Final Report

Developing a sustainability assessment framework and strategy

Developing a sustainability assessment framework and strategy for the Thomas Foods International US supply chain (stage 1 of 3)

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1.0 Executive Summary

This report provides a carbon footprint and an environmental impact assessment for Thomas Foods International's (TFI) meat post-processing facility in Swedesboro, New Jersey for the 2020 – 2021 financial year (FY21). The company aims to i) benchmark the carbon, water, energy and waste footprint of this operation for the 2021 financial year for reporting against customer requirements, and ii) identify options to reduce impacts into the future.

The assessment followed carbon accounting principles outlined in the Greenhouse Gas (GHG) Protocol for business accounting. Scope 1 and 2 emissions were reported based on primary data, and scope 3 emissions were estimated based on records of purchased inputs. An assessment of on-site energy, water and waste production was also conducted.

The annual GHG business emissions (scope 1 and 2) were 3,769 metric tonnes of CO_2-e, while the operation carbon footprint (scope 1, 2 and 3), was 1,401,773 metric tonnes of CO_2-e. Scope 3 emissions were dominated by purchased meat and to a lesser extent, transport.

Of the scope 1 and 2 GHG inventory, the majority of impacts were from grid electricity, which accounted for 50% of GHG emissions. Other major contributors to GHG emissions were estimated leakage of refrigerants R-505 and R-404A, at 24.6% and 19.3%, respectively.

The enterprise used 20,437,267 MJ of direct fossil energy (i.e., fossil derived grid electricity, and natural gas), and 19,187,733 MJ of renewable energy (i.e., renewable derived grid electricity and solar electricity). Total energy demand was 39,624,001 MJ. Direct freshwater consumption was 6,357,497 gallons. Waste production was 1,905,080 lb of mixed municipal solid waste (MSW).

Overall benchmarking of environmental indicators against similar post-processing facilities revealed that TFI performed well, with all indicators being lower than the comparisons except MSW. Future comparisons would be improved by having disaggregated data for warehousing and post-processing for all inputs related to energy, GHG and water. This would result in much more insightful comparison data for each side of the operation.

To move towards improved environmental performance to meet established company targets, IAE assessed the following options which have the potential to reduce emissions from the facility:

- Increasing energy productivity to reduce scope 1, 2 and 3 emissions and the energy footprint of the facility.
- Increasing the size of the solar installation to meet the renewable energy goal to reduce scope 2 emissions.
- Switching to refrigerants with lower global warming potential. Pending further detail regarding measured losses, this may have the potential to significantly reduce scope 1 emissions.

The following options were also assessed. These provided a minor opportunity to reduce impacts, or no opportunity depending on the strategy:

- Reducing waste to landfill to reduce scope 3 emissions and the waste footprint of the facility.
- Measuring and decreasing rendering to increase facility throughput and reduce scope 3 emissions.
- Using sustainable packaging to reduce scope 3 emissions.
- Redirecting material from rendering to compost. This strategy was found to slightly increase scope 3 emissions and was not recommended.

The following recommendations were made regarding improved measurement and assessment:

- Measuring loss rates (recharge) of refrigerants. This is currently not measured, and an estimate was used. Considering it was a large emission source, the level of uncertainty would be reduced by measuring this in the coming 12 months.
- Separately metering the electricity usage from warehouse and processing areas to accurately determine scope 1 and 2 emissions intensity for warehoused and processed products. This would allow more accurate recording of impacts for meat products that are post-processed and would allow greater insight into productivity measures that could improve efficiency, such as reduce warehouse storage time.
- Separate recording of storage times, product mass loss and packaging by product line.

Thomas Foods International have conducted a review of customer requirements for sustainability reporting and this was extended by the project team. This review found that goals exist for almost all suppliers covering reduction in GHG emissions. In most cases, this extends to reduction targets for scope 3 emissions (that is, emissions covering the full meat supply chain). Considering red meat is one of the biggest emission sources from a retailer or food service company, these reduction targets will inevitably be shifted down the supply chain as a market expectation. It should be expected that formal scope 3 reporting will be a feature in the near future as companies work to ‘make good’ on publicly stated goals.

In addition to GHG reporting, energy, packaging, waste and water are listed by most customers, and some specific targets exist for stand-out contributions to the processing and retail end of the supply chain. Of these, refrigerants and transport are notable. While many areas are covered by targets, GHG, energy, packaging and waste are by-far the most ambitious and should be seen as the first focus area both for processors, and for the whole supply chain.

The present study was designed as stage 1 of a three-stage project, with stage 2 and 3 covering review of strategy and consumer requirements, and potentially expansion of the study to assess impacts through primary processing and production. It was agreed with TFI that this stage 2 aspect has largely been done by TFI staff with assistance from the project team. The findings of this study can now consider stage 3, which focused on assessment of the supply chain.

2.0 Introduction

Thomas Foods International (TFI) is a family-owned Australian meat supply business with offices in Australia, the United States, Asia and Europe. TFI operates two abattoirs in eastern Australia that export beef primals and bone-in lamb to their U.S. facility in Swedesboro, New Jersey for further processing and sale in the U.S. domestic market. The Swedesboro facility also packages poultry, red meat and non-meat products, both from imported sources from around the world, and domestic supply within the USA. Facility operations produce warehoused items and products that undergo processing prior to packaging for customers. With increased consumer demand for sustainably produced products, TFI aims to be ahead of the curve through being transparent and accountable, and contributing to the reduction of the environmental footprint of the meat sector.

TFI sought to understand their current baseline emissions and impacts of their US post-port operations for customer reporting, and to develop a sustainability reporting strategy to meet the current and future needs of the US market. Current customers require reporting of the carbon footprint and other key impact areas such as water and waste for purchased products by September 2021, providing the initial impetus for action.

The operational scope covered in this report is:

- Input meat for processing.
- Emissions generated from post processing and warehousing (scope 1 and 2 emissions).
- Emissions associated with purchased inputs for post-processing and warehousing (scope 3 emissions).
- Emissions generated from meat prior to arrival at the facility (scope 3 emissions).
- Upstream transportation of product (scope 3 emissions).
- Staff commuting (scope 3 emissions).

