Measuring What Matters

Using technology to drive profitability and efficiency with the improvement of beef carcase yields

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Executive Summary

This report explores how the Australian beef industry can enter its next frontier by adopting objective carcase measurement for red meat yield, to run adjacent to objective eating quality traits that industry already measures well. It highlights technology that is predominantly being used throughout the Northern Hemisphere to drive price signals through livestock supply chains, explores trials and work completed domestically here in Australia. The report also challenges why Australia, a global leader in beef eating quality, has not yet captured the same value from yield.

Drawing on extensive travel through Australia, New Zealand, Singapore, Taiwan, Zimbabwe, Chile, Poland, Romania, United Kingdom, Ireland, Denmark, Spain and France, this report draws together conversations, observations and published scientific research from across the red meat supply chain, to examine the technology available, the trials undertaken and the benefits they have delivered, and could deliver for future adopters. It also makes the case that linking these objective measurements to a transparent feedback system will drive the right behaviours from producers to processors, while continuing to pursue eating quality and productive traits. The measurement of yield allows the processor to put a value on it. When that is measured and realised, the right payment incentives and can be fed back to producers, based on the measured performance of each carcase, regardless of the route to market.

The report is structured in four key parts. First, it documents the variation in beef carcase yield that exists before any processor decisions are made, drawing on bone out trails completed during my Nuffield Scholarship and published scientific studies. Second, it sets out the technologies available to predict individual carcase yield at commercial speed. Third, it explains how this technology can be adopted, installed and accredited within Australian processing plants. Finally, it builds the business case for why this technology, paired with a transparent feedback system, will be paradigm shifting for the Australian beef industry.

The scale of the opportunity is best illustrated by a bone-out trial I completed during my scholarship in partnership with Murdoch University. Seventeen carcase sides, representing a wide range of weights and fat depths within a single breed, reflecting a daily production run for this beef program, were dissected into commercial cuts and individually weighed. At the same carcase weight, the leanest and fattest carcases differed in value by as much as $300 per side ($600/Hd), while cumulative cut-weight range varied a 20kg range that carcase weight alone simply could not see (Williams, Carter and Gardner, 2025).

The findings align with broader industry research, which show that lean meat yield within a single processing lot can vary by 34.99% at the same carcase weight, with a standard deviation of 6.40% (H. Calnan et al. 2021). Using an average hot standard carcase weight (HSCW) of 300kgs, each 1% increase in yield represents 3kgs of additional lean meat. At an average value of $10-30 per kilogram of saleable red meat, this represents what it is being substantially under or overvalued per carcase, because it is neither measured, rewarded nor fed back to producers.

My conclusion is that the technology is available, the science is settled, and the gold-standard reference methods exist. What is missing is the industry architecture: an accredited device/s, a new yield trait in the AUS-MEAT trading language, a payment grid that rewards yield, new breeding values that lets producers chase that reward, partnered with a transparent objective feedback payment platform that connects the boning room back to the paddock. Australia built exactly this architecture for eating quality through Meat Standards Australia and this measurement of carcase yield in sheep. We now need to do it again for yield in beef!

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Foreword

I grew up on a beef cattle property near Crookwell, New South Wales, where my family run a Normande and Charolais crossbreed herd. I am the seventh generation of the Carter family to grow up at Lake Edward, which carries the oldest registered fire brand in NSW, registered in 1853. After moving to Brisbane to finish school, I began and completed a carpentry apprenticeship while studying business. Towards the completion of my apprenticeship, I started my journey back into agriculture by joining EC Rural. There I worked in sales and production, ranging from international sales through to working on the ground at the Casino abattoir.

From there I started at the Australian Agricultural Company (AACo) as a Livestock and Production Officer, where I really began to learn my craft in red meat processing, as well as understanding the intricacies of a fully integrated supply chain. After less than two years in the role I was promoted to Assistant Production Manager, and two years later to my current role as Processing Manager. In that role I manage a team, overseeing three service kills at JBS Beef City, JBS Rockhampton and Australian Country Choice, ensuring that all aspects of AACo's global premium branded beef program are met across the 1,000+ head of Wagyu we process every week. I am also a member of the National Intercollegiate Meat Judging (ICMJ) Committee and the Northern Committee Chair, which is a program that exists to inspire and develop the next generation of leaders in the global red meat industry. Through Nuffield and the networks I have created throughout the program, I now have the privilege of sitting on the Industry Calibration Working Group that assesses new traits and technologies that could potentially be approved by the AUSMEAT Language and Standards Committee, to better industry.

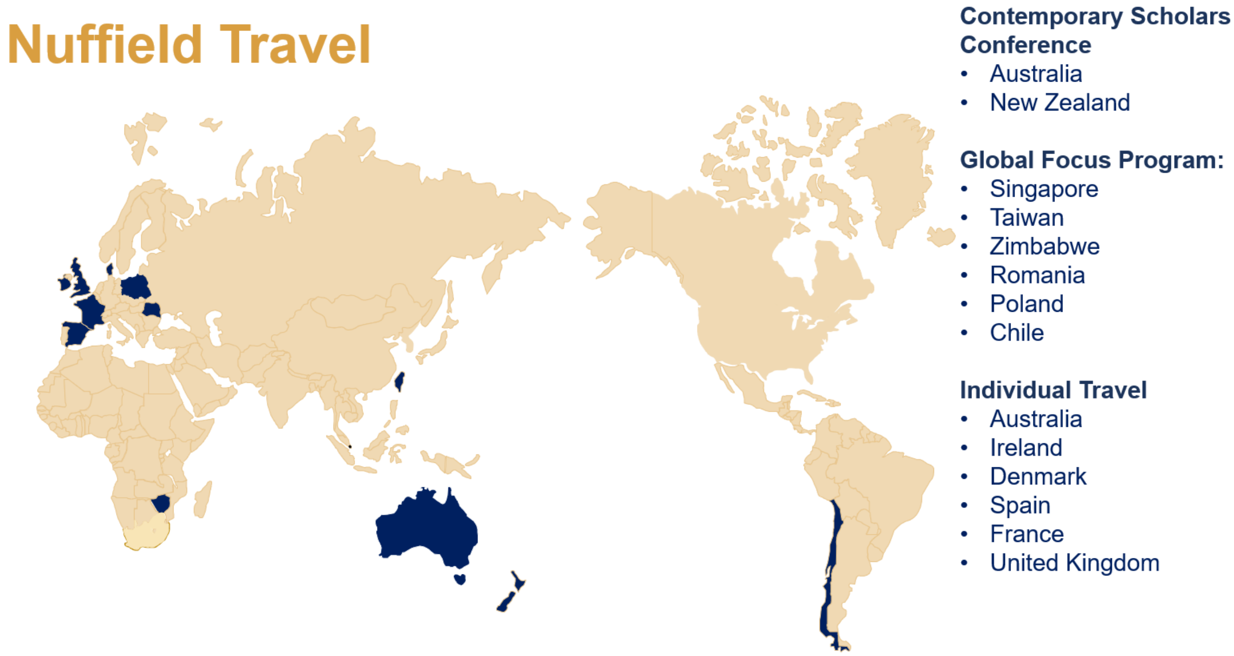
I applied for a Nuffield Scholarship because from a young age I have been deeply passionate about agriculture, and when I saw it as an opportunity to influence the industry for the better on a topic I believe will be paradigm shifting, I took it with both hands. Having grown up on a cattle property and then progressed throughout the supply chain into processing, I have been fortunate to see firsthand the work that goes into getting an animal from paddock to plate. This scholarship gave me the opportunity to learn from global industries where this knowledge and experience could fill gaps in my own understanding, having spent most of my life working in the Australian beef sector. From the beginning of my scholarship, I wanted to ensure I was contributing as much as I was learning. Through that approach, I have built lifelong professional and personal networks that have been instrumental in developing this report, and I am grateful to everyone who has shared their knowledge and experiences with me.

I chose the topic of 'using technology to drive profitability and efficiency with the improvement of beef carcase yields' because I believe the Australian industry has enormous potential to lift profitability and efficiencies through breeding for higher-yielding carcases, by measuring them with objective technology. This is combined with evidence that our genetic progress in yield has regressed over the past 2 decades in numerous influential breeds due to a lack of focus and importance on this. With a fundamental goal of feeding that information back to the producer through a transparent feedback platform where objective carcase performance is rewarded with the right payment incentives back to producers, regardless of the route to market. Better genetic decisions can then be made, and the right supply chain behaviours are able to prosper, to harvest more kilograms and dollars from paddock to plate. This will not only improve profitability but also sustainability, because we would be harvesting more saleable red meat kilograms into a box and thus reducing our emission intensity. Improved red meat yield per carcass which translates to reduced methane intensity (kg CH_4/kg of red meat) which is worth \$37/tCO_2-e (mid 2026).

Using technologies such as the DEXA X-ray, BCC3, VBS2000 and Microwave, clearly defining what “good” looks like and accrediting it, we will be able to share that information with a producer, backgrounder or feedlot and begin to build it into the over-the-hooks (OTH) payment grid, and hopefully longer term into a payment system that rewards a producer with a bonus for genetic selection, after carcase grading and processing. There may be exceptions to this rule where traders or feedlots may buy animals to background or feed, to then on sell to a processor when at the right weight spec. However, the way I see it is if the right feedback system is created, those traders and feedlots will position themselves with superior livestock producers/partners, by paying a premium to source those superior genetics, as both parties will know a bonus will be achieved off the back of superior genetics and feeding, thus creating a bonus payment naturally over time. Rewarding producers will help drive genetic progress based on the premium available based on additional saleable red meat kilograms produced before the carcase enters the boning room, for the same cost of production. Accurate measurement allows processors to put a value against individual carcase yield. Every advance in yield genetically translates into more dollars per head, as extra yield can be harvested from individual animals, and it is not required to be grouped into boning runs like quality must be for extracting dollars via brands.

Learning from international and national supply chains this has provided great insight into what I can bring to this report and share, and hope to help implement in the future. This program has given me the time, personal development, skills, knowledge and funding to dedicate my focus to a topic that I believe is genuinely valuable for the industry.

Overview of Nuffield Travel and Areas of Interest



Travel date	Location
2 weeks – March 2^{nd} - 16^{th} CSC	Australia (Canberra) and New Zealand (Ackland and surrounds)
1 week – April 7^{th} – 13^{th}	Australia (Rockhampton)
5 weeks - May 17^{th} -June 13^{th}, 2025, GFP	Singapore, Taiwan (Taipan to Tainan City), Zimbabwe (Harare to Chiredzi), Romania (Bucharest to Braila/Constanta), Poland (Warsaw to Poznan/Oswiecim) and Chile (Santiago to Puerto Montt)
1 week July 7^{th} – 13^{th} 2025	Australia (Wagga)
1 week March 31^{st} – April 3^{rd} 2026	Australia (Gundagai to Goulburn)
1 week April 6^{th} – 12^{th} 2026	Australia (Rockhampton)
6 weeks May 18^{th} – June 28^{th} 2026	Ireland (Dublin to Cork), Denmark (Copenhagen to Kolding/Aarhus), Spain (Barcelona to Monells, France (South of France area) and United Kingdom (London to Wye Valley)
2025 Jan – 2026 July	Southeast Queensland for opportunistic abattoir visits over multiple days/weeks and conferences

Acknowledgements

It has been an honour and a privilege to be awarded a Nuffield Scholarship, an experience that has truly changed my life and I will be forever grateful for. None of it would have been possible without my outstanding sponsors, Northern Pastoral, made up of the Australian Agricultural Company, Consolidated Pastoral Company, Elders and S. Kidman and Co, in partnership with Nuffield Australia, as well as my additional sponsor EC Rural who came on midway through my scholarship, thank you for everything. To AACo, my employer of over five years, thank you for the opportunity to grow and for allowing me the time to pursue this research.

To Professor Graham Gardner, Andrew Williams and the team at Murdoch University, Paul Gibson, Professor Peter McGilchrist, Claire Mahony, Jason Delaney, Dean Gutzke, Niels Toftelund Madsen, Mette Christensen, Thomas Lauridsen, Andrew Voke, Steinar Jens Gislason, John Walsh, Tommy Drennan, Jes Henningsen, Ciara McDonnell, Ruth Hamill, Maria Font, the Intercollegiate Meat Judging Committee and network, MLA and AMPC teams thank you for sharing your science, guidance and contacts so generously. To Frontmatec, JBT Marel, Danish Meat Research Institute, IRTA, CSIRO, Teagasc and the many processors (Teys, JBS, Australian Country Choice, Gundagai Lamb, ABP, Danish Crown, Himmerlandskod to name a few), researchers and producers who hosted me around the world, thank you for your openness and for the lifelong networks we have built.

To my Global Focus Program team and the broader Nuffield community of scholars and alumni, thank you for the friendships and the shared adventures.

Finally, to my wife Rachel and family in Brisbane and at Lake Edward in Crookwell, thank you for your love and support, and for instilling in me a passion for agriculture. I hope this report is a fitting tribute to the support and encouragement you have given me throughout this journey.

Abbreviations

ALMTech	Advanced Livestock Measurement Technologies project
AMPC	Australian Meat Processor Corporation
ASBV	Australian Sheep Breeding Value
AUS-MEAT	Authority for Uniform Specification Meat and Livestock
BCC3	Frontmatec beef carcase yield camera system
COP	Cost of Production
CT	Computed tomography
DEXA (DXA)	Dual energy X-ray absorptiometry
DMRI	Danish Meat Research Institute
EUROP / SEUROP	European carcase conformation classification scale
VBS2000	JBT Marvel beef carcase yield camera system
GR	Grade rule (tissue depth)
HSCW	Hot standard carcase weight
Hd	Head
IMF	Intramuscular fat
ICBF	Irish Cattle Breeding Federation
IRTA	Institute of Agrifood Research and Technology in Agro-Food
LMP / LMY	Lean meat percentage / lean meat yield
MLA	Meat and Livestock Australia
MSA	Meat Standards Australia
NATA	National Association of Testing Authorities
NIR	Near infrared spectrophotometry
OTH	Over the hooks
P8	Rump fat depth measurement site
R^2	Coefficient of determination
RMSE / RMSEP	Root mean square error / of prediction
RDC	Research and Development Corporation
SMY	Saleable meat yield
VBM	Value-based marketing
VIA	Video image analysis

Objectives

The objectives of this report are to:

- Highlight the extent and cost of variation in beef carcase yield before any processor decision is made, using published scientific evidence and bone-out data.
- Evaluate the objective measurement technologies capable of determining and predicting individual carcase yield at commercial chain speed.
- Examine how such technologies can be adopted, installed, calibrated and accredited within Australian processing facilities.
- Make the business case for pairing objective yield measurement with a transparent producer-feedback system and aligned payment signals.
- Recommend practical steps for the Australian beef industry to adopt yield measurement trait as a paradigm-shifting reform that benefits the whole supply chain.

Introduction

The composition of a beef carcase determines its saleable cut weights and the efficiency of the boning room, and it is therefore one of the most important profit drivers in the beef industry. Industry information and modelling suggest that there is significant variation in lean meat, saleable red meat yield and grading between individual animals, and crucially, much of that variation exists before any processor decision is made. Throughout this report I highlight the variation in carcase yield in beef and how objective carcase measurement can be used to identify and quantify that variation. When paired with comprehensive and transparent feedback to producers, objective measurement has the potential to drive greater profitability through improved consistency, increased efficiency, higher saleable meat yield, reduced emissions intensity, and a lower cost of production, creating value that can be shared between producers and processors through appropriate payment incentives.

