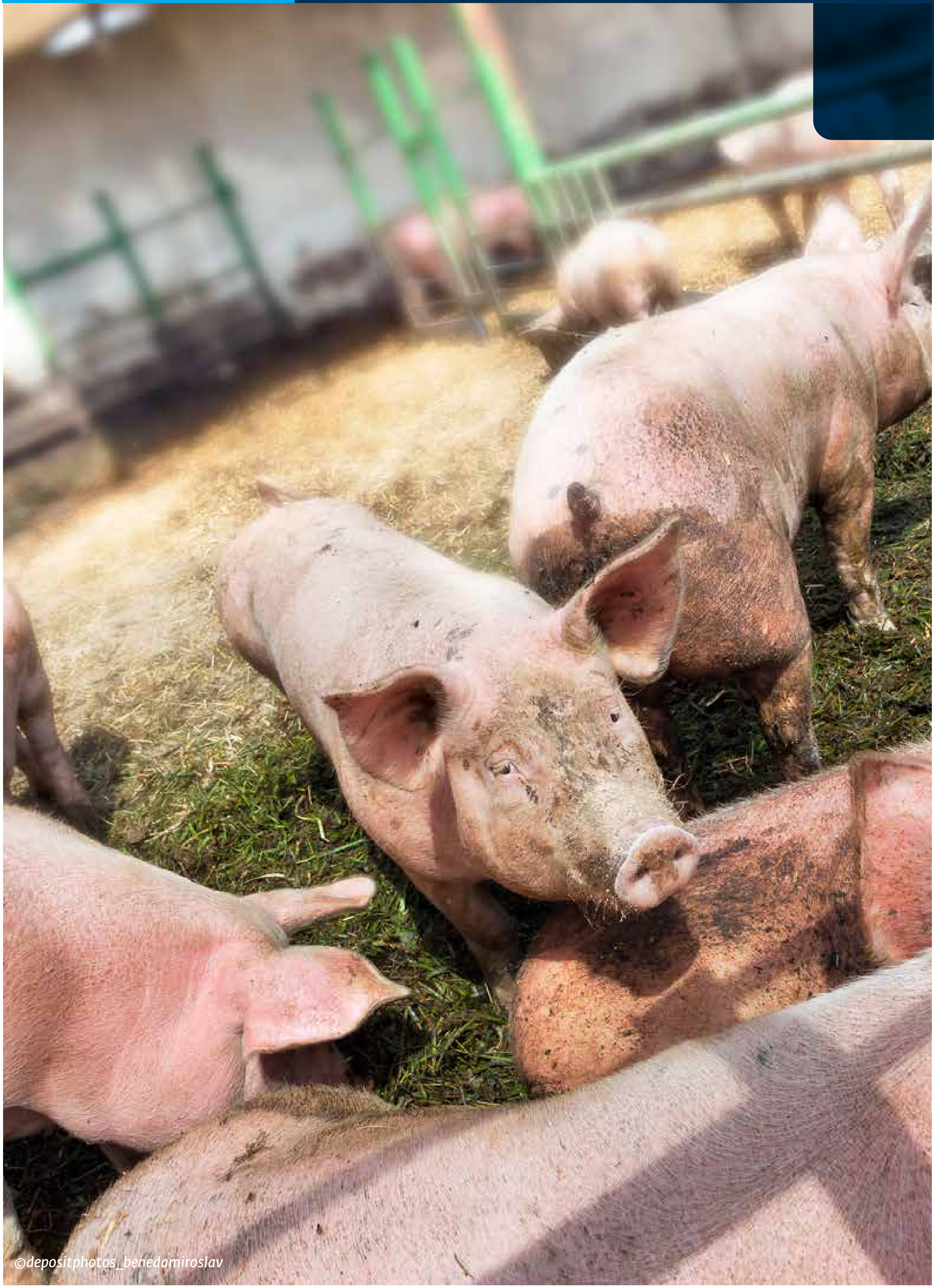
Baseline data across the agreed KPIs and subsectors was collected and where possible, data for 12 historical months was gathered. Thirteen of the participating plants were visited by the project team, and plant processing operations and performance were reviewed and data collected for the Benchmarking Project. A further 8 of the selected meat processing firms were provided with the Data Input Sheets of the Benchmark Tool and a non-specific version of the Benchmark Tool Output. These plants were contacted to assist with data collection in compliance with the protocols of the Benchmark Project. It was considered important to visit a number of plants to ensure that the operations were well understood and to make assessments of resource consumption at a departmental level in plants where there was limited monitoring.

A literature search of international best practices associated with meat processing utilisation of water and energy resources was conducted, and while a number of countries/regions have produced documents associated with best practice for the meat processing industry, only Australia and New Zealand have conducted benchmarking processes to a reasonable degree of rigour in recent years. While the Australian and New Zealand industries produce more product for the international market than South Africa, the plant visits confirmed that the technology employed and the processing practices were similar, with the differences as identified in Table 6.

A "Benchmark Tool" was developed that captures all relevant data and produces a "Resource Efficiency Benchmark Report" (see an example in Annex 2). This report provides comparisons with both International and domestic (South African) benchmark information. Participating plants were provided with the "Resource Efficiency Benchmark Report" and a second "Resource Efficiency Assessment Report", providing a gap analysis and making recommendations/observations addressing opportunities to reduce resource utilisation through the adoption of best practices.

Once the data collected had been checked for compliance, this report titled "*Benchmarking Study: Resource Efficiency in Red Meat Abattoirs in South Africa*" and a second report titled "*A Practical Guide for Improving Resource Efficiency in Red Meat Abattoirs in South Africa*" were generated.

The project was conducted in close collaboration with stakeholders to develop relevant KPIs and to obtain feedback on progress and recommendations as they arose.


©depositphotos_benedamiroslav

3

International Benchmarks

While a number of regions and countries have reported consumption data for the meat processing sector, only Australia and New Zealand have conducted regular surveys and provided an analysis of the data that enables an understanding of the functional departments operated by the benchmarked enterprises. While the Australian and New Zealand industries produce more product for the international market than South Africa, the plant visits confirmed that the technology employed and the processing practices are similar, with the differences as identified in Table 6.

The following section provides an overview of international benchmarks, with an emphasis on data that has been published for Australia and New Zealand.

OVERVIEW

A literature review was conducted to identify robust international benchmark data for the meat processing industry that could provide a basis for making comparisons with South African enterprises.

Australian Meat Processing Benchmarks

In 2015, the Australian meat processing sector conducted the fourth in a series of benchmarking studies that had commenced in 1998. The 2015 Environmental Performance Review Study[8] conducted a survey of Australian meat processing plants to assess their resource utilisation and made a comparison of gains made over the period 1998 to 2015. The meat processing enterprises were largely integrated plants (see Figure 13), with processing characteristics as outlined in Table 8.

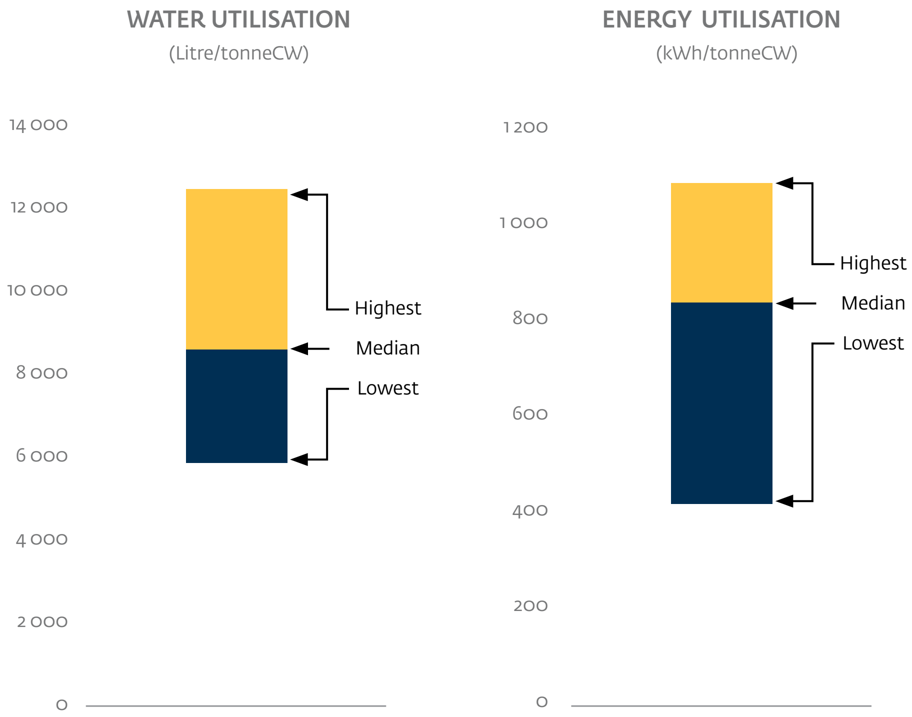
TABLE 8 - AUSTRALIAN MEAT ENTERPRISE CHARACTERISTICS IN THE 2015 STUDY

PARAMETER	RANGE
Production	16 288 to 220 353 tCW/year
Animal mix	Cattle only (9), mixed (3), small animal only (2)
Location	New South Wales (3), Queensland (5), South Australia (2), Victoria (4)
Operations	With rendering (12), without rendering (2)

The benchmark indicators (lowest, median and highest) for the plants represented in Table 8 are provided in Figure 15.

8 Alexander, Ridoutt and Sanguansri, 2015

FIGURE 15 – AUSTRALIAN RESOURCE USE EFFICIENCY INDICATORS: 2015 STUDY

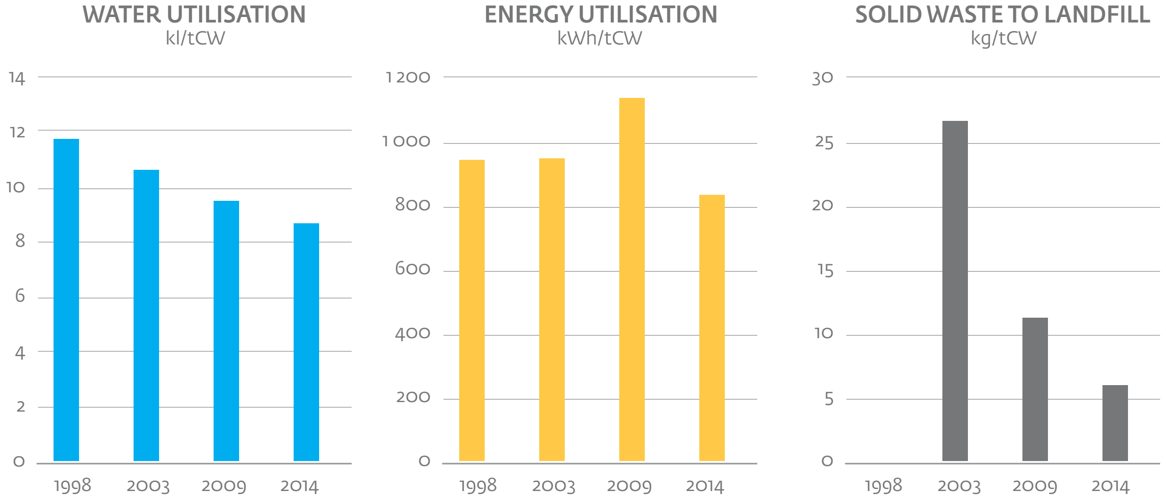


Australia's red meat processing sector reduced its water utilisation by 30% over 16 years, largely due to the impact of increased use of reused/recycled water.

Similar benchmark data was collected in Australia in 1998, 2003, 2009 and 2014. The progression in indicators over this period is provided in Figure 16. It can be observed from this data that over this 16-year period:

- Water utilisation fell from almost 12 kl/tCW to 8.5 kl/tCW. This represents a 30% overall reduction in water utilisation over 16 years. A significant impact on reduced water consumption was likely provided by an increased use of reused/recycled water.
- While energy utilisation reduction was more erratic, the overall reduction over the 16 years was around 12%.
- Solid waste data has been included to demonstrate how the red meat industry is able to respond when it is possible to focus on reducing a resource impact. Over the 16 years, the amount of solid waste disposed to landfill reduced by over 75% as plants concentrated on recycling solid waste.

FIGURE 16 – VARIATION IN RESOURCE UTILISATION INDICATORS OVER TIME: AUSTRALIA[5]



RESOURCE	INDICATOR	UNITS	1998	2003	2009	2014
Water	Water Utilization	kl/tCW	11.8	10.6	9.4	8.6
	Reuse & Recycling	%	NR	NR	11	13
Energy	Energy Utilization	MJ/tCW	3 411	3 389	4 108	3 005
Energy	Energy Utilization	kWh/tCW	948	941	1 141	835
Solid waste	Solid waste to landfill	kg/tCW		26.7	11.3	5.9
GHG emissions	GHG emissions intensity	kg CO2e/tCW	-	525	554	432

European Union (EU) Meat Processing Benchmark Indicators

The few European benchmark indicators which were reviewed are summarised in Table 9. It can be observed from the table that the data provided in most cells indicates a wide range in results and there is little detail on the enterprise departmental inclusions in the overall data. It is therefore considered that this information is of limited use for comparison with South African enterprises. It should be noted, however, that the water and energy consumption data cover ranges that are similar to the Australian data at the high end. It would be expected that many meat processing enterprises in Europe are essentially "slaughter and chill" operations, with a number of them also having fabrication operations. Very few European plants have rendering plants, as there are many third-party rendering enterprises available to process organic waste material.