Following the GHG baseline assessment, a review of the current company SMART Goals (Specific, Measurable, Achievable, Realistic and Timely) was conducted. A hotspot analysis of TFI's post-port production was used to determine potential revisions to these goals in conjunction with TFI staff. Further consideration, including cost-benefit analysis will be undertaken into the supply chain emission reduction strategy in 2022/2023.

SMART goals assessed in this report include:

- Increasing energy productivity by 10% in relation to sales by 2025
- Implementing 25% renewable energy (or 2,700,000 kWh) through solar PV by 2025 (other renewable energy such as biogas generation will be assessed).
- Reducing 25% of waste to landfill by 2025.

Other TFI goals assessed in this report include:

- Measuring rendering in 2021 and identify opportunities to decrease rendering (assisted by the data collection and analysis required within the baseline report).
- Researching the availability of local composting (this project will provide a desktop assessment of the GHG emissions associated with composting rendering material).
- Continual review and testing of emerging sustainable innovations in food-grade packaging (implications for GHG emission will be assessed briefly).
- Support for the MLA goal of carbon neutral beef production by 2030 (no requirement to report as part of post-port operations).

- Assessing impacts of grazing acreage and the potential impacts of carbon sequestration.

3.0 Project Objectives

The project objectives are:

- Stage 1 - Baseline assessment:
  - Deliver a carbon, water, energy and waste footprint of the post-port operations of identified meat products for Thomas Foods International.
- Stage 2 - Strategy to meet international market requirements (subject to stop/go):
  - Assist TFI to refine targets and a reduction strategy to meet US customer requirements for identified meat products.
- Stage 3 - Develop a framework to improve data collection, monitoring and reporting (subject to stop/go):
  - Develop a sustainability framework for the company to meet future customer requirements; improve data capture and reporting to meet company and customer needs and implement this in the TFI supply chain for reporting in 2022 and 2023.

4.0 Methodology

4.1 Project scope

This project completed a cradle-to-market carbon, water, energy and waste footprint (scope 1, 2 and 3 emissions) for the post-port operations of TFI's Swedesboro facility. All activities from 'upstream transport' to 'final product ready for distribution to customers' were included in the assessment. A generalised diagram of some pre-port and post-port inputs of TFI's the supply chain is provided in Figure 1.

Meat was freighted from several international sources to the Swedesboro facility for further processing.

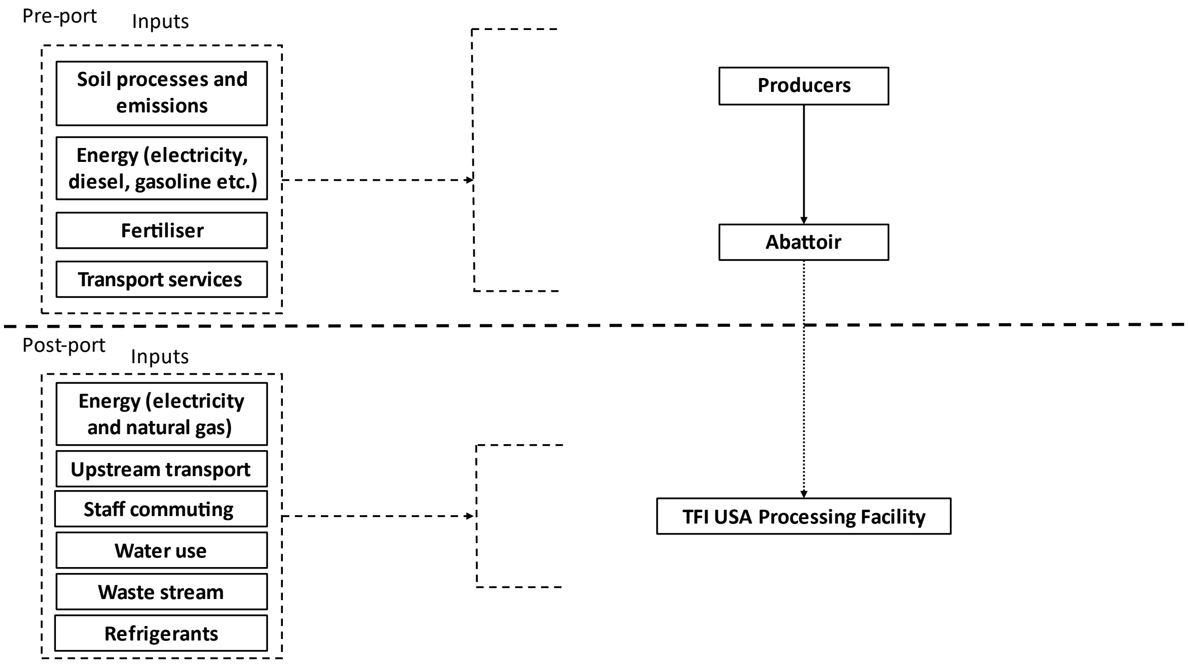

Figure 1. Thomas Foods International supply chain

We report total emissions using reference units that are aligned with the post-processing stage. Total emissions were reported as metric tonnes of CO_2-e, which generally aligns with customer reporting requirements.

4.2 Selection of environmental indicators

The study developed a carbon account for the enterprise, reporting scope 1 and 2 emissions and total scope 1, 2 and 3 emissions. An assessment of direct energy and water use was also conducted, along with an assessment of municipal solid waste (MSW) production. These indicators align with industry standards, such as NCBA sustainability executive summary (NCBA 2014) and AMPC environmental sustainability reporting (All Energy Pty Ltd 2021) together with the reporting guidance of key customers. Indicators are reported as per the NCBA standards with modifications to the water and waste units from metric to imperial.

4.2.1 Post-port inventory data – TFI USA

Inventory data of the post-port supply chain operations were collected, including waste stream management data, energy and water use, refrigerant losses, staff and freight transport, purchased inputs and cleaning data. While meat post-processing has a relatively small contribution to emissions in the supply chain, the largest change in emissions can be attributed to the complex changes in the processing chain from live animal to finished product. The general approach to modelling the flow of products, was described in Wiedemann and Yan (2014) and the methods used to handle co-production are described in the following section.

4.2.2 Handling co-production

During meat processing, several products were co-produced, including edible meat, tallow and rendering. No impacts were allocated to product sent to rendering and tallow.