The current Australian beef industry standard for estimating carcase composition is based on carcase weight and a measurement of fat depth at the P8 site or at the rib quartering site between the 5th and 13th ribs. Using P8 or rib fat depth in combination with carcase weight markedly improves the prediction of cut weights (Calnan et al. 2019). However, these single site fat depth measures are limited in their ability to predict the lean% and fat% of carcases. Williams et al (2017) demonstrated highly variable precision and accuracy of predicting CT fat % using measures of rib fat depth.

Measurement of yield and eating quality grading accounts for a substantial share of the variation in price, and these two attributes are the largest drivers of the value of the carcase. Studies consistently show variation in red meat yield between beef carcases, yet as an industry we currently have no ability to measure that variation at commercial speed.

Objective technology would improve red meat yield and consistency per carcase by optimising primal weight prediction at a carcase level, at commercial speed. When coupled with a carcase feedback system that returns information to producers and feedlots, this would enable genetic improvement and help recover value that is currently unrealised. The processor would benefit from more saleable kilograms delivered into the boning room prior to any processor impact, thus giving them the opportunity to recover a higher percentage of saleable red meat.

Although the focus of this report is centred on beef supply chains, the principles are transferable to other meat sectors. In fact, as explained later, some of those sectors may achieve quicker integration, particularly the smaller-stock industries where calibration is more straightforward.

Chapter 1: the hidden variation in beef carcase yield

Before a single knife touches a carcase, two animals of identical hot carcase weight and eating quality can be worth hundreds of dollars apart in saleable red meat. This chapter sets out the evidence for that statement, drawing on published science and on an original bone-out trial that I completed in collaboration with Murdoch University. The central point is simple but, in my view, profound: the variation that matters most is created long before the carcase reaches the processor, yet our current measurement and grading methods for the Australian beef industry are blind to it.

How we measure yield today, and why it falls short

The current Australian beef industry standard for estimating carcase composition is based on hot carcase weight and a single ruled measurement of subcutaneous fat depth, taken either at the P8 rump site on the hot carcase, or at the rib quartering site between the fifth and thirteenth ribs on the cold carcase (Calnan et al., 2021). Adding P8 or rib fat depth to carcase weight does improve the prediction of cut weights (Calnan, Gould and Gardner, 2019). However, these single-site measures are poor predictors of the lean and fat percentage of the whole carcase. Williams et al. (2017) demonstrated highly variable precision and accuracy when predicting computed tomography (CT) fat percentage from rib fat depth, with a bias of up to 6.47 fat percentage units and a slope deviating from a perfect prediction by as much as 0.58. In an earlier benchmark, rump P8 fat explained only up to 70% of the variation in retail beef yield (Johnson, 1987), while rib fat depth combined with carcase weight described 80.6% of the variation in beef carcase CT fat percentage, with a root mean square error of prediction of 3.15% units (Williams et al., 2017).

The deeper problem is that we are relying on a single point measure of fat depth to correlate with total fatness of a three-dimensional animal. Carcases of the same weight vary substantially in the weight of saleable cuts dissected from them, mainly because of variation in fatness, with fatter carcases yielding lighter commercial cuts (Gardner, Anderson et al., 2021). Worse yet, point measures introduce real bias in genetically diverse populations, particularly where selection has redistributed fat and lean between regions of the carcase (Anderson et al., 2015, 2016; Gardner et al., 2018). In a country with the breed diversity of Australia, from Wagyu through to Brahmans, a single ruler over one rib is never going to tell the full story. As (Gardner et al. 2024). To put it simply, lean meat yield has been measured poorly in Australia for the last 30+ years, relying on visual estimates, point measures or palpated scores.

Murdoch University and Teys Australia in partnership with MLA have undertaken one of the largest commercial bone-out trials at the Teys Lakes Creek abattoir in Rockhampton; to better understand variation in carcase yield and how objective technologies can be used to measure it. A total of 264 sides were selected across 15 days of production, which were deliberately chosen to span the full commercial range of weight and fat depths, ranging from carcase side weights of

89.5kgs to 235.5kgs and P8 fat depths ranging from 3mm to 32mm. The trial included heifers and steers representative of central and northern Queensland of Bos Indicus-cross breeds. Each side was scanned and boned out to a commercial cut plan, with every gram of meat, fat and bone weights being captured.

From this work the Murdoch team were able to identify significant variation in cut weight, with the use of technology. The below visuals illustrate the variation in cut weight yields even when carcases have the same hot standard carcase weight (HSCW), proving that variation in yield exists before any processor impact.

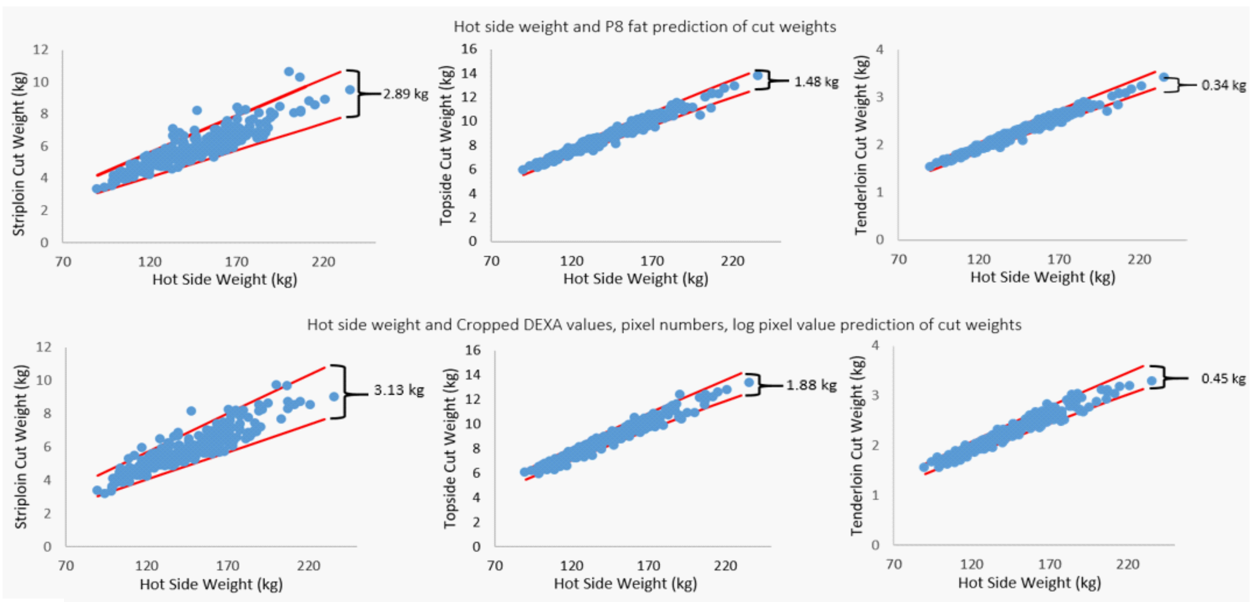


Figure 1 The relationship between hot side weight and the weight of the striploin, topside and tenderloin cuts using a model containing hot side weight and P8 fatness compared to a model containing cropped DEXA values, pixel count and the log pixel values . The blue dots represent the predicted cut weights of individual animals; the red lines represent the 95% range in the data and the value on the graph represents the magnitude difference in cut weight differ entiated by the model at 230kg side weight.

Figure 1. Variation in cut weight yields (Source: H. Calnan G.E. Gardner 2024)

The figures below also highlight the variation in carcase lean meat yield. It is important to note that the previous figure presents saleable red meat yield based on commercial specifications, including a 6 mm fat cover for some of those cuts. However, when the carcases were assessed as 100% lean meat, the variation in yield increased to 34.99%. This equates to a difference of 107.78kg between the highest- and lowest-yielding carcases of the same weight, with a standard deviation of 19.71kg per head, based on an average HSCW of 308.03kg.

Table 1. Variation in carcase lean meat yield (Source: H. Calnan et al., 2021)

H. Calnan et al. *Meat Science 173 (2021) 108397*

Table 1
Computed tomography (CT) composition values, DEXA values and weight (wt) of the forequarter, hindquarter and the entire side following Conventional or Spray chilling. Values are mean, standard deviation, minimum and maximum.

	Conventional chill				Spray chill			
	Mean	St Dev	Min	Max	Mean	St Dev	Min	Max
	Forequarter ($n = 51$)				Forequarter ($n = 51$)			
CT Lean %	58.76	6.34	41.19	74.73	58.44	6.35	38.86	72.75
CT Fat %	22.88	8.65	7.61	45.54	23.01	8.77	8.69	48.39
CT Bone %	18.36	3.13	13.27	26.49	18.55	3.30	12.75	28.13
DEXA Value	50.20	7.02	31.89	67.88	49.75	6.54	34.96	65.99
Quarter Wt (kg)	79.52	17.96	40.76	114.74	80.88	18.40	44.01	122.36
	Hindquarter ($n = 51$)				Hindquarter ($n = 49$)			
CT Lean %	65.27	6.62	40.91	77.62	64.95	6.74	40.01	77.14
CT Fat %	19.01	8.64	6.22	48.46	19.44	8.65	6.64	49.30
CT Bone %	15.71	2.72	10.62	22.60	15.61	2.63	10.69	22.78
DEXA Value	42.77	7.79	21.86	58.22	41.65	7.97	23.59	58.61
Quarter Wt (kg)	71.59	16.58	35.91	117.23	72.11	16.13	38.09	111.95
	Entire side ($n = 51$)				Entire side ($n = 49$)			
CT Lean %	61.84	6.40	41.05	76.04	61.50	6.54	39.41	74.77
CT Fat %	21.06	8.59	6.98	47.02	21.31	8.75	7.75	48.82
CT Bone %	17.10	2.90	11.93	24.67	17.19	2.97	11.77	24.82
DEXA Value	46.65	7.17	29.17	63.64	45.88	7.11	28.95	61.81
Side Wt (kg)	153.98	34.94	78.00	233.50	153.91	35.27	81.00	238.50
	Carcase ($n = 51$)				Carcase ($n = 49$)			
HSCW (kg)	308.03	69.52	159.00	472.00	307.68	70.85	159.00	472.00
P8 fat	14.69	12.15	1.00	50.00	14.73	12.40	1.00	50.00

The mean DEXA values of left and right carcase sections were strongly correlated. The left and right forequarters have a correlation of 0.98 while the hindquarters have a 0.89 correlation. Correlations between DEXA values and carcase weight at the time of CT scanning were lower and negative, ranging between −0.61 and − 0.71.

If you put this simply, the current way we look at yield is very crude and driven by a population of averages, and this also flows into how we measure cut/primal yield, which is why the variation highlighted above remains largely hidden. For example, processors are currently unable to measure individual carcase yield to predict cut weight at commercial speed, to try and account for every gram of meat, fat and bone back to its original carcase. Unless you were to slow right down and do individual bone outs, which would not be commercially sustainable for the whole herd due to the time and expense these entail. Yield at commercial speed is currently measured by comparing an average hot carcase weight against an average primal cut weight yield, at the end of a production run. The problem is that a single production run could include hundreds of carcases and thousands of primal pieces that vary in cut weight yield, even if all carcases have the same hot carcase weight. As seen above the variation exists already prior to a boner and slicer touching a carcase. This is then potentially impacted further depending on the boning rooms capabilities to achieve yield maximisation.

When all these factors are considered, the current method of measuring cut weight yield at commercial speed does not provide an accurate picture of supply chain performance. Due to this current method, industry is leaving huge amounts of money on the table for genetic improvements, when we are not being able to identify carcases with a lower percentage of saleable red meat that is increasing cost of production and lower overall carcase value; and bodies with a higher percentage of saleable red meat that is lowering our cost of production and increasing our overall carcase value.

This is important because, if harvested correctly processors can recover more saleable red meat from higher yielding carcases to be packed into a box, for the same processing cost. The additional kilograms recovered should ultimately be reflected in payment systems that fairly reward both producers and processors. Conversely, poorer-yielding carcases cost more to process across the supply chain while delivering less saleable product. In essence, a lot of variation is being hidden behind the current way industry measures yield and the science proves this.

The Australian beef industry sees continued reports from respected beef industry media sources showing exports continue to increase year on year, with the biggest drivers behind this being our carcase weight increasing, as well as the increased export of bones, tallow and byproducts, that historically went into rendering. Although this is a great news story that industry is finding ways to increase carcase weight and better value add the carcase, what is being hidden within these numbers is as carcase weights go up, we may be missing out on more profitable exports because we are misvaluing saleable meat yield. As I have explored in chapter one so far it is clear from the evidence because objective yield is neither measured or fed back, we are misvaluing individual carcases and not harnessing the full value of a carcase, through better genetic selection. However, I wanted to see this firsthand, through completing my own bone out trial to put this science to the test.

The Bone-Out Trial

To test this theory and quantify the variation I undertook a comprehensive bone-out experiment with Murdoch University (A. Williams, J. Carter, G.E. Gardner) targeting a single mob of cattle from a relatively narrow genetics base. Several months of kill data was analysed prior to map the weight and fatness range likely to be seen on the selection days, and 17 carcase sides were chosen across a deliberately wide grid of carcase side weight and P8 fat depth. The carcase sides were trimmed to a standard AUS-MEAT specification, and we used a hand-held microwave scanner designed by Murdoch to objectively confirm the P8 fat selection. Each side was then boned into 14 primals and sliced into 33 retail cuts (Topside, Topside Cap Off, Eye Round, Outside Flat, Knuckle, D-Rump, Rump cap, Rostbiff, Striploin 1 Rib, Tenderloin SS/Off, Rib Eye Roll 7 Rib, Chuck eye roll, Bolar Blade, Oyster Blade, Shoulder Petite Tender, Point End Brisket Deckle Off 5 Rib, Navel End Brisket, Karubi Plate 5 Rib, Chuck Tender, Chuck Tail Flap, Chuck Meat Square, Short Rib Meat, Chuck Meat Pieces, Rib Cap, Rib blade meat, Long Intercostals, Short Intercostals, Flank steak, Flap Meat, Tri Tip, Inside Skirt, Tenderloin Side Strap and Brisket Deckle) to a standard commercial specification, with every gram of saleable red meat, bone, fat and lean trimmings being weighed and tracked on a primal basis to minimise bone-out error. The trial took more than two full days to complete to ensure the accuracy was maintained and the data was reliable. To put this in perspective, this processor would typically bone out around 60-70 head per hour, however, our trial took 24 hours to bone out 8.5 head. I am very grateful to the processor, producer and Murdoch for their support throughout the trial.