TABLE 9 – EU RESOURCE IMPACT DATA: CATTLE, SHEEP AND PIG PROCESSING[9]

PER TONNE CARCASE WEIGHT	WATER CONSUMPTION (L)	ENERGY CONSUMPTION (KWH)	BOD EMISSION (KG)
CATTLE			
Unloading/vehicle wash	200-320		0.4
Lairage	152-180		0.4-3.0
Slaughter			
Bleeding			
Hide removal	5		
Head + hoof removal			
Evisceration			
Splitting			2.2
Chilling			
Offal treatment			
Intestine washing			
Tripe washing	500-2 760		
Cleaning			
Total	**1 623-9 000**	**90-1094**	**1.8-28**
SHEEP			
Unloading/vehicle wash			
Lairage			
Slaughter			
Bleeding			
Hide removal			
Head + hoof removal			
Evisceration		4-7	0.44
Splitting			
Chilling			
Offal treatment	1 667		
Intestine washing			
Tripe washing	278		0.33
Cleaning			
Total	**5 556-8 333**	**922-1 839**	**8.89**
PIGS			
Unloading +vehicle wash	78-290		0.3
Lairage	130-300		
Slaughter	10-50		
Bleeding	30-40		0.3
Skin removal	520-1 750		
Scalding	150-156	17-39	0.23-0.26
Hair + toenail removal	78-120		0.91-2.2
Singeing	162-208	47-182	
Rind treatment	260-460		1.25-2.21
Evisceration			
Splitting		55	5.5
Chilling	0-226		
Offal treatment			
Intestine washing	442-680		0.98-3.25
Cleaning	325		
Total	**1 600-8 300**	**110-760**	**2.14-10**

[9] EU, 2005

FIGURE 17 - UK PIG SLAUGHTERHOUSE WATER CONSUMPTION[10]

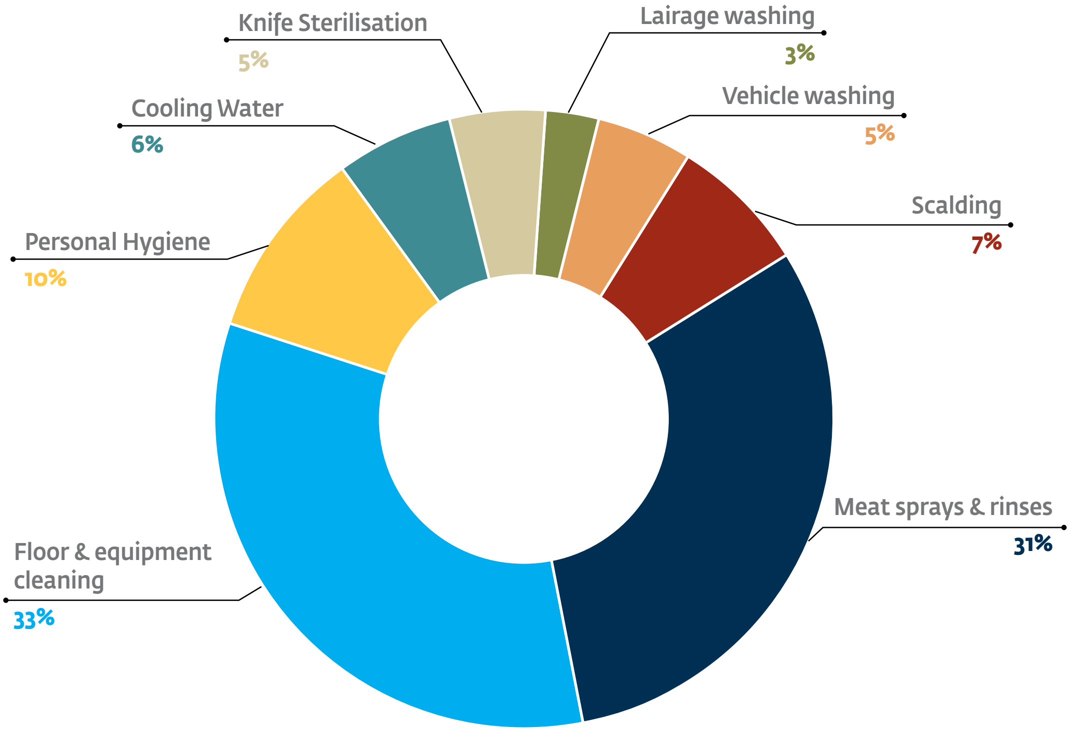


Figure 17 provides a breakdown of water consumption in the United Kingdom (UK) pig slaughterhouses. This indicates that around 7% of water is consumed in the scalding-dehairing process. This is consistent with the estimates provided in section titled "Enterprise Benchmark Adjustment Schedule" on page 41.

New Zealand Benchmark Indicators

The New Zealand (NZ) meat processing sector conducted four benchmark projects between 1993 and 2011. These studies were comprehensive and involved the installation of metering in plants to obtain improved data on departmental consumption patterns.

A number of factors that impact on resource consumption do, however, need to be noted:

- Most plants in New Zealand operate in compliance with EU third-country processing requirements which are the most demanding processing conditions in relation to hygiene and sanitation.
- Most stock in New Zealand are washed pre-slaughter. Washing is conducted to ensure clean product with a long shelf life.
- Relative to other meat processing sectors, New Zealand processes a much higher proportion of small-stock, and uses more water for rough offal recovery and processing.
- Water supply is generally not an issue in New Zealand and therefore attracts a lower degree of management attention.

[10] Atkins, 2000

TABLE 10 – NEW ZEALAND MEAT PROCESSING WATER UTILISATION

NZ MEAT PROCESSING WATER UTILISATION KL/TCW			
	1994/95	1995/96	2010/11
Potable water	26	27	21
Non-potable water	16	11	9
Total	**42**	**37**	**31**

Table 10 provides New Zealand data for water consumption for the three benchmark studies that have been conducted. Observations that can be made in relation to the data in Table 10 include the following:

- Non-potable water is mostly used for livestock washing.
- Due to EU regulations, there is little reuse or recycled water used in New Zealand.
- Overall water consumption at over 30 kl/tCW is considerably higher than Australia at 8-10 kl/tCW and the EU at 1.6-9 kl/tCW,
- Even potable water consumption at over 20 kl/tCW is considerably higher than Australian and EU indicators.

TABLE 11 – NEW ZEALAND MEAT PROCESSING ENERGY UTILISATION

NZ MEAT PROCESSING THERMAL ENERGY UTILISATION - KWH/TCW				
	1993/94	1994/95	2001/02	2010/11
All surveyed	1 170	1 080	1 110	940
Rendering	1 440	1 420	1 440	1 280
Non-rendering	140	310	190	390
NZ MEAT PROCESSING ELECTRICITY UTILISATION - KWH/TCW				
	1993/94	1994/95	2001/02	2010/11
All surveyed	500	440	640	530
Rendering	560	530	690	610
Non-rendering	280	220	470	390
NZ MEAT PROCESSING TOTAL ENERGY UTILISATION - KWH/TCW				
	1993/94	1994/95	2001/02	2010/11
All surveyed	1 640	1 530	1 720	1 440
Rendering	2 000	1 940	2 140	1 890
Non-rendering	440	530	670	780
NZ MEAT PROCESSING THERMAL ENERGY UTILISATION - PERCENT OF TOTAL ENERGY				
	1993/94	1994/95	2001/02	2010/11
All surveyed	71%	71%	65%	65%
Rendering	72%	73%	67%	68%
Non-rendering	32%	58%	28%	50%
NZ MEAT PROCESSING ELECTRICAL ENERGY UTILISATION - PERCENT OF TOTAL ENERGY				
	1993/94	1994/95	2001/02	2010/11
All surveyed	30%	29%	37%	37%
Rendering	28%	27%	32%	32%
Non-rendering	64%	42%	70%	50%

The New Zealand industry has closely investigated energy consumption, and Table 11 and Table 12 provide analysis of energy use distribution in New Zealand meat processing plants.

TABLE 12 - ENERGY USE IN NEW ZEALAND MEAT PROCESSING PLANTS

THERMAL ENERGY USE IN A PLANT THAT INCLUDES RENDERING	
Rendering process heat	75%
Hot water (Sourced from Rendering heat recovery)	35%
Other uses (space heating, etc.)	25%
ELECTRICITY USE IN A PLANT THAT INCLUDES RENDERING	
Refrigeration plant room	40%
Freezers and stores	18%
Services (air, hot water, etc.)	12%
Air conditioning process areas	12%
Meat Chillers	8%
Rendering	8%
Other	2%

It can be noted from Table 11 that:

- In a fully integrated plant (including rendering), 68% of all energy consumed is thermal heat; however, this does not take into account the heat recovered from the rendering process which is used as hot water in the other processing departments.
- In a plant without rendering, only 50% of all energy consumed is thermal heat.

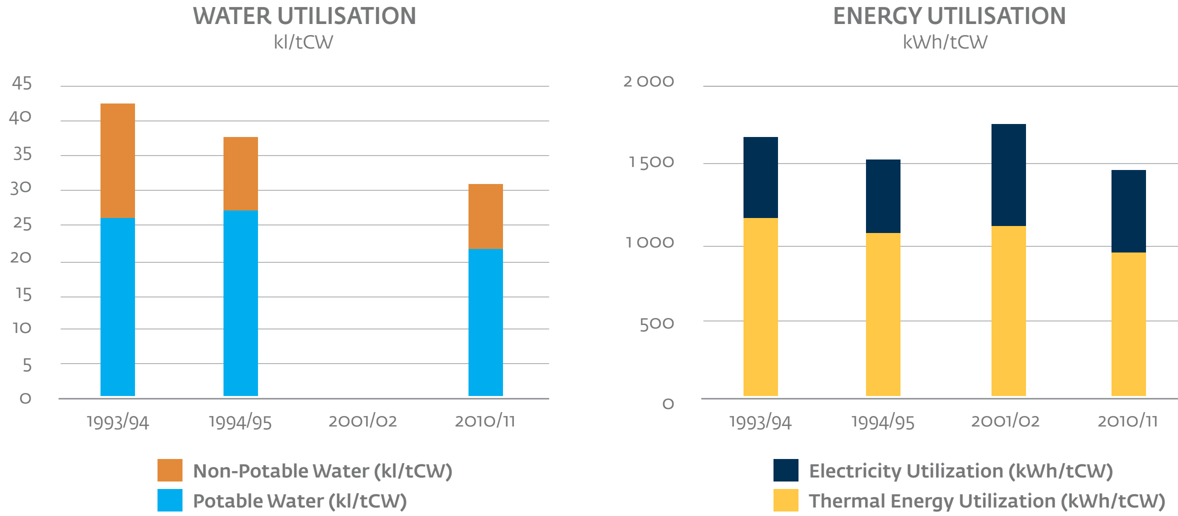
Table 12 indicates that 75% of thermal energy in a fully integrated processing plant is used as rendering process heat (processing solid organic waste and blood); however, around 35% of that heat is recovered and utilised to produce hot water. Thermal heat used for hot water and other uses in New Zealand therefore represents about 60% of total thermal use. Due to the colder climate in New Zealand, more thermal energy is used for space heating; however, from this analysis it is apparent that 40-50% of thermal energy in a fully integrated plant is used for rendering blood and organic waste after subtracting the amount of heat recovered for hot water. The 40-50% rendering utilisation of energy is consistent with the adjustment table provided in Table 20.

Benchmark data was collected in New Zealand in 1993/94, 1994/95, 2001/02 and 2010/11. The progression in indicators over this period is provided in Figure 18.

IT CAN BE OBSERVED FROM THE NEW ZEALAND DATA THAT OVER THIS 17-YEAR PERIOD:

- Water utilisation fell from almost 42 kl/tCW to 30 kl/tCW. This represents a 28% overall reduction in water utilisation over 17 years. This has essentially been achieved through a reduction in the amount of water used for livestock washing and the adoption of water efficiency practices, including more efficient sterilisation and washing equipment, installation of interlock controls and monitoring systems, and the adoption of centralised detergent/sanitation systems.
- While energy utilisation reduction was more erratic, the overall reduction over the 17 years was around 12%. This is considered to be due to more efficient refrigeration practices, including chiller cycle control, the adoption of plate versus blast freezing, and improved electronic load control.

FIGURE 18 – VARIATION IN RESOURCE UTILISATION INDICATORS OVER TIME: NEW ZEALAND[11]

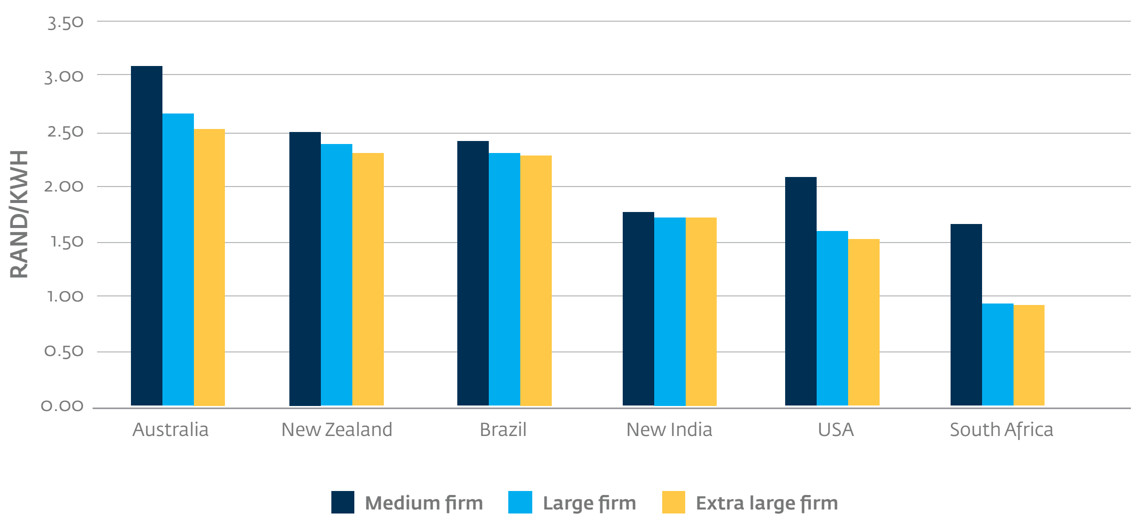


RESOURCE	INDICATOR	UNITS	1993/94	1994/95	2001/02	2010/11
Water	Potable Water	kl/tCW	26	27	NR	21
	Non-Potable Water	kl/tCW	16	11	NR	9
Thermal Energy	Thermal Energy Utilization	kWh/tCW	1 170	1 080	1 110	940
Electricity	Electricity Utilization	kWh/tCW	500	440	640	530
Total Energy	Energy Utilization	kWh/tCW	1 640	1 530	1 720	1 440

International Electricity, Fuel and Water Price Indicators

International foreign exchange (forex) rates are volatile and therefore, to provide indicative international cost benchmarks for water and energy use in meat processing industries, there is a need to determine indicative energy and water prices to be used as multipliers.

FIGURE 19 - GLOBAL ELECTRICITY PRICES (DEC 2019)[12]



[11] Kemp, 2011
[12] Global Petrol Prices, 2020

Figure 19 provides indicative electricity prices as at December 2019 for Australia, Brazil, India, New Zealand, South Africa and the United States of America (USA), converted to Rand/kWh. It can be observed from Figure 19 that South African electricity prices at that time (rand to dollar exchange rate of R14.5:US$1) were less than half the cost in Australia and New Zealand. This price advantage goes some way to explaining the greater use of electrical hot water heating in South Africa compared with Australia and New Zealand that utilise thermal fuels more for hot water heating (including indirect heating through heat recovery from rendering).

On the basis of the indicative prices provided in Figure 19, the Benchmark Tool was developed using the following assumptions to generate the international benchmark cost indicators (note that in the Benchmark Tool, these prices have been adjusted according to the ruling forex rate in April 2020):

- A low electricity price of R1.90/kWh
- A medium electricity price of R2.90/kWh
- A high electricity price of R3.90/kWh.

FIGURE 20 - INTERNATIONAL LNG PRICES[13]

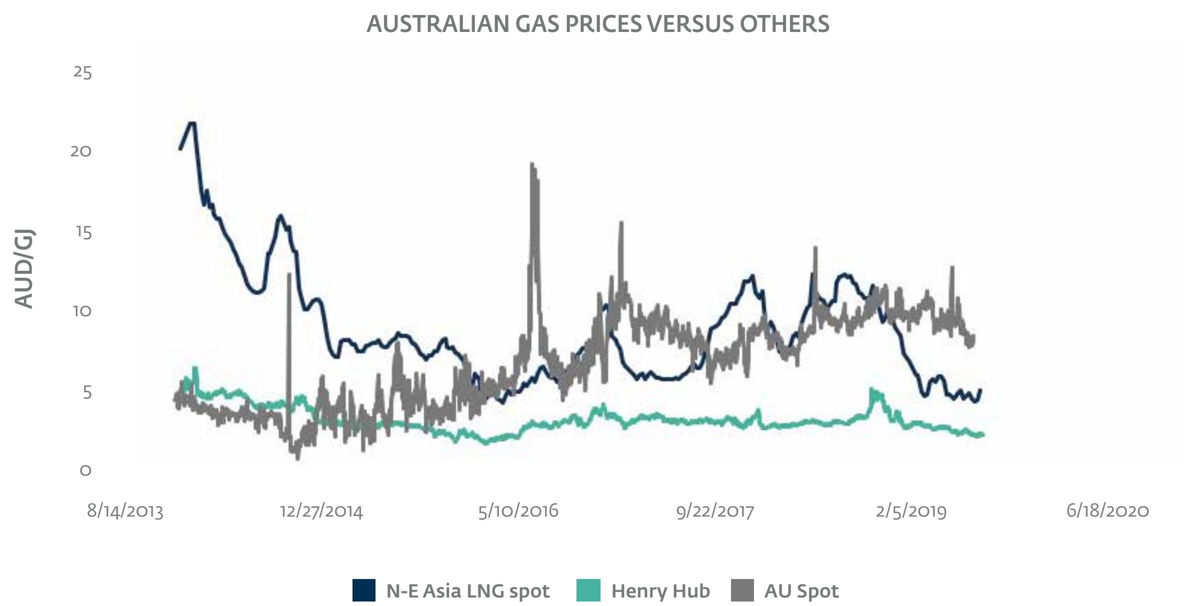


Figure 20 provides indicative Liquefied Natural Gas (LNG) prices in Australian dollars over the period 2013 to 2020. The major fuel used in the Australian meat processing industry is natural gas. It can be observed from Figure 20 that during 2019, the LNG spot price for Australian gas varied between $A8.00 and $A10.00/GJ.

