final report

Project code: A.ENV.0090

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Date published: July 2011

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Environmental data analysis

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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Introduction

In 1999, the red meat industry made a decision to encourage undergraduates into our industry by funding them to do 3 month vocation projects prior to starting their final year of study. These projects were chosen by processors with advice by MLA/AMPC on what could be realistically completed in the time. These projects also demonstrated the value of graduates to processors. Initially, engineering students were targeted but processors soon expanded their demand for all disciplines including some on farm projects.

From 4 students in the first year (2000/01) the summer vocation project grew to a 29 in a year. After 9 years, the project was terminated in 2008/09 after 134 students from 28 universities studying 47 different disciplines had completed projects for 32 large and small companies on 44 sites in all States. The data in this report is from the 64 reports that contained environmental data. The data gathered and reports written by undergraduates were done under the guidance of industry and external mentors. While the reports were used by individual sponsor companies, they were not circulated to other processors because of confidentiality.

The data that was measured is of use to the whole industry to assist in benchmarking, driving efficiency, setting achievable targets, and reducing environmental footprint. MLA decided to have this data gathered together in comparison tables and to issue the results in this report in a way which still ensures site confidentiality.

In many cases, data in the various reports was not expressed in comparable units so the numerical data has been manipulated so comparisons could be made between data. Data was recalculated in L/head and L/t SCW etc. where possible. Detailed data for water (1.2.11) and energy (2.9) from the reports was tabulated so others may do further analysis work in future. There is some data in the red meat literature of a similar nature (Appendix A) given for comparison.

The data is not equally divided between sheep and cattle or between water and energy, nor is it weighted equally between various sections of the abattoir. The given data represents where the individual processors wanted information. It is a retrospective gathering from 64 diverse reports.

There was no shortage of undergraduates willing to relocate and complete 3 month vocation projects in the red meat industry and no shortage of processors wanting projects. All universities were cooperative in promoting the undergraduate jobs.

1. Water consumption

1.1. Overall

Beef (kL water /head)

2.4 kL water/head (ref 134, beef, 2001) “quoted industry standard”
2.7 kL water/head (ref 134, beef, 2001)
0.27 kL water/head (ref 133, vealers, 2001)
2.597 kL water/head (ref 114, beef, 2003)
2.5 kL water/head (ref 3 beef 2004)
1.6 kL water/head (ref 3 beef 2009)
2.457 kL water/head (ref 99 beef 2004)
10.9 kL water/head (ref 76 beef 2005)
2.49 kL water/head (ref 55 beef 2006)
2.36 kL water/head (ref 49 beef 2006)
2.546 kL water/head (ref 47 beef 2006)
2.031 kL water/head (ref 41 beef 2007)
3.40 kL water/head (ref 39 beef 2007)
3.667kL water/head (ref 79 beef 2005)
2.49 kL water/head (ref 55 beef 2006) 1,142 head/day
2.36 kL water/head (ref 49 beef 2006) 865 head/day
2.86 -3.67 kL water/head (ref 31 beef 2007) – per month over 12 months
[R^2 =0.89 vs only R^2=0.65 for t HSCW, also water use dropped as number of head increase ie fixed cleaning amount spread over larger number of animals]
3.2 kL water/head (ref 31 beef 2007)

590 L hot+warm water/head (ref 97, beef, 2004)
Kill floor 200 kL/d hot water = 7.8% (ref 114 beef 2003)

Beef (kL water/t HSCW)

7.4 kL water/tHSCW (ref 134, beef, 2001) “quoted industry standard”
9.1 kL water/t HSCW (ref 134, beef, 2001)
12.0 kL water/t HSCW (ref 133, beef, 2001)
9.4 kL water/t HSCW (ref 133, beef, 2001)
6.32 kL water/t HSCW (ref 99, beef, 2004)
17.13 kL water/t HSCW (ref 16 beef 2008)
12.97 kL water/t HSCW (ref 114 beef 2003)
27.96 kL water/t HSCW (ref 76 beef 2005)
5.7 kL water/t HSCW (ref 49 beef 2006)
8.85 kL water/t HSCW (ref 47 beef 2006)
6.92 kL water/t HSCW (ref 41 beef 2007)
10.40 kL water/t HSCW (ref 39 beef 2007)
8. 78 – 12.67 kL water/t HSCW (ref 31 beef 2007) – month average over 12 months
10.55 kL water/t HSCW (ref 31 beef 2007)
1.18 kL water/t HSCW (ref 28 beef 2007) – small plant
5.7 kL water/t HSCW (ref 49 beef 2006) 865 head/day

Sheep (L water/head)

150 L/head (ref 126, sheep, 2003)
94 L/head (ref 104, sheep, 2004
230.9 L/head of water (ref 126, sheep, 2003)
163 L/head (ref 84, sheep, 2005)
182 L/head (ref 57 sheep 2006)

Sheep (kL water/t HSCW)

7.71 kL water/t HSCW (ref 84, sheep, 2005)
8.763 KL water/t HSCW (ref 57 sheep 2006)
3.94 KL water/t HSCW (ref 28 sheep 2007) – small plant

1.2. Cattle

1.2.1. Cattle yards

	% of total	L/head	L/t HSCW
Ref 49 beef 2006			
Cattle yards (recycle also used)	2.2	52	126
Ref 47 beef 2006			
Cattle yards	7.0	179	622

1.2.1.1. Cattle washing

Ref 114, beef, 2003)		kL/day	%	L/head
Cold water	Cattle wash	295	11.36	290

1.2.2. Kill floor

1.2.2.1. Overall

Ref 114, beef, 2003)		kL/day	% of total	L/head
Cold water	Kill floor	361	13.90	361
Hot water	Kill floor	440	16.94	440
Warm water	Kill floor	198	7.62	198
Total water	Kill floor	999	38.46	999

978 L/head (ref 95 beef 2004)

Ref 95 beef 2004	% of total	L/head	L/t HSCW
Kill floor			
Hot water	48	468	2,415
Warm water	19	189	975
Cold water	33	321	1,656
Total water	100	978	5,046

Ref 79 beef 2005	kL/shift	L/head
Kill floor		
Hot water	400	360
Cold water	490	441
Total water	890	801

	% of total	L/head	L/t HSCW
Ref 49 beef 2006			
Kill floor total	31.9	754	1,821
Ref 47 beef 2006			
Kill floor	30.9	787	2,736

1.2.2.2. Bleed table

(ref 114, beef, 2003) sprays when moving	kL/day	% total	L/head
Cold water	118	4.5	115
Warm water	43	1.6	42
Total	161	6.2	157