4.3 GHG calculation methods

Climate change impacts were modelled as the amount of greenhouse gas emissions (GHG) throughout the supply chain using the business accounting framework (scope 1, 2, 3 emissions, see below).

The impacts were then converted to carbon dioxide equivalent units (CO_2-e) for 100-year global warming potentials (GWP_{100}) using AR4 values of 298 for N_2O and 25 for methane (Solomon et al. 2007) which aligned with U.S. EPA reporting (U.S. EPA 2021b).

Emissions were disaggregated into scope 1, scope 2 and scope 3 sources (Figure 2) according to the GHG Protocol (Ranganathan et al. 2004). These emission sources are described as follows:

- Scope 1: “Direct GHG emissions occur from sources that are owned or controlled by the company.”
- Scope 2: “Accounts for GHG emissions from the generation of purchased electricity consumed by the company.”
- Scope 3: “Are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.” These can be further broken down into two sources:
  - Upstream emissions: These are sourced from pre-facility sources such as the production of purchased meat products for processing, transportation of meat for processing, manufacture of chemicals and the burning of fossil fuels, including the extraction, production and transport of fuel and electricity.
  - Downstream emissions: These are post-facility emissions associated with the transportation and distribution of products to customers. Downstream scope 3 emissions were beyond the scope of this report.

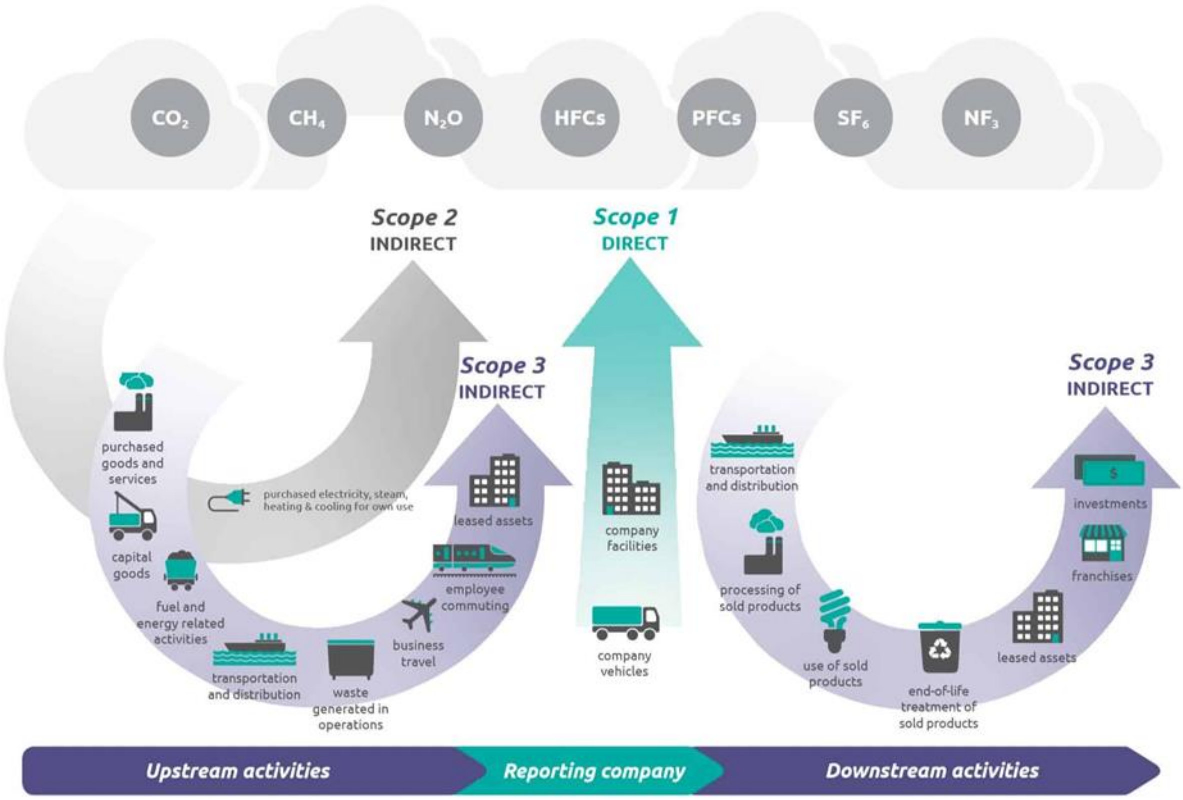

Figure 2. Scope 1, 2 and 3 emissions sources (Ranganathan et al. 2004)

Scope 1 emissions for natural gas and scope 3 emissions for recycled cardboard, recycled plastic, mixed municipal solid waste, staff commuting and refrigerants R-404A and R-410A were calculated from methods in the GHG Emission Factors Hub (U.S. EPA 2021b). The scope 1 emission factor for refrigerant R-505 was determined by summing the proportion of the individual components, R-12 syn. CFC-12 (Dichlorodifluoromethane) at 78% and R-31 syn. HCFC-31 (Chlorofluoromethane) at 22%. R-12 has a 100-year global warming potential (GWP_{100}) value of 10,900 (AR4) (GHG Protocol 2015), while R-31 has a GWP_{100} value of 83 (Charmet et al. 2013), with an overall GWP_{100} value of 8,520.

Grid electricity emissions were calculated from eGRID Summary Tables 2019 (U.S. EPA 2021a), where scope 2 was calculated using the New Jersey specific factor and grid gross loss percentage was taken from RFC East to calculate scope 3. SimaPro 9.1 (Pré-Consultants 2020) was used to source scope 3 emission factors for tap water, refrigerated road freight, continental road freight (> 32MT euro5 truck), polyethylene (PE) film, polyamide (PA) film (Nylon 6), polyvinyl fluoride (PVF) EPC film, the thermoforming process and the plastics for thermoforming, polyvinylchloride (PVC), PE and ethylene vinyl acetate (EVC) used rest-of-world criteria from the ecoinvent v3 LCA database (Wernet et al. 2016) while wastewater treatment, 100% recycled single-wall corrugated box, polypropylene (PP) granules, natural gas, solar electricity and transoceanic shipping factors were sourced from the US-EI 2.2 LCI database (EarthShift 2013). Polypropylene film emission factor was sourced from Industry Data 2.0 (Industry Data 2.0 2000). Emission from Makrofol® EPC films (PC-PVF) was calculated from 50% PVF and 50% PC.

