



Final report

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Refrigeration audit at a medium mixed species abattoir

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EXECUTIVE SUMMARY

After visiting the site on 16 December 2013, 14 January and the 5th of March to collect final information, we now take pleasure in submitting our comprehensive report for your close attention and scrutiny. Our considered opinions have led us to the following conclusions, recommendations, budget costing and four layout drawings attached.

1. We estimate the current active chilling capacities at 927 head of 280 kg dressed weight beef plus 6,162 head of 22 kg lambs. Current average dressed carcase weights are 205 kg for beef and 19.1 kg for lambs.
2. The current electrical energy usage amounts to 122.5 kWh/tETCW plus a gas consumption of 542.5 MJ/tETCW. This equates to a total of 983.5 MJ/tETCW. All three specific energy consumption figures are the lowest we have ever come across in some 40 years of practice. The plant does not have a large blast freezing and cold storage facility, nor is there a rendering plant.

Notwithstanding that, we believe the plant to be very efficient in both energy consumption and water consumption which at 2.92 kL/tETCW is by far the lowest specific water consumption we have ever observed.

We have confidence in all these figures. There is a direct correlation between gas and water consumption because a lot of the water used at the plant needs to be heated for processing and cleaning. Thus low water and gas consumption confirm each other.

Similarly, the total utilities cost is only \$38.15/tETCW (3.82 cents/kg) comprising \$19.06 for electrical energy, \$5.09 for gas and \$14.00 for water. This also is the lowest total cost. This is all the more surprising as your total water cost is the highest we have ever seen, no doubt due to the high effluent treatment charges. See Appendix 1 for utility data used.

3. The presently installed ammonia refrigeration plant capacity is more than adequate to cope with the current maximum refrigeration demand on the site for chilling, freezing and process area cooling. There is indeed a degree of redundancy available as only two of the three compressors need to run at any one time and then at reduced capacity. Two of the refrigeration compressors are old machines, i.e. the Stal S73 and the Mycom 250S are likely getting close to the end of their life. See Appendix 2 for a report on the refrigeration plant.
4. In Section 5 following we have evaluated a maximum daily port packing carton chilling facility for 1,632 cartons at an average weight of 16.8 kg/carton.

The estimated daily volume of product to be frozen in the near future is 61 tonnes of red meat product – both boneless and bone in – and edible offals producing nearly 2,900 cartons per day at an average weight of 21 kg.

We recommend a minimum daily carton freezing capacity of 3,615 cartons to cater for an increase of dressed weight in beef processed. Offal yields increase at approximately the same rate as the dressed weights.

In addition we have given consideration to on-site freezing of 300 out of spec lambs per day, as well as quarter beef – 100 head/day and perhaps skin on goats in future as well.

5. Assessment of active chilling capacity requirements to expand plant operations as defined above.
 - 5.1 The lamb processing chain can run at a production rate of 12 carcasses per minute and this equates to 5,000 head per shift or 10,000 head per day over two shifts. After product flow separation modifications to the existing active lamb chillers we estimate an effective active lamb chilling capacity of about 5,000 head.

Thus if expansion to 7,500 to 8,000 head per day is to be realised, additional active lamb chilling capacity for 2,500 to 3,000 head daily is required. This would cost about \$1,400/head i.e. a total capital investment of \$3.5-\$4.2 million would need to be made.
 - 5.2 After beef chiller modifications, the remaining active beef chilling capacity will be well over the maximum 800 head daily processing rate envisaged and thus there is adequate beef chilling capacity for the foreseeable future.
6. Other infrastructure requirements would be
 - 6.1 Pre-boning marshalling chillers

A new beef boning room is planned. We believe that the existing box chiller and boning room would make effective lamb pre-boning marshalling and pre-trim facilities.

The existing beef chiller No. 9 would be converted to a beef pre-boning marshalling area and extended to the full length of beef chiller No. 10.
 - 6.2 The new boning room would be increased in size to cater for both beef and small stock boning. Beef boning would be on the rail boning of either sides or quarters. Lamb boning could be done on the rail, or on tables.
 - 6.3 After packing cartons would need to go to port packing chilling and freezing. We have designed a new 2,200 m² facility including two off 1,920 cartons/day automatic plate freezers, and a cold store holding 880 pallets of frozen product with 176 single pallet SKUs on 352 two pallet SKUs. This represents about 10 day's production.

There would also be a chill store holding 192 single SKU pallets representing about one week production of chilled beef, lamb and edible offal.

Please note, both the chill store and the cold store could be used as distribution and order pick areas and hence the large number of SKUs.

Furthermore, there would be a two level sorting and palletizing area with a total 114 pallet sorting stations, 80% of which would be high volume products and the remainder for mixed product pallets for later resorting. There would be load out plus a staging/port marking area.

There would be a plant with a two stage transcritical CO₂ plant to provide refrigeration for the new freezing/cold storage/distribution operation, the new boning room and the pre-boning marshalling areas. Most of the hot water required at the facility would be generated by heat recovery from the CO₂ plant, which would cost nothing and reduce the gas bill by about 80%.

Finally, there would be a well sized battery charging area.

- 6.4 The existing blast freezers would be used for the freezing of out of spec lambs, beef quarters and, in future, skin on goats. Furthermore, all carton chilling of both edible offal and chilled lamb and beef would also be done in the existing blast freezers.

7. Alternative technology options

- 7.1 In Section 6.1 we evaluate the major benefit of installing a Low Temperature Blast Chilling system through which electrically stimulated lamb carcasses are cooled rapidly for a period of one hour at temperatures of about -25°C for 40 minutes and at about -12°C for 20 minutes. Eighty percent of the heat would be removed from the carcasses in one hour after which the lambs would be placed in the existing chillers to equilibrate. The advantages of such a system are:

- .1 A very long shelf life product is produced.
- .2 Chiller weight losses would be more than halved from the current 3% generating additional revenue of \$2 million/annum.
- .3 Lambs would be ready to be boned out two to three hours after leaving the scales. After a further two to three hours the lambs could be loaded out for distribution.
- .4 Last but not least, there would be no need to build additional active carcase chilling capacity estimated to cost \$3.5 to \$4.2 million for 2,500 to 3,000 head. Indeed such a blast chilling operation would permit the lamb processing rate to be increased to 10,000 head/day without the need for any additional active carcase chilling capacity.
- .5 Such a system would cost about \$2 million and therefore the simple payback would be 2 years. See Appendix 3 dealing with rapid chilling.