	Carcase Side weight Range				
P8 Fat Range	< 180 kg	>180- 200 kg	>200 - 220kg	>220 – 240k	>240 kg
<12 mm			×	×	
13 – 19 mm	×	×	×	×	×
20 - 25 mm	×		×	×	×
26 – 33 mm	×	×		×	×
> 33 mm			×	×	

Figure 2. Bone out trial (Source: A. Williams, J. Carter, G.E. Gardner 2025)

Figure 3. Bone out trial (Source: A. Williams, J. Carter, G.E. Gardner 2025)

From this trial, we determined the total saleable meat ranged from 90 to 145kgs in sides (half a carcase), pre-boning the sides weighed between 165 to 269kgs. As expected, heavier sides carried more saleable meat in absolute terms, but, interestingly, a lower saleable meat yield percentage: a 170kg side returned a saleable primal red meat of 53.3% yield (excluding trim), while a 270kg side returned 52.1% (excluding trim). That one percentage point understates what is really happening, because previous work by Calnan et al. (2021) found that carcase lean percentage falls by about 0.11% per kilogram of side weight, which across this weight range equates to a fall in lean of more than 11%. If saleable meat yield only fell by one per cent while lean fell by eleven, proportionately more fat was being retained inside the saleable cuts as intramuscular and intermuscular fat. (Figure 4)

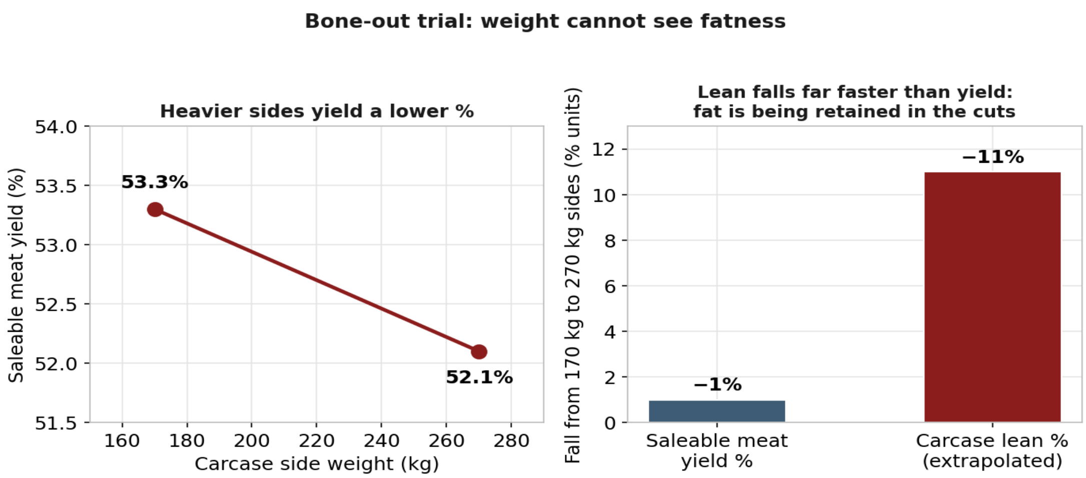


Figure 4. Saleable meat yield falls only slightly as sides get heavier, but carcase lean falls far faster, showing that fat is being retained within the saleable cuts (Source: Williams, Carter and Gardner, 2025; Calnan et al., 2021).

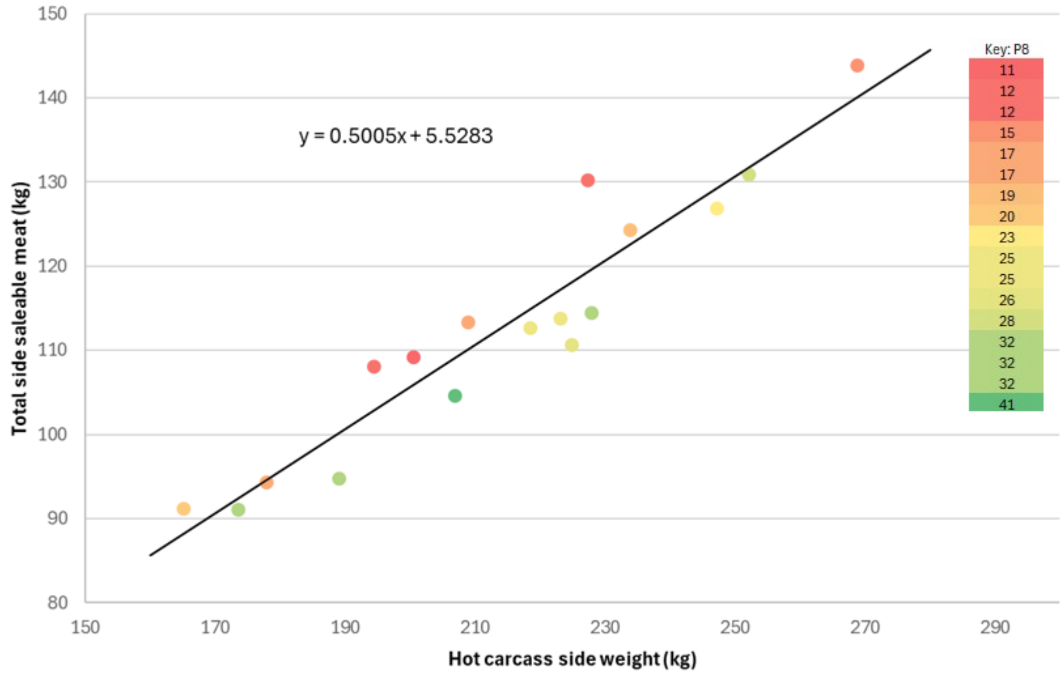


Figure 5. Total saleable meat weight versus carcase weight (Source: A. Williams, J. Carter, G.E. Gardner 2025)

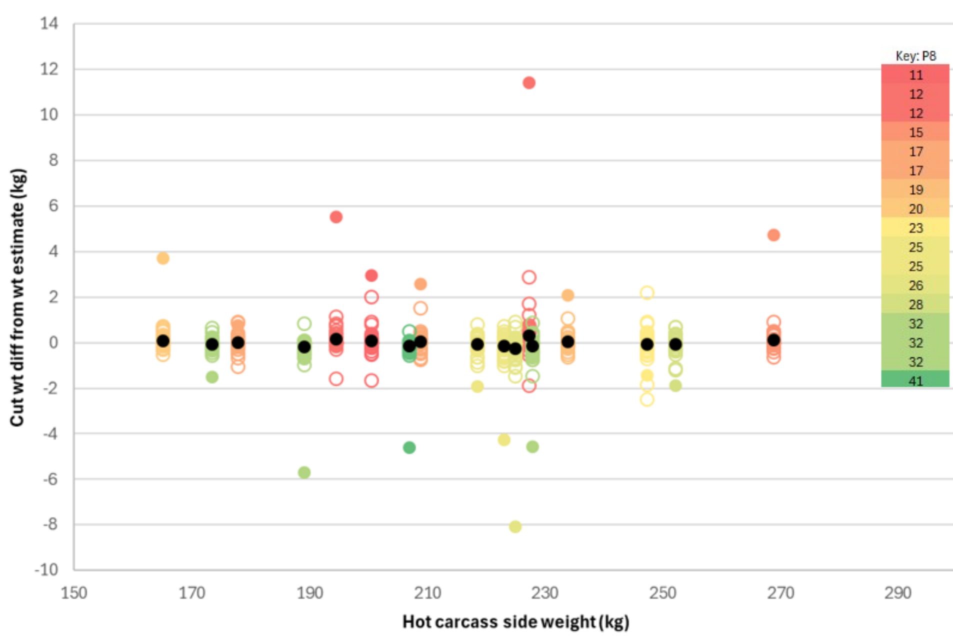


Figure 6. Difference between actual cut weight and predicted cut weight (predicted from hot carcass weight) for all cuts measured. Solid coloured dots represent the sum of all cut differences and black dots represent the average of the cut differences (Source: A. Williams, J. Carter, G.E. Gardner 2025)

The most powerful finding came when each cut weight was predicted from carcase side weight and compared with its actual weight. Individual cuts differed from their predicted weight by as much as ±3kgs, and when summed across the carcase, the cumulative difference ran from plus 12kgs to minus 8kgs from the predicted weight: a 20kg spread that carcase weight alone could not see. As a clear trend, leaner carcases with P8 fat between 11mm and 20mm tended to be under-predicted, returning more meat than expected, while fatter carcases above 20mm tended to be over-predicted and return less saleable red meat.

When those weight differences were converted into dollars using wholesale pricing, individual cuts varied by as much as ±$75, and the cumulative difference reached almost ±$300 for a single carcase (Williams, Carter and Gardner, 2025). In other words, at the same carcase weight, the fattest carcases were worth as much as $300 less than expected, and the leanest as much as $300 more ($600 variance). That is the amount by which a carcase is being over or under-valued before it enters the boning room but is hidden under current protocols! The same trend held when we restricted the analysis to the cuts representing 80% of carcase value, and again when we looked only at the prime cuts: the rib-eye roll, tenderloin, striploin, D-rump and oyster blade fatter carcases yielded less on these cuts and leaner yield more. These findings raise an important question: if saleable red meat yield can be measured objectively, could future phenotypes be developed to target greater yield in the higher-value cuts that account for most of the carcase value?

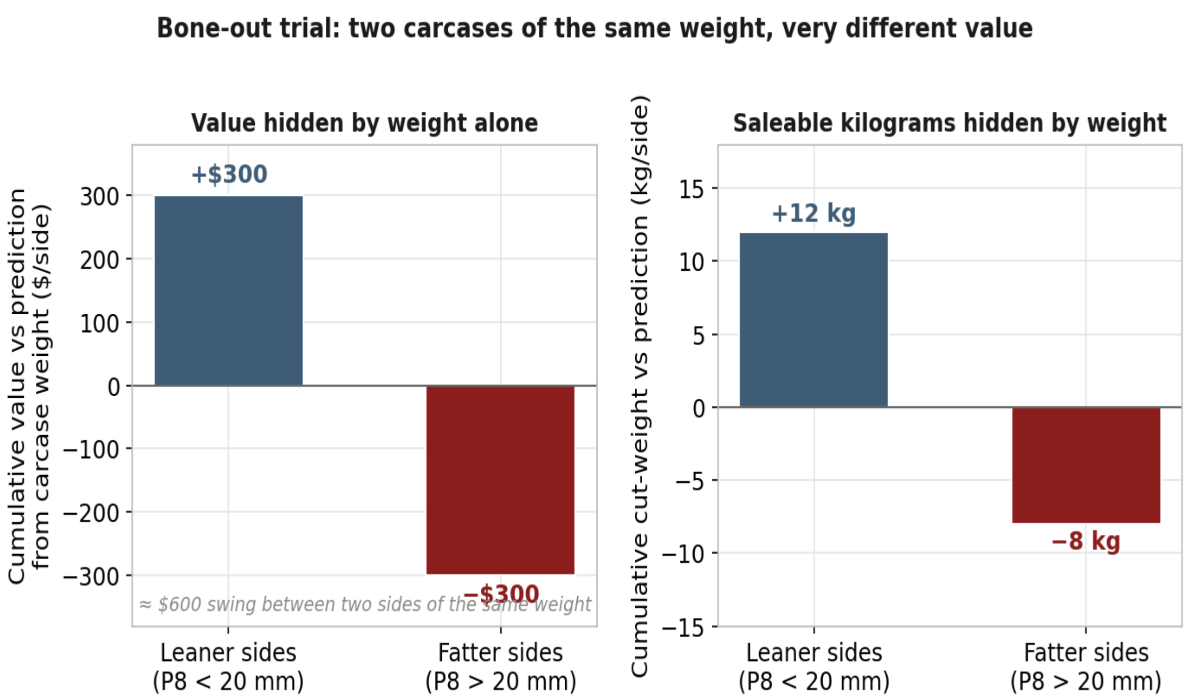


Figure 7. At the same carcase weight, leaner sides bone out heavier and more valuable than predicted, while fatter sides fall short, a swing of as much as $300 a side and 20 kilograms of saleable meat (Source: Williams, Carter and Gardner, 2025).

Table 2. Variation in the bone-out trial that is invisible to carcase weight alone (Source: Williams, Carter and Gardner, 2025).

Measure	Range observed	What it means
Saleable meat per side	90 – 145 kg	Widespread across 165 – 269 kg sides
Saleable meat yield %	53.3% (170 kg) vs 52.1% (270 kg)	Heavier sides yield a lower percentage
Per-cut weight error	± 3 kg	Carcase weight mis-predicts individual cuts
Cumulative weight error	+12 kg to −8 kg (20 kg range)	Yield variation hidden by weight
Per-cut value error	± $75	Largest swings in the prime cuts
Cumulative value error	up to ± $300 / side	Carcase over- or under-valued pre-fabrication

The variation is genetic, and therefore it is fixable

If this variation were purely random, measuring it would still help processors sort and value carcases, but it would not transform the industry. The reason it is transformational is that a substantial part of it, particularly the fat component, is under genetic control, and what is genetic can be selected for. The most rigorous evidence comes from the lamb industry, where sire breeding values were tested against CT-measured composition in 1,665 lambs. Reducing the sire fat-depth breeding value decreased carcase fat weight by 4.8% per unit, so that across the full 5.1mm sire range the leanest sires carried close to a quarter less carcase fat, while the same selection increased carcase lean weight by 9.5%, redistributed towards the high-value saddle (Anderson et al., 2016; Anderson et al., 2015). Increasing the sire eye-muscle-depth breeding value reduced carcase fat weight by 3.8% in maternal and 2% in terminal-sired lambs per unit, and increased carcase lean weight by 7.7% across its 7.8mm range, again concentrated in the saddle (Anderson et al., 2016; Anderson et al., 2015). Crucially for carcase value, this additional lean is not laid down evenly but is concentrated in the saddle, the mid-section carrying the loin and other high-value cuts: reducing sire fat depth made the saddle 3.7% heavier in lean, while increasing eye-muscle depth added 3.8% to saddle lean and pared 3.5% from the lower-value fore section (Anderson et al., 2015). Proving that genetic selection does more than just lift total yield; it can move saleable meat towards the cuts that return the most dollars per kilogram. Critically, the genetic effects on fatness were greater than the environmental or production effects. The same biological levers, leanness, fat, muscling and maturity, operate in cattle, and it is reasonable to expect a comparable, if not yet as fully quantified, genetic signal in beef carcase yield (Figure 8).

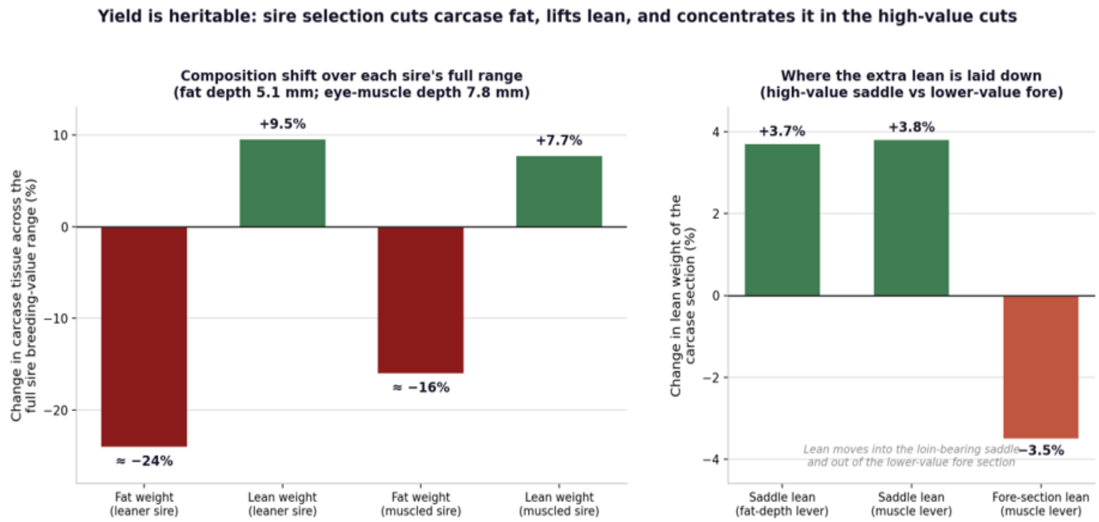


Figure 8. Yield is heritable. Across the full sire breeding-value range, selecting leaner, more muscled sires cuts carcase fat by roughly 15 to 25 per cent and lifts carcase lean by 8 to 10 per cent (left); that additional lean is laid down preferentially in the high-value saddle rather than the lower-value fore section (right), moving saleable meat towards the cuts that return the most per kilogram (Source: Anderson et al., 2015, 2016).