1.2.2.3. Steriliser pots

0.91 kL/day per pot of 26 pots (ref 133, beef, 2001)
135L/head (ref 132 beef 2001)
12L/head (ref 132 sheep 2001)

Ref 126, sheep, 2003	number	L/min	L/head	% total water	kL/pot/day
Total sterilisers	39		74.0	10.9	5.6
Knife (insulated pot)	14	2.1			
Knife (normal)	19	3.3			
Scissor/cutter	5	9.2			
Brisket cutter	1	11.5			
Head cutter	1	10.9			
Rotary saw	7	8.0			
Small (insulated)	2	0.5			

(ref 114, beef, 2003)	kL/day	L/head	% total water
Hot water	180	175	6.9

Sterilisers - 42 pots (ref 114, beef, 2003)	L
Maximum pot volume	20.8
Minimum pot volume	1.6
Average pot volume	6.2
	L/hr per pot
Maximum flowrate of hot water	356
Minimum flowrate of hot water	182
Average flowrate of hot water	239

	%	L/head	L/t HSCW
Ref 99 beef 2004			
Sterilisers (63 pots)	9.7	237	608
Ref 49 beef 2006			
Sterilisers (80 pots)	17.5	321	774
Ref 47 beef 2006			
Sterilisers (65)	8.0	204	704

Ref 38 beef 2007	Min flow	Max flow	Type
Steriliser pots	L/min	L/min	
Kill floor, hide on (16)	1.9	6.0	Double skin
Kill floor, hide off (26)	1.3	9.8	Double skin

1.2.2.4. Head & tongue washing

	kL/day	L/head	% of total
Head washer (ref 114, beef, 2003)			
Cold water	11.6	11.3	0.4
Tongue & cheek washer (ref 114, beef, 2003)			
Cold water	51.7	50.4	2.0

	%	L/head	L/t HSCW
Ref 99 beef 2004			
Head/tongue washer	0.5	11	
Ref 47 beef 2006			
Head wash	3.4	86	298

1.2.2.5. Viscera table

121 L/min hot water (Ref 133, beef, 2001)
193 L/min cold water (Ref 133, beef, 2001)
101 ML/year @0.5bar (ref 76 beef, 2005)
492 L/head; 1,260 L/t HSCW (ref 76 beef, 2005)
21.9% of total plant water (18.6% cold, 3.3% hot)
118L/head (ref 132 beef 2001)
3L/head (ref 132 sheep 2001)

Ref 126, sheep, 2003	L/min	L/head	%total
Viscera table hot water sprays	52.6	17.1	7.4
Viscera table cold water sprays	11.8	3.8	1.7

Viscera table (ref 114, beef, 2003) sprays on moving	kL/day	L/head	% total
Hot water	87.4	85	3.4
Cold water	75.6	74	2.9
Warm water	28.9	28	1.1
Total	191.9	187	7.4

Ref 99 beef 2004	L/head	L/t HSCW	% total
Viscera table cold water sprays	507	1,300	20.8
Viscera table hot water sprays	40	103	1.6
Viscera table sprays total water	547	1,402	22.4

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Viscera table sprays total water	143	346	7.0

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Viscera table hot water	112	141	4.4
Viscera table cold water	41	390	1.6

1.2.2.6. Carcass washing

Carcass sprays-sensor (ref 114, beef, 2003)	kL/day	L/head	% of total
Cold water	25.1	24.5	1.0

1.2.2.7. Paunch washing

43 L/head cattle (ref 106, beef, 2004)
151 L/head cattle (ref 114 beef 2003)
24 L.water for paunch wash in umbrella (ref 31 beef 2007)
7.8 L water/head sheep (ref 106, sheep, 2004)

Paunch room (ref 114, beef, 2003)	kL/day	L/head	% of total
Cold water	155	151	6.0

1.2.2.8. Tripe washing

Tripe washer (ref 114, beef, 2003)	kL/day	L/head	% of total
Hot water	51.6	50.3	2.0
Cold water	21.8	21.2	0.8
Total	73.4	71.5	2.8

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Tripe & hash room	210	730	8.3

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Tripe cooker, offal room & basins	276	960	10.8

Ref 38 beef 2007	Min flow	Max flow	Type
Tripe room (4)	6.2	7.1	Double skin

1.2.2.9. Edible offal washing

Ref 99 beef 2004	L/head	L/t HSCW	% of total
Head and offal sprays	61	156	2.5

1.2.2.10. Runners room

Ref 126, sheep, 2003	kL/day	L/head	% of total
Cold	37.4	12.7	5.5

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Runners room (no tripe)	227	548	9.6

1.2.3. Boning room

1.2.3.1. Overall

351 L/head (ref 95 beef 2004)

Ref 114, beef, 2003	kL/day	L/head	% of total
Cold water	62	62	2.39
Hot water	199	199	7.66
Warm water	19	19	0.73
Total water	280	280	10.78

Ref 95 beef 2004	L/head	L/t HSCW	% of total
Hot water	241	1,244	69
Warm water	32	165	9
Cold water	78	402	22
Total water	351	1,811	100

Ref 79 beef 2005	kL/shift	L/head
Hot water	210	107
Cold water	55	28
Total water	265	135

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Boning room total	139	336	5.9

1.2.3.2. Steriliser pots

Ref 126, sheep, 2003	L/min	kL/pot/day	L/head	% of total
Boning room sterilisers		4.8	9.8	1.4
Normal knife (5)	3.3			
Large knife (1)	10.2			

	L/head	L/t HSCW	% of total
Ref 99 beef 2004			
Boning room sterilisers (17 pots)	161	413	6.6
Ref 47 beef 2006			
Boning room steriliser pots	18	62	0.7
Ref 39 beef 2007			
Boning room sterilisers (16)	2.4		250

Ref 38 beef 2007	Min flow	Max flow	Type
Boning room sterilisers (17)	1.8	11.8	Double skin

1.2.4. Rendering plant

Ref 99 beef 2004	L/head	L/t HSCW	% of total
Rendering plant polishers	101	258	4.1

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Rendering plant total	201	485	8.5

1.2.5. Biofilter

20kL/d 1000 head cattle 2 shifts 5 days/week (ref 95 beef 2004)
18kL/d air washer 1000 head cattle 2 shifts 5 days/week (ref 95 beef 2004)

1.2.6. Boiler room

Boiler makeup (ref 114, beef, 2003)	kL/day	L/head	% total
Demineralised cold water		31	1.2

1.2.6.1. Boiler make-up

62% condensate returned to boiler (ref 91, beef, 2005)