7.2 Beef spray chilling

This process would reduce the shrink by at least 2% from 3% to 1% or less. This means extra saleable meat of $0.02 \times 800 \text{ head} \times 200 \text{ kg/head} = 3,200 \text{ kg/day}$. At a wholesale price of \$5.00/kg this would result in extra daily revenue of \$16,000.00 or \$4 million/annum when operating 250 days. Say 75% realisation would produce extra annual revenue of \$3 million for an investment not exceeding \$1.0 million. Therefore the simple pay back would be about 4 months.

8. Budget Cost Summary and Exclusions. See Section 10

8.1 Budget cost summary

.1 Plant and Equipment for new plate freezing/cold storage complex	\$7,500K
.2 Building and infrastructure cost	\$8,687K
.3 Optional – beef spray chilling and Low Temperature Blast Chilling	<u>\$3,000K</u>
.4 Total Budget	\$19,187K
.5 Add 10% contingency and escalation	<u>\$ 1,919K</u>
.6 Total budget including contingency	\$21,106K
.7 Fees and permits 5%	<u>\$ 1,055K</u>
.8 Grand Total Budget	<u><u>\$22,161K</u></u>

8.2 Exclusions

No consideration has yet been given to

- .1 Demolition of existing buildings and removal of debris, and replacement with new buildings if required
- .2 Amenities expansion
- .3 An additional HT power supply as the existing one is 3,000 kVA
- .4 Skin on goats facility
- .5 Upgrading of edible offal area and tripe processing
- .6 Increase in livestock yard capacity
- .7 A rendering plant
- .8 Laundry facilities
- .9 Cost/benefit analysis of additional value added operations like skin on goats, higher volume of boning
- .10 In depth financial analysis like project financing costs, depreciation allowances, taxes and potential availability of grants from the State Government or the AMPC for the development of Low Temperature Blast Chilling.

9. Estimated cost benefit

9.1 Operating cost savings by

.1 Eliminating offsite freezing of carcasses and cartons	\$1,750K
.2 Saving 100 off 20 foot export containers per annum	\$1,000K
.3 Reduction in gas bill	<u>\$ 200K</u>
.4 Total estimated reduction in operating costs	\$2,950K

9.2	Increased revenue from		
	.1	Beef spray chilling	\$3,000K
	.2	Low Temp blast chilling of lambs	<u>\$2,000K</u>
	.3	Total annual revenue increase	<u>\$5,000K</u>
9.3	Total annual benefit		\$7,950K
9.4	Annual increase in operating costs		
	.1	Additional extra electrical energy cost	\$1,000K
	.2	Cold store labour cost increase	<u>\$ 260K</u>
	.3	Estimated annual increase in operating costs	<u>\$1,260K</u>
9.5	Annual Nett Benefit		\$6,690K
9.6	Estimated Capital Expenditure		\$22,161K + 10% GST
9.7	Simple payback		3.15 years

1. TERMS OF REFERENCE

The following are the terms of reference for the audit report.

This initial project milestone will encompass collecting data in order to undertake measurements and modelling of the current and refrigeration system and proposed system optimisation and potential expansion in the future. The specifics of the report to be produced will include;

- .1 Collection of existing beef and small stock chilling capacities.
- .2 Assessment of current energy usage at the site level and also the refrigeration system.
- .3 Collect existing refrigeration plant capacity details for chilling, freezing and process area cooling.
- .4 Collect details of current electrical, energy, gas and water consumption and establish current specific utility consumption data per tonne of carcase meat produced.
- .5 Assessment of the plant expansion with respect to existing facilities and refrigeration system.
- .6 Calculate the total expansion required in active chillers, pre boning marshalling chillers, boning room space and port packing product chilling, freezing and storage facilities, including major distribution centres.
- .7 Budget of the total cost of the refrigeration plant augmentation to achieve the daily production, including evaluation of various processing alternatives like peak freezing, chilled carton variations.
- .8 Full technology options appraisal for the proposed plant upgrade, including preliminary CBA modelling.
- .9 Assessment of the existing internal capabilities and those required to implement and manage the identified solutions.

2. ACTION TO DATE

The plant was visited on 9 December last and note was taken of plant operations and existing facilities. Data on total monthly beef and sheep numbers and resulting dressed weight meat production in Estimated Total Carcase Weight (ETCW) for the five months from 1 July – 30 November 2013. We also collected electrical energy, gas and water bills for the same period. See attached Tables 1, 2 and 3. The plant was revisited on January 14 to do a physical count of the number of rails in all the chillers and collect the missing November gas and water bills, the last of which were received on the 29th of January. We received a CAD site layout drawing on the 11th of March, which was used to mark up the attached drawings to clearly show our ideas. We now report the following in order of the Terms of Reference.

3. EXISTING REFRIGERATION PLANT CAPACITY

The existing ammonia refrigeration plant has the following installed capacity. The machines are rated at their new capacity.

- .1 High stage capacity at -10°C SST / $+30^{\circ}\text{C}$ SCT
 - .1 Stal S73 1,511 kWR
 - .2 Mycom 250M 1,400 kWR
- .2 Mycom 250S booster at -40°C SST / -7°C SCT 350 kWR

NB. The Stal S73 stage compressor and the Mycom 250S booster are old vintage machines 30-40 years old and are unlikely to deliver their rated capacity. We estimate they deliver up to 80% of their rated capacity. The Mycom 250M compressor is of a later vintage and likely to be operating at or near full capacity. See attached copy of a report on the refrigeration plant we prepared in 2010. Appendix 1.