This is the heart of the argument presented throughout this report. When I look at a large spread in lean or saleable red meat yield within a single mob, I see an opportunity; however, I also see breeding and potentially feeding signals that we are currently throwing away. Without measurement, transparent actionable feedback and the right price incentives, that message never reaches the producer who could act on it.

Scaling the cost across the national herd

It is tempting to look at a ±$300 swing on a single carcase and treat it as an interesting outlier. It is not. It is a per-carcase signal that multiplied across a national kill of millions of head annually represents one of the largest pools of unrealised value in the supply chain. Even if the average carcase is mis-valued by only a fraction of the extremes observed in this trial, the cumulative impact is substantial. The bone-out data suggests that cumulative value differences routinely exceeded $200 per carcase, even before reaching the maximum observed difference of $600 from the best and worst carcase. Conservatively take the bone out result and put the average mis valuation to $50 per carcase, as of July 2026 the weekly kill in Australia is estimated at 150,000 animals per week, $50 per carcase totals at $7,500,000 of unrealised value each week. Multiply that by 50 weeks (allowing for maintenance shutdowns) that is a potential $375,000,000 of carcase value industry could be miss valuing for yield, without the ability to objectively measure it and feed that back. Recovering even a proportion of this value through improved measurement and genetic selection would have significant implications for supply chain profitability and efficiencies.

That value leaks in three directions, all of which our trial illustrates (Williams, Carter and Gardner, 2025). First, any pre-fabrication sorting based on carcase weight alone will mis-allocate carcases between markets, because two sides of the same weight can bone out very differently. Second, boning-room yield targets set on carcase weight will be missed in ways that look like processing problems but are really the result of front-end composition differences. Third, and most importantly for the producer, weight-only feedback with fat penalties applied only at the extremes, hides the true variation in value and weakens the price signal that should be shaping the next generation of cattle. Each of these is a direct cost and each is recoverable with an accurate yield measure. The prize is not a rounding error; it is structural (Figure 9).

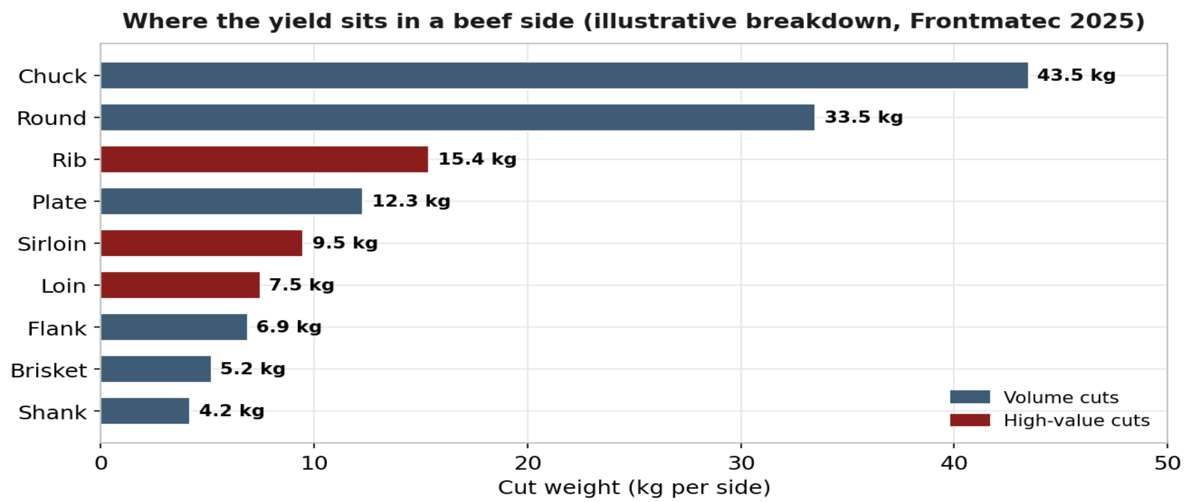


Figure 9. Saleable yield is spread right across a beef side, from the large-volume chuck and round to the high-value rib, loin and sirloin, so a single fat-depth measurement cannot describe how an individual carcase will break down (illustrative breakdown, Source: Frontmatec, 2025).

Why grading must be objective

Australia has made significant advances in measuring eating quality through Meat Standards Australia (MSA), but that system still relies on visual grading, which introduces human-derived error and bias (Watson, Polkinghorne and Thompson, 2008; Gardner et al., 2024). MSA grading data from more than one million carcases have shown consistent differences in marble scores between graders (Thompson, 2016). Internationally, Japanese marbling scores benchmarked annually against laboratory intramuscular fat showed marked differences in fat at the same visual score from year to year, such that a technology calibrated in 1998 would give markedly different predictions to one calibrated in 2004 (Gotoh et al., 2018).

The objective alternative already outperforms the human eye: computed tomography predicts intramuscular fat with high precision (an R-squared of 0.86) and does so more accurately than the MSA marble score itself (an R-squared of 0.89 against 0.81) (Anderson, Cook, Williams and Gardner, 2018). As reviewers of carcase evaluation have argued for years, genuine value-based marketing demands precise, objective techniques, because it is simply too difficult to judge by eye what lies under the hide (Gupta et al., 2013). Human grading is inherently variable; laboratory and instrumental based standards are not. This is exactly why on my travels a lot of supply chains have started to shift from subjective human grading to objective machine grading. Whether it is the EU, who are transitioning to objective EUORP grades, to Australia transitioning to objective cut surface MSA grading, the transition is building better trust in pricing signals, so better decisions can be made throughout the supply chain and on farm. If we are going to attach real money to yield, the measurement underneath it must be objective, repeatable and auditable, which is precisely what the next chapter addresses.

Historically, subjective grading represented the best technology available to industry. However, advances in objective assessment technologies now provide an opportunity to improve grading consistency, transparency and repeatability across the supply chain. With support from RDCs and industry investment, technologies such as cut-surface cameras are already being adopted by many Australian processors. Industry is now slowly transitioning to with the assistance of MLA, AMPC and industry funding, as change can be expensive, particularly when needing to add governance around it to be objective, accredited and traded on.

A useful framework I picked up from an industry yield workshop run by Frontmatec, was a short list of questions that any yield system must answer: What is yield, given that every region defines it differently? Can breeding or feeding actually change it, and is it worth measuring if it cannot? Who benefits from grading, the producer, the processor, or both? Should money change hands according to the result, and is AUS-MEAT approval required (Frontmatec, 2025)? The chapters to follow answers each of these in turn, but the bone-out data and science have already answered the most important one: yield can be changed, it is worth a great deal, and current systems do not adequately reward it.

Chapter 2: Technology to measure carcase yield at commercial speed

Having established that the variation is real, valuable and largely genetic, the obvious question is whether we can measure it on a moving chain. The answer after two decades of Australian and international research, is yes. This chapter walks through the technologies I examined internationally, domestically and from research papers, with the gold-standard reference method that underpins everything, to the on-line systems that can run at full commercial speed (Figure 10).

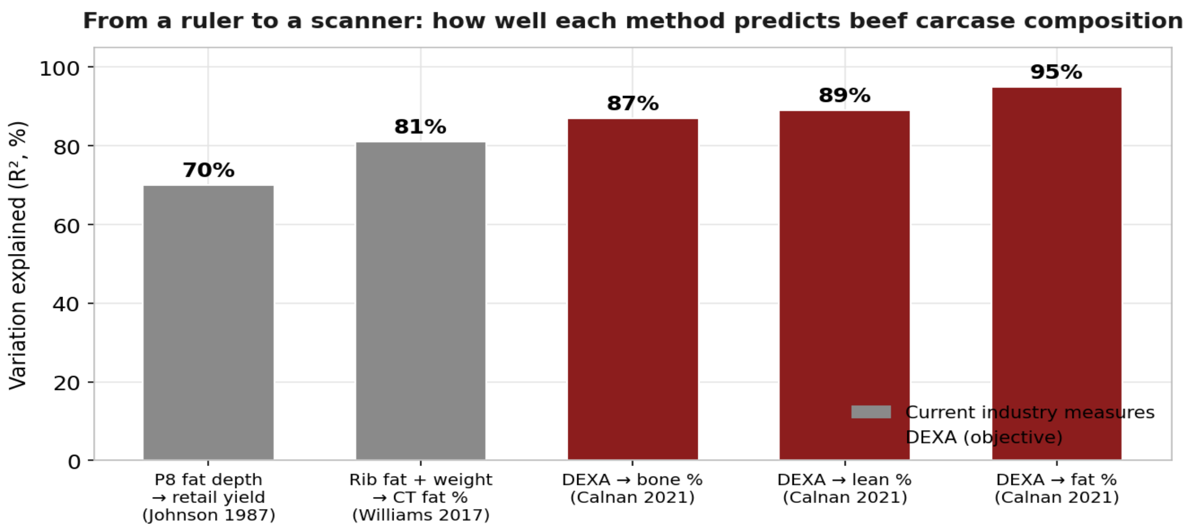


Figure 10. The leap in measurement: where current single-point fat measures explain only 70 to 81 per cent of the variation in beef composition, DEXA explains 87 to 95 per cent (Source: Johnson, 1987; Williams et al., 2017; Calnan et al., 2021).

Computed tomography: the gold standard reference

Computed tomography (CT) is the reference which every commercial device is judged against. It is a highly precise, reliable and repeatable measure of carcase composition (Kongsro et al., 2008; Scholz et al., 2015), and CT composition can in turn predict retail cut weights with high precision and accuracy (Carabús et al., 2015). CT works because fat, muscle and bone attenuate X-rays differently, producing distinct Hounsfield unit values, with fat around minus 50 to minus 100, water at zero, muscle between zero and 100, and bone above 250 (Delgado-Pando et al., 2021). CT however is not a chain-speed tool, it is too slow and too expensive to put on every carcase, but it is an extremely accurate calibration tool that allows faster devices to be trained and accredited.

This approach has been very successful in aiding the smaller stock industries like lamb and pork, as it is a lot easier to fit these carcases into a CT. In beef, no matter the carcase size, it requires the carcase to be broken down, which adds a lot more time and cost. Throughout my study, I became convinced that CT will be fundamental in establishing the reference standard should the Australian beef industry pursue its own lean meat or saleable red meat yield trait. As seen at DMRI in Denmark (Figure 11), Teagasc in Ireland (Figure 12) and IRTA in Catalonia Spain (Figure 13) the teams there where constantly using CT as a clear reference standard for a lot of their work, as it is the gold standard for calibration.

Figure 11.

Figure 12.

Figure 13.

Figure 11. DMRI Mobile CT, Figure 12. Teagasc CT, Figure 13. IRTA CT (Source: Author).

Dual energy X-ray absorptiometry (DEXA)

DEXA (Figure 14) is one of the most exciting whole-carcase yield technologies available, which can be run at commercial speed. However, due to its size, and the required infrastructure, it is not viable for a lot of processors unless they have sufficient space for installation.

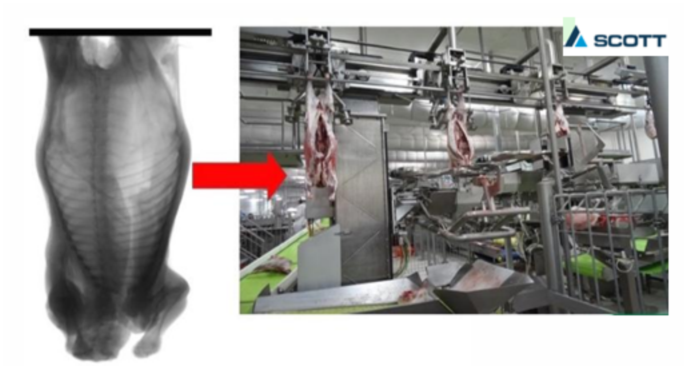


Figure 14. DEXA (Source: Author).

DEXA works by capturing X-ray images at two energy levels, and within each pixel. Expressing the attenuation of the low-energy image as a ratio, or R-value, to the high-energy image. Because R-values align with atomic mass, tissue types separate cleanly (Gardner et al., 2018). The breakthrough that made DEXA viable on a fast chain was the '"sandwich"' detector, which acquires the high and low energy images simultaneously from a single emission, overcoming the need to hold a carcase perfectly still that limits medical scanners (Gardner et al., 2018) (Figure 15).

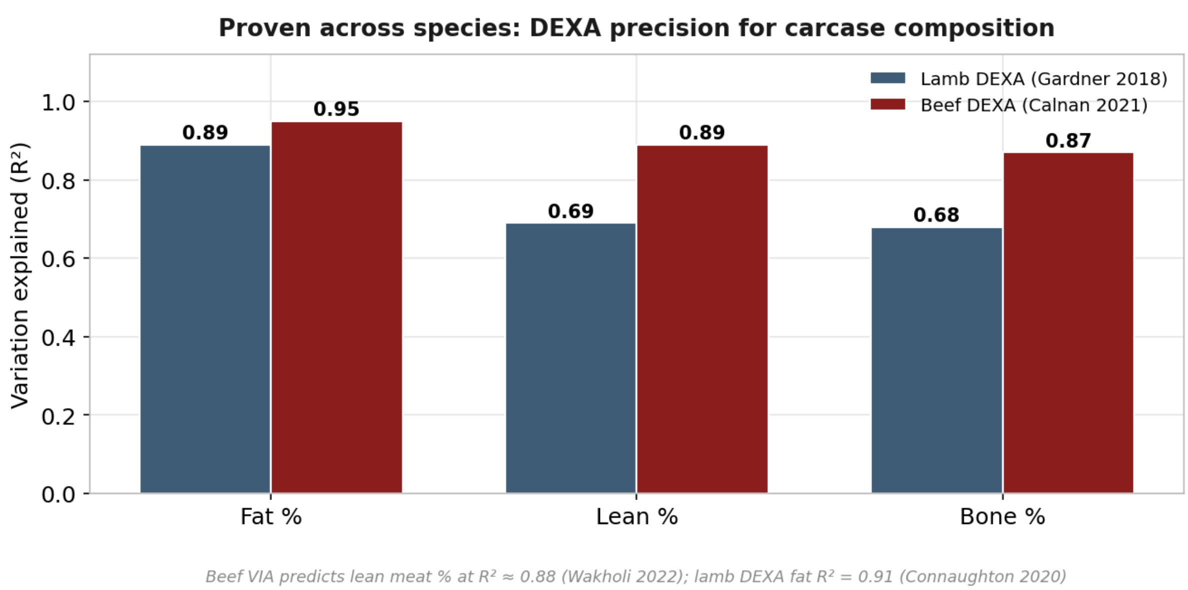


Figure 15. Proven across species and tissues: DEXA explains the great majority of the variation in fat, lean and bone in both lamb and beef, with beef predictions the strongest of all (Source: Gardner 2018; Calnan 2021; Connaughton 2020; Wakholi 2022).

In lamb, an on-line DEXA was installed in a commercial abattoir and trained against CT across 607 carcases from seven slaughter groups predicted CT fat percentage with a root mean square error of 1.32 and an R-squared of 0.89, with image processing completed in under one second per carcase (Gardner et al., 2018). A later study across 454 lambs and six kill groups achieved CT fat percentage prediction of R-squared 0.91 and a root mean square error of prediction of 1.19%, comfortably superior to the current grade-rule standard (Connaughton et al., 2020).

Importantly for our diverse national herd, that study concluded that DEXA is not biased by breed. The small residual biases it found were explained by a statistical regression paradox rather than by any genuine breed effect, meaning the device can be applied confidently across different genotypes (Connaughton et al., 2020) (Figure 16).