Attributional life cycle assessment (aLCA) datasets were used to determine scope 3 emissions, consistent with international standards (ISO 2006).

4.4 Energy, water and waste assessment methods

The study determined direct energy. The energy assessment was based on an inventory of all energy sources used in the processing facility and determining energy content (in megajoules – MJ). Energy demand was reported separately for fossil and renewable sources. The proportion of electricity generated from fossil (59%) and renewable (41%) sources for New Jersey's grid electricity was determined using the State Resource Mix (U.S. EPA 2021a).

The water assessment was based on water meter readings at the facility and included water use for cleaning and general purposes. Annual consumption of water supplied by American Water was available for FY21. This assessment represented direct water use by the processing facility. So-called "indirect" water use (analogous to scope 3 GHG emissions), associated with the production of feed commodities, purchased cattle and abattoir processing, was excluded from the assessment, as the enterprise has little insight into the amount of water used through the supply chain and little capacity to influence this water use.

The waste assessment was based on the total weight of mixed MSW for FY21. The weight of recycled cardboard and plastic was not included in the assessment of waste due to the diversion of these items away from landfill.

4.7 Product flows and inventory data

TFI sources meat products from several countries for processing and/or distribution from the Swedesboro facility Data from the facility operations were collected for fossil fuel use and estimated recharge mass for refrigerants to calculate scope 1 emissions and grid electricity use to calculate scope 2 emissions (Table 1).

Table 1. Inventory data for energy and refrigerants for FY21

Activity data	FY21
Electricity	
Grid electricity (kWh)	7,623,680
Fossil Fuel	
Natural gas (m^3)	110,824
Refrigerants (assumed 8% leakage)	
R-404a (kg)	185
R-505 (kg)	109
R-410A (kg)	8

Quantities of purchased inputs from chemicals, packaging and potable water are shown in Table 2.

Table 2. Purchased scope 3 inputs (excl. meat) for FY21

Input	FY 21
City water supply	
Water consumption (gallons)	6,357,497
Cardboard Boxes	
Cardboard box 100% recycled (85% PCR: 15% PIR) (thousand square feet [MSF])	27,522
Chemicals	
ND 200 (gallons)	7,920
Persan A (gallons)	1,320
Hydrogen Peroxide (gallons)	600
Bleach A-1 (gallons)	432
Dawn Detergent (gallons)	288
Pine-Sol Surface (gallons)	243
Alpet E3 Hand Sanitiser (gallons)	114
Granite & Stone cleaner (gallons)	27
Stainless Steel Cleaner (gallons)	18
Plastic Forming Roll Film	
Polyethylene (PE) (lb)	178,491
Polyamide (PA) (lb)	144,722
Makrofol® EPC films (PC-PVF) (lb)	67,537
Ethylene vinyl alcohol (EVOH) (lb)	57,889
Polypropylene (PP) (lb)	33,768
Plastic Non-forming Roll Film	
Polyethylene (PE) (lb)	155,099
Polyamide (PA) (lb)	76,278
Ethylene vinyl alcohol (EVOH) (lb)	22,883
Plastics Trays	
Polypropylene (PP) (lb)	421,254
Polyethylene (PE) Products	
Lidding Film (lb)	22,272
Bags (lb)	1,656
Pouches (lb)	7,962
TOTAL chemicals (gallons)	**10,962**
TOTAL plastic trays (lb)	**421,254**
TOTAL plastic film & bags (lb)	**768,557**

The waste stream consisted of mixed municipal solid waste (MSW), recyclables (aggregated cardboard and plastic), grease and inedible material to rendering (Table 3).

Table 3. Waste sources and proportion of waste sent to landfill for FY21

Waste source	FY21
Recycled Cardboard and Plastic (tons)	1,131
Mixed MSW to land fill (tons)	953
Grease (tons)	470
Rendering	
Bones (tons)	255
Fat (tons)	192
Meat & Trimmings (tons)	665
TOTAL Rendering (tons)	**1,112**
TOTAL Waste (tons)	**3,666**
Proportion diverted from land fill	**74.0%**

Staff commuting emissions were calculated based on the sum of staff attending the facility over three shifts per day. Staff were estimated to travel an average of 30 km (18.6 mi.) one way. The distances port to port for transoceanic shipping were assessed using transoceanic shipping routes (Searates 2021), while refrigerated road freight from port of Philadelphia to TFI was estimated at 40 km (25 mi.) one way and continental road freight was assumed to be 1,500 km (932 mi.) for domestic freight.

4.8 Data Limitations

In lieu of dedicated studies of the producers supplying meat to TFI USA, emission intensities for meat were taken from published literature and used as a proxy for scope 3 emissions for meat at the abattoir gate. Data for refrigerants were not available and were estimated at 8% of the full charge capacity. Data could not be separated for the processing floor and warehouse and were therefore grouped. Data could not be separated for recycled corrugate and HDPE/PET and were assumed to be 99% and 1% of the total weight, respectively. Emission factors for EVOH raw plastic and plastic film were not available in the available databases, hence emissions were calculated as the average of PVC, PE and EVC factors and PE film as a substitute, respectively. Emission factors for BoPET/PVDC plastic film and PU adhesive were not available in the available databases, hence PE film was used a substitute. Total annual chemical use was unavailable; hence usage was calculated from invoices and upscaled for FY21. Specific emission factors for some chemical ingredients were not present in SimaPro, hence a closely related ingredient was used as a substitute. Data from rendering was aggregated by meat type, hence mass loss was calculated for the total of processed meats and the calculated proportion was then applied to each processed meat type. This may result in losses being overestimated for some meats and underestimated for others.

4.9 Emission reduction assessment

A screening analysis was conducted to investigate possible options for emission reduction. This included assessment of the major scope 1 and 2 emissions sources with the goal of reducing emissions reported to TFI customers. Review of the SMART goals was completed with guidance from the EPA Food Recovery Hierarchy triangle (U.S. EPA 2021e) (Figure 3) and the EPA Waste Management Hierarchy (U.S. EPA 2021f) (Figure 4) ensuring the highest desirable outcome and lowest emissions were achieved.

