CLIMATE-SMART GENETICS - TARGET SETTING FOR REDUCTION OF GHG EMISSIONS THROUGH GENETIC IMPROVEMENT

14 OCTOBER 2022

Genus

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BACKGROUND

Our genetic improvement work helps farmers meet the challenge of producing milk and meat more efficiently and sustainably. This challenge is exacerbated by global climate change and the risks to food security that follow from it. As a result of bovine and porcine genetic improvement, our customers use less land, water and other natural resources to produce more milk or meat than they did some decades ago. We are therefore helping to nourish the world while reducing the impact of agriculture – which is a significant contributor to greenhouse gas ('GHG') emissions.

We achieve this by helping customers breed more productive and resilient animals which produce better milk and meat more efficiently and sustainably. The period between generations varies – it is around 1 year for pigs, and 3-3.5 years for cattle – but we are pursuing the same aim in each case: to ensure each generation has a lower carbon footprint than its predecessor.

We measure this by assessing the factors that shape each animal's carbon footprint during its lifetime. These include inputs to aid their growth (such and feed, supplements and water) and outputs from the animals (including direct and manure-related GHG emissions). By calculating inputs and outputs in this way, we can identify total emissions involved in the production of milk or meat and track the reduction from one generation to the next.

We have now set targets for reduction of GHG emissions through our genetic improvement work in each of our species. These targets were developed following thorough analysis of relevant academic research, assessment of industry practices and validation through our commercial operations. We will evolve them as we collect more data and refine our model, but they form a foundation for demonstrating and continuously improving our role as enablers of low carbon agriculture.

BEEF

GENETIC IMPROVEMENT AND REDUCED CARBON BEEF

Whilst it is not possible to reduce agricultural methane emissions to zero because of the biological and chemical processes at the heart of livestock production, it is possible to reduce emissions through breeding and livestock management. According to the UK Climate Change Commission's independent research[1], animal breeding (selecting animals for the next generation based on beneficial genetic traits) offers the most cost-effective pathway to lower carbon emissions.

This can be achieved through:

Genomics: Genetic improvement can be enhanced by using genomic tools in current breeding goals (the specification of the traits to be improved). This requires farmers to collect performance information on the individual animals which is used to develop the breeding goal. This measure can be applied to 90% of dairy and 20% of beef cattle.

Current breeding: Using current breeding goals to improve genetic material. Current uptake is around 25% for the dairy herd and lower for beef cattle, but this measure is applicable to 90% of dairy.

Low methane: This includes selecting lower-emitting animals for breeding which can reduce the methane emissions in subsequent generations.

The research also refers to the potential role of genetic modification to reduce enteric methane emissions. This is not an activity currently undertaken by Genus in any of its research or production facilities, and is currently not legal within the UK and the EU.

Genus's programmes focus on breeding to improve the efficiency with which beef animals convert animal feeds such as grass and grains into meat over an animal's lifetime. We have developed targets for our SimAngus breed (our T14 line). Over time, as we evolve more sophisticated targets, these will incorporate additional product lines.

1 https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Agriculture-land-use-land-use-change-forestry.pdf

BEEF

OUR BEEF TARGETS

CHANGE IN T14 INDEX EQUAL TO

9

POINTS PER YEAR
(equivalent to a decrease in feed-conversion ratio of 0.27 per year)