Table 13 provides a conversion table converting $A/GJ to R/kWh.

TABLE 13 – AUSTRALIAN COST OF GAS[10]

AUSTRALIAN GAS COST	$A/GJ	$A/KWH	R/KWH
Gas Cost - Low	$8.00	$0.0288	R0.2883
Gas Cost - High	$10.00	$0.0360	R0.3604

[13] Rios, 2019

On the basis of the indicative prices in Table 13, the Benchmark Tool has been constructed using the assumptions that the international benchmark cost indicators are as follows (note that in the Benchmark Tool, these prices have been adjusted according to the ruling forex rate in April 2020):

- A low LNG price of R0.23/kWh
- A medium LNG price of R0.34/kWh
- A high LNG price of R0.41/kWh.

The cost of water is highly variable in all countries of interest, depending on whether water can be sourced from local ground water or needs to be purchased from the local supply authority. Similarly, wastewater costs vary as rural enterprises are often able to treat and dispose treated wastewater by evaporation or irrigation, whereas enterprises located in urban areas commonly need to discharge treated wastewater into sewers and incur wastewater discharge charges. Table 14 provides indicative costs associated with purchasing water from a supply authority, discharging to sewer and incurring discharge fees in Australia.

TABLE 14 - AUSTRALIAN COST OF WATER AND WASTEWATER[14]

AUSTRALIAN WATER COST	$A/KL	R/KL
Cost of water supply	0.85	8.5
Cost of discharge to sewer	1.39	13.9

On the basis of the indicative prices in Table 14, the Benchmark Tool has been constructed using the assumptions that the international benchmark cost indicators are as follows (note that in the Benchmark Tool, these prices have been adjusted according to the ruling forex rate in April 2020):

- Assuming ground water supply – R0.13/kl
- Assuming third party supply – R8.50/kl
- Assuming on-site treatment and disposal – R0.90/kl
- Assuming on-site treatment and disposal to sewer – R17.60/kl.

Water Utilisation Benchmarks

Surveys of water consumption in meat processing plants show considerable variation between enterprises. Factors that affect water consumption include:

- Final products produced – e.g. chilled carcases/quarters, bone-in product, boneless product, and chilled red and rough offal for domestic consumption versus packed frozen product for export.
- Operating format and cleaning practices – the impact of shift operation and use of rinsing versus cleaning and sanitising.
- Processing operations included on-site (see 'Process Variation and the Impact on Resource Utilisation').
- Level of hygiene compliance – plants processing long shelf-life, chilled, vacuum-packed products use more water, while processing plants which produce meat for export often have stricter hygiene requirements and therefore consume more water for cleaning and sanitising than domestic operations.

[14] IPART, 2018

In abattoirs, water is used for numerous purposes, including:

- Livestock watering and washing
- Livestock yards cleaning
- Truck washing
- Scalding and polishing of pigs
- Washing and cleaning of red and rough offal and carcases
- Cleaning and sterilising of knives and equipment
- Cleaning floors, work surfaces, equipment etc., both during operations and end-of-day cleaning and sanitation
- Transport of certain by-products and waste
- Make-up water for boilers
- Cooling of machinery (compressors, condensers etc.).

Table 15 provides a summary of data from industry surveys on water consumption as a basis of units of production and demonstrates the high variability in results, with most datasets demonstrating multipliers of 2-5 times between low and high consumption.

TABLE 15 - WATER CONSUMPTION PER UNIT OF PRODUCTION

COUNTRY	KL/TCW	KL/TCW	KL/T MEAT	L/HEAD
US (1984)[15]	4.2 – 16.7	4 – 12		
UK (1980)[13]	5 – 15			
Europe (1979)[13]	5 – 10			
Hungary (1984)[13]	2 – 3.8			
Germany (1992)[13]	0.8 – 6.2			
Australia (1995)[16]				
Australia (1998)[17]		6 – 15		
Denmark (pigs)			5 – 20[18]	225[19]
Denmark (cattle)			4 – 17[16]	860[17]

The data in Table 16, although somewhat dated (1992-1995), provides a sound indication of the breakdown of water consumption across different departments in meat processing enterprises and also provides some comparison of the differences between cattle and pig processing.

[15] Johns, 1993 – As quoted from Eco Efficiency Manual Reference 12
[16] MLA, 1995 – As quoted from Eco Efficiency Manual Reference 12
[17] MLA, 1998 – As quoted from Eco Efficiency Manual Reference 12
[18] Hansen & Mortensen, 1992 – As quoted from Eco Efficiency Manual Reference 12
[19] Hansen, 1997 – As quoted from Eco Efficiency Manual Reference 12

TABLE 16 - BREAKDOWN OF WATER CONSUMPTION

AUSTRALIAN SURVEY DATA[20]		DANISH SURVEY DATA[21]		
Purpose	**General**	**Purpose**	**Pig**	**Cattle**
Stockyard wash-down and stock watering	7 – 22%	Livestock receipt and holding	8%	22%
Slaughter, evisceration and boning	44 – 60%	Slaughter	32%	28%
Casings processing	9 – 20%	Casings processing	24%	21%
Inedible and edible offal processing	7 – 38%	Scalding (pigs)	3%	NA
Rendering	2 – 8%	Hair removal (pigs)	8%	NA
Domestic-type uses	2 – 5%	Dressing (cattle)	NA	22%
Chillers	2%	Cleaning	25%	7%
Boiler losses	1 – 4%			

Table 17 provides an assessment of the percentage of water consumption by operational departments in a fully integrated meat processing operation in Australia.

TABLE 17 - DEPARTMENTAL WATER CONSUMPTION[22]

KEY AREAS OF WATER CONSUMPTION	PERCENTAGE OF TOTAL FRESHWATER CONSUMPTION	FLOW VOLUME	STRENGTH
Stockyards and truck washing	7 - 24%	Medium	High
Slaughter and evisceration	44 - 60%	High	High
Inedible and edible offal processing	9 - 20%		
Boning	7 - 38%	Low	Medium
Casing processing	2 - 8%	Medium	High
Rendering	2 - 8%	Low	Very High
Chillers	2%		
Boiler losses	1 - 4%	Low	Low
Amenities	2 - 5%		

Table 18 provides a more detailed breakdown of water consumption based on a collation of data from MLA, 1995b and internal data of the UNEP Working Group for Cleaner Production.

[20] MRC, 1995 – As quoted from Eco Efficiency Manual Reference 12
[21] Hansen and Mortensen, 1992 – As quoted from Eco Efficiency Manual Reference 12
[22] GHD Pty Ltd, 2005 – As quoted from Eco Efficiency Manual Reference 12

TABLE 18 - DETAILED MEAT PLANT WATER USE[23]

			KL/DAY	% OF TOTAL	
Variable water use	Stockyards	Stock watering	10	1.0%	**25%**
		Stock washing	70	7.0%	
		Stockyard washing	130	13.0%	
		Truck washing	40	4.0%	
	Slaughter and evisceration	Viscera table wash sprays	60	6.0%	**10%**
		Head wash	3	0.3%	
		Carcase washing	40	4.0%	
		Carcase splitting saw	1	0.1%	
	Paunch, gut and offal washing	Paunch dump and rinse	80	8.0%	**20%**
		Tripe/bible washing	30	3.0%	
		Gut washing	60	6.0%	
		Edible offal washing	30	3.0%	
Fixed water use	Rendering	Rendering separators	10	1.0%	**2%**
		Rendering plant washdown	5	0.5%	
	Sterilisers and wash stations	Knife sterilisers	60	6.0%	**10%**
		Equipment sterilisers	20	2.0%	
		Hand wash stations	20	2.0%	
	Amenities	Exit / entry hand, boot and apron wash stations	40	4.0%	**7%**
		Personnel amenities	25	2.5%	
	Plant cleaning	Washdown during shifts	20	2.0%	**22%**
		Cleaning and sanitising at end of shift	170	17.0%	
		Washing tubs, cutting boards and trays	30	3.0%	
	Plant services	Condensers	20	2.0%	**4%**
		Cooling tower makeup	10	1.0%	
		Boiler feed makeup	10	1.0%	
		Refrigeration defrost	3	0.3%	
		Total	**1 000**	**100%**	
		Per unit of production (kl/tHSCW)	**7**		
		Cold water	687	69%	
		Warm water [1]	85	9%	
		Hot water [2]	225	23%	
		Fixed water use	443	44%	
		Variable water use	554	55%	

[1] Warm water is used for hand wash stations, exit/entry hand, boot and apron wash stations, and personnel amenities.

[2] Hot water is used for knife and equipment sterilisers, and for viscera table wash sprays, tripe/bible washing, cleaning at the end of shifts, and washing tubs etc.

[23] UNEP, 2002 – As quoted from Eco Efficiency Manual Reference 12

Energy Utilisation Benchmarks

Table 19 provides an analysis of energy use in an integrated meat processing enterprise.

The data in Table 19 has been used to provide adjustment guidelines so that benchmarks can be based on actual enterprise operating departments. The resulting departmental adjustments are provided in Table 20. Although the raw data in Table 19 is somewhat dated (2002), the percentages are unlikely to have changed in any significant way and they have been used as the basis to construct Table 18.

TABLE 19 - DETAILED MEAT PLANT ENERGY USE[24]

HOT WATER				
Areas of hot water use		**MJ/day**	**Percent of total hot water use**	**Percent of total thermal energy**
Knife and equipment sterilisers		30 000	34%	10%
Hand wash stations		5 000	6%	2%
Slaughter and evisceration		15 000	17%	5%
Plant cleaning		25 000	28%	8%
Amenities		5 000	6%	2%
Tripe / bible washing		2 000	2%	1%
Hook wash tanks		1 000	1%	0%
Heat loss from hot water pipes		5 000	6%	2%
Total		**88 000**	**100%**	
STEAM				
Areas of steam use	**t steam/day**	**MJ/day**	**Percent of total steam use**	
Rendering	54	150 000	70%	50%
Hot water production	10	28 000	13%	9%
Blood processing	7	20 000	9%	7%
Tallow processing	2	5 000	2%	2%
Heat loss from steam pipes	4	10 000	5%	3%
Total	**77**	**213 000**	**100%**	**100%**
ELECTRICITY				
Areas of electricity use	**kWh/day**	**MJ/day**	**Percent**	
Refrigeration	22 222	80 000	68%	
Motors (pumps, fans, conveyors etc.)	15 000	25 000	21%	
Lighting	833	3 000	3%	
Air compression	2 778	10 000	8%	
Total	**40 833**	**118 000**	**100%**	
TOTAL ENERGY USE				
Energy Use	**GJ/tHSCW**	**MJ/day**	**Percent**	
Thermal	1.6	236 667	67%	
Electricity	0.8	118 000	33%	
Total energy input	**2.4**	**354 667**	**100%**	

[24] UNEP, 2002 – As quoted from Eco Efficiency Manual Reference 12

Enterprise Benchmark Adjustment Schedule

On the basis of interpretation of this water and energy data, Table 20 has been constructed to represent "best estimate" average water and energy consumption by operating department. Table 20 is used in the Benchmark Tool to make adjustments to accommodate South African meat processing enterprises with a different mix of operational departments.

TABLE 20 - DEPARTMENTAL ENERGY AND WATER CONSUMPTION ADJUSTMENTS

	THERMAL ENERGY	ELECTRICITY	TOTAL ENERGY	WATER
	Percent	Percent	Percent	Percent
Stockyards	0%	1%	1%	20%
Slaughter and Evisceration	25%	15%	23%	35%
Hide Processing	0%	1%	1%	1%
Blood Processing	6%	1%	4%	1%
Rendering	45%	10%	30%	5%
Paunch Processing	5%	1%	4%	20%
Offal Washing	5%	1%	4%	5%
Wastewater Treatment	1%	3%	2%	0%
Chilling	5%	35%	15%	1%
Boning	3%	5%	4%	10%
Packaging	0%	2%	2%	1%
Freezing	5%	25%	10%	1%
	100%	**100%**	**100%**	**100%**

The majority of the recent international benchmark information relates to beef and small-stock processing. In Australia and New Zealand, the greater majority of livestock are processed in single species plants, due to the significant export orientation and the need to comply with Halal requirements, whereby pig processing is almost always conducted at dedicated pork enterprises. In South Africa, there are dedicated pork plants as well as many other plants processing multi-species, including pigs. To allow for this circumstance, an adjustment has been considered necessary to account for the energy and water used in the scalding and dehairing process associated with pig processing.

Table 21 provides data on the utilisation of water and energy associated with scalding and dehairing pork carcases.

TABLE 21 - INPUT AND OUTPUT DATA FOR PIG SCALDING & DEHAIRING PER HEAD[25]

INPUTS		OUTPUTS	
Item	Quantity	Item	Quantity
Bled pig carcase	95 kg	De-haired pig carcase	93 kg
Water	60 l	Wastewater	60 l
Oil	0.6 l	BOD_5	0.3 kg
Gas (if used instead of oil)	0.5 m^3	Pig hair & Scrapings	2 kg

The data from Table 21 is therefore used in the Benchmark Tool to adjust the international and South African reference benchmarks to allow for the variation caused due to scalding and dehairing during pig processing.

FROM TABLE 21 IT CAN BE ESTIMATED THAT FOR PORK SCALDING AND DEHAIRING THE:

- Extra water is about 60 l/head or 600 l/tCW (120 l/SU)
- Extra energy use is around 6 kWh/head or 60 kWh/tCW (12 kWh/SU) – assuming the calorific value for gas is 12 kWh/m^3.

[25] COWI Consulting Engineers & Planners, 2000

International Benchmark Summary

Taking the above analysis into account, the international benchmarks used in the Benchmark Tool are summarised in Table 22, which provides indicators on the basis of SU and tCW for:

- Fully Integrated plants (including rendering)
- Slaughter, Chill and Bone plants (no rendering)
- Slaughter and Chill operations.