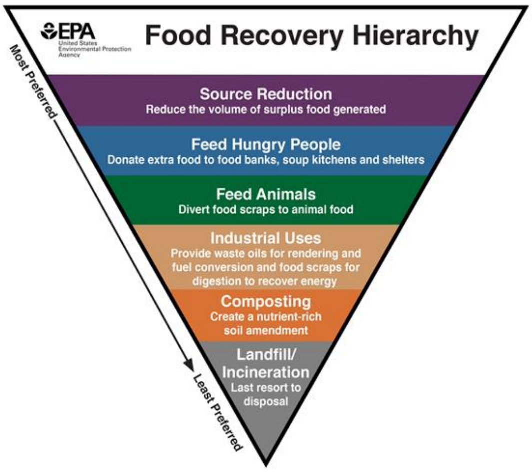

Figure 3. Food recovery hierarchy triangle (U.S. EPA 2021e)

Figure 4. Waste management hierarchy triangle (U.S. EPA 2021f)

5.0 Project Outcomes

5.1 Carbon account and emission contribution

Total emissions (scope 1, 2 and 3) for the whole enterprise were dominated by meat inputs, then oceanic transport.

The annual GHG business emissions (scope 1 and 2) were 3,769 metric tonnes of CO_2-e, while the operation carbon footprint (scope 1, 2 and 3), was 1,401,273 metric tonnes of CO_2-e. Scope 3 emissions were dominated by purchased meat and to a lesser extent, transport.

Of the scope 1 and 2 GHG inventory, the majority of impacts were from grid electricity, which accounted for 50% of GHG emissions. Other major contributors to GHG emissions were estimated leakage of refrigerants R-505 and R-404A, at 24.6% and 19.3%, respectively.

A hot spot analysis of scope 1 and 2 emission sources has been reported here, (Table 4) to illustrate the processing facility operations emissions and to provide benchmarks for company performance for reporting purposes. Grid electricity use was the largest emission source, contributing 50% of scope 1 and 2 facility emissions.

Table 4. Hotspot analysis of scope one and scope two emissions for TFI post-processing facility for FY21. High is indicated by (red), medium (orange) and low (green)

Year	**FY21**
Class	**Facility**
Scope 1	
Natural Gas	5.7%
Refrigerant R-404A	19.3%
Refrigerant R-410A	0.5%
Refrigerant R-505	24.6%
Scope 2	
Grid electricity	50.0%

Future insights will come by tracking data over time and benchmarks will improve with increased specificity in the results and with the growing comparison dataset of facilities.

A hot spot analysis was conducted across scope 1, 2 and 3 emissions in order to reveal the relative contribution of emissions from each source (Table 5).

Table 5. Hotspot analysis of scope 1, scope 2 and scope 3 emissions for TFI post-processing facility for FY21. High is indicated by (red), medium (orange) and low (green). Results are reported inclusive and exclusive of impacts from meat and transport

Class	Facility excl. transport and meat	Facility inc. transport excl. meat	Facility inc. meat
Scope 1			
Natural Gas	2.4%	0.9%	0.0%
Refrigerant R-404A	8.1%	3.0%	0.1%
Refrigerant R-410A	0.2%	0.1%	0.0%
Refrigerant R-505	10.4%	3.9%	0.1%
Scope 2			
Grid electricity	21.1%	7.8%	0.1%
Scope 3			
Grid electricity	1.1%	0.4%	0.0%
Solar electricity	2.1%	0.8%	0.0%
Natural Gas	0.6%	0.2%	0.0%
Refrigerant R-404A	unavailable	unavailable	unavailable
Refrigerant R-410A	unavailable	unavailable	unavailable
Refrigerant R-505	unavailable	unavailable	unavailable
Continental road freight	excl.	4.2%	0.1%
Road freight port-TFI	excl.	6.4%	0.1%
Staff commuting	excl.	8.2%	0.1%
Transoceanic shipping	excl.	43.9%	0.8%
Cardboard boxes	17.5%	6.5%	0.1%
Chemicals	0.1%	0.0%	0.0%
Plastic film and bags	22.6%	8.4%	0.1%
Plastic trays	6.8%	2.5%	0.0%
Recycled carboard	1.4%	0.5%	0.0%
Recycled plastic	0.0%	0.0%	0.0%
Waste to landfill	5.5%	2.1%	0.0%
Wastewater	0.1%	0.1%	0.0%
Water supply	0.1%	0.0%	0.0%
TOTAL meat	**excl.**	**excl.**	**98.3%**

5.3 Energy, Water and Waste

Energy consumption in MJ and kWh for the facility are shown in Table 6 and Table 7, respectively, while water consumption is shown in Table 8 and MSW waste production is shown in Table 9.

Grid electricity for New Jersey was comprised of 59% fossil and 41% renewable sources (U.S. EPA 2021a). Total electrical energy demand was predominantly contributed from grid electricity (78%), while solar electricity contributed 22%.

Table 6. Direct cumulative energy demand from fossil and renewable sources for operations for FY21

Direct Cumulative Energy Demand Units	FY21 MJ
Fossil sources	
Grid electricity	16,192,696
Natural gas	4,244,571
Renewable sources	
Grid electricity	11,252,552
Solar electricity	7,934,182
Total fossil energy	20,437,267
Total renewable energy	19,186,733
Total energy demand	**39,624,001**

Table 7 Total electrical energy demand for operations for FY21

Electrical Energy Demand **Units**	**FY21** **kWh**
Grid electricity Solar electricity	7,623,680 2,203,939
Total demand	**9,827,619**

Table 8. Total tap water consumption for FY21

Water Consumption **Units**	**FY21** **gal**
City water supply	**6,357,497**

Table 9. Solid waste production for FY21

Solid waste **Units**	**FY21** **lb**
Mixed MSW	**1,905,080**

5.5 Review of current SMART goals

5.5.1 Increasing energy productivity by 10% in relation to sales by 2025 (strategies to be further developed under Stage 2)

Energy productivity gains can also be made through production system efficiency such as reducing storage duration in the warehouse. Separate accounting for energy by product line will allow for a reduction in GHG attributed to some line items sold by TFI USA.