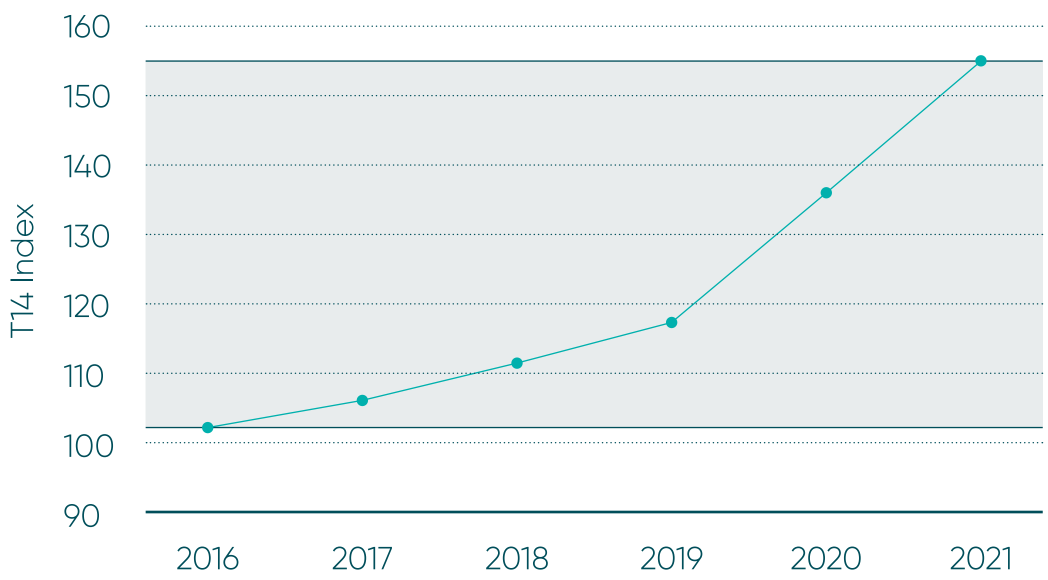
EQUIVALENT TO A YEARLY DECREASE IN CO_2E EMISSIONS OF

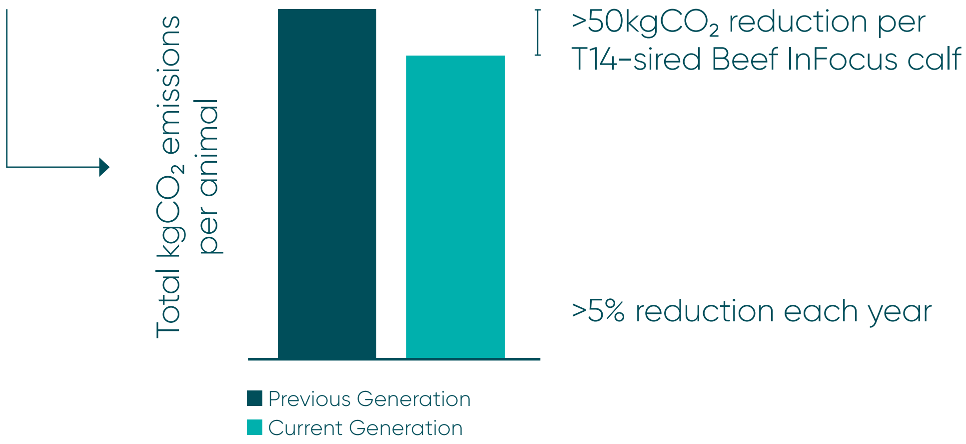
0.1260KG

/ KG CARCASS WEIGHT

NAM BEEF IN FOCUS (T14)