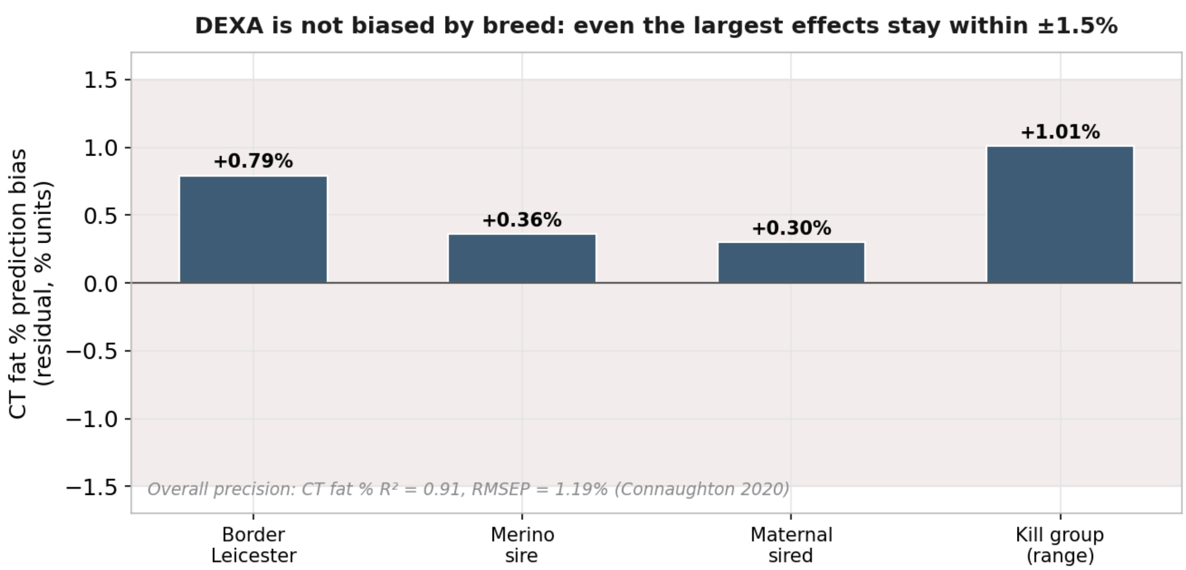


Figure 16. DEXA is not biased by breed: even the largest breed and kill-group effects on predicted fat stay within about ±1.5 per cent, against an overall precision of R^2 = 0.91 (Source: Connaughton et al., 2020).

The beef evidence is equally encouraging. A prototype rapid DEXA built into a shipping container scanned 51 beef carcases selected for a wide range of weight and fatness and, validated against CT, described 89% of the variation in lean percentage, 95% in fat percentage and 87% in bone percentage, with root mean square errors of prediction of 2.31, 2.15 and 1.12 percentage units respectively (Calnan et al., 2021). Spray chilling had no effect on the predictions, and, unlike the lamb work, the beef DEXA did not need carcase weight added to the model, suggesting it can measure composition commercially in its own right (Calnan et al., 2021). DEXA predictions of fat far exceeded the accuracy of single-point P8 or rib fat: where rib fat showed bias of up to 6.47 fat percentage units, DEXA fat bias was as low as 0.46 to 0.92 units on cross-validation (Calnan et al., 2021) (Figure 17).

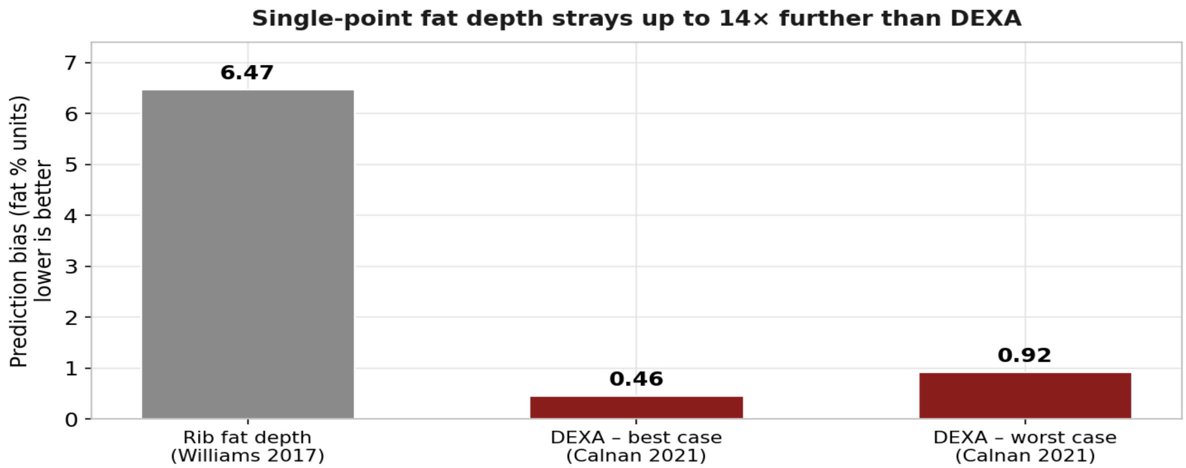


Figure 17. Accuracy matters as much as precision: single-point rib fat depth can stray from the true carcase fat percentage by up to fourteen times further than DEXA (Source: Williams et al., 2017; Calnan et al., 2021).

The exciting thing about DEXA when trained against CT, is its ability to predict commercial cut weights: across 200 lamb carcases it described more than 85% of the variation in most cut weights, with errors of 5% to 13% of average cut weight, again beating grade-rule depth (Gardner, Anderson et al., 2021).

As mentioned above, although this technology is very promising the biggest constraint is infrastructure: DEXA requires substantial floor space, for example the one installed at Teys Australia's Lakes Creek plant – the first in the Australian beef industry – occupies 48m². Most beef abattoirs don't have that available space, without significant capital investment to accommodate. There are also stringent X-ray safety requirements, although these can be managed with appropriate infrastructure and protocols.

There are findings that DEXA may even reach into eating quality measurement eventually as the mineral content of bone changes with maturity from what (Anderson et al 2021). For a processor, that raises the genuine prospect of a single rapid scan informing both yield and quality sorting on the same chain. This dual-purpose capability could significantly strengthen the business case for investment in the technology.

Surface imaging cameras: BCC3 and VBS2000

The technologies most widely adopted throughout Northern Hemisphere are surface-imaging cameras, and these are the systems I saw most often on my travels. The Frontmatec BCC3 (figure 19) and the JBT Marel VBS2000 (figure 20) scanner (previously called the E+V) are already in commercial use objectively grading the EUROP classification system used across the Europe and the United Kingdom.

Before discussing these devices in detail, it is worth explaining why much of my travel was concentrated in Europe. I was keen to understand their grading system, as well as their transition from subjective grading (human grading) to objective grading (camera grading) with the use of these types of devices for EUROP classification (figure 18).

Unlike Australia, where eating quality forms an important part of grading, the EUROP system is based primarily on conformation score (muscling) and fat coverage. I will highlight though, that in some regions I visited in the EU this is starting to change, and they are starting to adopt eating quality grading to become more competitive in the high-quality markets, and some of the processors I visited are aligning it to AUS-MEAT like marble scores.

Figure 18 illustrates the grid pricing system used by many European processors, where payment is linked to conformation and fat coverage scores. The desired outcome is a well-muscled carcase with even fat coverage, that in theory aligns better to commercial cut specifications and, theoretically, delivers superior cut yield. However, I did not find any data to prove whether EUROP is an accurate way to predict commercial cut yield but based off the variance you can have in each grade I am doubtful it would be and this would be just a band-aid fix if Australia adopted.

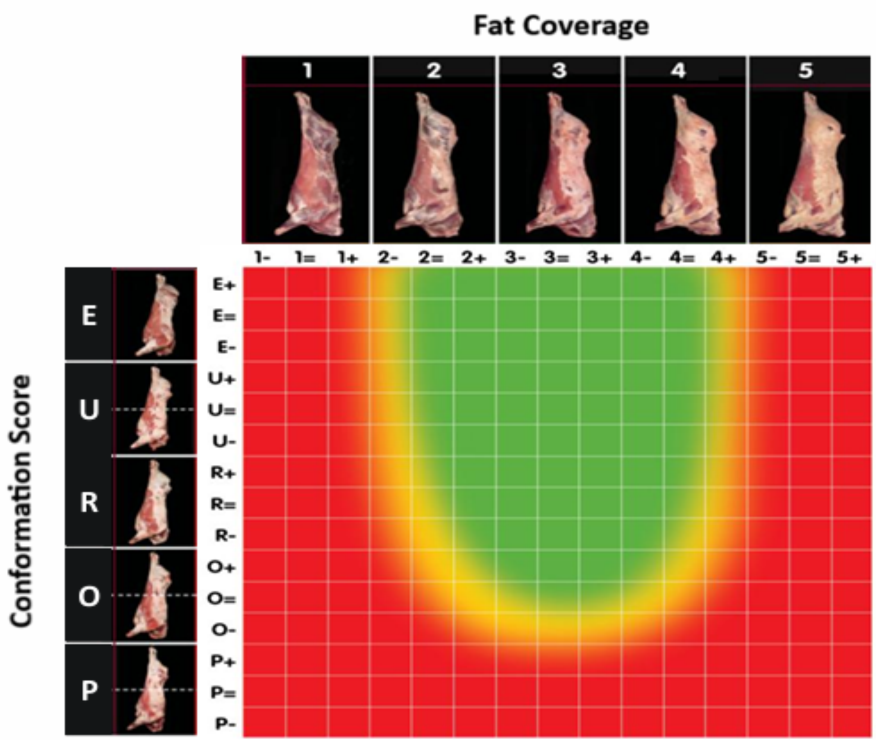


Figure 18. EUROP Classification (Source: Frontmatec 2026)

These grades historically were graded by trained human graders, like what we have in Australia for our eating quality traits. Today, however, the technology available has seen the European industry widely adopt objective grading systems accredited to EUROP scores, providing producers with greater transparency and confidence in the value of their livestock. Understanding this transition provides important context for evaluating the technologies discussed below.

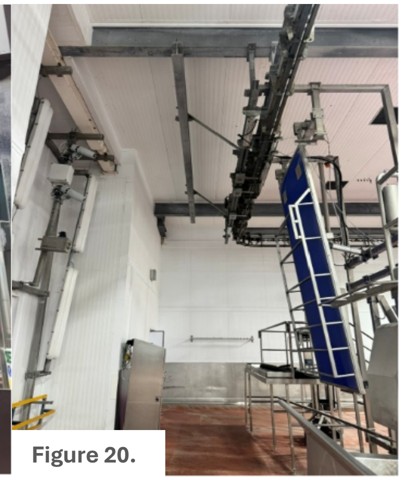


Figure 19. BCC-3, Figure 20. VBS2000 (Source: Author).

Video image analysis (VIA) captures the external shape of the carcase, including conformation and fat cover, and it can predict cut weight yield from these characteristics. The appeal is that a camera is comparatively cheaper, faster, safer and easy to install compared to a DEXA, with no ionising radiation and no shielding.

The bone-out results in chapter 1 illustrates the insufficiency of carcase weight as an indicator of expected saleable meat yield and highlights the potential for an objective measurement technology such as the BCC3 surface-imaging system that would estimate it with greater precision and accuracy (Williams, Carter and Gardner, 2025).

The precision achievable from imaging is well established. A VIA-style system applied to 140 Korean beef carcases predicted a lean meat percentage that was established by full carcase dissection, and the images were then modelled against it. With calibration R-squared around 0.92 and prediction R-squared of roughly 0.87 to 0.89 and found no significant difference between scanning warm and cold carcases, which is a major practical advantage because warm scanning gives instant results on the slaughter floor (Wakholi et al., 2022).

A landmark Irish trial put three commercial VIA systems side by side on 7,247 carcases at Dawn Meats, judged against a panel of expert classifiers using the EUROP grid: the Danish BCC2, the German VBS2000 and Australia's own VIA scan (Allen and Finnerty, 2000).

All three predicted the reference conformation grade to within one sub-class for 91 to 97% of carcases, and, most importantly for our purposes, all three predicted the saleable meat yield of boned-out steer carcases to a residual standard deviation of just 1.1 to 1.2%.

In other words, camera-based systems were accurately predicting saleable yield more than a quarter of a century ago. What is new is the accuracy now achievable, and the willingness to attach payment to it (Figure 21).

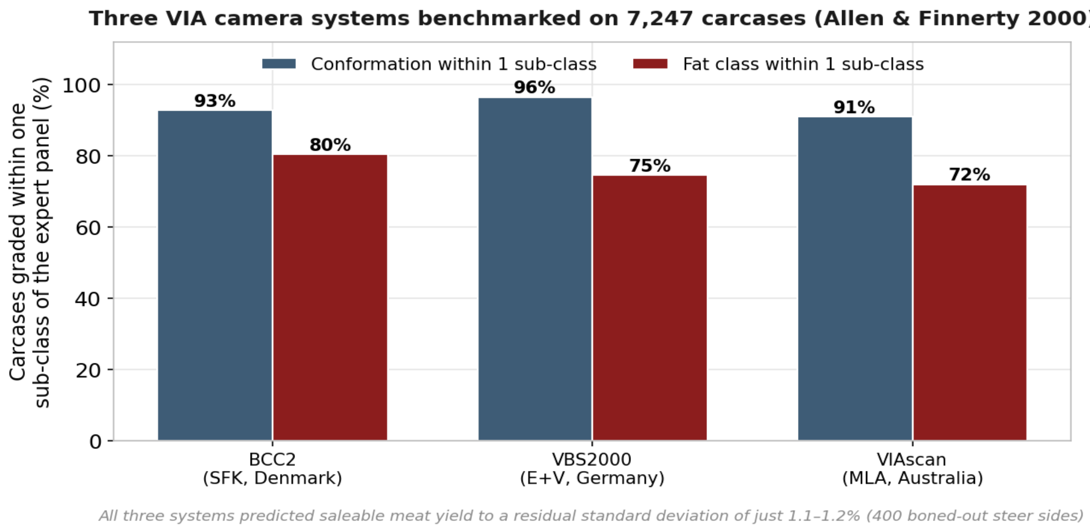


Figure 21. Camera grading is not new: three video-image-analysis systems benchmarked on 7,247 carcases each graded conformation within one sub-class for 91 to 97 per cent of carcases and predicted saleable meat yield to a residual standard deviation of 1.1 to 1.2 per cent (Source: Allen and Finnerty, 2000).

Seeing these surface camera technologies operating at commercial speed was very impressive. Conversations with both producers and processors consistently reinforced the same message: objective grading provides greater transparency across the supply chain. The grade is the grade, leaving little room for uncertainty or dispute.

Although much of the commercial company data on predicting saleable or lean meat remains confidential, through the conversations I had with companies and manufacturers abroad, it was clear that this technology can predict carcase yield and commercial cut weights accurately. One processor I visited was pairing this tech with a JBT Marel streamline system to be able to account for every kg of saleable red meat that should be harvested, based on each individual carcase entering the boning room and benchmark what should be packed into a box.