TABLE 22 – INTERNATIONAL BENCHMARK SUMMARY

INTERNATIONAL BENCHMARKS - SLAUGHTER UNIT BASIS			
KEY PERFORMANCE INDICATOR BASED ON SLAUGHTER UNIT (SU)	**FULLY INTEGRATED PLANT (INC RENDERING)**		
	Lowest	**Median**	**Highest**
Total water used (kl)	1 100	1 500	2 800
Total volume discharge (kl)	900	1 300	2 400
Total energy used (kWh)	100	200	200
KEY PERFORMANCE INDICATOR BASED ON SLAUGHTER UNIT (SU)	**SLAUGHTER CHILL BONE PLANT (NO RENDERING)**		
	Lowest	**Median**	**Highest**
Total water used (kl)	1 000	1 400	2 700
Total volume discharge (kl)	900	1 200	2 300
Total energy used (kWh)	100	100	200
KEY PERFORMANCE INDICATOR BASED ON SLAUGHTER UNIT (SU)	**SLAUGHTER & CHILL PLANT**		
	Lowest	**Median**	**Highest**
Total water used (kl)	900	1 200	2 300
Total volume discharge (kl)	700	1 100	1 900
Total energy used (kWh)	100	100	100
FINANCIAL	**Lowest**	**Median**	**Highest**
Cost / kWh Electrical including demand charges (R/kWh)	R1.50	R2.30	R3.10
Cost / kWh Thermal (R / kWh)	R0.18	R0.27	R0.36
Cost of water purchase (R/kl)	R0.10	R4.30	R8.50
Cost of water discharge including penalties (R/kl)	R0.90	R7.40	R13.90

INTERNATIONAL BENCHMARKS - CARCASE WEIGHT BASIS			
KEY PERFORMANCE INDICATOR BASED ON CARCASE WEIGHT (tCW)	**FULLY INTEGRATED PLANT (INC RENDERING)**		
	Lowest	**Median**	**Highest**
Total water used (kl)	5 000	7 000	13 000
Total volume discharge (kl)	4 200	6 000	11 000
Total energy used (kWh)	470	840	1 100

KEY PERFORMANCE INDICATOR BASED ON CARCASE WEIGHT (tCW)	**SLAUGHTER CHILL BONE PLANT (NO RENDERING)**		
	Lowest	**Median**	**Highest**
Total water used (kl)	4 700	6 600	12 200
Total volume discharge (kl)	4 000	5 600	10 400
Total energy used (kWh)	310	550	730

KEY PERFORMANCE INDICATOR BASED ON CARCASE WEIGHT (tCW)	**SLAUGHTER&CHILL PLANT**		
	Lowest	**Median**	**Highest**
Total water used (kl)	4 050	5 700	10 500
Total volume discharge (kl)	3 400	4 850	8 900
Total energy used (kWh)	230	410	540

FINANCIAL	**Lowest**	**Median**	**Highest**
Cost / kWh Electrical including demand charges (R/kWh)	R1.50	R2.30	R3.10
Cost / kWh Thermal (R / kWh)	R0.18	R0.27	R0.36
Cost of water purchase (R/kl)	R0.10	R4.30	R8.50
Cost of water discharge including penalties (R/kl)	R0.90	R7.40	R13.90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4

South African Benchmarks

Data Limitations

Obtaining the right resource use and cost data is an essential step in understanding resource efficiency performance. Most meat processing operations have data for labour, electricity, fuel and water, as the cost and quantity of these resources are well known and tracked by the enterprise (or can be obtained from invoices and accounting information). Data is less reliable for departmental consumption (unless internal metering is in place), and for organic and solid waste disposal.

Meat processing operations use a variety of methods to dispose of wastewater. Enterprises in South Africa generally treat and dispose of wastewater to municipal trade waste, or treat and dispose of water by irrigation onto nearby pastoral land. In some instances, enterprises reuse the treated wastewater in areas where potable water is not required, including wash yards, initial truck rinse, on-site irrigation, etc. The variation in wastewater treatment methods means that the data presented on wastewater volumes and quality is less reliable than the data on water and energy use.

South African Slaughter Units and Carcase Weights

In South Africa, meat processing enterprises monitor production levels based on SUs and metric tonnes carcase weight.

However, the SU relationships are based on a measure initially designed to indicate the capacity of carcase chilling facilities in meat processing enterprises. As a result, production measurement based on SU is considered less accurate than production measurement based on tCW.

AN SU IS THE NUMBER OF NON-BOVINE SPECIES CONSIDERED EQUIVALENT TO ONE BOVINE ANIMAL. THE RELATIONSHIP IS ACCORDING TO THE FOLLOWING CONVERSIONS:

- One cattle animal equals one SU
- Two pigs equal one SU
- Six sheep, goats or mixed small-stock equal one SU.

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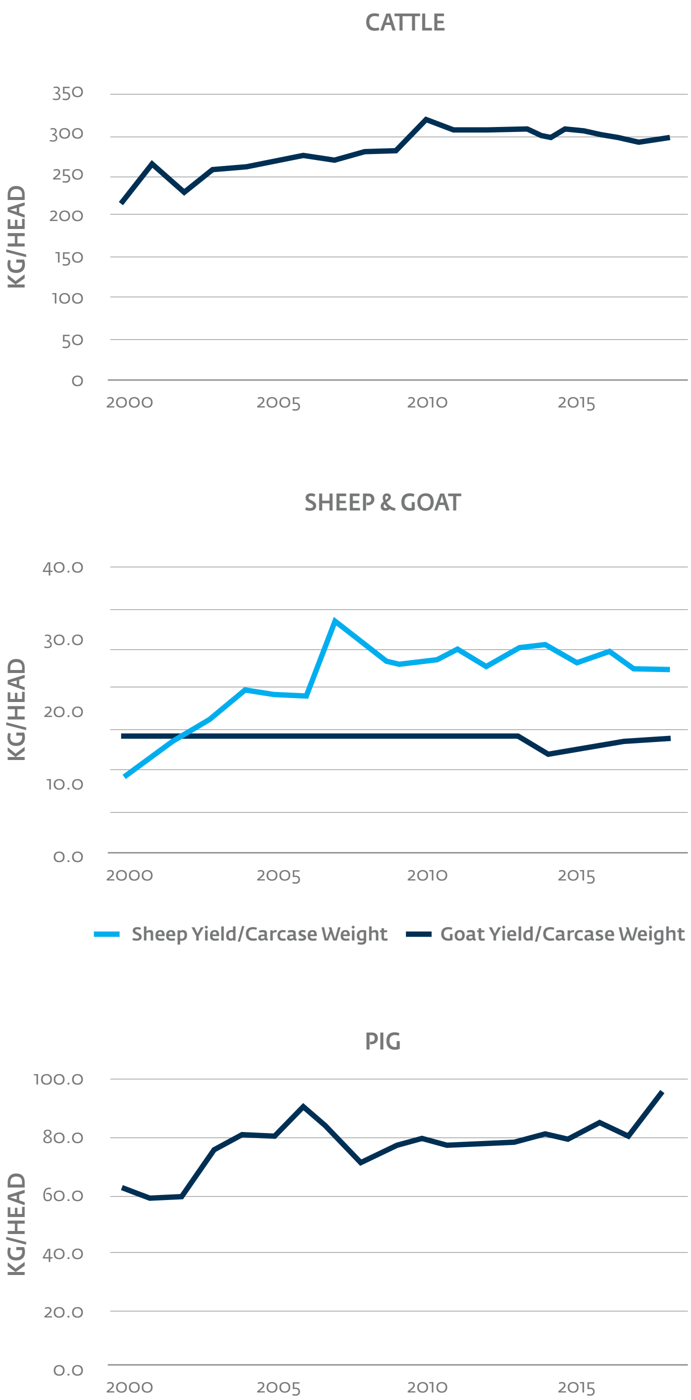
FIGURE 21 – SOUTH AFRICAN CARCASE WEIGHTS



Some South African enterprises do not record carcase weights as they are essentially a service process for third parties.

As a result, processing plants do not have good records of average carcase weights processed, but they all have good records of numbers processed by species.

To determine production based on tCW for those that do not have average carcase weight data, it is necessary in the Benchmark Tool to use default carcase weights.

Figure 21 provides average carcase weights for the period 1961-2017 as recorded by the Food and Agriculture Organization of the United Nations – Food and agriculture data (FAOSTAT).

The following default carcase weights have therefore been assumed in the Benchmark Tool so that every plant could be provided with benchmark data on the basis of both SU and tCW:

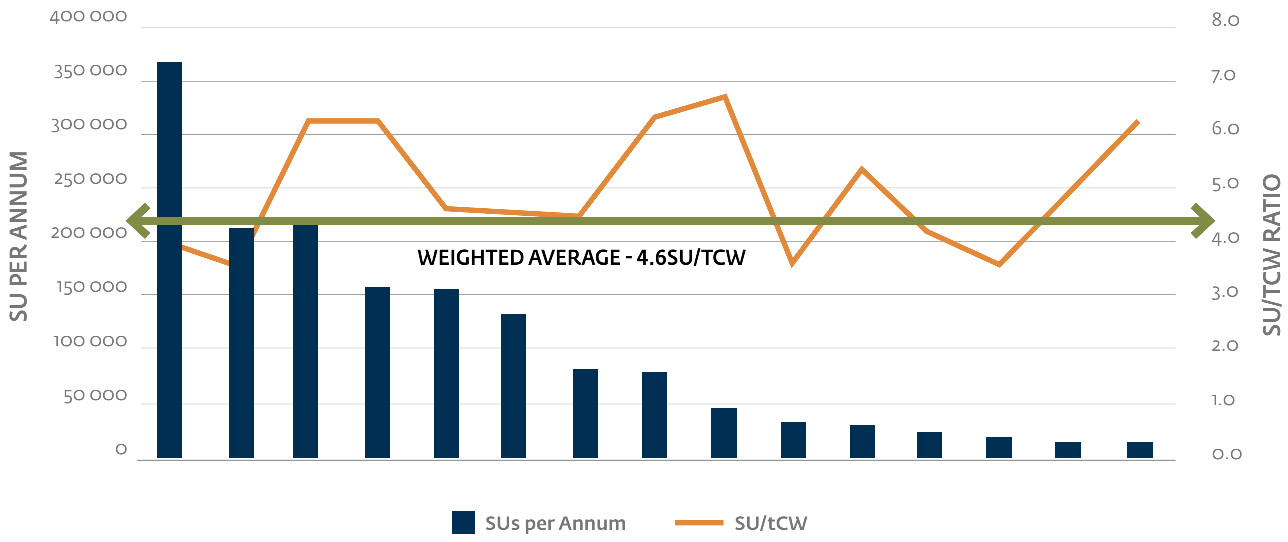
- Average cattle carcase weight – 280 kg
- Average pig carcase weight – 80 kg
- Average sheep carcase weight – 25 kg
- Average goat carcase weight – 15 kg.

Figure 22 provides a profile of the relationship between SU and tCW for South African plants. It can be observed from Figure 22 that the relationship between SU and tCW varies between 3.6 SU/tCW and 6.7 SU/tCW. This variable relationship will have some impact on individual plant SU versus tCW benchmarks. In relation to the international benchmarks, a weighted average of the relationship has been employed to convert the international benchmark data to South African SUs.

SU VERSUS TONNES PRODUCTION (tCW)

Due to the variability of the SU/tCW, relationship, Benchmark comparisons based on Production Unit (tCW) are considered to be more accurate indicators compared to those based on SUs.

FIGURE 22 - SLAUGHTER UNIT TO CARCASE WEIGHT CONVERSION



Participating Plant Profile

Table 23 provides a series of activities undertaken by plants that have participated in the Benchmark project.

TABLE 23 - PARTICIPATING PLANT PROFILE

PLANT PROFILES								
Facility	Slaughter & Chill	50%	Slaughter, Chill & Bone	36%	Fully Integrated	14%		
Shifts	Single Shift	93%	Double Shift	7%				
Offal Processing	Trim & Rinse	79%	Pack & Freeze	14%	Combination	7%		
Water Heating	Steam	50%	Electricity	50%				
Refrigeration	Hydrocarbon	79%	Ammonia	21%				
Blood Disposal	Wastewater	57%	Compost	21%	Dried	14%	Land	7%
Wastewater Disposal	Irrigation	50%	Sewer	43%	Surface water	7%		

A number of observations in relation to the impact on benchmark outcomes can be associated with the different operations outlined in Table 23. These impacts are detailed in Table 24.

TABLE 24 - IMPACT OF PLANT OPERATION ON BENCHMARK OUTCOMES

OPERATION	BENCHMARK IMPACT
Facility	A Fully Integrated plant uses a lot more specific energy (kWh/SU) than a Slaughter, Chill and Bone operation due to rendering, blood processing and the use of steam for water heating. A Slaughter and Chill plant uses even less energy due to the absence of boning processes, and lower or no need for refrigeration, chilling, freezing and storage of packaged product. A Fully Integrated plant only uses marginally more specific water (kl/SU) than a Slaughter, Chill and Bone operation since the major water uses are associated with slaughter, chill and boning operations. A Slaughter and Chill operation uses less water as use associated with boning operations and cleaning is absent. The relationship between facility operation, and utilisation of energy and water is profiled in Table 25.
Shift Operation	A double shift operation uses less water per production unit than a single shift operation since a rinse is performed between shifts rather than a full clean-down.
Offal Processing	Plants that simply trim and rinse offal material before despatch to market use less water and energy than plants that trim, wash, process, pack, chill and freeze offal.
Water Heating	Plants that use steam for water heating will use significantly more thermal energy than those that use electricity, and this is due to heat losses associated with boiler operation (flue gas losses) and heat losses from the distribution network.
Refrigeration	Centralised ammonia refrigeration plants are more energy efficient than distributed hydrocarbon refrigeration installations.
Blood Disposal	Plants that discharge blood to wastewater will have a significantly higher COD on discharge due to the oxygen demand associated with the blood.
Wastewater Disposal	Plants that can discharge to irrigation are able to take advantage of the water and nutrients (nitrogen and phosphorous) to not only minimise discharge costs but also generate income from farming operations. Plants that discharge to sewers incur significant costs associated with trade waste charges.

TABLE 25 - RELATIONSHIP BETWEEN ENERGY AND WATER UTILISATION AND PLANT OPERATION

	THERMAL ENERGY	ELECTRICITY	TOTAL ENERGY	WATER
	Percent	**Percent**	**Percent**	**Percent**
SLAUGHTER & CHILL	41%	57%	50%	82%
SLAUGHTER, CHILL & BONE	49%	89%	66%	94%
FULLY INTEGRATED	100%	100%	100%	100%

Results of Data Analysis

The benchmark data has been represented graphically in Figures 24-26 and Figures 28-33. In these charts, the range of data is presented with colour changes representing the median point of the data. Plants with utilisation above the median are those that have a greater opportunity to achieve savings than those that are below the median.