AVERAGE INDEX FOR NUERA T14 ANIMALS



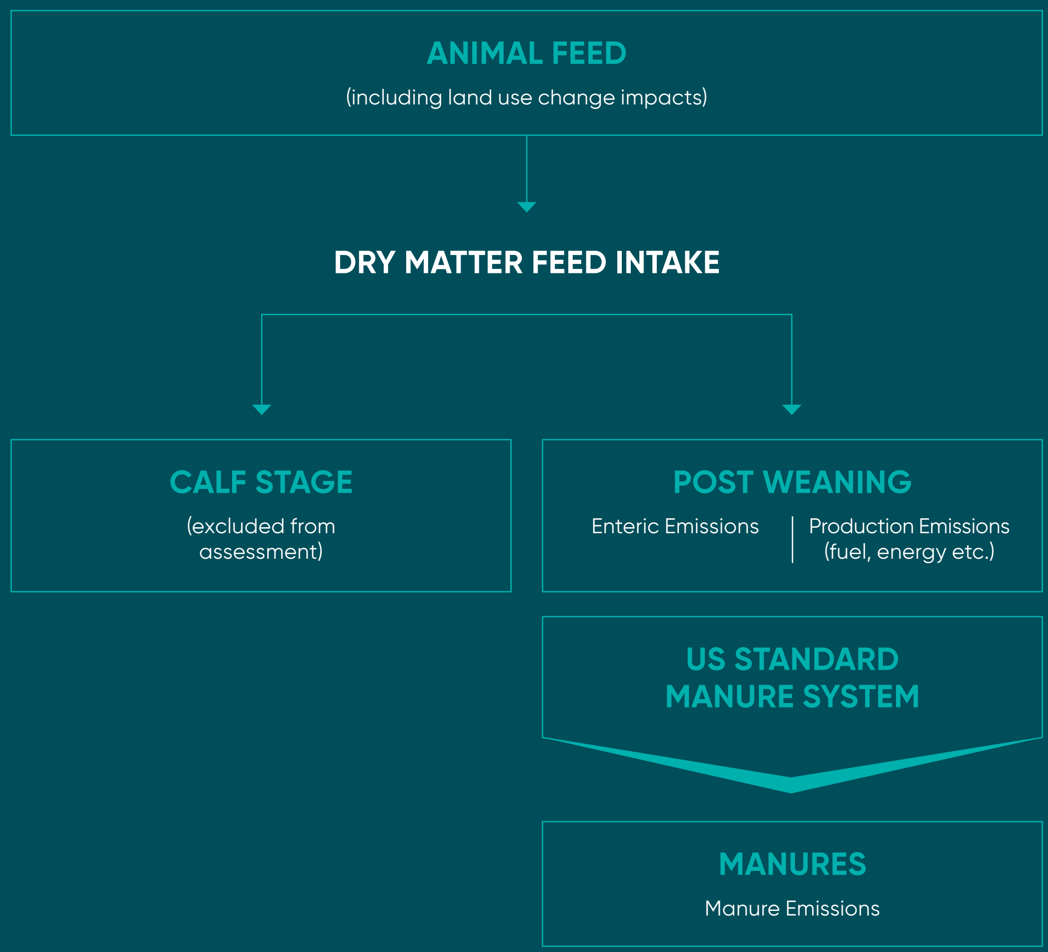


BEEF

HOW WE CALCULATE OUR BEEF TARGETS

LINKING LIFE CYCLE CARBON EMISSIONS TO GENETIC PROGRESS:

The carbon impacts related to production of beef carcasses are measured and applied to part of the process indicated in the life cycle diagram using a standard methodology developed by the Intergovernmental Panel on Climate Change ('IPCC'). The mean T14 Index and feed conversion ratio ('FCR') Expected Progeny Difference ('EPD') were calculated for three birth years and change in FCR relative to progress in the T14 Index overall was evaluated.