4. SUMMARIES OF UTILITIES CONSUMPTION AND ACTIVE CARCASE CHILLING CAPACITIES

4.1 Summary of utilities consumption 1 July 2013 – 30 November 2013

Table 1: Utilities consumption

PERIOD – MONTH 2013	TOTAL DRESSED WEIGHT, TONNES T ETCW	ELECTRICAL ENERGY				GAS				WATER				TOTAL COST ALL UTILITIES ELECTRICAL ENERGY, GAS \$/ T ETCW
		CONSUMPTION		COST		CONSUMPTION		COST		CONSUMPTION		COST		
		MWh TOTAL	kWh/ T ETCW	TOTAL, \$K	\$ / T ETCW	GJ TOTAL	MJ / T ETCW	\$K TOTAL	\$ / T ETCW	MI TOTAL	KI / T ETCW	\$K TOTAL	\$ / T ETCW	
JULY	4,478.3	528.2	117.9	82.6	18.44	2,415.1	539.3	21.76	4.86	12.46	2.78	56.3	12.57	35.87
AUG	3,667	514.2	140.2	79.8	21.76	2,362.1	644.2	21.56	6.44	11.42	3.11	46.16	12.59	40.79
SEPT	4,772	508.4	106.5	78.9	16.53	2,258.7	505.1	23.77	4.98	11.31	2.37	47.1	9.87	31.38
OCT	4,143.4	533.3	128.7	82.4	19.89	2,432.7	587.1	22.17	5.35	12.24	2.95	70.14	16.94	42.18
NOV	4,141.7	513.7	124.0	80.5	19.44	2,033.0	490.1	18.59	4.49	14.50	3.50	77.10	18.62	42.55
TOTAL/AVG	21,202.4	2,597.8	122.5	404.2	19.06	11,501.5	542.5	107.85	5.09	61.93	2.92	296.8	14.00	38.15

4.2 Estimate of active carcase chilling capacity installed

Table 2: Estimate of active carcase chilling capacity installed

SMALL STOCK CHILLERS – Say 285mm rail length / carcase							BEEF CHILLER – Say 660mm rail length / carcase						
NO.	DIMENSIONS, m		NO. OF RAILS	RAIL LENGTH, m		NO. OF CARCASE S	NO.	DIMENSIONS, m		NO. OF RAILS	RAIL LENGTH, m		NO. OF CARCASES
	L	W		EACH	TOTAL			L	W		EACH	TOTAL	
1	11	5.8	11	9.2	101	354	1	8.4	5.0	5	6.6	33	50
2	10.6	5.3	8	8.8	70	245	2	8.4	5.8	6	6.6	40	60
3	15.6	8.5	17	13.8	235	822	3	10.1	6.7	7	8.3	58	88
4	8.6	9.0	18	6.8	122	427	4	10.1	6.7	7	8.3	58	88
5	15.6	5.8	11	13.8	152	532	5	12.4	5.8	6	10.6	63	95
6	10.6	5.4	10	8.8	88	308	6	10.0	4.0	4	8.2	33	50
7	17.2	9.0	18	15.4	277	970	7	10.0	5.8	6	8.2	49	74
8	17.2	9.9	20	15.4	308	1,076	8	12.4	5.8	6	10.6	63	95
9	17.5	6.7	13	15.7	204	714	9	7.4	4.0	4	5.6	22	33
10	17.5	6.7	13	15.7	204	714	10	11.4	11.3	12	9.6	115	174
TOTAL			139		1,761	6,162	11	9.8	5.0	5	8	40	60
							12	9.8	5.0	5	8	40	60
							TOTAL			73		614	927

5. PRODUCTION DATA AND FUTURE PORT PACKING CARTON CHILLING AND FREEZING CAPACITY REQUIREMENTS

5.1 Summary of carcase meat production 1 July 2013 – 30 November 2013

Table 3: Smallstock and beef kill numbers. Period 1 July – 30 November 2013

MONTH 2013	SMALLSTOCK				CATTLE				ETCW SMALLS & CATTLE, KG
	NO. OF HEAD HD	DRESSED WEIGHT, KG			NO. OF HEAD HD	DRESSED WEIGHT, KG			
		PER HD	TOTAL ETCW	%		PER HD	TOTAL ETCW	%	
JUL	100,440	18.71	1,879,257	42.0	12,369	210.13	2,599,051	58.0	4,478,308
AUG	86,909	18.71	1,626,338	44.4	9,928	205.55	2,040,677	55.6	3,667,015
SEPT	112,428	19.39	2,180,189	45.7	12,667	204.61	2,591,813	54.3	4,772,002
OCT	97,942	19.13	1,873,952	45.2	11,135	203.82	2,269,493	54.8	4,143,445
NOV	94,286	19.38	1,827,020	44.1	11,539	200.60	2,314,698	55.9	4,141,718
TOTALS	492 005	19.08	9 386 756	44.3	57 638	205.00	11 815 732	55.7	21 202 488

5.2 Definition of proposed production

- .1 Slaughter 5,000 small stock head a day (1 shift) maximum envisaged small stock 7,500 – 8,000/day.
- .2 600 cattle (2 shifts) / 200 head boned – primals typically chilled and trim frozen. Consider 800 head/day.
- .3 Boning room – 1,500 head of lambs per day boned (60% chilled/40% frozen). An additional 1,000 lambs cut into 6 way.
- .4 Small stock offals chilled/frozen 50/50 (liver, kidney, hearts).
- .5 Beef offals 90% frozen (hearts, livers) tails, tongues and cheeks chilled.
- .6 200 – 300 out of spec lambs frozen.
- .7 Some quarter beef is also to be frozen.
- .8 There is also a possibility that 400 head of skin on goats are to be produced for the export market.

5.3 Evaluation of port packing chilling and freezing of red meat and edible offal

In this Section we are interpreting the requirement of proposed production.