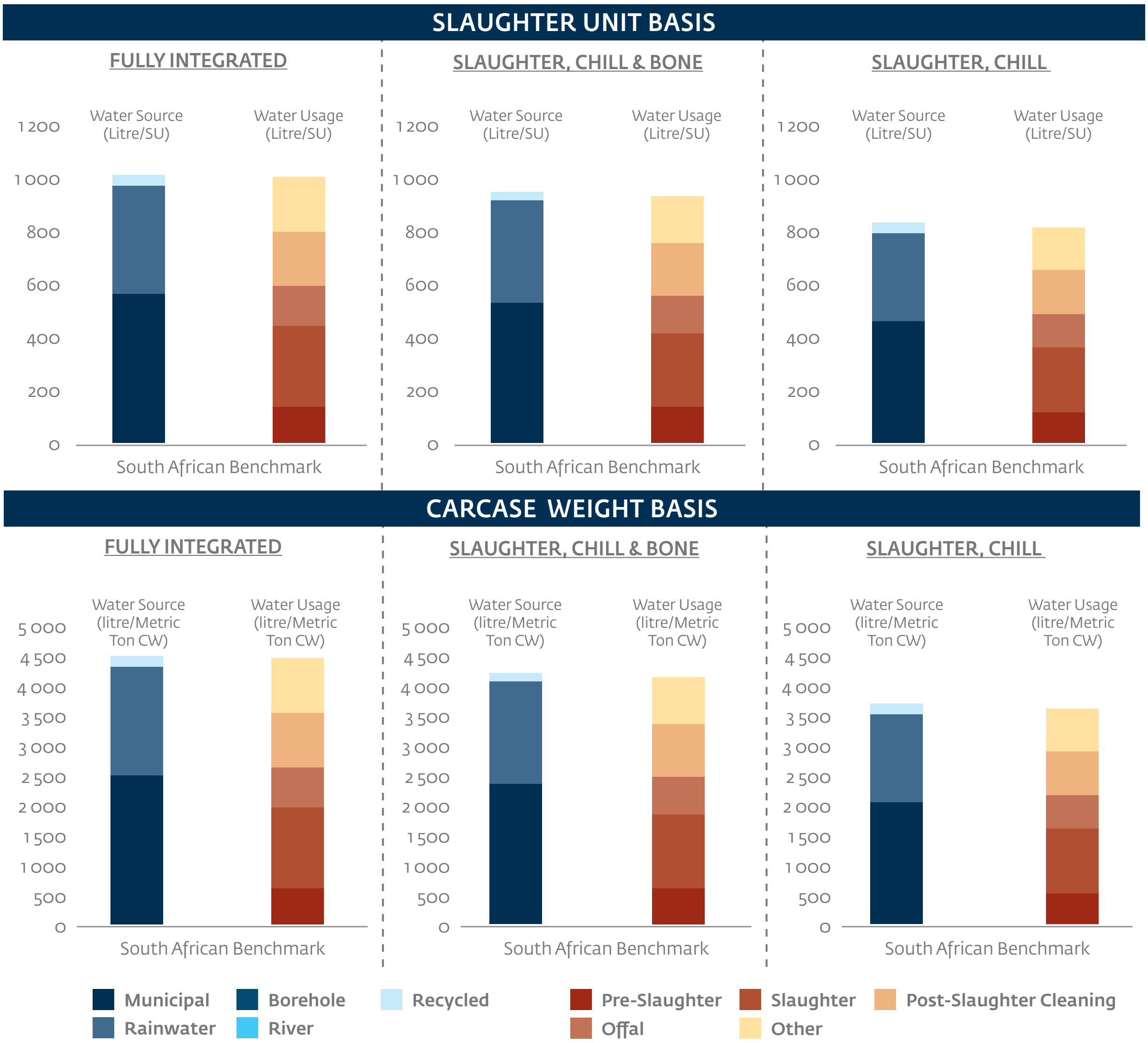
Water and Effluent Utilisation and Cost

Figure 23 provides graphical representations of median South African benchmarks based on SUs and carcase weight for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill operations for:

Water Supply Source (by municipal, borehole, rainwater, river and recycled water). Municipal is the biggest supplier of water, with borehole supply second. The use of rainwater, river water and recycled water is negligible.

Departmental Water Usage (by pre-slaughter, slaughter, offal, post-slaughter cleaning and other processes). The Slaughter department is the biggest user of water, while the other four departments use similar quantities per production unit.

FIGURE 23 - WATER SOURCE AND USAGE BENCHMARKS



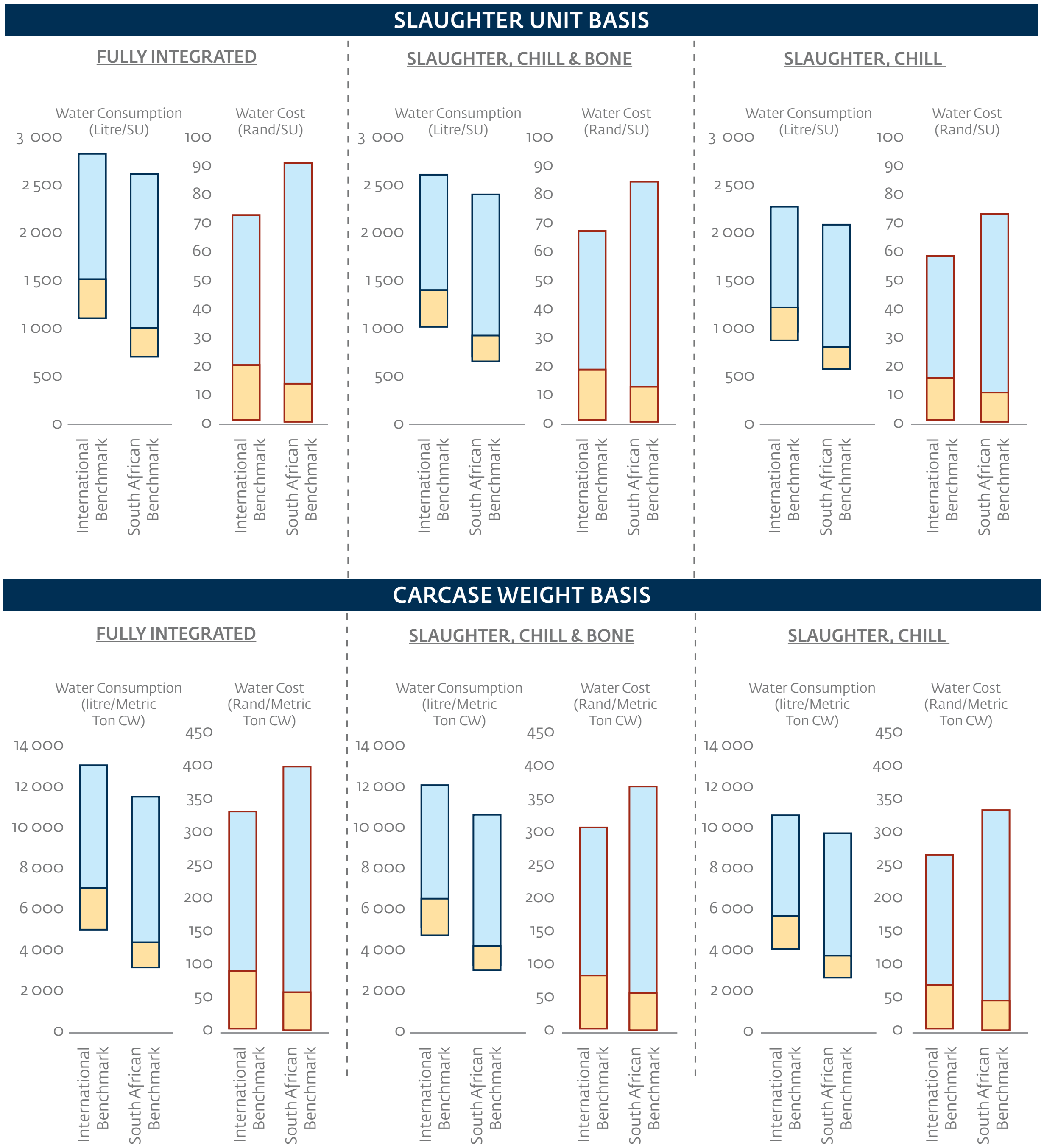
Detailed benchmark results for water consumption and cost for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill enterprises are provided in Table 26. The table provides lowest, median and highest benchmark results on an SU basis. A full set of results also providing carcase weight data is provided in Annex 1 (Table 28).

TABLE 26 - WATER BENCHMARK RESULTS

KPI BASED ON SLAUGHTER UNIT (SU)	INTERNATIONAL BENCHMARKS - SLAUGHTER UNIT BASIS			SOUTH AFRICAN BENCHMARKS - SLAUGHTER UNIT BASIS		
	FULLY INTEGRATED PLANT (INC RENDERING)			FULLY INTEGRATED PLANT (INC RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	1 087	1 522	2 826	700	1 000	2 600
Water cost (purchase & discharge) (R/SU)	1	22	72	1	15	90
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER CHILL BONE PLANT (NO RENDERING)			SLAUGHTER CHILL BONE PLANT (NO RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	1 011	1 413	2 630	650	930	2 400
Water cost (purchase & discharge) (R/SU)	1	20	67	1	13	85
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER & CHILL			SLAUGHTER & CHILL		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	870	1 239	2 283	590	810	2 100
Water cost (purchase & discharge) (R/SU)	1	16	59	1	12	75

Figure 24 provides graphical representations of the range of South African and international benchmarks for water consumption and water cost (supply and discharge) based on SUs and carcase weight for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill operations.

FIGURE 24 - WATER CONSUMPTION AND WATER COST BENCHMARKS



It can be observed from the charts that:

- The range per production unit is similar for the international and South African benchmarks for water consumption; however, the South African benchmarks are somewhat lower (by 15-30%) than international figures. This is expected due to higher food safety compliance for Australian and New Zealand plants to meet predominantly export conditions, and the lower use of water for offal processing in South Africa due to trim and rinse for local supply rather than fully processed, packaged and refrigerated product for Australia and New Zealand due to low domestic demand for these items.
- The water cost per unit of production varies widely between lower-end enterprises that are able to source borehole water and dispose wastewater to irrigation, and higher-end enterprises that source water from municipal potable supply, discharge to sewer and incur trade waste charges. The high water cost per unit of production in South Africa appears to be driven by higher charges associated with municipal supply and disposal to sewers.

Effluent Quality

FIGURE 25 – EFFLUENT QUALITY

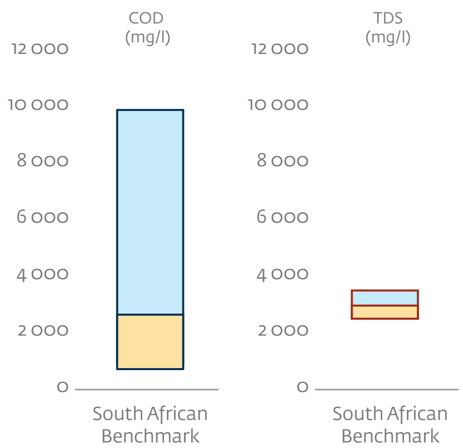


Figure 25 provides the range of water quality parameters (COD and TDS collected in the South African benchmark survey).

The wide range of COD results from the low COD levels being associated with plants that perform primary and secondary treatment processes prior to disposal, while the high COD plants include blood disposal in the wastewater and discharge to sewer without treatment.

TDS levels in abattoir wastewater are highly associated with the TDS level of the incoming water. Low TDS levels would be associated with surface water supplied either directly or via a municipality, while higher TDS levels would more likely be associated with borehole water supply. Very few companies were monitoring TDS actively, which impacted on the sample size as well as the range.

Water and Effluent Cost

FIGURE 26 – WATER AND EFFLUENT COST

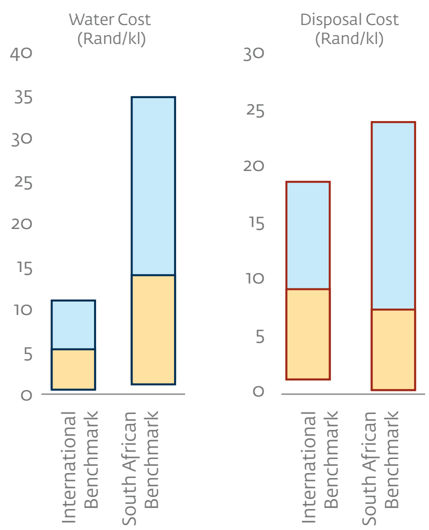


Figure 26 provides an analysis of the range of water supply and disposal costs for both international sites (essentially Australia and New Zealand) and South Africa.

Water supply and disposal costs in South Africa can be high, as it is controlled by municipalities which set their own tariff rates.

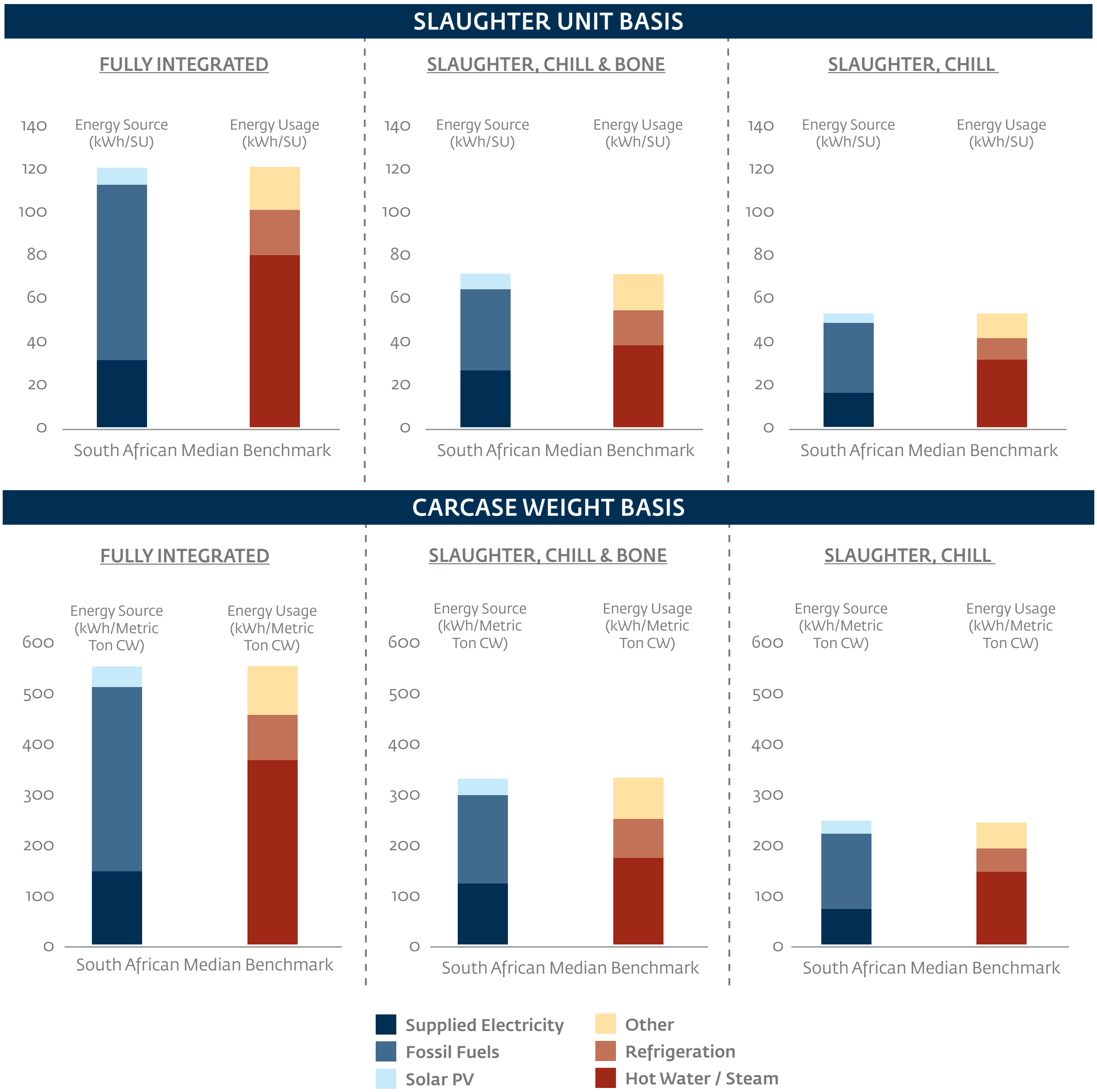
It appears from this analysis that high supply costs charged by municipalities are impacting on the operational costs and competitiveness of South African plants versus international plants; however, the charge rates are somewhat countered by lower utilisation levels in South Africa (see Figure 24).

Energy Utilisation and Cost

Figure 27 provides graphical representations of median South African benchmarks based on SUs and carcase weight for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill operations for:

- Total Energy Source (by electricity, fossil fuel, and solar PV). Fossil fuel makes up about 60% of supply and electricity makes up about 30%. Following discussions with plants, it appears that interest in establishing solar PV is increasing.
- Total Energy Usage (by hot water/steam, refrigeration and other, including plant equipment and lighting). Hot water/steam utilises about 66% of total energy, while refrigeration utilises about 20%. It should be noted that none of the companies were actively sub-metering electricity supply; the refrigeration utilisation was assumed based on local and international benchmarks.