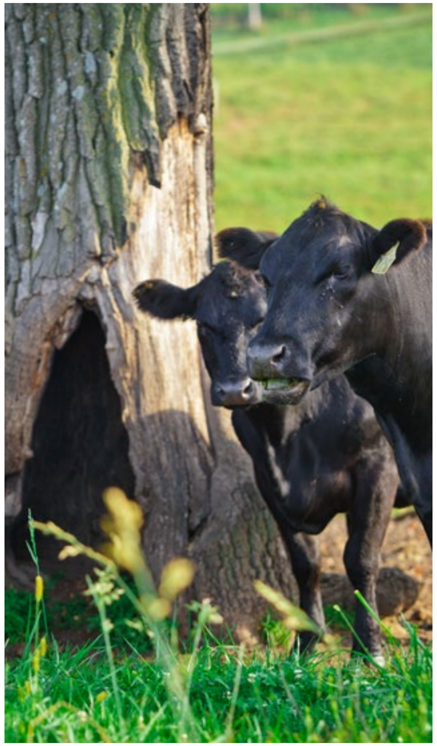


BEEF

HOW WE CALCULATE OUR BEEF TARGETS

THE RESULT – REDUCED FEED MEANS REDUCED EMISSIONS ACROSS THE ENTIRE LIFE CYCLE

Genetic progress on our T14 index was established as a 0.27 change in feed-conversion ratio for 9 points of genetic improvement. As the beef animal requires less feed for the same level of output, not only does this result in a change in carbon emissions directly related to its feed, but also the life cycle emissions related to enteric fermentation, manure methane and all of the emissions used on farm (e.g. diesel, water, waste). The overall result (calculated using the industry-standard IPPC methodology is a reduction of 0.1260 Kg CO_2/Kg carcass weight (where we can maintain a 9 point change in progress).



LIMITATIONS AND ASSUMPTIONS OF OUR MODEL

Methane emissions from livestock are difficult to measure accurately – we therefore use robust IPPC models to assess the volume of methane and other GHGs produced from the feed produced. In calculating GHGs related to genetic improvement, we measure inputs, such as animal feeds and water at the farm level using our own farm-level (Tier II) data and those from collaborator farms. We then calculate emissions from enteric fermentation and raw manures based on commonly used management techniques based on feed-lot production systems. We do not take into consideration emissions at the calf stage of production –assumed to be representative of a typical beef on dairy production system where calves move from the dairy at 1-2 days of age, to a calf ranch, then backgrounding and then to the feedlot.

This draft model was built using the standard IPCC methodology (2019 refinement of the 2006 methodology). The main trait of focus was feed conversion rate in the backgrounding and finishing phases of production, which would account for most of the production phase. Given our current genetic evaluation, we focus on emissions in the feedlot as we can most accurately predict the emissions change based on genetic progress for this phase. Daily weight gain is assumed to be consistent in each stage to assess an 'average' weight. While growth rates would not be exactly linear, impact on the average is likely to be low and the data does not allow for more specific modelling. The energy content of the diet is based on a high forage intake at calf ranch and backgrounder yard, moving to a more grain-based high energy diet on the feedlot. This is based on overview information provided by observations in the field. Refining this with more specific detail (particularly by animal) will provide a more accurate footprint assessment.

Manure storage emissions vary based on the type of system. To allow uniform modelling a standard US split of slurry, solid storage and dry lot storage has been used. This split is defined by the IPCC. FCR is not directly used as a trait in the Index but is represented by the traits post-weaning gain ('PWG') and average daily dry matter intake ('ADMI'). An FCR EPD was calculated from the PWG and ADMI EPD, adjusted by actual days on feed.

PORK

GENETIC IMPROVEMENT AND REDUCED CARBON PORK

In pigs, unlike cows and bulls, only a small proportion (11%) of emissions are produced through enteric emissions, whilst most direct GHG emissions are from pig manures (methane and nitrous oxides). Many producers do not include the carbon costs of producing animal feeds in their analyses, but these can account for 50-70% of GHGs during pig rearing. Pork is the most widely consumed meat on the plant, with China leading global production. Whilst it is possible for producers to reduce GHG emissions by capturing methane from manures and using this for power and heat, genomics can influence emissions and sustainability across the entire process by reducing the demand for land for growing animal feeds, reducing the volume of water required (often in areas where water scarcity is an issue) and in reduced volumes of, and emissions from, manures.

THE IMPACT OF GENE EDITING ON CARBON

Porcine reproductive and respiratory syndrome virus (PRRSv) is an aggressive disease which affects pigs. Highly pathogenic strains of the North American variety of this disease emerged in China in the late 2000s, which are more virulent than the other strains: some 2 million pigs were infected and 400,000 died. Today, the Roslin Institute (University of Edinburgh) considers that PRRSv is responsible for an average of $2.5 Billion a year in financial losses to the pork industry in the UK and US alone[2]. We estimate the carbon impact of this to equate to around 5 Million tonnes per year of GHG emissions from animals which do not ultimately end up in the food chain. Genus is pioneering research which has rendered the PRRS virus almost harmless to pigs, so our food system can remain healthy and sustainable and our animals can have a better quality of life. The gene editing technique deletes a small section of DNA of an animal without introducing genetic materials from other species. This deletion of DNA turns off genes that make the animals susceptible to this disease and our research is being reviewed by regulatory authorities for safety and efficacy.