.1 Carton chilling

- .1 Chill daily 3,000 kg of small stock offal packed in 12.5 kg cartons. Total cartons/day 240
- .2 Chill daily 2,500 kg of beef offal – tails, tongues, cheek meat packed in 12.5 kg cartons. Total cartons/day 200
- .3 Beef primal cuts obtained from boning 200 head average 210 kg dressed weight at 70% boning yield of which 40% are primals. Total 11,760 kg/day at 20 kg/cartons a day 588

.4	Say additional cartons/day	<u>60</u>
.5	Total number of cartons to port packing chilling daily	1,088
.6	Add 50% for future increase in beef dressed weight, boneless lamb and goat meat, tripe, etc.	<u>544</u>
.7	Daily port packing carton chilling design capacity	<u>1,632</u>

.2 Carton freezing

.1	Small stock offal, kg - 13.6 kg cartons	3,000
.2	Beef offal, kg – 13.6 kg cartons	3,600
.3	Trim from boning 200 head of 210 kg dressed weight beef at 70% yield and 60% to trim freezing, kg	17,640
.4	1,000 off 20 kg lambs/day into 6 way cut, kg	20,000
.5	Quantity of boneless meat from 1,500 – 20 kg lambs, 55% yield	<u>16,500</u>
.6	Total weight boneless meat and offal produced daily, kg	60,740
.7	Say average carton product weight, kg	21
.8	Total number of meat cartons to freezing daily	2,892
.9	Add for future 25% increase in carcass dressed weight	<u>723</u>
.10	Daily port packing carton freezing capacity	<u>3,615</u>
.11	Design quantity of red meat frozen daily, kg	<u>75,915</u>

.3 Carcass freezing – current

There is a need to freeze up to 300 out of spec lambs daily. Estimated total weight up to 7,000 kg.

5.4 Potential future products

.1 Skin on goats

These would be processed on the small stock line. It would be necessary to incorporate a scalding/dehairing/singeing or shaving operation. The dehaired carcasses would be placed on the dressing chain prior to the evisceration table from where the skin on carcasses would continue to be dressed out in the conventional way through to scales. After the scales they would be placed in the carcass chillers before being placed on freezer racks to be frozen in the existing manual blast freezers.

If the carcasses are electrically stimulated they may be placed in the blast freezer about one hour after leaving the slaughter floor after the pH of the neck muscle drops to 6 or below. In this condition no cold shortening would occur.

.2 Quarter beef freezing – 100 head/day

Beef quarter freezing for export to South Korea was quite common practice 20-40 years ago. To avoid toughening due to cold shortening it is advisable to apply electrical stimulation to carcasses to be frozen. The sooner electrical stimulation is applied after sticking, the more effective the process is. If there is a long interval between sticking and a downward hide puller, broken backs may occur during the hide stripping process.

6. POSSIBLE FUTURE PROCESSES TO IMPROVE YIELD BY REDUCING SHRINK IN THE ACTIVE CHILLERS

6.1 Current chiller weight losses due to shrink

The writer's observation of the active chilling operation led him to the conclusion that carcase shrink would be high.

The chiller shrink rates at the plant are indeed excessive at about 3% of dressed weight for both species processed. It is possible to chill lamb carcasses to a final deep bulb temperature of +5°C within 4 to 5 hours of slaughter. This would be accomplished in Low Temperature Blast Chillers (LTBC) similar to the units used in Europe and the USA for the LTBC of pig carcasses. See attached 1976 paper in Appendix 3.

With proper control we would expect the shrink to be reduced by at least 50% to 1.5% of Hot Dressed Weight at the Slaughter Floor Scales which amounts to 95,400 kg/day. This would therefore result in 1,431 kg extra saleable weight of lamb carcase/day. At a wholesale price of say \$7.00/kg this equates to extra daily revenue of \$10,000.00, which equates to \$2,500,000.00/annum when operating 250 days per year. Say \$2,000,000.00 additional revenue per annum for an estimated investment of \$2.0 million for electrical stimulation, 30 minute hanging ground, blast chiller and refrigeration plant augmentation. Simple payback about 12 months. Apart from the additional yield in saleable meat, the improvement in shelf life would be significant. Furthermore, some of the product would be ready for dispatch the same day it is processed, or alternatively, could be boned out or packed as 6 way cut the same day it is processed. Last, but certainly not least, such a facility would allow production to be increased to 10,000 lambs/day without the need for additional active chilling capacity. The existing active lamb chillers would become equilibration chillers. Thus the capacity of the existing chillers would increase as the cold lamb carcasses would be placed close to each other on the rail. This would largely offset any loss in chiller holding capacity due to creating fewer fully separated chillers.

6.2 Spray chilling of beef carcasses

This process would reduce the shrink by at least 2% from 3% to 1% or less. This means extra saleable meat of $0.02 \times 800 \text{ head} \times 200 \text{ kg/head} = 3,200 \text{ kg/day}$. At a wholesale price of \$5.00/kg this would result in extra daily revenue of \$16,000.00 or \$4 million/annum when operating 250 days. Say 75% realisation would produce extra annual revenue of \$3 million for an investment not exceeding \$1.0 million. Therefore the simple pay back would be about 4 months.

7. ASSESSMENT OF REQUIRED INFRASTRUCTURE

7.1 Slaughter floors

If LTBC is considered a desirable option, it would be necessary to install an Electrical Stimulation system to thoroughly stimulate carcasses to prevent cold shortening when entering the LTBC. It would also be desirable to create a hanging ground to retain carcasses 30 minutes prior to entering the LTBC.

7.2 Active chillers

It would be desirable to remodel both the beef and small stock chillers to five independent operating units in each case.

.1 Small stock chiller expansion

If an LTBC system is installed for lamb blast chilling some of the product would be ready for load out or boning and such product would not need to be retained in chillers, depending on the relative proportions of wholesale carcass meat.

.2 Beef chiller capacity increase

Even after remodelling there is adequate chiller space for 750 bodies of beef at an average dressed weight of 280 kg and more than 800 at the current dressed weight at 205 kg average. No expansion needed.