FIGURE 27 – TOTAL ENERGY SOURCE AND USAGE BENCHMARKS



Detailed benchmark results for energy consumption and cost for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill enterprises are provided in Table 27. The table provides lowest, median and highest benchmark results on an SU basis. A full set of results also providing carcase weight data is provided in Annex 1 (Table 28).

TABLE 27 – ENERGY BENCHMARK RESULTS

KPI BASED ON SLAUGHTER UNIT (SU)	INTERNATIONAL BENCHMARKS - SLAUGHTER UNIT BASIS			SOUTH AFRICAN BENCHMARKS - SLAUGHTER UNIT BASIS		
	FULLY INTEGRATED PLANT (INC RENDERING)			FULLY INTEGRATED PLANT (INC RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Electricity Used (kWh/SU)	33	54	72	25	40	65
Thermal Energy Used (kWh/SU)	67	125	163	16	80	200
Total Energy Used (kWh/SU)	102	180	239	40	120	265
Total Energy Cost (R/SU)	74	202	361	30	140	420
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER CHILL BONE PLANT (NO RENDERING)			SLAUGHTER CHILL BONE PLANT (NO RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Electricity Used (kWh/SU)	20	35	46	22	35	55
Thermal Energy Used (kWh/SU)	39	80	109	10	40	95
Total Energy Used (kWh/SU)	65	115	152	32	75	150
Total Energy Cost (R/SU)	48	128	228	25	88	240
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER & CHILL			SLAUGHTER & CHILL		
	Lowest	Median	Highest	Lowest	Median	Highest
Electricity Used (kWh/SU)	15	26	35	13	20	35
Thermal Energy Used (kWh/SU)	33	61	80	7	35	80
Total Energy Used (kWh/SU)	48	85	113	20	55	115
Total Energy Cost (R/SU)	35	96	170	15	65	180

Figure 28 provides a graphical representation of the range of South African and international benchmarks for total energy utilisation and cost based on SUs and carcase weight for Fully Integrated; Slaughter, Chill and Bone; and Slaughter and Chill operations.

FIGURE 28 – TOTAL ENERGY USAGE (KWH) AND COST BENCHMARKS

In South Africa, plants that operate deboning operations commonly only debone hindquarters and despatch a significant proportion of forequarters directly to the domestic market in chilled form. Forequarters that are boned normally yield a high proportion of product that comprises secondary cuts and manufacturing product which is subsequently frozen. As a result, less electrical energy is required for refrigeration in South Africa.

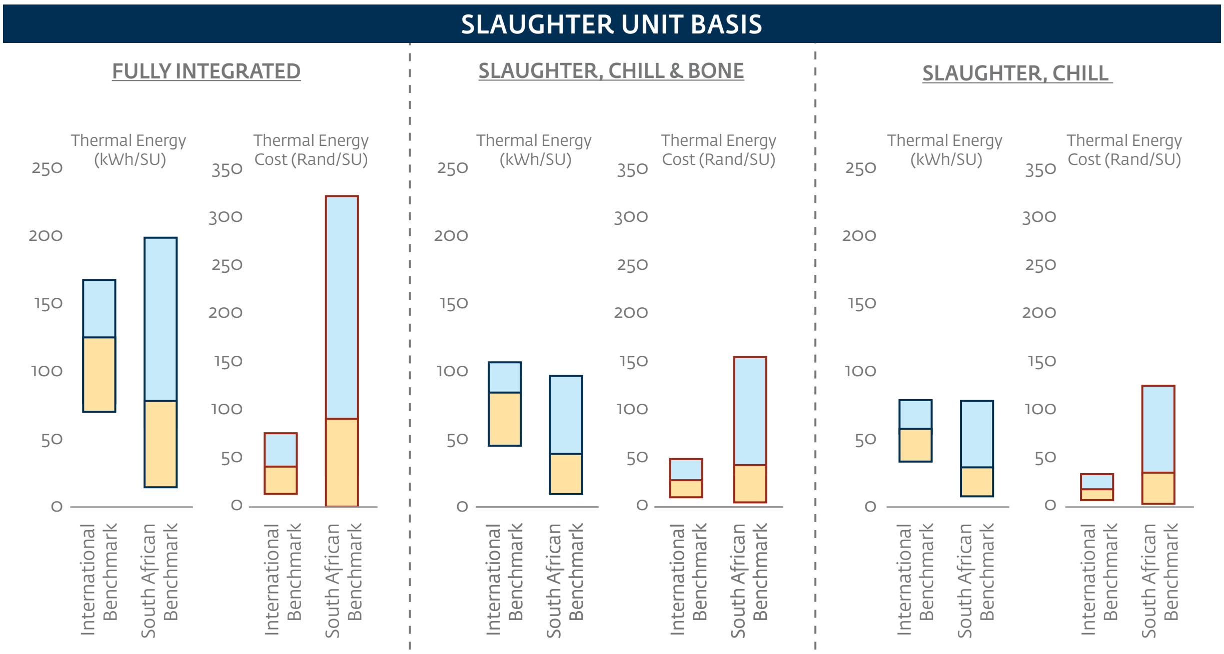
It can be observed from the charts that the range per production unit is significantly wider for South Africa than for the international benchmarks for both consumption (kWh) and cost (Rand). This is considered to be the result of:

- Thermal heat load in South Africa plants significantly differing from international counterparts in that they either utilise electrical energy and point-of-use heating systems (heating elements) for hot water generation, resulting in low energy use but high cost, or they utilise steam generated with coal as a fuel source, which results in high energy use (including boiler losses) and lower costs.
- LPG is used on pig processing lines for singeing and is significantly more expensive than international LNG prices. The reason for this is that LPG is predominantly used in domestic applications in South Africa as a replacement for electrical heating, and the supply chain and pricing structures align closely to electrical heating costs which are five times more costly than coal on a R/kWh basis.

It is likely that South African companies will continue to be reliant on coal and electrical-based heating systems in the medium term (5-10 years); however, the establishment of natural gas reserves and heavy CO_2-equivalent taxes on coal-based systems may change this reliance in the longer term (10-20 years).

Figures 29 and 30 provide similar charts for thermal energy and electrical energy. These charts confirm the impact of high costs for thermal energy and low costs for electrical energy.

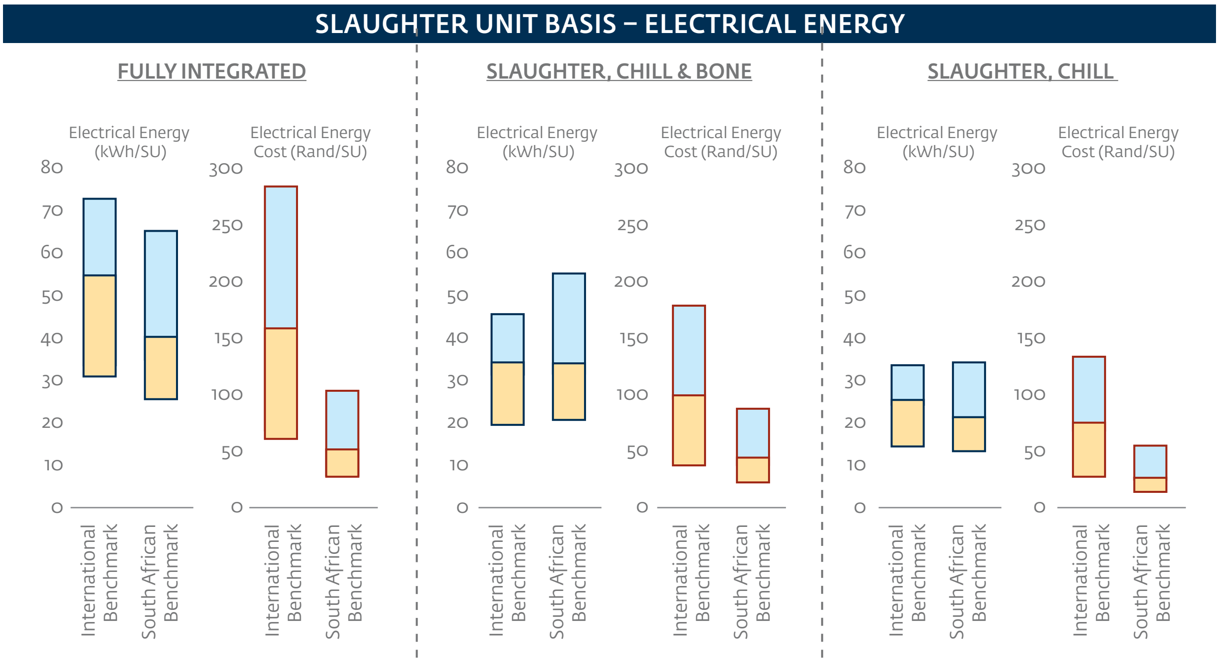
FIGURE 29 – THERMAL ENERGY USAGE (KWH) AND COST BENCHMARKS



The analysis of thermal energy supply and use further indicates that at the median:

- A Fully Integrated enterprise uses 80 kWh/SU of thermal energy at a cost of R90/SU
- A Slaughter, Chill and Bone enterprise uses 45 kWh/SU of thermal energy at a cost of R50/SU
- A Slaughter and Chill enterprise uses 35 kWh/SU of thermal energy at a cost of R40/SU.

FIGURE 30 - ELECTRICAL ENERGY USAGE (KWH) AND COST BENCHMARKS



The analysis of electrical energy supply and use further indicates that at the median:

- A Fully Integrated enterprise uses 40 kWh/SU of electrical energy at a cost of R50/SU
- A Slaughter, Chill and Bone enterprise uses 35 kWh/SU of electrical energy at a cost of R40/SU
- A Slaughter and Chill enterprise uses 21 kWh/SU of electrical energy at a cost of R30/SU.

Cost of Electricity and Thermal Energy

FIGURE 31 - COST OF ELECTRICITY AND THERMAL ENERGY

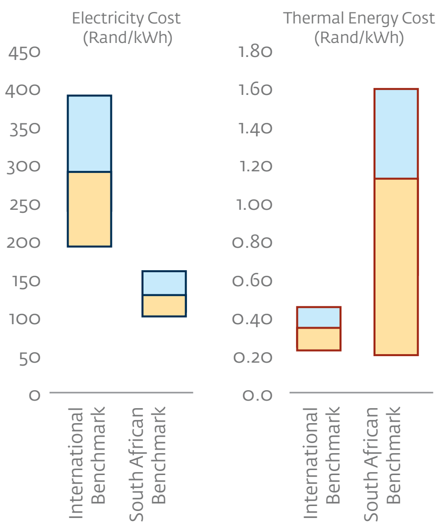


Figure 31 provides ranges for electricity and thermal energy costs for international (Australia and New Zealand) and South African environments. This figure clearly demonstrates:

- The low cost of electricity in South Africa compared to the international comparison median – R1.25/kWh (South Africa) to R2.90/kWh (internationally).
- The highly variable cost of thermal heat due to significant amounts of electricity being used in South Africa to provide direct water heating.

Estimate of GHG Emissions

FIGURE 32 – ESTIMATE OF GREENHOUSE GAS EMISSIONS

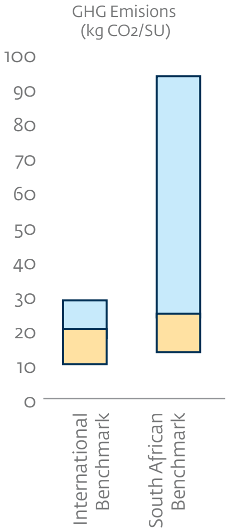
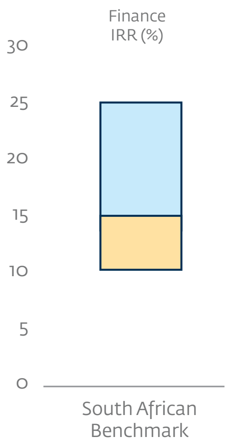


FIGURE 33 - EXPECTED RETURN ON CAPITAL (IRR)



GHG emissions have been calculated from the energy data obtained from the plants, and Figure 32 provides the median and range of GHG emissions.

While the median level of emissions is similar for both South Africa (27 kgCO_2/SU) and international environments (22 kgCO_2/SU), the South African data shows some high levels of GHG emissions. This is essentially due to the impact of the direct utilisation of electricity for hot water heating where the electricity is primarily generated from thermal fuel at a centralised generation facility. South Africa is still heavily reliant on coal power stations, resulting in comparatively high CO_2 emissions per kWh electricity.

Financial Parameters

During the benchmark survey, participants were asked to indicate their expected Internal Rate of Return (IRR) for capital investment projects. While many of the projects identified in the Practical Guide for Improving Resource Efficiency would be fundable from operating expenses as they require limited capital expenditure, an indication of the expected IRR provides a top-level assessment of the industry's propensity to invest (the lower the IRR, the greater the propensity to invest). For example, a low expected IRR for resource efficiency projects, of say 10%, indicates a high willingness to invest in projects of this kind because many projects / investments would offer an IRR of greater than 10% and would therefore be attractive to the company investing.

Figure 33 demonstrates that the range of expected IRR was recorded from 10-25%, with a median of 15%. It is considered that many water and energy efficiency interventions would provide better returns than required, with an IRR limit of 15%.

Practical Guide for Improving Resource Efficiency

A Practical Guide for Improving Resource Efficiency has been developed as a separate document to provide South African meat processing enterprises with a range of interventions that could reduce the utilisation of water and energy resources.

It should be noted that the Australian and New Zealand experiences indicate that over time, with management paying greater attention to resource utilisation, water consumption was reduced by 30% and energy consumption by 12%.

The number of SUs processed in South Africa is approximately five million per annum (according to RMLA).

Adopting the opportunities identified in the Practical Guide will have a significant impact on meat processing plant operations and make a social contribution to South Africa by reducing demand for water and reducing GHG emissions.

The median utilisation of water and energy in South Africa has been established to be 891 l/SU and 77 kWh/SU.

5

Benchmarking Tool for Self-Assessment

THE BENCHMARK TOOL IS CONTAINED WITHIN A MICROSOFT EXCEL SPREADSHEET WITH THREE TABS FOR DATA ENTRY:

1. "Facility Data Input" – see Figure 34
2. "Consumption Data Input" – see Figure 35
3. "Supplementary Data Input" – see Figure 36.

Guidelines for Completing the Benchmark Tool

Figures 34 - 36 depict screenshots of the tab-sheets to illustrate how an enterprise can run a self-assessment using the study's benchmarking data, generating results in the graphic depicted in Figure 37.

FIGURE 34 – FACILITY DATA INPUT


Plant Information

What is the company and site name?

Enterprise Name
Location 1
Location 2
Contact
email
Mobile phone

What is the level of hygiene compliance

Compliance Level	Please fill in from dropdown

What facilities do you have in your plant?