5.5.2 Implementing 25% renewable energy (or 2,700,000 kWh) through solar PV by 2025 (other renewable energy such as biogas generation will be assessed)

The solar PV installation generated 22.4% of electricity used by the facility or 81.6% of the 2,700,000 kWh goal in FY21. A relatively small additional installation will increase the production of solar electricity while simultaneously decreasing demand on grid electricity, enabling TFI to meet the target of 25%. There is potential to expand the solar infrastructure over the North-East carpark and South-West truck bays, highlighted in blue in Figure 5, though this may also be limited by planning approval requirements, which would need to be assessed prior to undertaking more detailed feasibility assessment.

The capability of the large water feature to the west of the facility to hold floating solar PV could also be evaluated. The water surface area is greater than 11 acres and could produce more solar power than is being produced on the rest of the property. The water feature area is highlighted by the yellow polygon outline in Figure 5. Cost-effectiveness of solar is recognised as a limitation to further development at present.

A simple assessment of biogas suggests wastewater volume and quality would not support a commercial scale installation at the site. This option is more suited to primary processing.

Figure 5. Aerial image of TFI New Jersey facility. Blue rectangles depict potential areas for roof mounted solar PV. Yellow polygon outline indicates potential water feature area for floating solar PV. Image from Google Earth (Google LLC 2021)

5.5.3 Reducing 25% of waste to landfill by 2025

Waste flow baselines were determined in 2021 by compiling invoices for disposal of mixed MSW, recycling, grease and rendering. Presently, 74% of waste is diverted away from landfill. To reach the goal of a 25% reduction of waste to landfill, an assessment should be made as to which materials can be diverted to uses that are higher on the waste hierarchy (Figure 4). For example, the combustion of MSW with energy recapture.

5.6 Review of other TFI goals

5.6.1 Measuring rendering in 2021 and identifying opportunities to decrease rendering (assisted by the data collection and analysis required within the baseline report)

Consideration could be given to interventions, e.g., machine guards to minimise spillage of the product during processing. With respect to changing from rendering to composting, the waste hierarchy for food (see Figure 3) shows that either directing material to animal feed, or processing food products and then feeding to animals (i.e., rendering) is more desirable compared to composting.

5.6.2 Researching the availability of local composting (this project will provide a desktop assessment of the GHG emissions associated with composting rendering material)

As noted in the previous section, composting is lower on the Food Recovery Hierarchy triangle than rendering. For this reason, it is not recommended to divert material from rendering to composting. In environmental accounting, no impacts arise from rendering, but composting meat generates scope 3 emissions and is calculated at 0.15 metric tonnes CO_2-e/short Ton of material (U.S. EPA 2021b). A recent study estimated emissions generated from rendering to be 0.2 kg CO_2-e/kg of meat compared to composting which was between 2.5 – 4 kg CO_2-e/kg of meat (Gooding & Meeker 2016).

5.6.3 Continual review and testing of emerging sustainable innovations in food-grade packaging (implications for GHG emission will be assessed briefly)

There are options for sustainable packaging including biodegradable packaging and packaging made from recycled materials. Generally, these products reduce emissions through reduction of end-of-life treatment, in the case of biodegradable packaging or reduction in the input of virgin material for production, in the case of recycled materials. An assessment of the implications of these packaging options is outlined in section 5.7.7.

5.6.4 Support the MLA goal of carbon neutral beef production by 2030 (no requirement to report as part of post-port operations)

The Australian red meat industry has established an ambitious goal to achieve carbon neutrality by 2030. This could be supported by initiating benchmarking and emission reduction activities in the TFI supply chain. This will be investigated further in the next stage of the project.

5.6.5 Assess impacts of grazing acreage and the potential impacts of carbon sequestration

Sequestration of soil and vegetation carbon in grasslands may have the potential to store significant amounts of carbon when favourable conditions are present. However, soil carbon is known to be highly variable at both temporal and spatial levels, meaning that accurately measuring a change in carbon stocks is challenging. This area represents a major potential opportunity for the supply chain to reduce reported impacts for red meat, and it will be investigated further in the next stage of the project.

5.7 Reducing environmental impacts

A screening assessment of potential options to reduce emissions was conducted. A total of three options focused on the SMART Goals outlined in section 5.5, three options from other TFI goals outlined in section 5.6 and a further two options: i) to disaggregate energy allotted to warehouse and processing, and ii) switching to refrigerants with lower GWP_{100} values.

5.7.1 Screening – Mitigation scenarios

Scenarios were investigated to determine potential emission intensity reduction from changes in facility operations. These scenarios are summarised in Table 10.

Table 10. Mitigation scenarios to reduce facility emissions

Parameters	S1	S2	S3	S4	S5	S6	S7	S8
Operations change	Increase energy productivity	Increase energy from solar	Reduce waste to landfill	Measure and decrease rendering	Investigate rendering to compost	Investigate sustainable food grade packaging	Disaggregate warehouse and processing energy	Switch to lower GWP refrigerants
Throughput	0	0	0	↑	0	0	0	0
Scope 1 & 2 emissions	↓	↓	0	0	0	0	[A]↑ and ↓	↓
Scope 3 emissions	↓	↓	↓	↓	↑	↓	0	0
Energy usage	↓	0	0	0	0	0	0	[B]↑ or ↓
Water usage	0	0	0	0	0	0	0	0
Waste production	0	0	↓	0	0	0	0	0

[A] Increase emissions for warehoused products and decrease emissions for processed products

[B] May either increase or decrease emissions depending on the refrigerants used

5.7.2 Scenario 1 - Increase energy productivity

In line with the SMART Goal – 'increasing energy productivity by 10% in relation to sales by 2025, the impact of increased energy productivity' was assessed. This scenario would decrease scope 2 and 3 emissions and the energy footprint of the facility.

5.7.3 Scenario 2 - Increase energy from solar

In line with the SMART Goal – 'implementing 25% renewable energy (or 2,700,000 kWh) through solar PV by 2025 the impact of increasing solar production' was assessed. This scenario would decrease scope 1 and 2 emissions through grid electricity consumption. During FY21, the solar installation on the facility generated 22.4% of the 25% electricity demand goal and 81.6% of the 2,700,000 kWh target. Increasing solar production to 25% would equate to 91% of the 2,700,000 kWh target. The electrical energy intensity would remain unchanged. Assuming current emissions remain the same, if the 25% solar electricity target is achieved, scope 1 and 2 emissions are reduced by 63 t CO_2-e, a change of 3.3%, while if the 2,700,000 kWh target is achieved, emissions would reduce by 123 t CO_2-e, a change of 6.5%.