7.3 Pre-boning marshalling areas

This depends on a number of factors like variety in stock sizes, boning to order, stock ownership, etc. As a rule of thumb we would normally allow to hold one hour boning room stock supply in a pre-boning marshalling area, which equates to about 350 lamb carcasses plus 35 beef carcasses.

7.4 Boning room and pack off

We estimate a two species boning room floor area of 500 square metres maximum depending on the degree of vacuum packaging, final pack off and associated materials handling systems. An elevated carton store would be part of any boning room construction.

7.5 Offal processing and packing areas

These areas exist but need augmentation and improvement, including carton supply.

7.6 Port packing carton chilling capacity

In Item 5.3.1 above we have estimated a total port packing carton chilling requirement for a maximum of 1,632 cartons/daily. We suggest that the three existing blast freezers be used for all carton chilling and the freezing of lamb and goat carcasses and beef quarters.

7.7 Port packing carton freezing

In Item 5.3.2 above we have estimated a total maximum freezing capacity of 3,615 cartons with an average weight of 21 kg/carton giving a total weight of 75,915 kg. This includes a 25% increase for future increases in dressed weights.

7.8 Port chilling and freezing packing carton sorting and palletizing

Sorting and palletizing is an important aspect of port packing chilling and freezing and a liberal area is required. This is a high risk OH&S area and deserves a lot of attention and even consideration of robotic palletizing for the approximately 20% of the Stock Keeping Units (SKUs) representing approximately 80% of the total production.

7.9 Cold storage and distribution facilities

The port chilling and freezing storage capacity depends on a number of factors such as shipping frequency availability, the need for distribution and order picking and shelf life requirements of particularly chilled product.

.1 Chill store

As a rule of thumb one week of chilled product storage is required equating to 8,160 cartons. With an average of 48 cartons/pallet for a mix of 27.2 and 13.6 kg cartons, this equates to 170 pallets. This requires a relatively small chill store four pallets high. Store dimensions 17.5m long x 15.2m wide x 6m high. In this case each individual pallet is available from a pallet aisle, i.e. each pallet is an SKU. This is an ideal situation, but requires 8.3m³ per pallet, i.e. 1,596m³ for 192 pallets and is suitable for distribution.

.2 Cold store

We would normally design such a facility for 10 days production, i.e. 36,000 cartons. At an average of 40 cartons/pallet this represents 900 pallets. Say 4 pallets high requires 225 pallets on the floor. Such a store would measure about 24m wide by 31.5m long x 6m high, i.e. 4,460 m³ and hold 880 pallets. This equates to about 5.07 m³/pallet.

8. DISCUSSION AND CONCLUSIONS

8.1 Current utilities consumption and cost

The specific utilities consumption per tonne ETCW at the plant were 441 MJ for electrical energy, 543 MJ for gas and 2.92 kL for water.

The specific utilities cost per tonne ETCW were \$19.02 for electrical energy, \$5.09 for gas and \$14.00 for water and effluent treatment. The total utilities costs amounted to \$38.11/tETCW or 3.811 cents/kg ETCW.

The water cost is the highest we have ever encountered, but both the electrical, gas and total utility costs are by far the lowest we have ever come across in about 35 years.

Even allowing for the facts that a) the amount of on-site blast freezing and cold storage is minimal, and b) that no rendering takes place on site, we believe this operation to be highly efficient.

8.2 Active chiller operations

In a number of instances chillers need to be unloaded and re-loaded through other chillers. For example lamb chiller 2 is loaded through chillers 4 and 6, and chiller 4 is loaded through lamb chiller 6. Conversely, chiller 6 needs to be unloaded through chiller 4 and 2 and chiller 4 is unloaded through chiller 2.

The same holds true for chillers 1, 2 and 3.

Another example is that chillers 9 and 10 are loaded via chiller 7 and unloaded through chiller 8. Chiller 7 is unloaded through chiller 8 and chiller 9 is reloaded through chiller 7. Chiller 10 is unloaded and reloaded through chiller 9.

Furthermore, some chillers have shared refrigeration equipment in a plenum between the two chillers.

This method of chiller operations would not be acceptable in an export meat packing plant.

8.3 Active chiller rail capacity. See Table 2

There is more than adequate rail capacity to hold 6,162 head of small stock and 927 head of beef in the active chillers. The daily production rates are 5,000 head of small stock in one shift and 600 head of beef in two shifts.

However, the present layout does not comply with export standards in terms of separation of chilled product from unchilled product, shared refrigeration equipment by various chillers and thus the difficulty of cleaning some of the active chillers independently between unloading and reloading with unchilled carcasses. It is possible to modify the chiller layout to alleviate these problems but this will inevitably lead to losing active chiller capacity.

We estimate that the total active small stock carcase chiller capacity will reduce from the present 6,162 head to about 5,000 head when the present ten active small stock chillers have been remodelled into four chillers.

A similar rationalization of the twelve active beef chillers into six will reduce the beef carcass chilling from the present 927 head to about 800 head.

8.4 Existing refrigeration plant

The existing refrigeration plant capacity at new machine capacity ratings are 2,911 kW high stage and the booster capacity is 350 kW.

The Stal S73 and the Mycom 250S boosters are both 30-35 years old and of old rotor design. Modern machines are inherently more efficient.

We therefore conclude that the existing machines would deliver 80-90% of their rated capacity. New machines would use an estimated 15 to 25% less energy for the same amount of work.

8.5 Future expansion small stock processing capacity

.1 Expansion of Small Stock processing capacity – Business As Usual

This would mean construction of additional active chiller capacity of 3,000 head/day. At about \$1,400/head for active chiller construction this would mean capital investment of about \$4.2 million.

.2 Low Temperature Blast Chilling (LTBC)

This is dealt with in some detail in Item 6.1 above.

The total estimated cost would be \$2 million for \$2 million extra annual revenue due to the reduced shrink, i.e. a simple payback of about 12 months. Should the rate of lamb processing need to increase, the LTBC operation will comfortably handle 10,000 lambs during a two shift operation.

Thus a blast chilling operation costs about 50% of the expansion in active chilling capacity.