Lairages	Please fill in from dropdown
Slaughter and Evisceration	Please fill in from dropdown
On-site Hide Processing	Please fill in from dropdown
Blood Processing (coagulation and dried)	Please fill in from dropdown
Rendering plant (wet or dry)	Please fill in from dropdown
Rough Offal Processing	Please fill in from dropdown
Red Offal Washing	Please fill in from dropdown
Wastewater Treatment	Please fill in from dropdown
Chilling	Please fill in from dropdown
Boning	Please fill in from dropdown
Packaging	Please fill in from dropdown
Freezing	Please fill in from dropdown
Operating Schedule	Please fill in from dropdown
Operating Days per year	Please fill in from dropdown

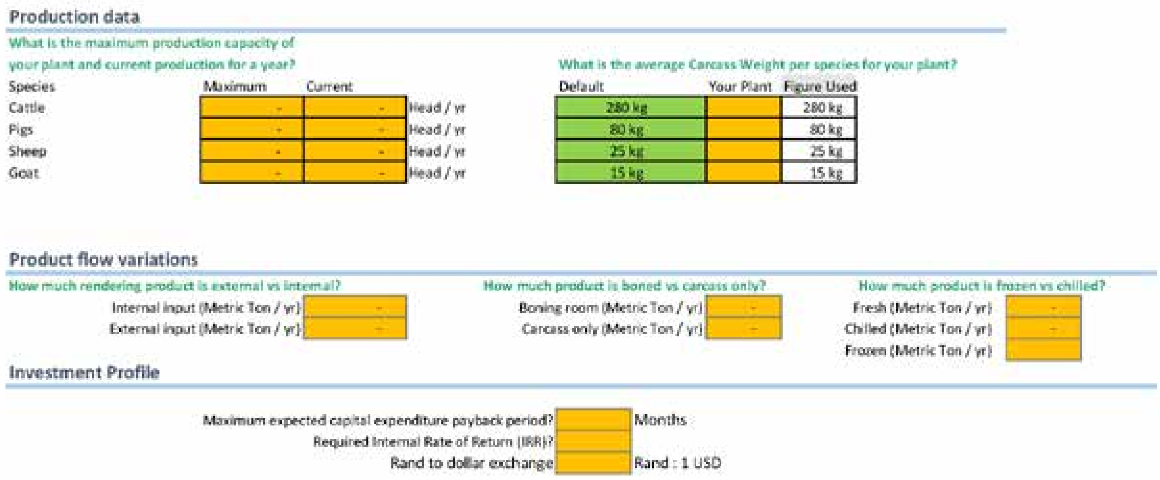
Input data into the orange cells.

Comments:

Fill in data in the **ORANGE** cells as indicated

Insert carcase weights if known – if not, the Tool will assume the Default weight

The boned versus carcase weight should be added together to be close to the current production, multiplied by the appropriate carcase weights.


Production data

What is the maximum production capacity of your plant and current production for a year?

Species	Maximum	Current	
Cattle	-	-	Head / yr
Pigs	-	-	Head / yr
Sheep	-	-	Head / yr
Goat	-	-	Head / yr

What is the average Carcass Weight per species for your plant?

Default	Your Plant	Figure Used
280 kg		280 kg
80 kg		80 kg
25 kg		25 kg
15 kg		15 kg

Product flow variations

How much rendering product is external vs internal?

Internal input (Metric Ton / yr)	-
External input (Metric Ton / yr)	-

How much product is boned vs carcass only?

Boning room (Metric Ton / yr)	-
Carcass only (Metric Ton / yr)	-

How much product is frozen vs chilled?

Fresh (Metric Ton / yr)	-
Chilled (Metric Ton / yr)	-
Frozen (Metric Ton / yr)	

Investment Profile

Maximum expected capital expenditure payback period?		Months
Required Internal Rate of Return (IRR)?		
Rand to dollar exchange		Rand : 1 USD

FIGURE 35 – CONSUMPTION DATA INPUT

Consumption data

What is your annual consumption and spend of the following utilities?

CONSUMPTION OF COMBINED UTILITIES

	USED	Annual consumption		Annual spend (Rand p.a.)	Calculated rate	Default rate	Figure Used	Units
Natural Gas	No		GJ	R	R -	R 120.00	R 120.00	R / GJ
Coal	No		Metric Ton	R	R -	R 1 500.00	R 1 500.00	R / Metric Ton
LPG	No		litres	R	R -	R 120.00	R 120.00	R / litres
Tallow	No		Metric Ton	R	R -	R 2 000.00	R 2 000.00	R / Metric Ton
Fuel Oil	No		litres	R	R -	R 8.50	R 8.50	R / litres
Diesel (for heating)	No		litres	R	R -	R 12.00	R 12.00	R / litres
Parraffin	No		litres	R	R -	R 9.50	R 9.50	R / litres
Biogas - flared	No		GJ	R	R -	R -	R -	R / GJ
Biogas - used in process	No		GJ	R	R -	R -	R -	R / GJ
Grid Electricity - Heating	No		kWh	R	R -	R 1.20	R 1.20	R / kWh
Grid Electricity - Total	No		kWh	R	R -	R 1.20	R 1.20	R / kWh
Solar PV Electricity	No		kWh	R	R -	R 1.10	R 1.10	R / kWh
On-site Standby Electricity Generation	No		kWh	R	R -	R 5.00	R 5.00	R / kWh
Municipal Water Used	No		kl	R	R -	R 25.00	R 25.00	R / kl
Ground Water Used	No		kl	R	R -	R 1.00	R 1.00	R / kl
River Water Used	No		kl	R	R -	R 1.00	R 1.00	R / kl
Rain Water Used	No		kl	R	R -	R 1.00	R 1.00	R / kl
Recycled Water Used	No		kl	R	R -	R 1.00	R 1.00	R / kl
Wastewater Disposed (~85% of usage)	No		kl	R	R -	R 20.00	R 20.00	R / kl

USE OF WATER

	Annual Consumption (if known)		Estimated % of Total Water use (if annual consumption unknown)	
Water Used Lairages and Truck Wash		kl		
Water Used on Slaughter Line		kl		
Water Used in Offal Processing		kl		
Water Used in Post Operative Cleaning		kl		
Water Used - other		kl		

Comments:

Fill in data in the **ORANGE** cells as indicated.

Insert annual spend if known – if not, the Tool will assume the Default rate.

The "Use of Water Table must add up to the same total as the combined water used (i.e. Municipal + Ground + River + Rain water used). The percentage used will provide a guide to assist.

FIGURE 36 – SUPPLEMENTARY DATA INPUT

Lairages

	Is most water used municipal	Please fill in from dropdown
	Is recycled water used	Please fill in from dropdown

Slaughter Evisceration & Hygiene

PROCESS	Slaughter Process	Mechanical Line
	Evisceration System	Pan Evisceration
WATER	Hot Water ring main installed	Please fill in from dropdown
	Are water cut-off valves installed	Please fill in from dropdown
	Type of Equipment Sterilisers	Please fill in from dropdown
	Post Operative Wash-down water	Please fill in from dropdown
	Detergent/Sanitation System	Please fill in from dropdown
	Ante-room Handwashing	Please fill in from dropdown
	Ante-room Boots Apron & Equipment washing	Please fill in from dropdown
ELECTRICITY	Slaughterfloor Environment	Please fill in from dropdown

Offal & Paunch Processing

PROCESS	Red Offal Processing	Please fill in from dropdown
	Rough Offal Processing	Please fill in from dropdown
WATER	Is any water from the slaughterfloor reused for offal processing	Please fill in from dropdown

Rendering

PROCESS	Rendering Process	None - Raw material sent offsite
FUEL	Is heat recovery installed	NO
	Is steam condensate recovered and directed back to boiler feed	NO

Wastewater Treatment

PROCESS	Wastewater Treatment	Please fill in from dropdown
	Wastewater Disposal	Please fill in from dropdown
	Wastewater Sampling	Please fill in from dropdown

Hot Water Generation

FUEL	Principal fuel for hot water generation	Please fill in from dropdown
	Is rendering heat recovery and hot water generation installed	Please fill in from dropdown
	If steam is used - percent of condensate returned	Please fill in from dropdown

Refrigeration

PROCESS	Refrigeration System	Please fill in from dropdown
	Is Spray Chilling utillised	Please fill in from dropdown
	Are plate freezers utilised	Please fill in from dropdown

Comments:

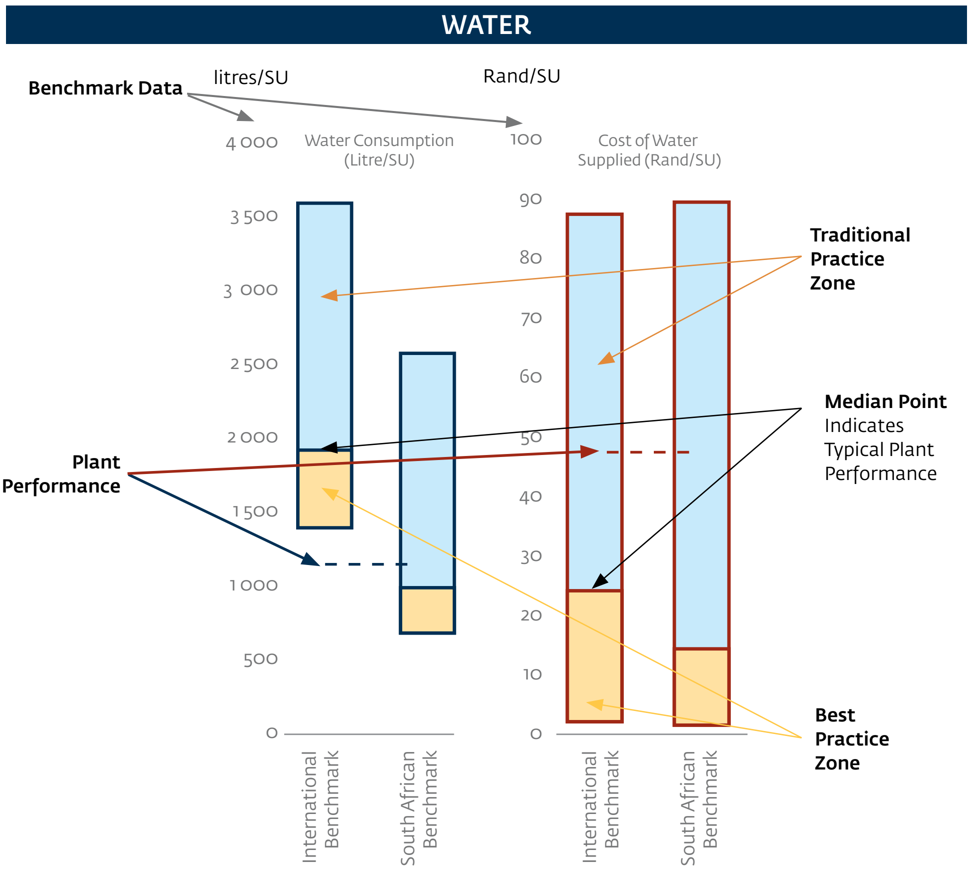
Fill in data in the **dropdown** cells as indicated.

Presentation of Benchmark Output Data

Figure 37 provides an overview of how the benchmark data is presented in the Benchmark Tool.

The international and South African benchmarks are adjusted for each plant based on the "Facility Input Data" according to the assumptions outlined in Section 3.8 of this report, and are presented in a graph showing low, median and high benchmark indicators. The plant data is represented by a line across the bars (as seen in the **blue** line in Figure 37).

FIGURE 37 – GRAPHICAL PRESENTATION OF BENCHMARK DATA



An example of an Output Report produced directly from the Benchmark Tool is provided in Annex 2.

References

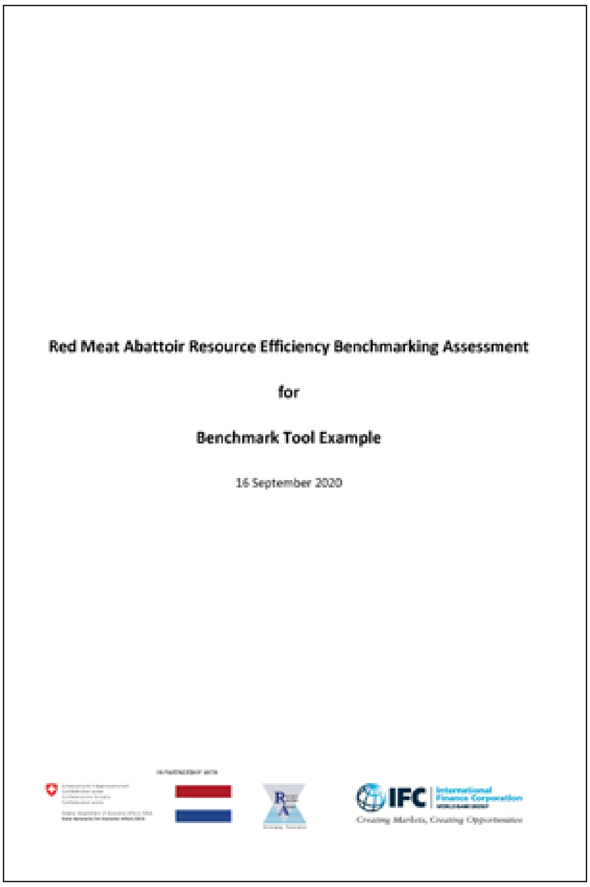
- Alexander, D., Ridoutt, B. & Sanguansri, P. (2015). *Environmental Performance Review: Red Meat Processing Sector.* Australian Meat Processor Corporation (AMPC).
- Atkins, W.S. (2000). *Model Approach for Producing BAT Guidance for Specific Sub-sectors within the Food and Drink Industry, Red Meat Abattoirs.* Environmental Protection Agency. United Kingdom.
- COWI Consulting Engineers and Planners, Denmark for United Nations Environment Programme (UNEP) Division of Technology, Industry and Economics. (2000). *Cleaner Production Assessment in Meat Processing*.
- Department of Agriculture, Forestry and Fisheries (DAFF). (2019). *Abstract of Agricultural Statistics*.
- European Union. (2005). Integrated Pollution Prevention and Control. *Reference Document on Best Available Techniques in the Slaughterhouses and Animal By-products Industries. Intergovernmental Panel on Climate Change (IPCC).*
- Food and Agriculture Organization (FAO) of the United Nations. *Food and Agriculture Data*. Retrieved 15 April 2020, from http://www.fao.org/faostat/en/#home.
- Global Petrol Prices. Retrieved 10 January 2020, from www.globalpetrolprices.com/data_electricity_download.php
- Independent Pricing and Regulatory Tribunal (IPART). (2018). *2019-23 Water and Sewerage Pricing Submission – Customer Summary.* Retrieved 3 May 2020, from https://www.ipart.nsw.gov.au/files/sharedassets/website/shared-files/pricing-reviews-water-services-metro-water-working-papers-prices-for-essential-energys-water-and-sewerage-services-in-broken-hill-from-1-july-2019/essential-water-pricing-proposal-for-2019-customer-summary.pdf.
- Kemp, R. (2011). *Energy & Water Benchmark Survey.* Agresearch.
- Red Meat Abattoir Association, South Africa. *List of Abattoirs.* Retrieved 12 December 2019, from https://www.nda.agric.za/vetweb/VPH/AbattoirLists/Abattoir%20list%202018_13Feb2018.PDF.
- Red Meat Levy Admin. (2020). *Abattoir Statistics for November 2018 to October 2019.* Retrieved 30 July 2020, from https://levyadmin.co.za/statistics/.
- Rios, J. (2019). *What's Next for Australia's Natural Gas Market.* E&C Consultants. https://www.eecc.eu/blog/whats-next-for-australias-natural-gas-market
- United Nations Environment Programme (UNEP). (2002). *Eco-Efficiency Manual for Meat Processing, Meat and Livestock Australia Ltd.* Working Group for Cleaner Production in the Food Industry.
- J R Müller & Associates - South Africa: Water Research Commission (2017). NATSURV 7 - Water and Wastewater Management in the Red Meat Abattoir Industry (Edition 2).