1.2.6.2. Condensers and cooling towers

(ref 114, beef, 2003)	kL/day	L/head	% total
Cold water	150.9	147	5.8

Ref 99 beef 2004	L/head	L/t HSCW	% total
Condensers only	223	572	9.2

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Condensers only (cold water)	149	360	6.3

Ref 47 beef 2006	L/head	L/t HSCW	%
Condensers only	388	1,349	15.2

1.2.7. Refrigeration

1.2.7.1. Spray chilling water

15 L/t HSCW (ref 47 beef 2006)

1.2.7.2. Defrost water

9.4 kL/day or 48.6 L/t HSCW (ref 95, beef, 2004)

1.2.8. Plant washing

Ref 126, sheep, 2003	kL/day	L/head	% of total
Hot	66.1	22.4	9.7
Cold	12.8	4.4	1.9
Total	78.7	26.8	11.6

Ref 99 beef 2004	L/head	L/t HSCW	% of total
Cleaning during production	29	74	1.2
After production wash down	303	777	

Ref 84, sheep, 2005	kL/day	kL/week	% of total
Kill floor nightly clean	250		
Other nightly clean	13		
Nightly wash down	263	1,656	12.7

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Nightly wash down	300	724	12.7

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Abattoir clean down (151kL/shift)	233	809	9.1

260kL nightly wash down (ref 49 beef 2006)

1.2.8.1. Exit/entry hand & boot washing

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Boning room entry-basins, boot, apron	37	130	1.5

1.2.8.2. Hand basins

15 L/min per basin (Ref 133, beef, 2001)

Ref 126, sheep, 2003		
Boot and hand wash basins	number	L/min
Kill entry (thigh operated)	10	8.5
In kill (ball operated)	4	6.0
In kill (optical)	43	6.8
Knocking box (ball operated)	1	12.5
Boning room entry (optical)	10	12.0
In boning room (foot operated)	6	8.2
In boning room (optical)	6	6.2

Ref 114, beef, 2003	kL/day	L/head	% of total
Kill floor hand basins warm water	70	68	2.7

Kill floor hand wash basins (ref 114, beef, 2003) 35 basins sensor activated- 3 to 12 secs	L/hr per basin
Maximum flowrate of warm water	250
Minimum flowrate of warm water	18
Average flowrate of warm water	106

Ref 99 beef 2004	L/head	L/t HSCW	%
Wash basins	149	382	6.1

Ref 47 beef 2006	L/head	L/t HSCW	%
Kill floor hand basins (warm water)	183	636	7.2
Boning room hand basins (warm water)	20	70	0.8

1.2.8.3. Personnel equipment cleaning

600 L/person [basins, boot washing, PPE, amenities] (ref 84, sheep, 2005)

1.2.9. Effluent handling

1.2.9.1. Overall wastewater

ref 16 beef 1999 to 2008	kL wastewater/t HSCW
1999	19.3
2000	17.7
2001	19.4
2002	Not available
2003	18.1
2004	16.3
2005	16.4
2006	16.1
2007	17.1
2008	16.3
2008 (monthly variation)	14.6-19.1

85.5 L wastewater/head (ref 104, sheep, 2004)
240.1 L wastewater/head (ref 126, sheep, 2003)
14.6-19.1 kL monthly wastewater/t HSCW (ref 16 beef 2008)

Ref 49 beef 2006	L/head	L/t HSCW	% of total
Effluent plant (cold water)	182	440	7.7

Ref 47 beef 2006	L/head	L/t HSCW	% of total
Waste treatment & DAF	107	372	4.2

1.2.10. Amenities

	L/head	L/t HSCW	% of total
Ref 49 beef 2006			
Amenities (cold water)	73	176	3.1
Ref 47 beef 2006			
Amenities	84	292	3.3
Ref 47 beef 2006			
Amenities, laundry, admin, canteen	3.3	85	294

1.2.11. Detailed breakdown of water use

Ref 126, sheep, 2003		kL/day	L/head	% of total water
Kill floor sterilisers	Hot	217.9	74.0	10.9
Boning room sterilisers	Hot	28.8	9.8	1.4
Viscera table	Cold	11.3	3.8	1.7
Viscera table	Hot	50.5	17.1	7.4
Runners room	Cold	37.4	12.7	5.5
Offal room	Cold	9.6	3.3	1.4
Lubrication for chutes	Cold	8.5	2.9	1.3
Hand wash	Warm	30.0	10.2	1.5
Boot wash	Warm	30.0	10.2	1.5
Shrink tunnels	Hot	1.9	0.6	0.3
Wash down	Hot	66.1	22.4	9.7
Wash down	Cold	12.8	4.4	1.9
Hand wash pump		14.4	4.9	2.1
Contra shear	Hot	23.0	7.8	3.4
Leaking valves		24.5	8.3	3.6
Other		138.0	46.9	20.3
Total		680.0	230.9	100.0

Ref 114, beef, 2003)		kL/day	%
Cold water	Kill floor	361	13.90
Cold water	Boning room	62	2.39
Cold water	Market chiller(retail ready)	61	2.35
Cold water	Cattle wash	295	11.36
Cold water	Condensers & cooling towers	151	5.81
Cold water	Demin water boiler make up	32	1.23
Cold water	Amenities	14	0.54
Cold water	Other	220	8.47
Hot water	Kill floor	440	16.94
Hot water	Boning room	199	7.66
Hot water	Market chiller	211	8.12
Hot water	Wastewater treatment plant	312	12.01
Hot water	Other	12	0.46
Warm water	Kill floor	198	7.62
Warm water	Boning room	19	0.73
Warm water	Other	21	0.81
Cold water	Total to site	2,597	100

Ref 114, beef, 2003	Total water	kL/day	%
	Kill floor	999	39
	Boning room	280	11
	Market chiller	272	10
	Cattle wash	295	11
	Condensers & cooling towers	151	6
	Demin water boiler make up	32	1
	Amenities	14	0.5
	WWTP (Contrashear)	312	12
	Other	241	9
	Site	2,597	100

Viscera table (ref 114, beef, 2003) sprays on moving	kL/day	L/head	% total
Hot water	87.4	85	3.4
Cold water	75.6	74	2.9
Warm water	28.9	28	1.1
Total	191.9	187	7.4
Steriliser pots (ref 114, beef, 2003)			
Hot water	180	175	6.9
Bleed table (ref 114, beef, 2003) sprays on moving			
Cold water	118	115	4.5
Warm water	43	42	1.6
Total	161	157	6.2
Paunch room (ref 114, beef, 2003)			
Cold water	155	151	6.0
Tripe washer (ref 114, beef, 2003)			
Hot water		50.3	2.0
Cold water		21.2	0.8
Total		71.5	2.8
Kill floor wash basins (ref 114, beef, 2003)			
Warm water	70	68	2.7
Carcass sprays-sensor (ref 114, beef, 2003)			
Cold water	25.1	24.5	1.0
Tongue & cheek washer (ref 114, beef, 2003)			
Cold water		50.4	2.0
Head washer (ref 114, beef, 2003)			
Cold water		11.3	0.4
Condensers & cooling towers (ref 114, beef, 2003)			
Cold water		147	5.8
Boiler makeup (ref 114, beef, 2003)			
Demineralised cold water		31	1.2