Other benefits highlighted during my travels, beyond yield prediction that could benefit the Australian industry includes:

- The ability to sort carcases while hot into chillers according to market categories, aligning better to production plan and customer specifications.
- When paired with a hot probe that can grade eating quality, it removes the need post-chill sortation in a marshalling room post chilling, saving time and thousands in labour costs each day.
- Objective hump height measurement.
- Objective dressing compliance.
- The ability to spot carcase contamination that may be difficult for the human eye to identify and direct trimming where required, providing benefits to shelf life and food safety.
- Assessing pelvic bone shape to collect phenotypes associated with improved calving ease and potentially many other internal visuals that are yet to be discovered.
- Sharing actual grading images to producers and customers that builds trust and transparency throughout the supply chain.
    - A cool example of this was when I was in Denmark, a carcase passed the BCC-3 camera towers and was graded. The image was pulled up to its 3-D graded model

(Figure 22), and not only could the Danish Crown team share the exact image with a farmer or customer, but they could also reprint this carcase with a 3-D printer due to its accuracy, very cool paperweight! (Figure 23/24).

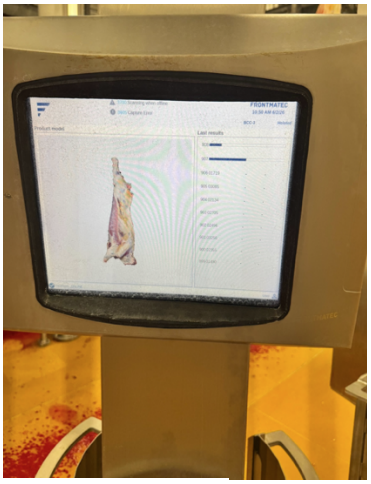


Figure 22.

Figure 23.

Figure 24.

Figure 22, 23, 24. Danish Crown image & 3D printed carcasses (Source: Author).

Lower-cost and complementary technologies

Not every plant can justify the size and expense of a DEXA tunnel, so a tiered set of options matters. A hand-held microwave system (Figure 25), created in Australian by Murdoch University, offers a low-cost, easily deployed measure of fatness. It is accredited for grade-rule tissue depth in sheep, has been tested at 12 carcases per minute, and predicts fat depths in both live cattle and carcases, albeit with less precision than DEXA (Gardner et al., 2024). This is the very device we used to confirm P8 fat selection in the bone out trial, and it is now being trained to predict CT lean percentage at Teys Australia's Rockhampton abattoir.

Figure 25. A hand-geld microwave system (Source: Author).

I also had a catch up with the team at Texas Tech University, who are partnering with the Australian Wagyu Association to trial the use of both artificial intelligence and 3-Dimensional imaging to predict red meat yield on a smart phone/tablet. If this can be anchored to CT, it also has potential to be a cheaper, more viable option to for industry to explore.

Other tools fill specific gaps and pair with objective carcase composition this is where industry can really enter its next frontier. Near infrared spectrophotometry predicts intramuscular fat post-chill; needle probes, nuclear magnetic resonance and X-ray systems target intramuscular fat pre-chill; and three-dimensional imaging systems predict yield and have been adapted for live cattle on a drafting race (Gardner et al., 2024).

Table 3. Summary of objective yield technologies considered (Source: Author).

Technology	Speed	What it measures	Maturity for beef yield
CT	Slow / reference	Fat, lean, bone (whole carcase)	Gold-standard reference only
DEXA	Chain speed	Fat, lean, bone %; cut weights	Proven in lamb; strong beef prototype
BCC3 / VBS2000 (VIA)	Chain speed	Conformation, fat cover, yield	Commercial overseas; trials in Australia
Microwave (hand-held)	Chain speed	Fat depth; training to lean %	Accredited in sheep; low cost

My read of the landscape is that there is no single right answer. The fully integrated, automated plant scanning chilled sides for robotic boning will favour DEXA; the high-throughput plant that wants a fast, safe yield grade on the hot chain will favour a BCC3 or VBS2000 cameras; and the smaller operation may start with Microwave measuring fat depth, or 3-D imaging, if or when it gets traction.

For accrediting these technologies there are four ways that we can measure to predict lean meat yield as our reference standard and that includes: CT measurement (expensive and slow), grounding up a whole carcase into meat, fat and bone as test tube measurements (expensive, slow and product can't be used post), objectively measuring fat depth (not as accurate as the first two) or setting a commercial spec for lean or saleable red meat yield across all of industry, as the reference standard (no matter how slowed down the carcase breakdowns are, there will be variation in the boner/slicer achieving this). Whichever the method, it is my opinion that in order to make a national yield language possible, training and accreditation of a reference standard must be anchored to CT and that would establish a common source of truth.

Although there may be no single right answer for the technology, I strongly believe the Australian industry is at a crossroads, where we can embrace this technology and take this opportunity seriously, recognising their potential to be paradigm shifting for profitability and efficiency, or we can stay where we are and risk falling behind the rest of the world in innovation and competitiveness.

Australia currently has one of the best eating quality grading systems that translates to higher market pricing and QA procedures that gives industry one of the longest product shelf life's I've seen globally. However, other countries are and will catch up, and a lot of our biggest competitors have much cheaper input costs than Australia, particularly for labour. To remain globally competitive, Australia cannot afford to stand still when it comes to creating an objective yield trait.

Chapter 3: Adoption, installation and accreditation

A technology that works in a research trial is not the same as a technology that an industry trusts enough to move and invest in. The bridge between the two is a rigorous chain of reference standards, accreditation, calibration and auditing, plus the physical reality of installing equipment in a working plant, not to mention the mindset of change which can sometimes be a bigger barrier than the technology itself.

This chapter draws heavily on the European and Australian systems I studied, because they show exactly how this is and can be done. Most of the companies I visited and or spoke to were, or had transitioned to these objective technologies, as it took away any questions or variation that can be prone to subjective human grading. They all had a similar story about the accreditation process, and it will be a similar one here. It will take time, alignment from the whole supply chain and needs to be completed to an objective trait the first time. There is no room for error or variance once the objective trait goes live and businesses begin to trade on it.

The reference method: learning from the Danish CT system

The most instructive system I saw was the Danish reference method based on CT, developed by the Danish Meat Research Institute (DMRI), that calibrates the on-line classification of pig carcases. The method scans an entire carcase, producing an image every 10mm, with each voxel, measuring one by one by 10mm assigned to fat, meat or bone. This creates a virtual dissection that parallels what a butcher does with a knife (DMRI, 2011).

It is governed by a tightly specified protocol, 140 kilovolts, 80 milliamps, a 47cm field of view, a defined standard carcase preparation, and it is rigorously validated. Repeated scans of the same carcase under different protocols and scanners track each other almost perfectly, and the predicted carcase weight can be checked against the actual weigh within 150g at 70% confidence, giving an immediate quality control on every scan (DMRI, 2011) (Figure 26).

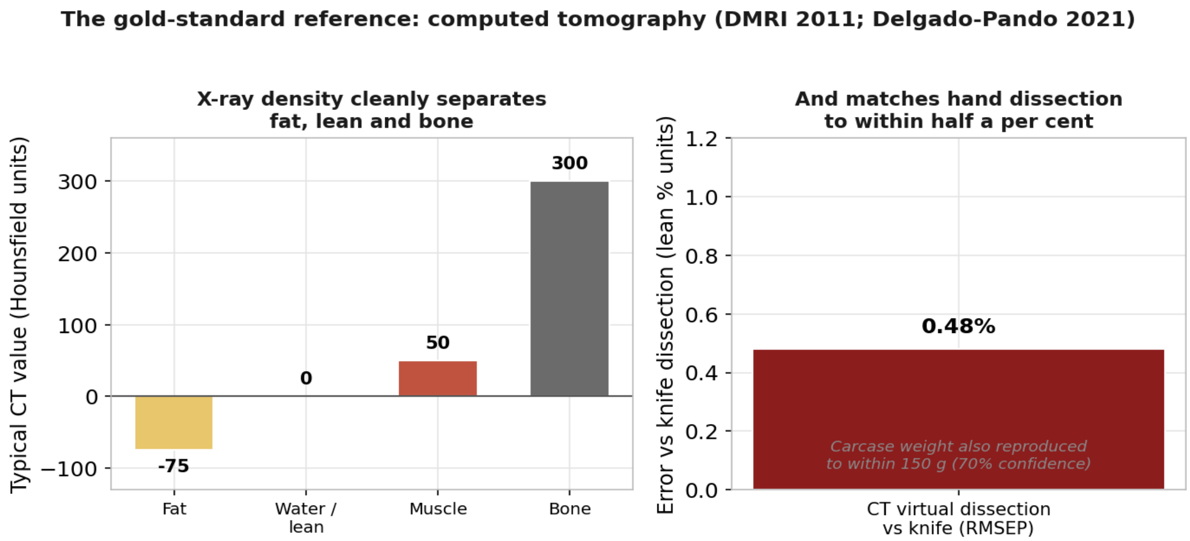


Figure 26. The gold-standard reference: computed tomography separates fat, lean and bone by X-ray density and matches knife dissection to within 0.48 lean % units (Source: DMRI, 2011; Delgado-Pando et al., 2021).

The Danes treat the reference method as an asset, marketed as objective, versatile and capable of primal yield prediction; once the reference is sound, any new on-line device can be calibrated against it. The European Union codifies this in Commission Regulation (EC) No. 1249/2008, which lays down the rules for classifying beef, pig and sheep carcases. Australia does not need to invent this from scratch, it needs to adopt the same discipline, establish a trait that suits the Australian industry and anchor it to CT calibration.

The final phase of the Teys Rockhampton work is, to my mind, the most important piece of measurement research underway in this country. The plan is to regenerate the bone-out on carcases that have been measured by every candidate technology at once, including DEXA, microwave and three-dimensional surface imaging, as well as CT (Calnan and Gardner, 2024).

Every technology would be trained to predict the same trait, CT-derived composition, rather than each chasing its own definition of yield. This has the potential to create a common reference standard for industry adoption. An additional bonus is that any device trained against CT could also inherit the cut-weight prediction equations, meaning future adopters of a technology may not need to fund or complete their own bone-out (unless their commercial cuts specifications differed from the cut weight equation specifications during the reference standard accreditation).

The objective should be to build agreed reference standards for lean meat yield or saleable red meat that can be accredited and routinely audited to ensure compliance. Once the industry has established what good performance looks like, appropriate price incentives can be introduced to encourage genetic improvement on farm. This is precisely the architecture that the Danes built for pigs and as I continued to learn on my travels, the more I believed Australia should be pushing this adoption for beef.

The AUS-MEAT accreditation pathway

Australia already has the institution required to make yield official: AUS-MEAT, which governs the trading language and standards as well as accrediting measurement technologies. The accreditation model that was developed through the Advanced Livestock Measurement Technologies project (ALMTech) is a great example of this.

A technology must demonstrate that it can predict a robust reference value within minimum error tolerances, tested across carefully designed sample sizes. For CT composition, accreditation requires 20 carcases to be scanned within every quarter of the accreditation range, repeated across three weight categories, amounting to 240 carcases for full coverage. For beef intramuscular fat, 25 samples are required within every three-unit increment, with a minimum of 80 samples (Gardner et al., 2024). A Markov chain Monte Carlo analysis is used so that random outliers do not unfairly cause a technology to fail, while keeping sample numbers, and therefore costs, contained (Gardner et al., 2024).

Once accredited, the technology's calibration method and reference values are formally described so that AUS-MEAT can establish routine auditing. By doing this, it removes the expensive accreditation process that then only needs to be completed once (unless there are major changes to the device). Daily calibrations and routine audits can then ensure that the agreed trading language and standards are upheld across the supply chain. Currently, all accredited technologies used for commercial trading are listed publicly on the AUS-MEAT website, signalling compliance to the wider industry. This is the model that a yield trait should follow.

Calibration, drift and consistency across plants

Calibration is not a one-off event and like any technology, whether it's a set of scales at an abattoir or an x-ray machine in a hospital, all technology will require calibration and in this case prior to starting the day and potentially multiple times throughout the day if required.

It is not unusual for technology to stray or deteriorate over time as it gets older, which is exactly why the robust procedures for calibration and auditing must be created and consistently followed through. By doing this it will ensure the technology does not drift from the agreed objective reference measure.

For example, DEXA systems are standardised against a synthetic Nylon-6 block. Even so, a small '"kill group"' drift was observed across 100 days despite phantom adjustment. The researchers attributed this to machine calibration, highlighting the value of more frequent and multi-point calibration, especially as the same technology is rolled out across multiple plants (Connaughton et al., 2020).

In practical terms, effective national calibration should ensure that a carcase scanned or processed at Australian Country Choice receives the exact same grade as it would at JBS Riverina, every day for the next decade plus. A national yield trait cannot be unique to one accredited device or facility. It requires a national calibration and audit framework that keeps every installation consistent and accountable. I'm not saying that everyone must install one, that's up to each business independently, but if they do, and they wish to trade commercially based off the grading of the device, it must be accredited and calibrated to the national standard.

There is also a gap to close. The prototype beef DEXA was validated on cattle drawn from a south-eastern Australian abattoir, a population that is highly representative of southern Australian production but less representative of the Bos indicus-cross cattle produced across northern Australia's rangelands under arid, sub-tropical and tropical conditions. The researchers themselves flagged the need to validate the equations on a larger, more diverse population of cattle in a commercial setting (Calnan et al., 2021). The gap, however, is narrowing, thanks to the great work being done in this area. Industry is getting closer, but industry organisations, and the RDCs need to continue to fund and back this innovative work. If rolled out correctly, the potential return on investment will be immense.

Installing the hardware in a working plant

The practical barriers are real but solvable, and they differ between devices. DEXA requires an X-ray-shielded tunnel through which the chain is diverted. Where a plant already uses X-ray imaging to drive cutting automation, this is a simple upgrade, but in most cases new floor space must be found and site works undertaken (Gardner et al., 2018).

To capture the full value of pre-fabrication sorting, a plant also needs the ability to identify and track individual carcases through the chilling period, using hook tracking and automated lines would also assist to reduce human error for traceability. However, many plants do not have this capability yet.

Surface-imaging cameras such as the BCC3 (11.54m²) and E+V (3.75m²) are far less demanding, needing no shielding and requires far less space. This is why they are often the entry point, particularly on the hot chain, where they all offer the benefits of sorting carcases into chillers.

Industry appetite does not seem to be a barrier, from processors wanting to innovate. A survey of 65 Australian red meat processors found that 88% considered on-line measurement to have a role in the future (Toohey, Van de Ven and Hopkins, 2018). However, there are hurdles that we need to overcome with initial significant investment, requiring on/off-site expertise for operation and maintenance and workforce availability in remote areas. This is why industry needs to focus on the attraction and recruitment of Science, Technology, Engineering and Mathematics (STEM) aligned workers as this technology evolves, develops and is adopted. Our workforce will need to evolve too, not only to keep these systems operating but also to adapt to change, working alongside new technologies and embrace their capabilities.

From my perspective, as a producer that sells cross bred cattle through the Wagga sales yards and through my experience working within Australia’s biggest fully integrated beef supply chain, none of these barriers is a reason not to act. They are challenges that the entire industry must collectively embrace, fund and overcome. Responsibility cannot sit at only one end of the supply chain; we need to be working together to achieve these common goals.

Adding a yield trait to the trading language

The final and most important piece of adoption is not hardware at all, it is language. Australia has done this before through ALMTech, intramuscular fat was introduced into the beef and sheep trading language, alongside carcase lean, fat and bone percentages for sheep.

Establishing a new trait requires a clear link to commercial value, a proven and repeatable gold-standard reference, and a cost-effective way to generate the calibration and audit data (Gardner et al., 2024). The path is currently being mapped: the industry needs to fund and embrace it, so that a yield trait can sit on an over-the-hooks grid alongside carcase weight and MSA eating quality traits.