2 https://www.ed.ac.uk/roslin/content-for-re-use/gene-edited-pigs-resistant-to-billion-dollar-virus

PORK

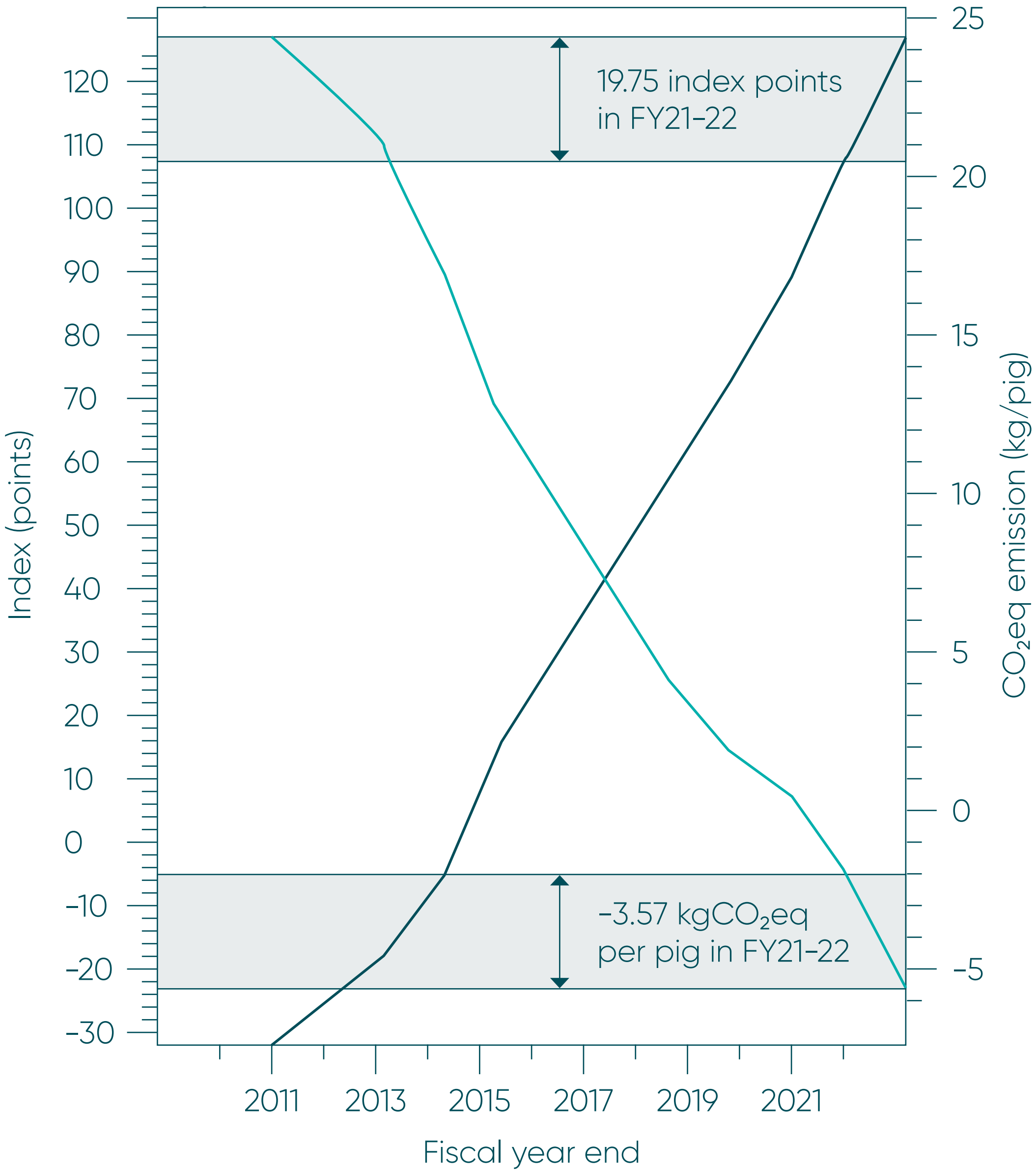
OUR PORK TARGETS

15

INDEX POINTS PER YEAR
or 0.75 standard deviation of improvement on the PIC proprietary index