Ref 133 beef 2001		kL/day	% total
Hot water	Bleed table	47.00	2.0
Hot water	Viscera table	25.83	1.1
Hot water	Pulse sterilisers (26 off)	23.72	1.0
Hot water	Rail sterilisers (5 off)	12.31	0.5
Hot water	Hock cutter/air knife steriliser	14.89	0.6
Hot water	Manual sterilisers (8 off)	23.72	1.0

Hot water	Head chain steriliser	2.60	0.1
Hot water	Offal table	0.20	0
Hot water	Splitting saw steriliser	15.20	0.7
Hot water	Brisket saw steriliser	3.20	0
Warm water	Splitting saw spray	0.40	0
Warm water	Hand basins	26.44	1.1
Cold water	Bleed table	80.60	3.5
Cold water	Viscera table	41.52	1.8
Cold water	Viscera table (end)	19.00	0.8
Cold water	Splitting saw	0.26	0
Cold water	Offal wash	5.20	0
Cold water	Offal table	23.97	1.0
Cold water	Cheek & tongue wash	8.20	0.4
Cold water	Cheek & tongue rumbler	6.90	0.3
Defrost water	15 units	70.08	3.0
	Sub total of above	450.88	
Total water	Viscera table	86.35	3.7
	Total per day	2,321.00	

Ref 99 beef 2004	% total water	% hot water	% warm water	% cold water	% RO water
Cattle yards	**3.0**			9.1	
Kill floor					
Viscera table	22.4	3.7		62.9	
Sterilisers	9.8	22.4			
Hand basins	8.6		43.6		
Trammel chutes	3.8		14.8	4.2	
Shrink tunnel		0.8			
Hose down		1.2			
Sprays			13.8	1.7	
Carcass wash			6.5		
Pet food room			3.5	1.8	
Head & tongue wash			3.3		
Back split saw			3.2		
other	5.4	2.5	3.6		
Total	**49.6**	**30.6**	**92.1**	**70.6**	
Boning room					
Sterilisers	6.6	15.2			
Hand basins	0.3		1.8		
Shrink tunnel		0.1			
other	0.1				
Total	**6.9**	**15.3**	**1.8**		
Rendering plant					
Polisher	4.1	9.4	0.2		
Clean down		2.2			
other	1.4	0.9			
Total	**5.5**	**12.5**	**0.2**	**0.3**	
Effluent plant					
Contrashear		7.3			
Clean down		0.2			
Total	**3.3**	**7.5**			
Boiler make up	**0.7**				**7.5**
Condensers	**9.2**				**92.5**
End of day clean	**12.4**	**28.3**			
Amenities	**5.0**			**15.1**	
other		1.3			
Total water accounted for	**95.6**	**95.5**	**94.2**	**95.0**	**100.0**

Ref 99 beef 2004	%	L/head	L/t HSCW
Overall plant			
Hot water	43.7	1,074	2,753
Warm water	13.4	329	844
Cold water	42.9	1,054	2,703
Total	100.0	2,457	6,300
Kill floor			
Hot water	13.4	326	836
Warm water	12.9	314	805
Cold water	23.3	569	1,459
Total	49.6	1,209	3,100
Boning room			
Hot water	6.6	162	415
Warm water	0.3	6	15
Total	6.9	168	431
Rendering plant			
Hot water	5.4	133	341
Warm water	0.1	2	5
Cold water	0.1	1	2
Total	5.6	136	348
Boiler make up (RO water)	6.3	154	395
Effluent plant (cold water)	3.3	78	200
Condensers (cold water)	9.1	223	572
Amenities (cold water)	5.0	122	313

Ref 99 beef 2004	%	L/head	L/t HSCW
Viscera table cold water sprays	20.8	507	1,300
Viscera table hot water sprays	1.6	40	103
Viscera table sprays total water	22.4	547	1,402
Kill floor sterilisers (63 pots)	9.7	237	608
Boning room sterilisers (17 pots)	6.6	161	413
Cleaning during production	1.2	29	74
After production clean down	12.4	303	777
Condensers	9.2	223	572
Wash basins	6.1	149	382
Head and offal sprays	2.5	61	156
Offal chutes	2.2	54	138
Shrink tunnels	0.4	9	23
Rendering plant polishers	4.1	101	258
Head/tongue washer	0.5	11	28
Back splitting saw	0.5	11	28

Ref 84, sheep, 2005	%	L/head	L/t HSCW	kL/week
Stockyard	0.3	0.5	22	33
Kill floor	62.7	87	4,132	6,115
Boning room	4.6	6	302	447
By products	10.5	15	695	1,028
Pet food	0.5	0.6	30	45
Condensers	4.9	7	326	482
Boiler make up	16.4	23	1,084	1,604
Unaccounted	17.0	24	1,119	1,656
total	100.0	163	7,709	11,410
Kill floor nightly clean		250		
Other nightly clean		13		
Total nightly clean		263		1,656

Ref 57 sheep 2006	%	L/head	L/t HSCW
Note: no rendering			
Hot water	35	64	3,081
Warm water	19	35	1,685
Cold water	46	83	3,996
Total water	100	182	8,763

Ref 49 beef 2006	%	L/head	L/t HSCW
Hot water	47.1	1,112	2,685
Warm water	8.7	205	496
Cold water	44.2	1,043	2,519
Total Plant water	100.0	2,360	5,700
Kill floor total	31.9	754	1,821
Boning room total	5.9	139	336
Rendering plant total	8.5	201	485
Runners room (no tripe)	9.6	227	548
Effluent plant (cold water)	7.7	182	440
Cattle yards (recycle also used)	2.2	52	126
Condensers (cold water)	6.3	149	360
Amenities (cold water)	3.1	73	176
Viscera table sprays total water	7.0	143	346
Sterilisers (80 pots)	17.5	321	774
After production clean down	12.7	300	724
Head and offal sprays & chutes	5.2	106	255