I see this as a way of truly unifying industry for the better. If a nationally accredited trait can be agreed to that is anchored to CT, supported by transparent feedback that is linked to meaningful genetic price incentives for producers. Australia will enter a new frontier for the beef industry, that captures objective data to maximise and extract the full value of a carcase (Figure 27).

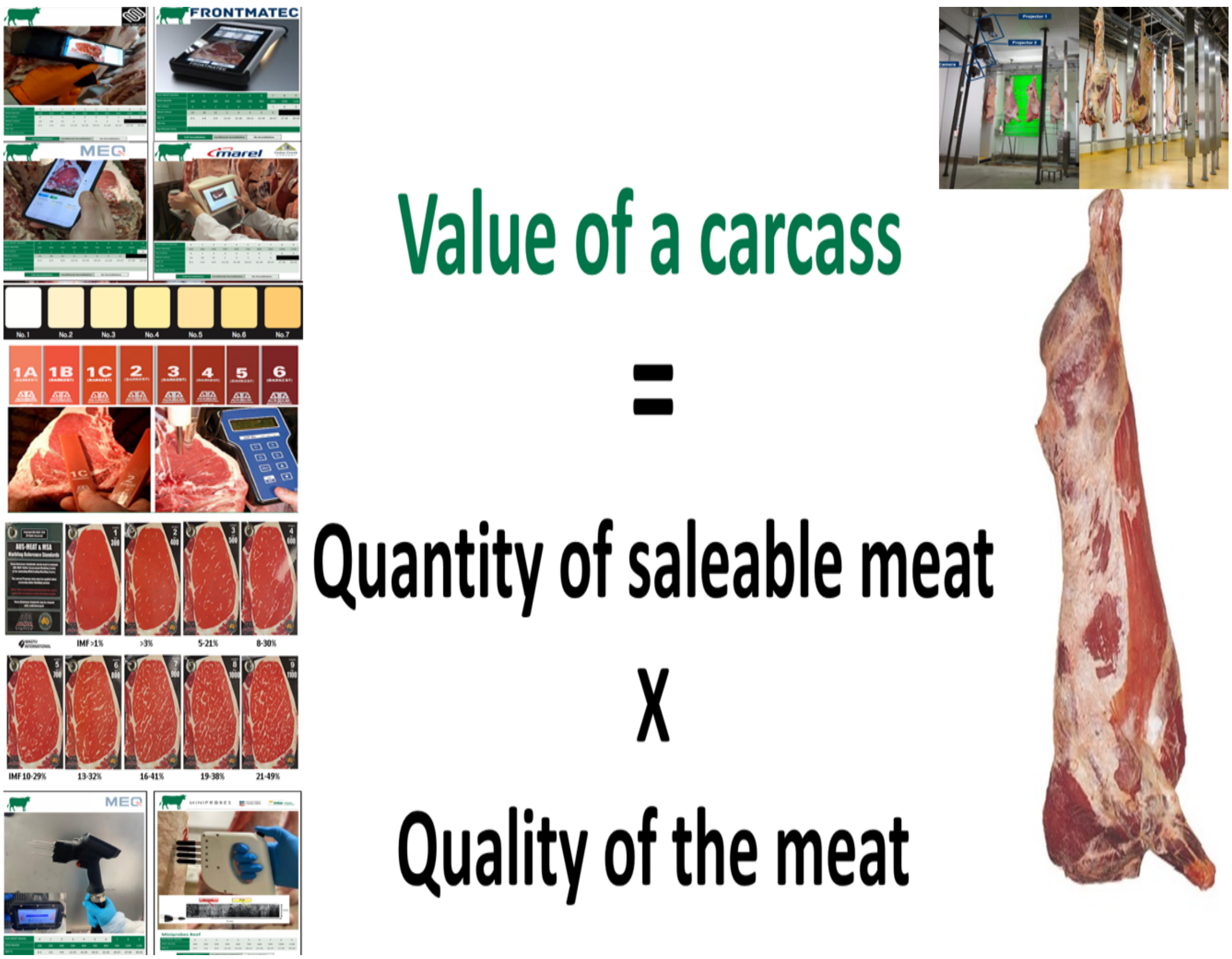


Figure 27. Extracting the Full Value of a Carcase (Source: Author).

Chapter 4: The business case for measurement paired with transparent feedback

Measurement on its own is a cost and only benefits one part of the supply chain. Measurement paired with transparent feedback and aligned with payment is a transformation. This is the argument I care about most, because I have watched the impact that value-based signals have had on eating quality for this country in global markets, and I am convinced that yield is the next, and possibly a larger prize. This chapter makes the business case and sets out how the pieces fit together.

Why feedback is the multiplier

The technology only changes behaviour if the information flows back to the people who can act on it. When new measurement traits were introduced through ALMTech, they delivered benefits on three fronts at once: technology providers gained the confidence to commercialise because achievable accreditation standards existed; processors gained the confidence to invest and to establish payment grids based on the measurements; and data flow into genetic databases, industry systems and producer feedback was enhanced (Gardner et al., 2024).

That third point is the multiplier. A measurement for yield that stays inside the plant improves sorting and boning-room benchmarking, which is worth real money, but represents only a smaller piece of the pie. A measurement that flows back to the producer and changes what gets bred and fed, will compound in value year after year.

The standout feedback system I saw during my travels was observed in Ireland where I learnt from producers, processors and research bodies about what is, in my mind, a world-leading traceable feedback system where producers are rewarded based on true animal and carcase performance.

The Irish Cattle Breeding Federation (ICBF) is a non-profit organisation that exists to provide Irish beef and dairy producers with transparent performance feedback with the intent to promote genetic improvement, so profitability and efficiencies can be pick up across the whole supply chain. Every animal is required to have an electronic identification ear tag (EID/RFID) shortly after birth, which allows full traceability throughout its life. This can be thought of as the animal's identity card. We have similar in Australia, but it is usually added at branding or later in life, but the Irish go to another level for the national herd. From there, the animal is genotyped to create a record of its full genetic lineage. Because of how extensive this process is, the Irish have developed an incredible national breed plan for their entire cattle herd.

Throughout the animal's life, increased information is added to its EID and collected in the ICBF data base, from animal health details to the carcase grading and all aligning to what the producer is paid. What this system has bred, are the right behaviours across the supply chain. Producers receive the information they need to make precise genetic selection on farm, and they are then rewarded by processors because a greater proportion of their carcases are consistently achieving the top of the pricing grid. I was able to confirm this through discussions with Irish processors, producers and technology manufacturers. The national breeding plan is giving producers the opportunity, if they wish to, to breed the best animals they can, knowing that they will be compensated for doing so. This is something I believe the Australian industry needs to improve. Fully integrated corporate supply chains in Australia already have these capabilities, and now the Irish have proven that non-integrated supply chains can do the same (majority of the Aus industry), if the right architecture is put in place.

One great piece of transparency I saw in relation to this conversation around feedback is (figure 28), an Irish processor who had a viewing room for any producer who was selling cattle to them. The window was located at the objective grading station and the screen on the right populates the producers/company name, animal ID, all grading data (EUROP) and the price for the carcase based on the payment grid. This simple but great piece of transparency allowed producers to not only see visually what good looks like but, also receive feedback that allows them to make better genetic decisions and to target the top of the grid more consistently. Why? Because it is objectively measured and therefore can be actioned with extreme accuracy and confidence.

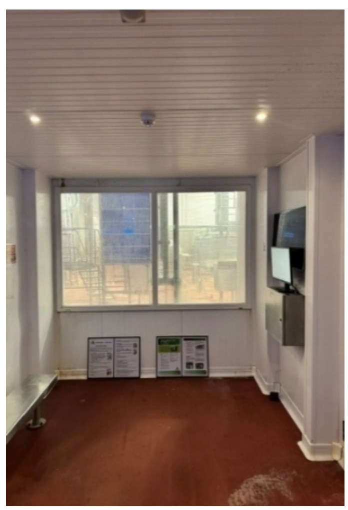


Figure 28. Viewing Room, Ireland (Source: Author).

Although our feedback system in Australia is robust when trading over the hooks, there is room for improvement, as I have highlighted in previous chapters. Take Teys Lake's Creek as an example - it currently returns carcase composition feedback to its producers, based on our existing measures of HSCW, P8 fat, Eye Muscle Area and Rib Fat. However, these measures do not tell the full story of carcase composition. They represent the best information available from human assessment using a ruler, and while this approach has served industry well, it is no longer the standard we should aspire to.

The same plant now has a DEXA system scanning every side, and a prototype equation capable of converting those scans into CT-referenced lean and fat percentages that the researchers expect to outperform the equation currently in use, even before full calibration (Calnan and Gardner, 2024). Deploying it is no longer a scientific question; it is an integration question. The prediction equations must be applied automatically to every scan, carcases must be reliably identified through radio frequency identification, and the outputs must flow into the feedback systems the plant already runs (Calnan and Gardner, 2024). Get those three things done and Lakes Creek becomes the first abattoir in the country to report DEXA-derived lean meat yield back to the producers who bred the cattle!

I do not think the industry has fully registered what that would mean. It is not an incremental improvement to a feedback report. It is the first time an Australian producer would be told what their cattle yielded, measured objectively across the whole carcase rather than inferior measures from a fat depth. It is the moment of where the loop I have argued throughout this report, based off real data closes for the first time. Everything else, the trading language, the grid, the breeding values, becomes buildable once that number for lean meat or saleable meat yield exists and is trusted. My strong view is that this deployment should be treated as an industry priority rather than a single company's project or responsibility, because the first plant to do it proves the model, for everyone who follows.

Our own bone-out work shows why the current feedback is failing producers, while the evidence presented earlier also demonstrates shortcomings of current systems for producers, and others selling stock solely on live weight. There is currently little incentive to push for eating quality or, hopefully soon, objective lean meat yield and why a better feedback system is what will change this. We must remember though, that these current systems were once considered best practice and reflected the technology available at the time. However, the technology has now evolved and so too must the industry.

When a producer can be ±$300 a carcase (referencing our bone-out work above), the signal that should be guiding their genetics and feeding decisions is simply lost. An accurate yield measure restores that signal and now we have the technology to achieve this.

As I have mentioned before, the right price signals must be established if we want to see real change. Feedback, regardless of the route to market, needs to be provided to producers, like the ICBF model in Ireland. What the industry needs to work towards is a system where if a producer sells through a sale yard and is paid on live weight grid but achieves superior objective eating quality and yield scores at processing, they then should receive a bonus paid by the processor. This then rewards and recognises that those carcases that are worth significantly more, than those that fail to meet quality and yield specifications. There may be exceptions to this rule where traders or feedlots may buy animals to background or feed, to then on sell to a processor when at the right weight spec. However, the way I see it is if the right feedback system is created, those traders and feedlots will position themselves with superior livestock producers/partners by paying a premium to source those superior cattle. As they will know a bonus will be achieved off the back of superior genetics and feeding, thus creating a bonus payment naturally over time. If you reward the right behaviours, in this case carcase quality and yield, you will start to see greater consistently, with more animals arriving at the processing plant that consistently meet the top of the pricing grid. Money talks and that's what will drive real change.

There is no better domestic example of this working well than what Gundagai Meat Processors (GMP) have achieved with their in-house objective grade, GLQ5+, which rewards producers with a bonus when they achieve a favourable carcase yield aligned to commercial specs and targeted eating quality traits. Not only does GMP reward producers for superior carcase performance, but it also provides feedback around animal health, which helps producers manage animal health issues on farm. This benefits producers by reducing productivity losses for sick animals that go backwards, while also reducing the volume of condemned offal available for GMP to market and sell.

This is a perfect example of where transparent feedback, implemented with the right price incentives, drives the right behaviours, where everyone benefits in the supply chain. A producer is rewarded on true carcase performance if the right on farm decisions are made, and the processor justifies this bonus because they are able to pack more saleable product into a box and also capture additional premiums in the marketplace through improved eating quality.

Fully integrated supply chains like AACo, Australian Country Choice and many other paddock-to-plate brands already have the advantage of using carcase data and feedback to increase productivity and profitability, as they own their whole supply chain. However, this level of data access should not be a luxury available only to fully integrated businesses., It should be accessible to all producers, regardless of their route to market. Transparent feedback supported by meaningful price incentives, is the true enabler for all of this to work and for the Australian industry to become a world leader in both quality and yield.

Paying for yield: lessons from pork and the value-based model

The clearest working example I saw of a yield-based payment system was in European pork. Under the SEUROP system used by processors such as Danish Crown, the payment matrix is built on grade class, driven by lean meat percentage, and hot carcase weight. The grid below defines an optimal pig, in one example a lean meat percentage of 65% at a hot carcase weight of 96kgs, that maximises farmer income (Frontmatec, 2025).

The point is not the pig numbers; it is the principle: an objective lean measurement is converted directly into a price signal that tells the producer exactly what the market wants and rewards them for achieving it. Beef can do the same. Improved composition or meat yield measurement would let processors link producer payment to both eating quality and yield, moving beef towards a genuine value-based marketing system and giving producers an incentive to use carcase feedback to improve quality and consistency (Calnan et al., 2021) (Figure 29).

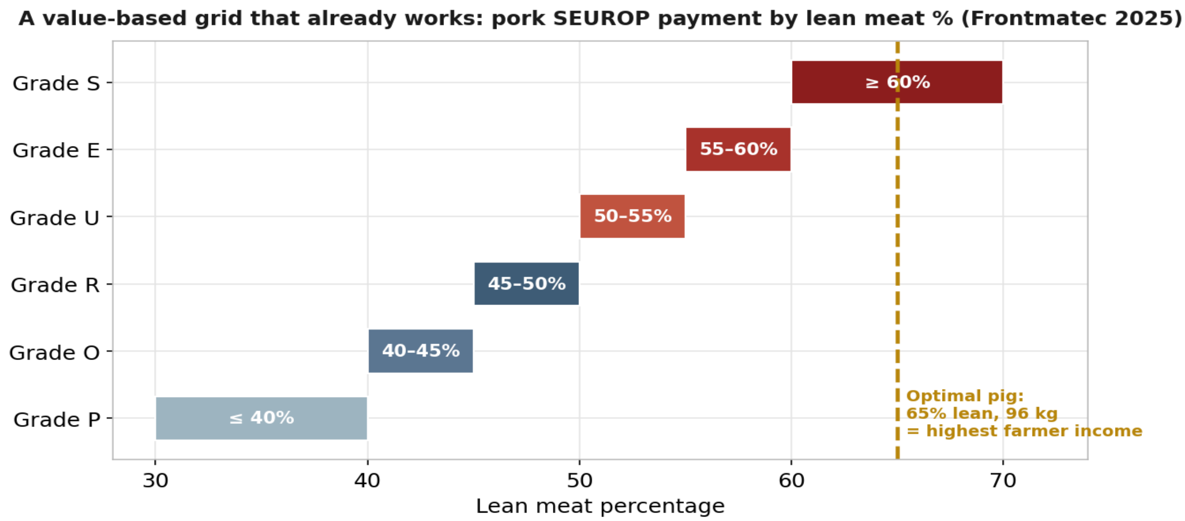


Figure 29. A value-based grid that already works: European pork is paid on lean meat percentage bands, with an optimal pig at 65 per cent lean and 96 kilograms maximising farmer income (Source: Frontmatec, 2025).