The capacity of the remaining existing active chiller space would increase by about 20% because 80% of the heat is removed from the carcasses in the blast chiller. Thus there would be 6,000 head of lamb hanging space in the existing chillers or equilibration chillers with very low refrigeration loads and low air movement.

If a total of about 4,000 small stock were to be delivered the same day as being processed, and boned out the same day, it would be possible to process 10,000 small stock daily during 15 hours of operation over two shifts.

8.6 Ante LTBC hanging ground

This stage may not be necessary if the pH in the carcass neck muscle consistently reaches 6 or lower after Electrical Stimulation (ES). The earlier ES is applied in the carcass dressing process, the more effective it is in accelerating rigor mortis and the shorter the interval required, if any at all, to lower the pH of the neck muscle to 6 or less. With such a pH value when entering the LTBC, the chances of cold shortening of the meat occurring during the LTBC process are greatly diminished, if not entirely eliminated. Cold shortening leads to tough meat and must be avoided at all costs.

8.7 Equilibration chillers

After approximately one hour retention time in the LTBC, the thinner parts of the carcasses are quite cold, whilst the thicker portions are warmer. It would be desirable to leave the carcasses hang two to three hours to equilibrate at a temperature of +4 to +7°C before loading them out for distribution or entry into the boning room.

Including 30 minutes in the hanging ground before entry into the LTBC, carcasses would thus be available for distribution or boning room entry 3 to 4 hours after passing over the slaughter floor scales.

8.8 Carcase load out

The existing carcase load out would not require any changes. Indeed, with an LTBC cycle small stock would be ready for delivery much sooner and this may improve the operations of the carcase load out.

8.9 Pre-boning marshalling

In our evaluation of carcase holding capacity we have assumed that the existing box chiller and boning room would be converted to a pre-boning marshalling area for 520 head of small stock. About 40 head of beef in sides would be held in a remodelled chiller 9.

8.10 Boning room for beef and small stock

The currently planned boning room would be extended in length to a total floor area of 500m². There would be two boning lines, one for small stock table boning and the other one for beef quarter or side boning on the rail.

A new carton room would be built on a mezzanine floor at the Northern end of the new boning room.

8.11 Port packing carton freezing

We estimate a total daily production of 3,615 cartons of red meat and edible offal to be frozen. See Section 5.3.2.

The existing carton freezing capacity on the site is about 1,200 cartons/day in four blast freezers.

Thus an expansion in port packing carton freezing capacity is desirable if the expensive practice of freezing cartons off site is to be discounted. Current freezing costs, including transport to Melbourne, blast freezing, one week storage, handling out of store for despatch and container loading, amounts to about \$2.50/carton. Thus if you send 2,400 cartons off site for external freezing, you would incur a cost of about \$6,000.00/day. This equates to about \$1.5 million per annum with 250 days operation.

8.12 Other requirements for freezing

.1 Freezing out of spec lambs

There is a need to freeze about 300 out of spec lamb carcasses every day. This costs about \$3.50/carcase frozen off site. Say this costs \$1,000/day if frozen off site, or \$250,000/annum. There may be merit in boning these carcasses out for freezing, thereby adding value and removing costs. This would amount to some 150 to 200 cartons/day.

.2 Beef quarter freezing

This is not yet clearly defined and may be an occasional opportunity. It is therefore difficult at this stage to plan specific infrastructure. We have assumed it would be done on racks in the existing rails with 12 quarters/rack (3 head).

.3 Skin on goats freezing

This is also in the planning stages.

8.13 Port packing carton chilling

There are a future maximum of 1,632 cartons of boneless beef and small stock and beef offal to be expected with increased dressed weight of beef, boneless lamb, goat meat, tripe, etc.. These would be chilled in the existing blast freezer.

8.14 Carton sorting and palletizing after chilling and freezing

Referring to Item 7.8 it is clear a new carton sorting and palletizing facility for a significant number of SKUs would need to be provided. If there are say 500 SKUs 100 sorting stations for the approximately 80% of fast moving products plus say a further 10 for mixed products would need to be provided.

We have developed a sorting and palletizing area with 114 sorting and palletizing stations on two levels.

Mixed product pallets are again arranged according to rate of production. Once adequate numbers of cartons are available on the various pallets, they are broken down and fed back into the port packing sorting and palletizing conveyor system for sorting and palletizing outside normal working hours.

8.15 Cold and chill carton storage and distribution

Very little capacity exists on site. In Section 7.9 the desirable cold and chill carton storage capacities have been evaluated based on about 10 days frozen and 5 days chilled carton storage. These facilities are laid out to permit order picking for distribution operations.

8.16 Load out and port marking

A load out area measuring 3.6m wide x 14.2m long in front of the sorting and palletizing area gives access to three load out doors.

A port marking area is desirable and must be large enough in area to allow a minimum of 20 pallets, i.e. one 20 foot container load to be port marked on the floor. The available area is quite liberal and would allow

32 pallets to be placed on the floor without interfering with sorting and palletizing and product distribution to and from the cold store and chilled carton store.

8.17 Offal preparation and packing areas

This area needs upgrading to comply with export standards. Any upgrade would include carton storage and assembly areas.

Tripe processing operations are to be added and these would require their own infrastructure.

8.18 Electrical power supply

The electrical energy billing shows a steady Maximum Demand (MD) of 1,247 kW. Normally monthly MDs change, so we conclude that you are on a punitive tariff which means that the highest MD reached in a supply contract period becomes the contracted MD, irrespective of whether the plant operates or not.

The existing power supply capacity to the plant is rated at 3,000 kVA, which equates to 2,700 kW at a Power Factor of 0.9. This means that more than 1,400 kW additional power supply capacity is available, which is significantly more than we estimate is required for the highest MD which may be generated in the most energy intensive operation which includes LTBC.

Although there would be a significant increase in MD due to new operations, there would be a marked offset in MD when the small stock active chilling demand is reduced with LTBC.

We estimate the MD increase at 750 kW when adding plate freezing and cold storage.

Should you decide to install an LTBC system for lambs, we expect the MD increase to be about 1,100 kW.