Ref 47 beef 2006	%	L/head	L/t HSCW
Total water	100	2,546	8,850
Kill floor	30.9	787	2,736
Condensers	15.2	388	1,349
Cattle yards	7.0	179	622
Waste treatment & DAF	4.2	107	372
Amenities	3.3	84	292
Tripe & hash room	8.3	210	730
Kill floor steriliser pots (65)	8.0	204	704
Viscera table hot water	4.4	112	141
Viscera table cold water	1.6	41	390
Kill floor hand basins (warm water)	7.2	183	636
Head wash	3.4	86	298
Boning room hand basins (warm water)	0.8	20	70
Boning room steriliser pots	0.7	18	62
Boning room entry-basins, boot, apron	1.5	37	130
Tripe cooker, offal room & basins	10.8	276	960
Amenities, laundry, admin, canteen	3.3	85	294
Abattoir clean down (151kL/shift)	9.1	233	809

Ref 39 beef 2007	%	L/head	L/t HSCW
Total water	100	3,400	10,400
Kill floor (total)	39.8		
Boning room (total)	19.4		
Cattle yards (total)	9.4		
RO (boiler, cooling tower make up)	3.4		
Amenities	1.7		
	%	L/head	L/t HSCW
Boning room sterilisers (16)	2.4		250
Boning room sprays (hand, boot, apron)	1.3		
Items on kill floor using >1% of total water			
Steriliser pots	5.5		
Cleaning	4.5		
Viscera table	2.3		
Shackle table	1.9		
Tripe washing	1.7		
Intestine washing	1.3		
Carcass wash	1.0		

Ref 31 beef 2007	%	L/head	L/t HSCW
Total water	100	3,200	10,550
Cattle yards & wash	16.6		
Clean down	17.0		
Steriliser pots (55)	16.0		
Viscera table	12.0		
Contrashear	2.6		
Umbrella wash		24L/paunch	

Ref 38 beef 2007	Min flow	Max flow	Type
Steriliser pots	L/min	L/min	
Kill floor, hide on (16)	1.9	6.0	Double skin
Kill floor, hide off (26)	1.3	9.8	Double skin
Boning room (17)	1.8	11.8	Double skin
Tripe room (4)	6.2	7.1	Double skin

Ref 28 sheep 2007 small	%	L/head	L/t HSCW
Cold water	63		2,470
Hot water	37		1,470
Total water	100		3,940
sterilisers		19.2	

Ref 28 beef 2007 small	%	L/head	L/t HSCW
Cold water	68		800
Hot water	32		380
Total water	100		1,180
sterilisers		79.1	

Typical water use at meat processing plant	Ref r3			
		kL/d	% of total	% of total
Stockyards	Stock watering	10	1	
	Stock washing	70	7	
	Stockyard washing	130	13	
	Truck washing	40	4	
				25
Kill & evisceration	Viscera table wash sprays	60	6	
	Head wash	3	0.3	
	Carcase wash	40	4	
	Carcase splitting saw	1	0.1	
				10
Paunch, gut and offal washing	Paunch dump and rinse	80	8	
	Tripe/bible washing	30	3	
	Gut washing	60	6	
	Edible offal washing	30	3	
				20
Rendering	Rendering separators	10	1	
	Rendering plant washdown	5	0.5	
				2
Sterilisers and wash stations	Knife sterilizers	60	6	
	Equipment sterilizers	20	2	
	Hand wash stations	30	2	
				10
Amenities	Exit/entry hand/boot wash			
		40	4	
		25	2.5	
				7
Plant cleaning	Wash down during shifts	20	2	
	Cleaning and sanitizing at end of shift	170	17	
	Washing tubs, cutting boards and trays	30	3	
				22
Plant services	Condensers	20	2	
	Cooling tower makeup	10	1	
	Boiler feed makeup	10	1	
	Refrigeration defrost	3	0.3	
				4

2. Energy consumption

2.1. Overall

Beef (MJ/t HSCW)

4,492 MJ/t HSCW (ref 107, beef, 2004)
2,790 MJ/t HSCW (ref 97, beef, 2004) coal 276,920 head, 68,954 tHSCW
1,391 MJ/t HSCW (ref 16 beef 2006 to 2008)
3,207 MJ/t HSCW (ref 14 beef 2008)
5,065 MJ/t HSCW (ref 30 beef 2007)

Sheep (MJ/t HSCW)

4,809 MJ/t HSCW (ref 120, lamb, 2003)
6,665 MJ/t HSCW (ref 12 sheep 2008) inc woolscour
4,873 MJ/t HSCW (ref 12 sheep FY2007
5,163 MJ/t HSCW (ref 12 sheep FY 2008

Beef (MJ/head)

225 MJ/head (ref 16 beef 2006 to 2008)
1,546 MJ/head (ref 30 beef 2007)

Sheep (MJ/head)

101 MJ/head (ref 120, lamb, 2003)
104 MJ/head (ref 13 sheep FY2007
114 MJ/head (ref 13 sheep FY 2008

2.2. Electricity

Beef (MJ/t HSCW)

708 MJ/t HSCW (Ref 134, beef 2001) 3500 hd/wk 297kg HSCW/hd inc. rendering
604 MJ/t HSCW (Ref 134, beef 2001) @ 4,000 head/week
864 MJ/t HSCW (Ref 134, beef 2001) @ 2,500 /week
1,692 MJ/t HSCW (ref 107, beef, 2004)
660 MJ/t HSCW (ref 97, beef, 2004) inc rendering
947 MJ/t HSCW (ref 98, beef, 2004) 650 head/day, electricity only
994 MJ/t HSCW (ref 14 beef 2008)
1,057 MJ/t HSCW (ref 99 beef 2004)
1,670 MJ/t HSCW (ref 30 beef 2007)

Sheep (MJ/t HSCW)

1,391 MJ/t HSCW (ref 103, sheep, 2004) [abattoir & rendering]
1,004 MJ/head to 2,342 MJ/head [r^2=0.92, maximum down to 20% of maximum]
1,432 MJ/t HSCW (ref 13 sheep FY2007
1,447 MJ/t HSCW (ref 13 sheep FY 2008

Beef (MJ/head)

467 MJ/head (ref 30 beef 2007)

Sheep (MJ/head)

31 MJ/head (ref 13 sheep FY2007
32 MJ/head (ref 13 sheep FY 2008
28.5 MJ/head (ref 103, sheep, 2004) or [1,759.609hd/yr]

Beef (kWh/t HSCW)