To meet the target of 25% renewable energy through solar, an additional installation of approximately 0.4 ac (approximately 1,600 m^2) would be required. To meet the target of 2,700,000 kWh, an additional installation of approximately 0.78 ac (approximately 3,150 m^2) would be required.

In a scenario where solar was added to the north-eastern car park (approximately 0.44 ac), emissions would reduce by approximately 69.3 t CO_2-e, a change of approximately 3.7%. In a scenario where solar was added to the south-western truck bays (approximately 0.1 ac), emissions would reduce by approximately 16.3 t CO_2-e, a change of approximately 0.9%. In a scenario where floating solar was installed on the entire water feature (approximately 11 ac), emissions would reduce by approximately 1,733 t CO_2-e, a change of approximately 92%.

In a scenario where solar was added to all three locations (approximately 15 ac), emissions would reduce by approximately 1,817 t CO_2-e, a change of approximately 96.4%.

5.7.4 Scenario 3 - Reduce waste to landfill

In line with the SMART Goal – 'reducing 25% of waste to landfill by 2025 the impact of reducing waste to landfill' was assessed. The scenario would decrease scope 3 emissions and the waste footprint of the facility. The next highest use on the waste management hierarchy triangle (U.S. EPA 2021f) is energy recovery or combustion. While redirecting waste away from landfill is the SMART goal, it is not considered waste minimisation (U.S. EPA 2021c). In a scenario where 25% of the current mixed municipal waste was redirected to combustion, a reduction in emissions of 22 t CO_2-e would result. In a scenario where 25% of the current mixed municipal waste was redirected to recycling as mixed plastics or metals, a reduction in emissions of 69 – 72 t CO_2-e would result. In a scenario where spilled meat was collected was redirected away from landfill, the reduction of emissions from rendering, combustion and composting would be 124, 112 and 88 t CO_2-e, respectively.

5.7.5 Scenario 4 - Measure and decrease rendering

In line with the other TFI goal – 'rendering was measured in 2021 and opportunities to decrease the impact of rendering' were assessed. Reducing rendering would have the effect of increasing facility output and increasing allocation to meat products thereby reducing scope 3 emissions.

5.7.6 Scenario 5 - Investigate rendering to compost

In line with the other TFI goal – 'researching the availability of local composting, assessment of the GHG emissions associated with composting rendering material' was assessed. Rendering does not have an environmental burden on GHG emissions and is a more desirable outcome compared to composting (U.S. EPA 2021e). IAE does not recommend redirecting meat from rendering to composting.

5.7.7 Scenario 6 - Investigate sustainable food grade packaging

In line with the other TFI goal – 'continual review and testing of emerging sustainable innovations in food-grade packaging' was assessed. There are options for reducing emissions associated with packaging, including biodegradable packaging and packaging made from recycled materials. Biodegradable packaging does not produce any downstream GHG emissions associated with end-of-life treatment. Compared to mixed plastics which, when landfilled, recycled or combusted produces 0.02, 0.22 and 2.34 t CO_2-e per short ton of material. A recent study found that the use of recycled polyethylene terephthalate (rPET) compared to polypropylene (PP) saw an 18% reduction of emissions over the entire life cycle of a food tray (Maga, Hiebel & Aryan 2019).

5.7.8 Scenario 7 - Disaggregate warehouse and processing energy, water, waste and inputs

Through the course of this project, it was identified that separate metering would give the ability to disaggregate the electricity usage for products exclusively warehoused compared to those which are processed and stored in the warehouse for a short period of time. In a scenario where emissions could be more accurately estimated for these different products, the emissions intensity associated with processed products would likely reduce, while the intensity for warehoused products would increase. Disaggregating water, waste and facility inputs would enable accurate attribution of emissions between warehousing and processing. This would more closely reflect reality within the facility.

5.7.9 Scenario 8 - Transition to lower GWP refrigerants

Through the course of this project a hotspot analysis identified that refrigerants are the major source of scope 1 emissions for the facility. There are many options available that have been approved by the U.S. EPA Significant New Alternatives Policy (SNAP) (U.S. EPA 2021d) and some are listed below.

Current refrigerants used in the facility, R-404A, R-410A and R-505, have GWP_{100} values of 3,922, 2,088 and 8,520, respectively. R-410A is already considered a low GWP refrigerant. A recent SNAP rule change, specifically rule 21, mean that R-125 containing refrigerants will no longer be acceptable to use in new cold storage installations from January 1, 2023. R-404A is comprised of 44% R-125. Use of R-12, the main component of R-505, is generally being phased out in the economy.

There are currently low GWP, ultra-low GWP and blends of low/ultra-low GWP refrigerants available.

Low GWP refrigerants

Potential low GWP replacements include:

- R-134A – GWP_{100} 1,430 (Cold storage warehouses, for use as the primary heat transfer fluid in new secondary-loop equipment for not-in-kind replacements of systems and Industrial process refrigeration [new] [HFC–134a as a substitute for CFC–12 and R–502] [SNAP- notice 15])
- R-417C (Hot shot 2) – GWP_{100} 1,820 (cold storage warehouses and Industrial process refrigeration –retrofit only [Hot Shot 2 as a substitute for CFC–12, R–500, R–502, HCFC–22 and HCFC blends, including those containing HCFC–22 and/or HCFC–142b] [SNAP – notice 26])
- R-420A – GWP_{100} 1,548 (cold storage warehouses and Industrial process refrigeration – new and retrofit [R–420A as a substitute for R–500 and CFC–12.] [SNAP notice 19])
- R-426A (RS-42) – GWP_{100} 1,508 (cold storage warehouses and Industrial process refrigeration – new and retrofit [R–426A {RS–24} as a substitute for CFC–12] [SNAP – notice 21])
- R448A – GWP_{100} 1,387 (cold storage warehouses and Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 33])
- R449A – GWP_{100} 1,397 (cold storage warehouses and Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 33])
- R449B – GWP_{100} 1,412 (cold storage warehouses and Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 33])
- R-453A – GWP_{100} 1,770 (cold storage warehouses and Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 33])
- R-458A – GWP_{100} 1,650 (Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 33])

Ultra-low GWP refrigerants

Fourth generation ultra-low GWP refrigerants, hydrofluoroolefins (HFOS) HFO-1233zd(E) and HFO-1244YD(Z) have GWP_{100} values 3.7 and 1, respectively, while hydrofluoroether (HFE) HFE-7100 has a GWP_{100} value of 390 and is only suitable in new installations. Depending on cost benefit analysis, these refrigerants may be viable long-term options.