If that feels novel, it should not, and it is worth remembering that the science behind it was settled decades ago. As far back as 1990, a joint study by the Danish National Institute of Animal Science and the Danish Meat Research Institute modelled exactly this shift for beef. Using an objective carcase classification centre, they compared the existing conformation-based EUROP payment system against a '"Basis Model"' built on objectively calculated saleable meat, fat trim and muscularity. Their conclusions read like a blueprint for what I am proposing: payment based predominantly on the carcase's true cutting and yield value; payment made more descriptive and more transparent for the individual producer; payment made less dependent on carcase weight; and a single combined value index returned to the producer alongside the detailed result (Madsen et al., 1990).

Two findings from that study matter most.

First, where the old EUROP grid effectively rewarded fatness through a positive relationship between price and fat, the objective Basis Model reversed this, so that surplus fat reduced the price and muscling and yield were rewarded, the same correction my own bone-out data suggests is still missing in Australia today.

Second, the authors anticipated the genetic consequence we now take for granted: that selection for muscularity and cutting yield would gain economic importance, and that fat-prone breeds would be downgraded while muscular ones were upgraded. Thirty-five years on, Australia finally can acquire chain-speed technology to deliver what that study could only model on paper. The case has been proven for a generation; what has been missing is the means and the will to act on it.

The reviewers of the global state of play reach the same conclusion: combining yield and quality measurement most accurately describes the true value of a carcase, and objective systems, coupled with international standards, could deliver genuine value-based marketing with clear, transparent price signals between consumers and producers, which in turn would direct genetic selection (Delgado-Pando et al., 2021).

Australia is very well placed to lead this, because we have already built half of the required framework through MSA. However, as with the introduction of MSA, the entire supply chain will need to be educated and support producers through the transition. Clear communication and extension will be essential to ensure everyone has the opportunity to succeed through improved genetic and management decisions.

A complete carcase language: eating quality and yield together

Australia's great advantage is that we have already built half of the value-based system the world is reaching for, and I saw evidence of this during my travels where AUS-MEAT marble scores are starting to be adopted within European supply chains. What we have never had is the other half: an equally objective, equally trusted measure of how much saleable meat a carcase yields. My argument is simply that yield should run adjacent to MSA, not instead of it or ahead of it, so that a carcase is finally valued on the full picture of what it delivers.

Running the two together also resolves a tension I see every week in our Wagyu production. Marbling and yield can pull in different directions, however, there will always be animals that can achieve both, and the only way we will identify them is by measuring both traits objectively. A system that rewards only one will distort breeding and feeding decisions towards that single outcome. A complete carcase language, combining eating quality and yield, lets producers optimise for total carcase value rather than chasing a single number, while also enabling processors to pay for exactly what they want to be packed into a box and sold in market.

Who benefits, and the route-to-market principle

A fair question, and one Frontmatec poses directly, is who benefits from grading: the producer, the processor, or both (Frontmatec, 2025)? My answer is both, but only if the system is designed that way. The processor benefits immediately from more accurate carcase valuation at purchase, from pre-fabrication sorting that maximises saleable meat into the highest-value markets, from boning-room benchmarking that compares expected with actual yield, and from more uniform cut sizes for retail customers (Gardner, Anderson et al., 2021).

The producer benefits when the premium for a high-yielding carcase is actually paid back to them. In my opinion you cannot have one without the other. The additional value created through objective measurement must be shared across the supply chain, if we want to drive meaningful change and unlock the next level of performance for the Australian beef industry.

This is where I feel strongly about a route-to-market principle. The reward for yield should be attached to the carcase's actual measured performance, regardless of whether the animal was sold over the hooks, through a saleyard, or out of a feedlot, just as it should for eating quality.

In the short term, yield can be built into the over-the-hooks grid for direct consignment. Longer term, a producer who sells through a saleyard, then onto trader or feedlot should still be able to receive a bonus off the back of feedback once their cattle are graded and processed, if they hit the required yield and quality grade. Which as stated above I believe that bonus comes naturally based on industry partnerships between producers and feedlots/traders will align themselves together off the back of feedback architecture that rewards the implementation of better genetic decisions on farm.

Crucially, the reward is for the saleable red meat kilograms present before the carcase enters the boning room. If yield is then lost due to boner or slicer error, that becomes the processor's responsibility rather than the producers. That clear line of accountability is what makes the whole system fair, and what gives producers the confidence to trust the measurements and change their breeding decisions.

If the evidence in this report is not enough to convince you that paying more for saleable red meat yield as the biggest profitability driver for the Australian beef industry in recent times, then let me put this statement in front of you to think about. Eating quality grading is grouped into production runs of multiple head, and the price of that eating quality is influenced or valued at a market price that a customer justifies paying for it, at that point in time. This can fluctuate and that price can change tomorrow based on what the market is willing to pay, or the impact of geo-politics. Yield is different in the sense that it is individualised by each animal. An extra kilogram sold, no matter what the customer dictates the market price to be at that time based on eating quality, is still an extra kilogram harvested through better genetic selection. Another kilogram more than you would get off a carcase next to it that may be genetically inferior for yield but has been graded the exact same on eating quality in that production run, and more than likely gets packed into the same box. If the price for quality froze and yield increased, through genetic selection for carcases that carry more saleable red meat, industry profitability goes up.

Genetics, sustainability and the size of the prize

The compounding value sits in genetics. Once yield is measured and fed back, producers can build and use breeding values for yield, conformation and fat coverage, in the same way the sheep industry uses breeding values that demonstrably shift carcase fat, lean and bone (Anderson et al., 2016). With consistent feedback, a producer can assess how their genetics stack up across the herd and breed towards higher-yielding animals, whilst also achieving eating quality. The target I keep coming back to is moving a heavy grain-fed animal from an average of around 300kgs of saleable red meat per head towards 315kgs or more, well within the roughly 34.99% lean-meat-yield spread we see within a single mob or a standard deviation of 6.40%. At $10 to

$30 per extra kilogram, the per-head returns are substantial, and across a national kill of hundreds of thousands each week, the pay back will be enormous.

There is a sustainability dividend too. Harvesting more saleable red meat from the same animal through better muscle conformation and less waste, lowers the emissions intensity of every kilogram of beef and reduces the cost of production for both producers and processors. In a world where our customers increasingly ask about the footprint of their food, producing more usable protein per animal is one of the most credible efficiency stories we can tell. Improving red meat yield per carcase also reduces methane intensity (kg CH_4/kg of red meat), creating an estimated value of around $37/t$CO_2$-e (mid 2026). Yield improvement is therefore not only a profit lever, but also an environmental one.

Collaboration: the non-negotiable

None of this works in isolation. The history of objective measurement in Australia is littered with technologies that failed for industrial or accuracy reasons, with only a couple of probes surviving in routine use (Gardner et al., 2024). The successes, including MSA, and the ALMTech rollout, succeeded because processors, researchers, breed societies, MLA, AMPC and AUS-MEAT pulled together around a shared standard. A yield trait will demand the same. What this collaboration might look like: processors must be willing to share what good looks like and pay for it too; researchers must keep the reference methods and calibration honest; the trading language, accreditation framework and genetic evaluation systems must evolve in step with the technology.

The technology is the easy part. The collaboration is the hard part, and it is this part that will determine whether this becomes paradigm shifting or just another good idea.

Conclusions

Beef carcase composition is one of the largest profit drivers in our industry, and yet the variation that matters most is created on-farm, long before the processor, and is currently invisible within the carcase-weight-and-fat-depth system we trade on. The evidence for that invisibility is now overwhelming. Single-point fat measures predict whole-carcase composition poorly and are biased in genetically diverse herds (Williams et al., 2017; Gardner et al., 2018). In our own bone-out, carcases of identical weight differed by up to $300 per side in yield and by up to a 20kg spread in cumulative cut weight, with the leanest under-valued and the fattest over-valued before fabrication even began (Williams, Carter and Gardner, 2025). That variation is largely genetic, and what is genetic can be selected for.

The technology to measure it at commercial speed exists. DEXA describes the overwhelming majority of the variation in beef fat, lean and bone, is not biased by breed, and can predict commercial cut weights, all in under a second per carcase (Calnan et al., 2021; Connaughton et al., 2020; Gardner, Anderson et al., 2021). Surface-imaging cameras such as the BCC3 and VBS2000 offer a faster, cheaper, a safer entry point that is already proven across the Northern Hemisphere, while a microwave option exists for plants that cannot justify costs or space is prohibitive. However, it is crucial for successful implementation that each of the technologies are anchored to the same CT reference standard.

The adoption pathway is also well understood, and AUS-MEAT already has the accreditation architecture to follow, demonstrated through ALMTech. The hardware hurdles, including space, shielding, carcase tracking and calibration drift, are engineering and program-management problems, not scientific ones. Importantly, 88% of processors already see a future role for on-line measurement.

What turns all of this from a cost into a transformation is feedback, paired with aligned payment. The evidence presented in this report highlights how lean-based payment grids are driving producer behaviour, and Australia has already proven the value-based model through MSA. Apply this to yield, with the reward attached to each carcase's measured performance and with the clear accountability line that protects producers from boning-room error, this would close the loop from paddock to box. Producers would gain breeding values and better feeding decisions for yield and quality; processors would gain more saleable kilograms, higher valued product, sorting and benchmarking (potentially an abundance more benefits discussed in chapter two); consumers would gain greater volumes of better primal consistency and higher eating quality in a box, which industry can justify higher pricing off the back of; and the planet would gain a lower emissions intensity per kilogram of beef produced. The conclusion of this report is therefore clear: the science is settled, the technology is ready, and the only missing ingredient is the industry architecture, and the collective will to build it.

If I refer to a statement I made in chapter 1, to highlight the potential of this is. Conservatively take the bone out result and put the average mis valuation to $50 per carcase, as of July 2026 the weekly kill in Australia is estimated at 150,000 animals per week, $50 per carcase totals at $7,500,000 of unrealised value each week. Multiply that by 50 weeks (allowing for maintenance shutdowns) that is a potential $375,000,000 of carcase value industry could be miss valuing for yield, without the ability to objectively measure it and feed that back. Recovering even a proportion of this value through improved measurement and genetic selection would have significant implications for supply chain profitability and efficiencies.

On a personal note, I have spent my career watching the work that goes into rising an animal, from the land my family has farmed for seven generations, through to the boning rooms I help manage today, that is why I chose this topic. The idea that hundreds of dollars in value can be created or lost on each carcase, yet remain hidden because it is neither measured, rewarded nor fed back to the producer, is the gap I want to help close. Australia led the world in eating quality because the industry chose to. We can lead the world again in yield, for the same reason. The tools are in our hands; but the decision is ours to make and support.

Recommendations

1. Invest in objective carcase yield grading technology. Processors should begin installing fit-for-purpose yield technology now, choosing DEXA where automated boning and chilled-side scanning are already in place, surface-imaging cameras such as the BCC3 or VBS2000 where a fast, low-infrastructure hot-chain solution is needed and handheld microwave technology where costs or space is prohibitive.
2. Created and calibrate technology against a nationally accredited reference standard. Adopt CT as the gold-standard reference and run every device through the AUS-MEAT accreditation pathway, supported by a national calibration and audit framework that keeps every installation consistent.
3. Add a yield trait to the AUS-MEAT trading language. Work through the AUS-MEAT Language and Standards Committee to introduce a whole-carcase yield trait, covering conformation and fat coverage that correlates to saleable red meat yield, so that yield-based price points can be added to an over-the-hooks grid, that can be shared between the producer and processor.
4. Build transparent, objective feedback platforms. Deliver carcase-level yield results back to every producer in a form they can act on, replacing carcase/live-weight-only and ruler-based measurement feedback, that masks the true value variation between carcases.
5. Create breeding values for yield. Develop genetic evaluations for yield traits so producers can capture the premium available when the grade is achieved at processing, while not sacrificing eating quality or production on farm, whilst increasing saleable red meat per head across all cattle breeds. Enhancing the value chain the below MLA roadmap highlights (Figure 30).
6. Reward measured performance regardless of route to market. Pay for the saleable red meat yield present before the boning room, whether cattle are sold over the hooks, through a saleyard, or from a feedlot, with processing losses in production worn by the processor.
7. Collaborate across the whole supply chain. Bring processors, producers, feedlots, breed societies, researchers, MLA, AMPC and AUS-MEAT together around a shared yield standard, that runs alongside eating quality, because collaboration, not technology, is the true determinant of success. Red tape, siloed supply chains and a producer vs processor mindset will result in Australia falling behind the rest of the world. The choice is ours to make.

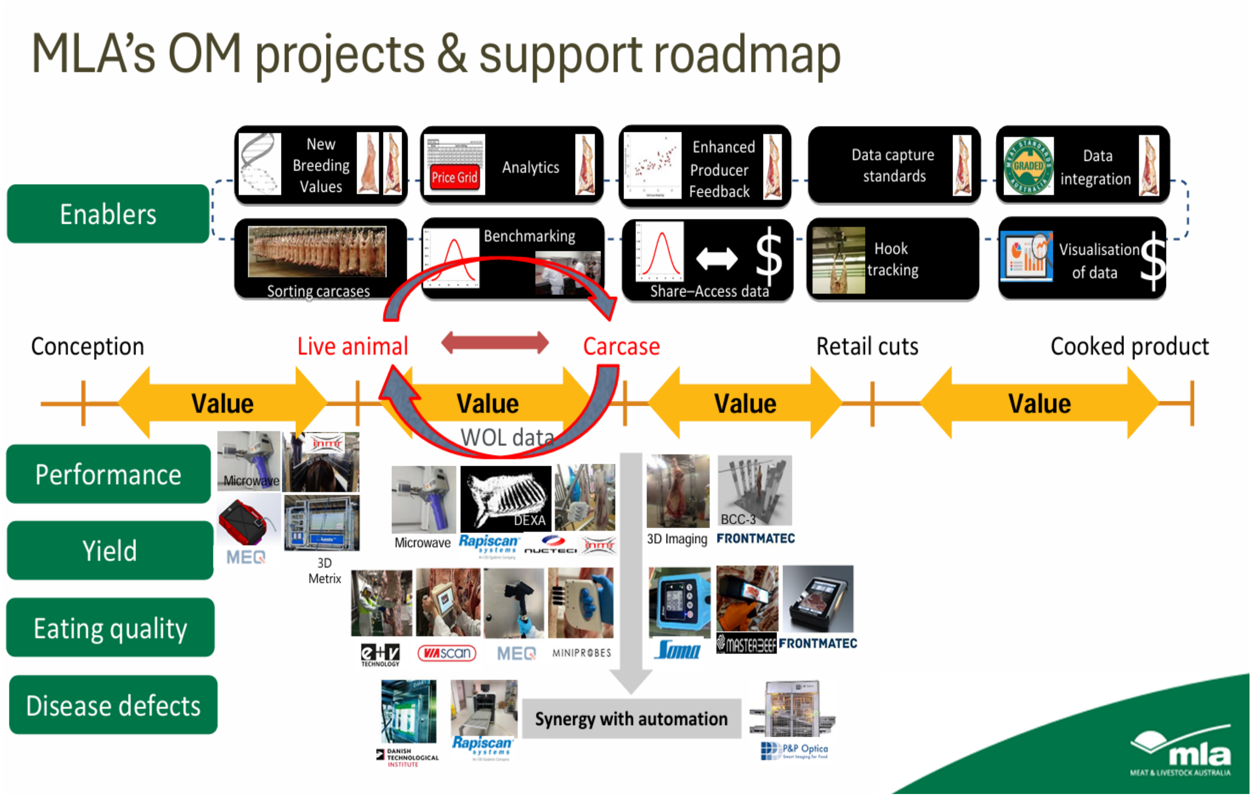


Figure 30. MLA roadmap (Source: D. Gutzke, J. Cook, 2024).

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