386.3 kWh/t HSCW (ref 16 beef 2006 to 2008)
470 kWh/t HSCW (ref 107, beef, 2004) 6,590 head/week
263 kWh/t HSCW [235 to 287] (ref 98, beef, 2004) 650 head/day,
240 kWh/t HSCW (ref 97 beef 2004) Dinmore inc rendering
217 kWh/t HSCW (ref 97 beef 2004) Toowoomba inc rendering
183 kWh/t HSCW (ref 97 beef 2004) Townsville
410 kWh/t HSCW (ref 95, beef, 2004) inc rendering
285kWh/t HSCW (ref 14 beef 2008)
293 kWh/t HSCW (ref 99 beef 2004)
425 kWh/t HSCW (ref 30 beef 2007)

Average 317.2 kWh/t HSCW

Beef (kWh/head)

79 kWh/head (ref 95, beef, 2004) inc rendering
129.6 kWh/head (ref 30 beef 2007)
62.6 kWh/head (ref 16 beef 2006 to 2008)
8.1-10.0 (average 9.2) kWh/head (ref 24 beef 2007) 1,200 head/10hr shift

Sheep (kWh/head)

7.9 kWh/head (ref 103, sheep, 2004) 1,759.609hd/yr
7.9 kWh/head (ref 103, sheep, 2004) [1,759.609hd/yr]

2.3. Steam

0.16 kg steam/head (Ref 134, beef, 2001) 297kg HSCW/head
126.7 kg steam/head (ref 107, beef, 2004)

2,800 MJ/t HSCW (ref 107, beef, 2004)
3,232 MJ/t HSCW (ref 91, beef, 2005) inc rendering

324kg steam/GJ natural gas (ref 30 beef 2007)

$13.50/t steam 10MW coal boiler (ref 79, beef, 2005)
$20 /t steam 3MW gas fired (ref 79, beef, 2005)
$22 /t steam 8.5MW gas fired (ref 79, beef, 2005)

2.4. Refrigeration

135 kWh/t HSCW (ref 99 beef 2004) 46% of energy demand
178 kWh/t HSCW (ref 30 beef 2007) 41.9% of energy demand
54.3 kWh/head (ref 30 beef 2007) 41.9% of energy demand

1.2 kW/tHSCW stored (Ref 134, beef, 2001)
2.0 kW/tHSCW processed (Ref 134, beef, 2001)
1.65 COP for two stage system (Ref 124, beef, 2003)
1.94 COP two stage system (ref 99, beef, 2004) 650 head/day
40.0 to 50.7% of total plant load [average 46.1%] (ref 99, beef, 2004)
333 kWh for refrigeration /t HSCW (ref 134 beef 2001)

2.4.1. Chilling

164 kWh/t HSCW average for chilling sides of beef (Ref 124, beef, 2003)
290 KWh/t HSCW peak for chilling sides of beef (Ref 124, beef, 2003)
687 vealers + 330 head cattle/day (Ref 124, beef, 2003)

2.4.2. Freezing

260 kWh /t average to freeze chilled boned beef (Ref 124, beef, 2003)
equivalent to 169 kWh/t HSCW at 65% yield
580 kWh /t peak to freeze chilled boned beef (Ref 124, beef, 2003)
80kWh per hr for holding 64t boned meat frozen (Ref 124, beef, 2003)
Note: increased by 7% with ambient temperature changing from 25 to 45^0C.
687 vealers + 330 head cattle/day (Ref 124, beef, 2003)

2.5. Compressed air

5.8 kL air/head @ 690kPa (Ref 134, beef, 2001) 297kg HSCW/head

2.6. Boiler

2,213 MJ/t HSCW (ref 14 beef 2008)
3,440 MJ/t HSCW (ref 30 beef 2007)
1,070 MJ/t HSCW (ref 30 beef 2007)

Boiler efficiency 81% solid fuel (ref 91, beef, 2005)
Sawdust fuel 9.3 MJ/kg @ 45% moisture (ref 91, beef, 2005)
Macadamia shell fuel 14.9 MJ/kg @ 21.8% moisture (ref 91, beef, 2005)
Tea tree fuel 12.0 MJ/kg @ 50.0% moisture (ref 91, beef, 2005)
Camphor laurel 10.0 MJ/kg @ 52.0 moisture (ref 91, beef, 2005)
Coal 33.5 MJ/kg @ 10.0 moisture (ref 91, beef, 2005)
Gas (butane) 50.1 MJ/kg dry (ref 91, beef, 2005)
LPG 25.4 MJ/L (internet)
Flue gas temperature 120^0C on solid fuel with economiser (ref 91, beef, 2005)
Flue gas temperature 217^0C on solid fuel with no economiser (ref 91, beef,2005)

2.7. Rendering plant

15t/hr steam for 19t/hr MAM @ 85.5kg MAM/head cattle

2.8. Power factor

0.83 (ref 30 beef 2007)
0.91 (ref 24 beef 2007)

2.9. Detailed breakdown of energy use

Ref 16 beef 2006 to 2008	kWh/t HSCW	kWh/head
Monthly average	386.3	62.6
Monthly maximum	490.4	84.6
Monthly minimum	329.7	51.7

Ref 14 beef 2008	%	TJ/year	MJ/t HSCW
Boiler fuel energy	69	124.2	2,213
Electrical energy	31	55.8	994
Total energy	100	180	3,207

Ref 95, beef, 2004	%
Refrigeration(chillers, no freezers)	42.6
Waste treatment plant inc DAF and aerators	11.6
Lighting & power	8.3
Boning room	8.9
Rendering plant inc biofilter	6.8
Air compressors	5.0
Boilers	3.7
Value added	2.4
Water distribution	2.3
Kill floor	1.3
Admin/offices	0.9
Other	6.2
Total	100.0

Ref 99 beef 2004	%	kWh/t HSCW
Refrigeration	46.0	135
By-products	12.2	32.9
Boning room	1.7	4.6
Kill floor	1.4	3.8
Boiler house	1.4	3.8
Reservoir	1.0	2.7
Other (effluent, hide plant)	32.3	87.2
other	4.0	
Total	100.0	

Ref 30 beef 2007	%	kWh/head	kWh/t HSCW
Electrical energy	100	129.6	425
Refrigeration	41.9	54.3	178
By-products	10.6	13.7	45
Kill floor	15.9	20.6	68
Boning room	6.1	7.9	26
Other	8.5	11.0	36
Waste treatment	12.6	16.3	54
Details			
Biofilter	6.0	7.8	26
Aerators	6.5	8.4	28
Lighting	4.3	5.6	18
Air compressors	6.1	7.9	26
Admin & workshops	5.3	6.9	23

Ref 30 beef 2007	Min	Max	Average
kWh/t HSCW	329	513	464
kWh/head	99	155	140
GJ elec/t HSCW	1.18	1.85	1.67
GJ elec/head	0.36	0.56	0.50
GJ gas/t HSCW	2.64	3.84	3.44
GJ gas/head	0.81	1.21	1.07
Total GJ/t HSCW	3.893	5.727	5.065
Total GJ/head	1.200	1.726	1.546