2.22KG

EQUIVALENT TO REDUCTION
in life cycle CO_2e per market pig per year

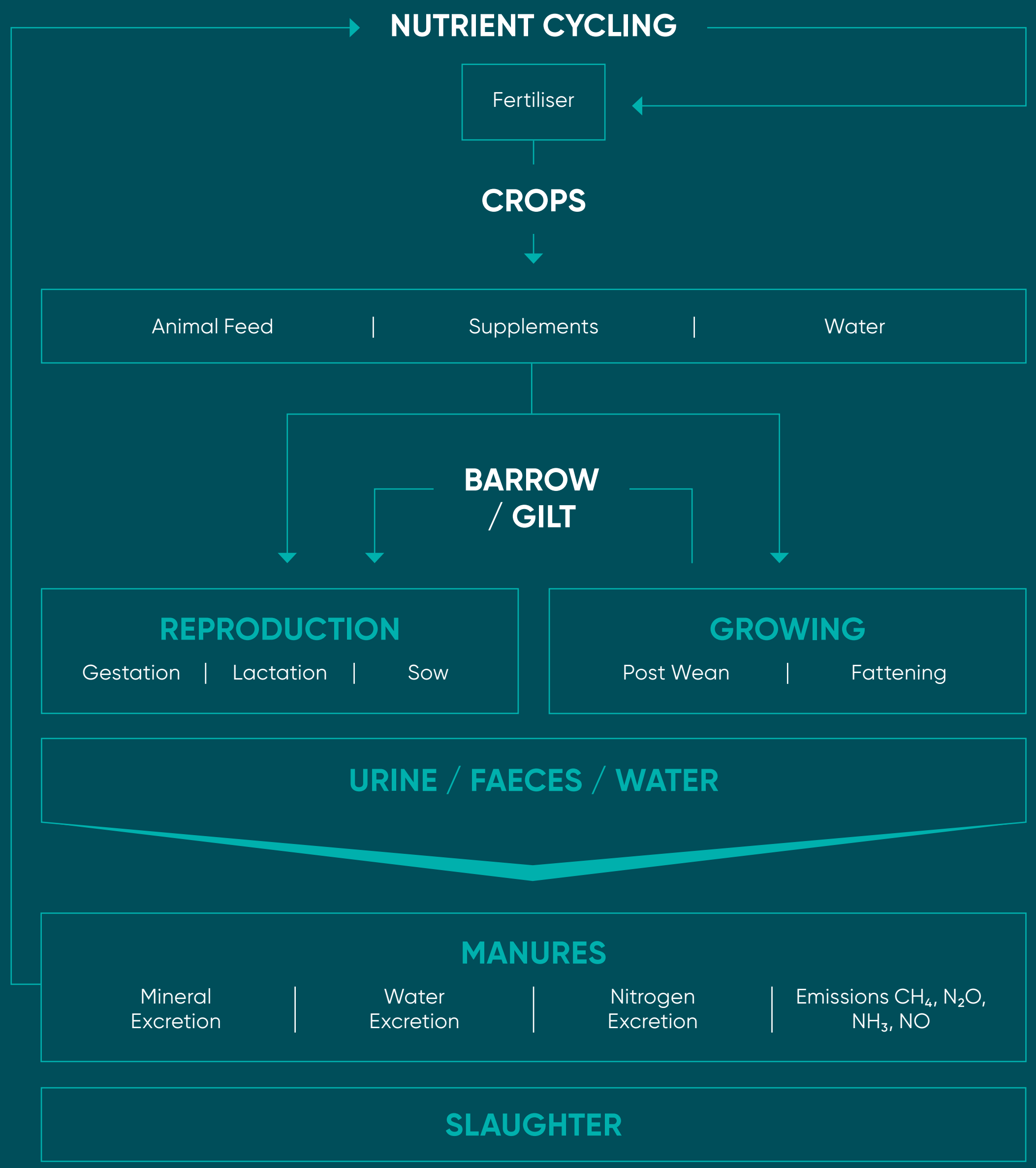


PORK

HOW WE CALCULATE OUR PORK TARGETS

LINKING LIFE CYCLE CARBON EMISSIONS TO GENETIC PROGRESS:

Life cycle emissions from pork production are related to genetically derived progress in feed conversion. As is the case in beef, these emissions include those related to growing of the feed itself and the efficiency with which animal feed becomes high quality pork. They also include the ability of the sow to produce large, healthy piglet litters.



PORK

HOW WE CALCULATE OUR PORK TARGETS

THE RESULT – REDUCED FEED MEANS REDUCED EMISSIONS ACROSS THE ENTIRE LIFE CYCLE

We have calculated the relationship between genetic progress (measured using our proprietary global sales index) and have established that there is 0.16 kg reduction in CO_2eq GHG emissions per market pig per global sales index point reduction.

The table (bottom) gives the contribution of each trait to these predicted changes in whole-enterprise feed conversion ratio ('FCRwe') and in lifetime GHG emissions, for the typical PIC-derived market pig: a reduction of 0.163 kg CO_2eq for each index point improvement in the breeding populations. PIC's current improvement target is 15 index points per year; with that, the total annual targeted reduction is 2.22 kg CO_2eq per market pig.

LIMITATIONS AND ASSUMPTIONS OF OUR MODEL

PIC routinely designs the weighting factors for its indices with a profit equation that quantifies the impact of each trait in the index on-farm profitability. For the current assessment, this equation was rearranged to quantify those impacts on FCRwe, differentiating the equation with respect to each trait. These derivatives give the change in FCRwe due to a unit change in each trait. Second, PIC uses classical selection index theory to predict the actual change in each trait from one pig generation to the next, due to a unit genetic improvement in the index.