Potential ultra-low GWP replacements include:

- R-744 (CO_2) – GWP_{100} 1 (cold storage warehouses – new only [(R–744 {CO_2} as a substitute for CFC–12, R–502, HCFC–22, and blends containing HCFC–22] [SNAP – notice 24])
- HFE-7100 – GWP_{100} 390 (industrial process refrigeration, for use as a secondary heat transfer fluid in new equipment for not-in-kind replacements of systems [HFE-7100 as a substitute for CFC–11, CFC–12, CFC–114, CFC–115, HCFC–22 and R–502] [SNAP – notice 14])
- HFO-1233zd(E) – GWP_{100} 3.7 (Industrial process refrigeration– new and retrofit [no additional comments listed] [SNAP – notice 36])
- HFO-1244YD(Z) – GWP_{100} 1 (Industrial process refrigeration– new and retrofit [no additional comments listed] [SNAP – notice 35])

Low/ultra-low GWP blended refrigerants

The following two refrigerants are blends comprised of HFC-134A and either HFO–1234ze(E) in the case of R-450A or HFO-1234yf in the case of R-513A. HFO-1234yf has a GWP_{100} value of less than 1.

- R-450A – GWP_{100} 604 (cold storage warehouses and Industrial process refrigeration – new and retrofit [no additional comments listed] [SNAP – notice 29])
- R-513A – GWP_{100} 630 (cold storage warehouses and Industrial process refrigeration– new and retrofit [no additional comments listed] [SNAP – notice 30])

Mitigation scenarios for low GWP refrigerants

In a scenario where low GWP refrigerants are used and assuming the current leakage rate, changing from R-404A and R-505 to R-448A and R-134A would see a total scope 1 and 2 emissions reduction of 1,241 t CO_2-e. Scope 1 emissions attributed to refrigerants would reduce by 74.3%.

In a scenario where ultra-low GWP refrigerants are used and assuming the current leakage rate, changing from R-404A, R-410A and R-505 to HFOS would see a total scope 1 and 2 emissions reduction of 1,671 t CO_2-e. Scope 1 emissions attributed to refrigerants would reduce by 99.9%.

In a scenario where blended low/ultra-low GWP refrigerants are used and assuming the current leakage rate, changing from R-404A, R-410A and R-505 to these blends would see a total scope 1 and 2 emissions reduction of 1,480 – 1,488 t CO_2-e. Scope 1 emissions attributed to refrigerants would reduce by 88.6 – 89.1%.

6.0 Discussion

The carbon footprint and environmental impact assessment of TFI's Swedesboro facility provided in this report revealed that scope 1 and 2 GHG emissions were low relative to emissions for the full supply chain and were low compared to primary processing (Asem-Hiablie et al. 2019; Battagliese et al. 2015).

Greenhouse gas impacts were similar to previous assessments of red meat imports from Australia (Wiedemann et al. 2015) but this comparison was limited because data relating to the specific TFI red meat supply chain were not available, and literature values were utilised from the same Wiedemann et al. (2015) study.

6.1 Improvement options for TFI USA

Of the scope 1 and 2 GHG inventory, the majority of impacts were from grid electricity followed by emissions from estimated leakage of refrigerants, and then natural gas.

Improvement options for data collection were identified and the following recommendations were made:

- Measuring loss rates (recharge) of refrigerants. This is currently not measured, and an estimate was used. Considering it was a large emission source, the level of uncertainty would be reduced by measuring this in the coming 12 months.
- Separately metering the electricity usage from warehouse and processing areas to accurately determine scope 1 and 2 emissions intensity for warehoused and processed products. This would allow more accurate recording of impacts for meat products that are post-processed and would allow greater insight into productivity measures that could improve efficiency, such as reduce warehouse storage time.
- Tracking of storage times, product mass loss and packaging by product line.
- Separately measuring waste stream materials by type to identify opportunities to reduce scope 3 emissions through disposal that is more preferred on the waste hierarchy triangle.

6.2 Assessment of Supply Chain requirements

As part of this study, customer goals and targets were reviewed. This review found that goals exist for almost all suppliers covering reduction in GHG emissions. In most cases, this extends to reduction targets for scope 3 emissions (that is, emissions covering the full meat supply chain). Considering red meat is one of the biggest emission sources from a retailer or food service company, these reduction targets will inevitably be shifted down the supply chain as a market expectation. It should be expected that formal scope 3 reporting will be a feature in the near future.

In addition to GHG reporting, energy, packaging, waste and water are all listed by most customers, and some specific targets exist for stand-out contributions to the processing and retail end of the supply chain. Of these, refrigerants and transport are notable.

While targets exist for many environmental indicators, GHG, energy, packaging and waste are by-far the most ambitious and should be seen as the priority for processors, and for the whole supply chain.

7.0 Conclusions / Recommendations

The results of this study form the baseline reference to which future reporting of TFI will be compared. The study found impacts were relatively low for the TFI USA operation and as expected, supply chain impacts upstream in production and primary processing were much higher. The study was designed with a stage 2 and 3 aspect covering review of strategy and consumer requirements, and potentially expansion of the study to assess impacts through primary processing and production. The following recommendations from this first stage of the project are as follows:

We recommend reviewing and revising data collection processes to improve reporting in the coming year.

We recommend reviewing the results and mitigation scenarios presented here, to select options for implementation in the coming year.

Considering the clear drivers for sustainability reporting across all customers and the particular focus on GHG emission reduction through the whole supply chain, we recommend TFI engages across the whole supply chain to develop an assessment framework and emission reduction strategy to meet future customer expectations. It is reasonable to expect impacts from the TFI supply chain in Australia would be lower than reported in this study, resulting in the potential for a better reporting outcome. It is also noted that supply chain assessment and emission reduction is a substantial undertaking, with assessment alone likely to take 12-18months. Emission reduction activities typically operate over decadal timeframes. For this reason, action now is needed to be ready for the expectations of 2024-25.

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