Total GJ=elec+natural gas+LPG
36,607t HSCW/year (ref 30 beef 2007)
Power factor 0.83 (ref 30 beef 2007)
COP=1.75 two stage ammonia system (ref 30 beef 2007)
126,381 GJ natural gas Nov06-Oct 07 (ref 30 beef 2007) for boiler
[economiser fitted in boiler to heat incoming boiler water]
3.441GJ/t HSCW (ref 30 beef 2007) 305kg average carcass weight
$0.0844/kWh (ref 30 beef 2007)
$8.02/GJ natural gas (ref 30 beef 2007)
$1.3967/L LPG (ref 30 beef 2007)
324kg steam/GJ natural gas (ref 30 beef 2007)

Ref 30 beef 2007	Usage	Emissions factor	Emissions
Electricity	15,476,766 kWh	1.054 kg CO_2 –e/kWh	16,312 t CO_2-e
Natural gas	126,381 GJ	71.3 kg CO_2 –e/GJ	9,011 t CO_2-e
LPG	36,974 L	1.6 kg CO_2 –e /L LPG	59 t CO_2-e
Total			25,382 t CO_2e

Ref 16 beef 2008	%	KWh/24hrs	GJ
Refrigeration	59	10,835	39,006
Boning room	10.4	1,904	6,854
Offal processing & Pet food	10.2	1,867	6,721
Boiler, Laundry, Engineering	7.2	1,331	4,792
Rendering plant	5.9	1,081	3892
Kill floor	3.1	572	2,059
Hot water pumps	1.6	296	1,066
Emergency lighting /UPS	1.2	214	770
Saveall	1.1	195	702
Administration	0.4	80	288
Other	0.7	133	479
total	100.0	18,364	66,110

(No. of head/day) x 0.126+6.23=daily t CO_2-e discharged (ref 14 beef 2008)
0.675 tCO_2-e /t HSCW using NGER data (ref 14 beef 2008)

819kg CO_2/t HSCW (ref 13 sheep 2008-09)

Ref 13 sheep FY 2007	kg CO_2/t HSCW	kg CO_2/head
Scope 2 (electricity)	346	7.4
Total emissions	570	12.1
Ref 13 sheep FY 2008	kg CO_2/t HSCW	Kg CO_2/head
Scope 2 (electricity)	350	7.7
Total emissions	822	13.8

Conclusions

1. Almost half of the undergraduate reports related to the environment ie water, energy, waste water, and emissions.
2. Undergraduates were highly skilled at gathering unbiased numerical information even though they were on a very steep learning curve in an industry they knew little about.
3. Many processors record information which could be used to drive change but it is often just recorded for historical purposes.
4. Many sites did not have the measuring equipment (meters, gauges, PLCs) installed to help them drive the changes they wanted to make.
5. There was a large variation in performance between the class leaders, the median and the poorer performers and it was not always indicative of the size of the operation.
6. Undergraduates introduce new skills to meat industry personnel
7. There is further information in the reports not related to the environment which could help processors.
8. The information can be used as a prompt to encourage other processors to look at the services they use and their emissions for comparison.
9. There is not an equal weighting of numerical information across the entire abattoir site unit operations or between sheep and cattle.

Recommendations

1. The data presented in this report can be examined to find the knowledge gaps.
2. Undergraduates can be used by MLA/AMPC to fill those knowledge gaps.
3. The reports can be further exploited to make their non environmental information available to the industry.
4. This data in this report can be used as a basis to complete a mass and energy balance of a sheep and cattle abattoir targeting the services used (water, fuel, energy) and emissions generated.

Appendix A Data from red meat literature

"typical meat plant"
150 tHSCW
625 head cattle
240kg HSCW/head
5 days/week, 250 days/year

Overall water use 4.1 to 43.0 kL/t HSCW (Ref r1, p.13.)
Overall water use 6 to 15 kL/t HSCW & average 11.8 kL/t HSCW (Ref r3, p.14)
Cattle yards 100-300L/d (Ref r7)

Ref r3 p.21		kL/d	% of total	Sub total
Stockyards	Stock watering	10	1.0%	
	Stock washing	70	7.0%	
	Stockyard washing	130	13.0%	
	Truck washing	40	4.0%	25%
Kill	Viscera table	60	6.0%	
	Head wash	3	0.3%	
	Carcass wash	40	4.0%	
	Carcass splitting saw	1	0.1%	10.4%
Paunch/Offal	Paunch dump	80	8.0%	
	Tripe & bible washing	30	3.0%	
	Gut washing	60	6.0%	
	Edible offal washing	30	3.0%	20%
Rendering	Rendering separators	10	1.0%	
	Plant washdown	5	0.5%	1.5%
Sterilisers	Knife sterilisers	60	6.0%	
	Equipment sterilisers	20	2.0%	
	Hand wash stations	20	2.0%	10%
Amenities	Exit/entry boot & apron wash	40	4.0%	
	Personnel amenities	25	2.5%	6.5%
Plant cleaning	Washdown during shift	20	2.0%	
	Cleaning at end of shift	170	17.0%	
	Washing tubs, boards, trays	30	3.0%	22%
Plant services	Condensers	20	2.0%	
	Cooling tower make up	10	1.0%	
	Boiler feed make up	10	1.0%	
	Refrigeration defrost	3	0.3%	4.3%
Total		1000		100%
	kL/t HSCW	7		
	Cold water	687	68.7%	
	Warm water	85	8.5%	
	Hot water	225	22.5%	
	Fixed water use	443	44.3%	
	Variable water use	554	55.4%	

Ref r4				
Cattle wash	L/min	L/min	Time in use	L/head
Dirty cattle wash				80
Pre kill wash	50-240	100	0.5min/head	50
Final spray wash		100	10min/mob	50

Viscera table	Cold water		Hot water		Total water		
	L/min	L/min	L/min	L/min	L/min	L/min	
	range	average	range	average	range	average	
Wash sprays	65-220	150	15-230	150	80-450	300	ref r8
Continuous		156		156		312	ref r9
Intermittent		54		54		108	ref r10
Sheep		235		223		458	ref r11
Cattle		193		121		314	ref r11