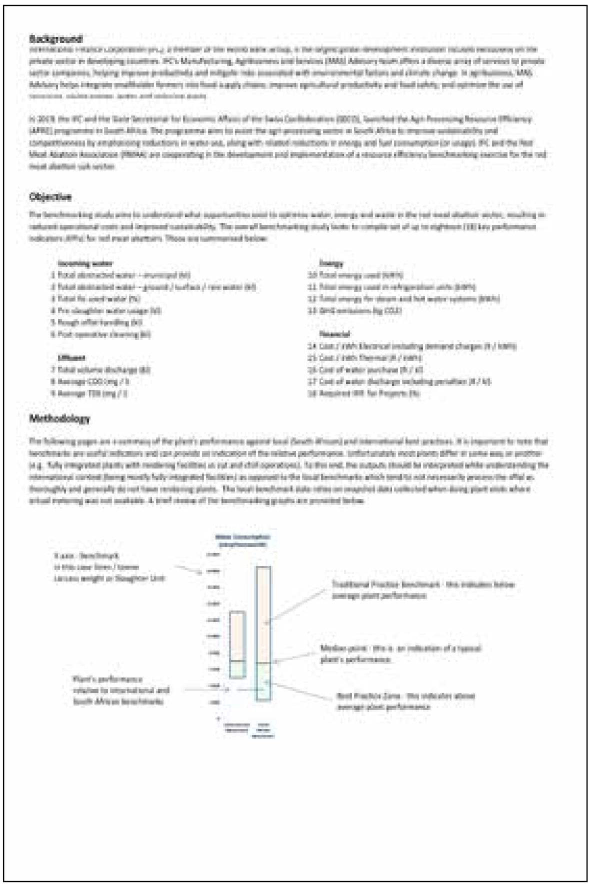
Annex 1 –
Detailed Table of Important Benchmark Results

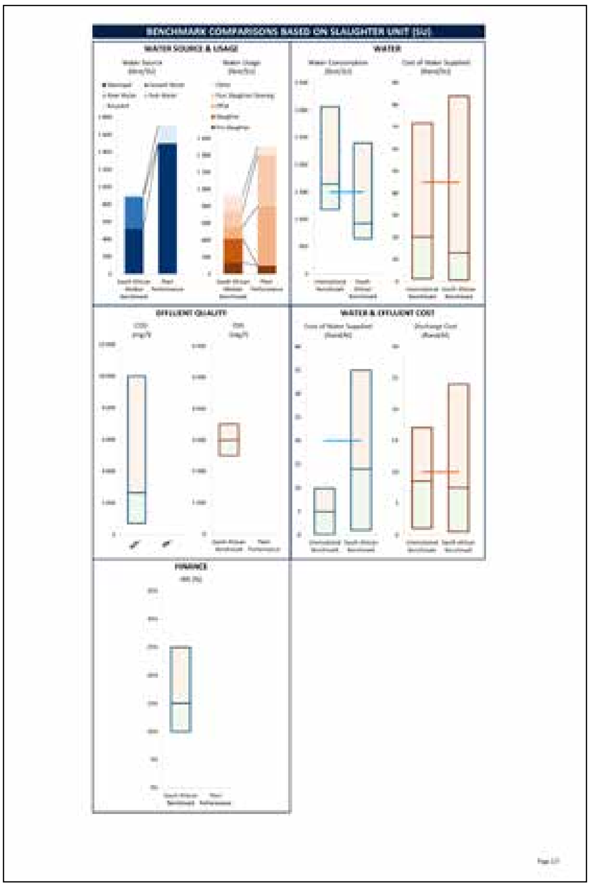
TABLE 28 – IMPORTANT BENCHMARK DATA

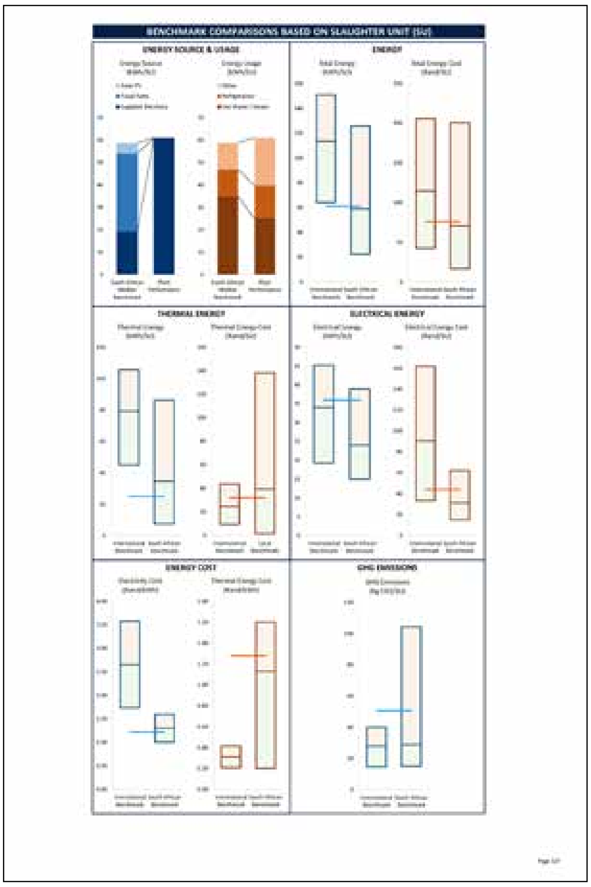
KPI BASED ON SLAUGHTER UNIT (SU)	INTERNATIONAL BENCHMARKS - SLAUGHTER UNIT BASIS			SOUTH AFRICAN BENCHMARKS - SLAUGHTER UNIT BASIS		
	FULLY INTEGRATED PLANT (INC RENDERING)			FULLY INTEGRATED PLANT (INC RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	1 087	1 522	2 826	700	1 000	2 600
Water Cost (Purchase & Discharge (R/SU)	1	22	72	1	15	90
Electricity Used (kWh/SU)	33	54	72	25	40	65
Thermal Energy Used (kWh/SU)	67	125	163	16	80	200
Total Energy Used (kWh/SU)	102	180	239	40	120	265
Total Energy Cost (R/SU)	74	202	361	30	140	420
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER CHILL BONE PLANT (NO RENDERING)			SLAUGHTER CHILL BONE PLANT (NO RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	1 011	1 413	2 630	650	930	2 400
Water Cost (Purchase & Discharge (R/SU)	1	20	67	1	13	85
Electricity Used (kWh/SU)	20	35	46	22	35	55
Thermal Energy Used (kWh/SU)	39	80	109	10	40	95
Total Energy Used (kWh/SU)	65	115	152	32	75	150
Total Energy Cost (R/SU)	48	128	228	25	88	240
KPI BASED ON SLAUGHTER UNIT (SU)	SLAUGHTER&CHILL PLANT			SLAUGHTER&CHILL PLANT		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/SU)	870	1 239	2 283	590	810	2 100
Water Cost (Purchase & Discharge (R/SU)	1	16	59	1	12	75
Electricity Used (kWh/SU)	15	26	35	13	20	35
Thermal Energy Used (kWh/SU)	33	61	80	7	35	80
Total Energy Used (kWh/SU)	48	85	113	20	55	115
Total Energy Cost (R/SU)	35	96	170	15	65	180
KPI BASED ON CARCASE WEIGHT (TCW)	INTERNATIONAL BENCHMARKS - CARCASE WEIGHT BASIS			SOUTH AFRICAN BENCHMARKS - CARCASE WEIGHT BASIS		
	FULLY INTEGRATED PLANT (INC RENDERING)			FULLY INTEGRATED PLANT (INC RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/tCW)	5 000	7 000	13 000	3 220	4 600	11 960
Water Cost (Purchase & Discharge (R/tCW)	5	100	330	0	70	410
Electricity Used (kWh/tCW)	150	250	330	120	180	300
Thermal Energy Used (kWh/tCW)	310	575	750	70	370	920
Total Energy Used (kWh/tCW)	470	830	1 100	180	550	1 220
Total Energy Cost (R/tCW)	340	930	1660	140	640	1 930
	SLAUGHTER CHILL BONE PLANT (NO RENDERING)			SLAUGHTER CHILL BONE PLANT (NO RENDERING)		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/tCW)	4 650	6 500	12 100	2 990	4 280	11 040
Water Cost (Purchase & Discharge (R/tCW)	5	90	310	0	60	390
Electricity Used (kWh/tCW)	90	160	210	100	160	250
Thermal Energy Used (kWh/tCW)	180	370	500	50	180	440
Total Energy Used (kWh/tCW)	300	530	700	150	350	690
Total Energy Cost (R/tCW)	220	590	1050	120	400	1 100
	SLAUGHTER&CHILL PLANT			SLAUGHTER&CHILL PLANT		
	Lowest	Median	Highest	Lowest	Median	Highest
Total water used (litre/tCW)	4 000	5 700	10 500	2 710	3 730	9 660
Water Cost (Purchase & Discharge (R/tCW)	4	75	270	0	60	350
Electricity Used (kWh/tCW)	70	120	160	60	90	160
Thermal Energy Used (kWh/tCW)	150	280	370	30	160	370
Total Energy Used (kWh/tCW)	220	390	520	90	250	530
Total Energy Cost (R/tCW)	160	440	780	70	300	830
FINANCIAL	INTERNATIONAL BENCHMARKS			SOUTH AFRICAN BENCHMARKS		
	Lowest	Median	Highest	Lowest	Median	Highest
Cost / kWh Electrical including demand charges (R/kWh)	R1.90	R2.90	R3.90	R1.00	R1.30	R1.60
Cost / kWh Thermal (R / kWh)	R0.23	R0.34	R0.46	R0.20	R1.13	R1.60
Cost of water purchase (R/kl)	R0.13	R5.45	R1.77	R1.00	R14.00	R35.00
Cost of water discharge including penalties (R/kl)	R1.14	R9.73	R17.60	R0.50	R7.50	R24.00

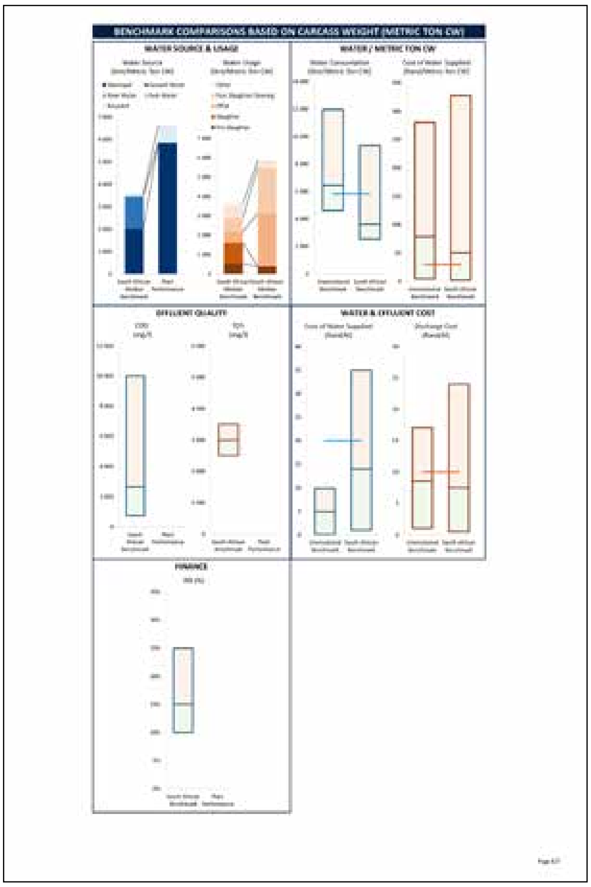
Annex 2 – Example of Output Report from Benchmark Tool

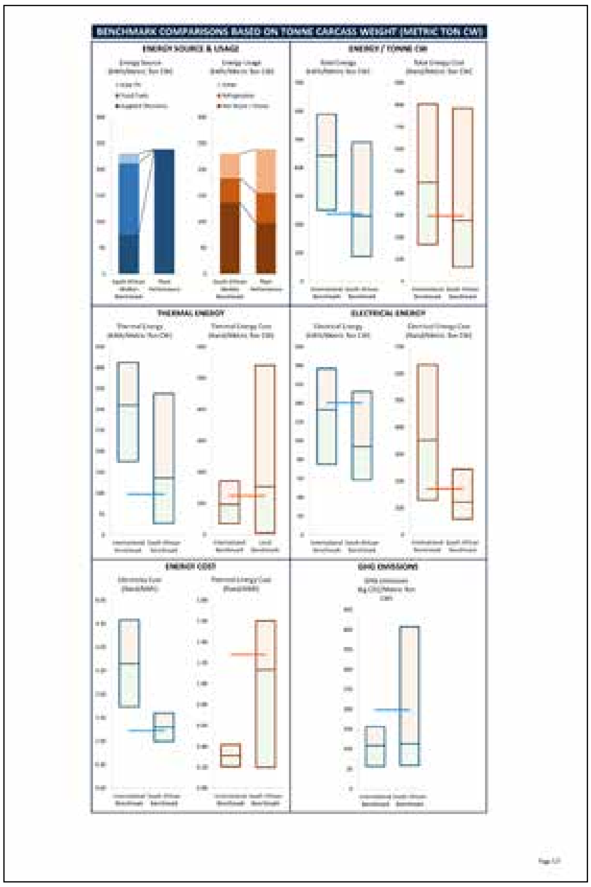


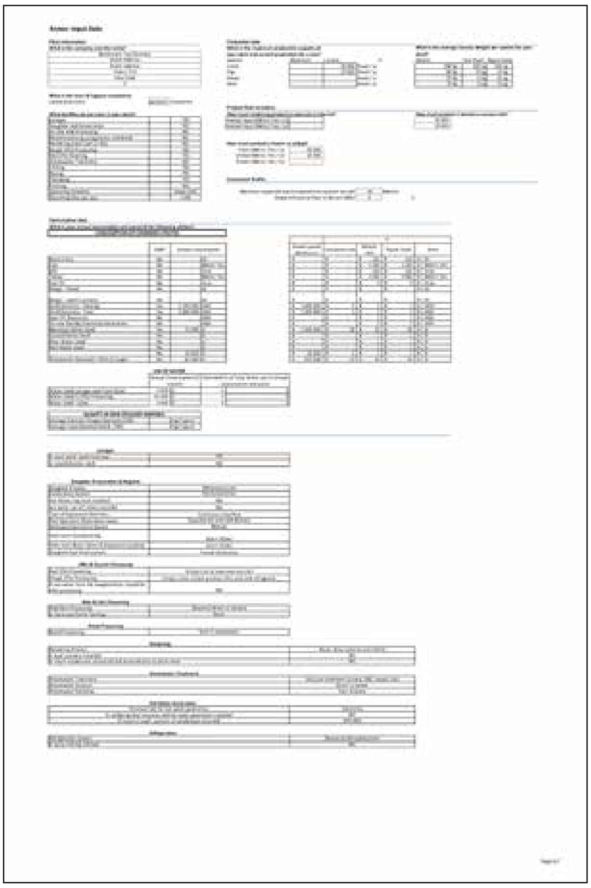







BENCHMARK COMPARISONS BASED ON CARCASS WEIGHT (METRIC TON CW)
WATER SOURCE & USAGE
WATER / METRIC TON CW
EFFLUENT QUALITY
WATER & EFFLUENT COST
FINANCE


BENCHMARK COMPARISONS BASED ON TONNE CARCASS WEIGHT (METRIC TON CW)
ENERGY SOURCE & USAGE
ENERGY / TONNE CW
THERMAL ENERGY
ELECTRICAL ENERGY
ENERGY COST
GHG EMISSIONS



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