Both MD increases are less than the 1,400 kW available and thus the available power supply has more than adequate capacity.

8.19 In-house project management ability

Judging by the past history at the plant, the in-house project management ability is excellent. This allows construction economies to be achieved as particularly building work may be carried out by your in-house project management rather than letting the entire project to a builder, who more often than not is a Project Manager. Furthermore, a lot of the work needs to be carried out without being able to shut the plant down. Provided that the in-house Project Manager is supported by sound designs, drawings and documentation, in-house project management is the most cost effective approach to projects like these.

9. RECOMMENDATIONS

Our recommendations are based on the previous conclusions. They are made to

9.1 Parameters

- .1 Enable two new processes to be introduced at a market prevailing capital cost.
- .2 Carry out such processes in an efficient, safe and consistent manner having regard to the highest standards of food safety and yield under the best practice OH&S conditions.
- .3 Optimise the best utilisation of both existing and new facilities.

9.2 Recommendations

- .1 Convert the active beef chillers to six independent units so they may be filled with hot unchilled carcasses, refrigerated, unloaded and cleaned independent of the other chillers.
- .2 Do the same for the active small stock chillers, i.e. create 4 units.
- .3 Build a new carton freezing, carton sorting/palletised, cold store, chill store and load out facility with port marking area and facilities. This would comprise the following.
 - .1 Two off 30 station, 1,920 cartons per day, each split into two independently refrigerated and closing and opening sections.
 - .2 A two level sorting and palletizing facility with 114 dedicated pallet stations of which about 90-100 are dedicated to a single SKU and the balance to mixed SKUs. These proportions may change once production records have been examined and the number of SKUs produced daily has been established.
 - .3 A three door -18°C cold store with a holding capacity of 920 pallets each with an average of 40 cartons per pallet. Total 36,800 cartons representing about 10 days frozen production.
 - .4 A two door -1°C chilled carton store with a holding capacity of 192 pallets with average 48 cartons/pallet, i.e. 9,216 cartons total. This represents a little over 5 days production.
 - .5 A three door load out with an operating temperature of about +5°C and fast recovery refrigeration in case the temperature is exceeded.

The load out incorporates an area where up to 32 pallets may be placed on the floor for port marking purposes.
 - .6 A carton entry and leaving air lock.
 - .7 A dehumidification unit to reduce the plate freezer cleaning frequency to once per year.
 - .8 An electrical switch room and a control room.
 - .9 A plant room with a two stage transcritical CO₂ refrigeration plant with heat recovery. The heat recovery will reduce the gas bill by about 80%, but a large hot water storage is necessary.
 - .10 Spare space for an additional plate freezer in future.

- .11 Install an in-ground 500,000 litre hot water storage including pump station.
- .4 A refrigerated elevated conveyor bridge to convey cartons from the boning room to the plate freezers.
- .5 A set of enclosed conveyors from the offal packing rooms to the existing blast freezers for port packing carton chilling.
- .6 Assign the port packing carton chilling and lamb and goat carcase and beef quarter freezing duties to the existing blast freezers.
Reduce the speed of the existing Mycom 250S booster and Stal S73 to half speed. This will extend the life of the machines for a long time to come.
- .7 Convert the existing box room and the existing boning room to a pre-boning marshalling area holding
 - .1 520 head of small stock on 11 off 12 metre long rails; and
 - .2 40 head of beef in quarters on four off 16 metre long rails in a remodelled beef chiller 9.
- .8 Double the length of the proposed new boning room and equip the room with a small stock table or on the rail boning system and a quarter beef or beef sides on the rail boning system. Incorporate a carton store/carton assembly area on a mezzanine floor at the Northern end.
- .9 Equip the active beef chillers with a spray chilling system and refrigeration cycle control system to reduce the carcase shrink during the chilling cycle by at least 1.5% from the current very high 3% to 1.5% or less.
- .10 Install a Low Temperature Blast Chilling system for electrically stimulated small stock to remove 80% of the heat from the small stock carcasses in about one hour. This includes a 30 minute hanging ground for 360 carcasses to ensure pH reduction to 6 or below to avoid cold shortening.

As part of this modify the refrigeration cycles in the small stock chillers for equilibration with little heat removal and low air movement.

The benefits of such a system are:

- .1 Reducing the shrink during the active chilling cycle by at least 1.5% from the currently excessively high shrink of 3% to 1.5% or less.
- .2 Small stock is ready for entry into the boning room 3 to 4 hours after leaving the slaughter floor scales and two hours longer for distribution.
- .3 A very hygienic product with a long shelf life is produced.
- .4 It would not be necessary to build additional active small stock carcase chilling capacity. With such a system the plant would be able to process a daily volume of 10,000 small stock during two full shifts.

10. BUDGET COSTING

The recommendations in the preceding section are budget costed in the following items.

10.1 Capital expenditure budget for on-site freezing and cold storage

	Budget Cost
	\$K
.1 Convert 12 active beef chillers to six to comply with export regulations, to hold 800 head	400K
.2 Convert ten (10) active small stock carcase chillers to four equilibration chillers with improved refrigeration systems and air flow control for low shrink operation.	600K
.3 Equipment pricing	
.1 Two off 30 station 1,920 cartons/day automatic plate freezers @ \$950/carton	3,650K
.2 A two level manual mechanised sorting and palletizing area providing 114 dedicated pallet sorting stations comprising conveyors, platforms and walkways, electronics, etc. The ruling principle here is to bring the work to the man and provide a safe OH&S environment.	700K
.3 A dehumidification unit	150K
.4 A two stage transcritical CO ₂ refrigeration system with a capacity of 432 kWR at -40°C and a high stage capacity of 1,030 kWR, complete with heat recovery. The system serves the entire new complex, the boning room and the pre-boning marshalling area.	1,500K
.5 An 80 metre long insulated refrigerated conveyor bridge to transport cartons from the boning room to the plate freezer. Say \$6K/metre including supports and entry air lock.	<u>500K</u>
.6 Total equipment cost plate freezing cold storage complex	<u>6,500K</u>
.7 Total Cost all Plant and Equipment	<u>7,500K</u>
.4 Building and Other Infrastructure	
.1 2,200 m ² of insulated PIR panel building comprising the cold store, chill store, sorting and palletizing area, port marking area, plate freezer housing plus space for a future plate freezer, entry air lock, dehumidification room, CO ₂ accumulator	