Sterilisers	Hot water L/min		
Knife			
Continuous flow single skin	1-9	4.5	ref r3,p35
	2-8		ref r9
	2-3	2.5	ref r12
Continuous flow single skin with restrictor	0.6-4.5	1.7	ref r3,p35
Continuous flow double skin	1-4	3.6	ref r3,p35
	1-8	4.0	ref r9
		0.5	ref r12
	0.6-3.1	1.6	ref r10
Continuous flow hot water jacket	1.1-1.5	1.3	ref r9
Intermittent ring spray	6-18	15.0	ref r10
Intermittent rose spray		3.0	ref r10
Intermittent sparge pipe spray		4.6	ref r10
Equipment			
Hock & horn cutter-foot operated	8.4-23	15.8	ref r3,p36
		15.0	ref r10
Hock & horn cutter-timer operated	8.4	8.4	ref r3,p36
Brisket cutter with spray nozzles		12.0	ref r3,p36
Briskett cutter with drilled sparge pipe		40.0	ref r3,p36
Beef head with continuous spray		4.4	ref r3,p36
Beef head with continuous overflow		3.0	ref r10
Splitting saw with spray		16.8	ref r3,p36
Splitting saw with drilled sparge pipe		83.0	ref r3,p36

Ref r13		
Carcass washing	L/min	
Manual wash – entire carcass		50
Manual wash – backbone & cavity		20
Automatic wash – both sides	200-300	250
Automatic wash – both sides	90-130	110

Ref r14		
Paunch dumping	L/head	
	Range	Average
Wet dump	145-310	220
Dry dump	7-20	15
Dry dump/spray rinse		150

Gut washing	L/t HSCW		
	Range	Average	
Contrashear system		2,260	ref r15
Rotary drum system	500-3,300	1,500	ref r15
Immersion system	680-1,100	900	ref r15
Brentwood shredder		320	ref r5

Plant cleaning	Hot water		Cold/warm water		Total	ref
	L	L/m^2	L	L/m^2	L/m^2	r9
Morning smoko	1,500	1.9	1,212	1.6	3.5	r9
Lunch clean			1,260	1.6	1.6	r9
Kill floor final	2,600-2,980	2.1-3.9	3,900-10,800	5.9-7.6	9.7-9.8	r9
					11.8	r10
Boning room final	9,520	15.1			15.1	r9
					12.9	r10

Hose cleaning	L/min		
	Range	Average	
Low pressure hose	30-90	50	ref r9
High pressure hose	11-25	17	ref r9

Hand wash station	L/carcass		
	Range	Average	
Knee operated	0.03-2.97	0.7	ref r17
Sensor operated	0.04	0.04	ref r17

1,200 to 4,800 MJ/t HSCW & average 3,400 MJ/t HSCW (Ref r3, p.14.)
1,080 MJ/tHSCW (Ref 134, beef “industry standard”)

Typical plant ref r3			
Hot water	MJ/day		MJ/day
Knife/equipment sterilisers	30,000	Hot water demand	88,000
Hand wash stations	5,000	Recovered heat	60,000
Kill/evisceration	15,000	Supplementary steam	28,000
Plant cleaning	25,000		
Amenities	5,000		
Tripe/bible washing	2,000		
Hook wash tanks	1,000		
Piping heat loss	5,000		
total	88,000		

Typical plant r3				
Steam	t/day	MJ/day		MJ/day
Rendering	54	150,000	Steam demand	213,000
Hot water produced	10	28,000	Boiler energy consumed	236,667
Blood processing	7	20,000	Assumed boiler efficiency	90%
Tallow processing	2	5,000	Coal consumption (t/day)	8
Piping heat loss	4	10,000		
Total	77	213,000		
Electricity	kWh/day	MJ/day		
Refrigeration	22,222	80,000		
Motors	15,000	25,000		
Lighting	833	3,000		
Air compressors	2,778	10,000		
Total energy	kg/ tHSCW	kWh/ tHSCW	GJ/t HSCW	MJ/day
Coal	51		1.6	236,667
Electricity		272	0.8	118,000
Total energy			2.4	354,667

Conversion factors (ref r3)		
Coal	30.7	MJ/kg
Natural gas	39.5	MJ/m^3
Fuel oil	43.1	MJ/kg
Electricity	3.6	MJ/kWh
Steam	2.8	MJ/kg

Ref r3 page 71	Wastewater digestion		Solids digestion	
Material available/day	1,000kL	wastewater	2,040	Dry manure
Organic load/day	5,700kg	COD	1,632kg	VS
Methane conversion rate	0.352	m^3/kgCOD removed	0.4	m^3/kg VS removed
Organic load removed	85%		NA	
Methane yield/day	1,705	m^3	653	m^3
Energy yield/day	61,055	MJ	23,370	MJ
% of thermal abattoir energy	18%		7%	

Ref r18	Total power used by abattoir kWh/ t HSCW	Estimated refrigeration power kWh/t HSCW
1	228	103
2	229	103
3	281	126
4	297	134
5	210	95
6	180	81
7	159	72
8	273	123
9	381	171
10	346	156
11	391	176
12	302	136
13	502	226
14	209	94
15	289	130
average	285	128

Appendix B General industry references

Please note that these references have an “r” before the ref no. in the report

r1. “Abattoir Waste Water & Odour Management” CSIRO Meat Research Laboratory ISBN 0 643 05433 X
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r3. “Eco-Efficiency Manual for Meat Processing” MLA (2002) ISBN 174036631X
r4. “Cattle cleaning” Meat Research Report 3/94 Wescombe (1994)
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r7. “Identification of nutrient source reduction opportunities and treatment options for Australian abattoirs and rendering plants” MLA Sydney M445
r8. “Water and waste minimisation. Optimisation of water use and control of waste in abattoirs” AMT, Brisbane (1995)
r9. “Measurement and modelling of hot and warm water usage in meat plants” Walford J et al MIRINZ (1994)
r10. “Dynamic modelling of meat plant energy systems” Kallu RDS Massey Uni (1993)
r11. “Use of chlorinated detergents for continuous cleaning of viscera tables” Spooncer WE, Barkley MB MLA A/84 (1984)
r12. “Knife sterilizer design-Energy conservation case studies” Pearson RG NZERDC no.51 (1981)
r13. “Removal of bonedust during beef carcase sawing” Green JM et al AMT Meat Research Report 1/94 (1994)
r14. “Evaluation of beef paunch contents handling practices” Van Oostrom AJ et al MIRINZ 967 (1996)
r15. “Assessment of four viscera cutting and washing systems” Swan JE et al MIRINZ 843 (1986)
r16. “Evaluation of a system for cutting and washing soft offals” Hamilton RG (1989)
r17. “Energy Management-Advisory Package” MLA (1997)
r18. “Country Meatworks Association Beef Processing Benchmark Study” (1995)
r19. “Top 25 Processors-2003”, Feedback Aug 2004, MLA
r20. “Top 25 Processors-2004”, Feedback Oct 2005, MLA