and pump room, battery charging room. Say average cost \$2,000/m ² budget.	4,400K
.2 Finish off boning room building and increase to 500m ² .	800K
.3 A set of conveyors from the offal rooms to the existing blast freezer area 100 metre, some elevated.	600K
.4 Pre-boning marshalling area.	300K
.5 Boning room equipment including vacuum packing, carton room, conveyors, tables and stands, scales, pack off areas etc.	1,500K
.6 Cold store racking – 920 pallets @ \$150	138K
.7 Chill store racking – 192 @ \$150	29K
.8 Power supply to new switch room board, 750 kW	300K
.9 Build 500,000 litres in-ground hot water storage, say 3 metres deep x 15 metres diameter including pump station.	500K
.10 Water supply to new building.	20K
.11 500m ² of heavy duty concrete paving	75K
.12 Roads and path, etc.	<u>25K</u>
.13 Total Budget for Buildings and Other Infrastructure	<u>8,687K</u>

10.2 Optional expenditure budget

.1 Equip six beef chillers with spray chilling for 800 head	1,000K
.2 Install a Low Temperature Blast Chilling system including electrical stimulation, a 30 minute hanging ground, conveyor, building, refrigeration equipment, and refrigeration plant and power supply augmentation.	<u>2,000K</u>
.3 Total Budget Estimate	<u>\$3,000K</u>

10.3 Budget cost summary

.1 Plant and Equipment for new plate freezing/cold storage complex	\$7,500K
.2 Building and infrastructure cost	\$8,687K
.3 Optional – beef spray chilling and Low Temperature Blast Chilling	<u>\$3,000K</u>
.4 Total Budget	\$19,187K
.5 Add 10% contingency and escalation	<u>\$ 1,919K</u>
.6 Total budget including contingency	\$21,106K
.7 Fees and permits 5%	<u>\$ 1,055K</u>
.8 Grand Total Budget	<u>\$22,161K</u>

11. PRELIMINARY SUMMARY OF COST BENEFIT

11.1 Identified annual operating cost savings and revenue increase

.1 Offsite freezing elimination

.1	Cartons. See Item 8.11	\$1,500K	
.2	Small stock carcase. See Item 8.12	<u>\$ 250K</u>	
.3	Total		\$1,750K

.2 Plate freezing

There are many advantages associated with plate freezing. The main one is improved container utilisation in the case of 20 foot containers. We would expect you to save 1 in 10 containers. At a production rate of 3,600 cartons/day, this equates to about 5 containers/day or 1,250 containers/year. If 8% of these are saved you would save 100 containers/year, \$10K per container. This equates to annual freight savings of about			
			\$1,000K

.3 Reduced gas consumption

80% of gas bill would be saved with heat recovery from the two stage CO ₂ plant. Your current annual gas bill runs at about \$250K. Saving			
			\$ 200K

.4 Additional revenue

.1	From beef spray chilling. See Item 6.2	\$3,000K	
.2	From Low Temperature Blast Chilling of small stock. See Item 6.1	<u>\$2,000K</u>	
.3	Total increase in revenue		<u>\$5,000K</u>

.5 Total amount cost savings and revenue increase \$7,950K

11.2 Operating costs

.1 Electrical energy

If the entire project is implemented the electrical energy consumption at the plant would increase 80 to 100%. At current rates of production and including LTBC the annual energy cost would increase by			
			\$1,000K

.2 Labour

You would need to employ a total of six workers plus a leading hand and a manager for the cold store operation. This means you would need to employ about four more workers @ \$65K/annum			
		<u>\$ 260K</u>	

.3 Operating cost increase \$1,260K

11.3 Nett benefit \$6,690K

11.4 Estimated capital expenditure. Item 10.3.8 \$22,161K

11.5 Simple payback 3.15 years

11.6 Other benefits

- .1 Installation of an LTBC obviates the need for additional active small stock chillers when doubling the processing rate to 10,000/day in two shifts. This would avoid capital offset of about \$7 million in not having to double small stock active chilling capacity. In addition, the LTBC stands on its own feet in terms of about 12 months payback due to a conservatively estimated 1.5% reduction in shrink during the chilling. Furthermore, with an LTBC system operating no further expenditure would be required to double the small stock daily processing rate to 10,000 or more. Depending on the final destination of such product you may need to install additional plate freezing capacity and space for it has been allowed in the budget.
- .2 Although the specific electrical energy consumption would about double to 245 kWh (882 MJ)/tETCW there would be an 80% reduction in gas consumption, equating to a reduction of 434 MJ/tETCW. This leaves a gas consumption of 108.5 MJ/tETCW and a total energy consumption of 990.5 MJ/tETCW. This is 7 MJ/tETCW more than the current total energy consumption of 983.5 MJ/tETCW. This clearly demonstrates the benefit of the heat recovery from the discharge of the high stage transcritical CO₂ compressors.
- .3 The final outcome of the implementation of all the recommendations would be that the facility would be fully or nearly fully compliant with export regulations.

This aspect has the attention of the Victorian State Government (VSG). If recent events in South West Victoria are a guide, the VSG may well be prepared to support this project.
- .4 Another advantage of a CO₂ system is that it may be used as a fire extinguishing system.

12. DRAWINGS

Drawing No.	Title
.1 VIC-122-001	Proposed plate freezer and cold store complex
.2 VIC-122-002	Site plan – proposed plate freezer, cold store, small stock chillers & boning, beef chillers & boning
.3 VIC-122-003	Small stock Low Temperature Blast Chilling, beef chiller rationalization & preboning marshalling
.4 VIC-122-004	Small stock chiller rationalization