The profit model is based on peer-reviewed methodology published by Knap (2005; Australian Journal of Experimental Agriculture 45:1–11) and favourably audited in 2019 by AbacusBio Ltd (www.abacusbio.com). Selection index theory is standard methodology used everywhere in animal breeding and is applied here to routinely recorded performance data. The LCA model is peer-reviewed methodology published by Soleimani & Gilbert 2020; Animal 14:2598–2608).

Our modelling (and the work of Soleimani & Gilbert) is based on observations within European slatted floor systems and therefore may not translate to deep straw regimes.

Trait	Derivative	Change per index point
Growth rate	-5.276	0.00049
Feed intake	1.4828	0.00097
Litter size	-0.0280	0.00868
Stillbirth	0.0280	-0.00062
Preweaning mortality	0.4363	-0.00040
Postweaning mortality	2.535	-0.00019
FCR_{we}		-0.0021
kg CO_2eq		-0.163

DAIRY

GENETIC IMPROVEMENT AND REDUCED CARBON IN DAIRY PRODUCTION

Cows only produce milk after they've given birth to calves and can typically only do this at around 23 months of age. Cows have almost two years before first milking where they are consuming feeds or grass and producing enteric emissions as they digest these, as well as producing manure methane and nitrous oxides.

Once a cow has started to produce milk, udder diseases or other health concerns can impact negatively on productivity. After two or three seasons of milking, a farmer may decide that the volume or quality of milk the cow produces is poor compared to others in the milking herd and the cow is dispatched.

Genetics play a dual role both in ensuring cows have a long, productive and healthy life and also in ensuring efficiency in the way feed or grass is converted into high quality milk. In simple terms, a cow that remains healthy and productive in the herd two or three times longer than the 'average' cow, has around half its carbon footprint per litre of milk produced. The contribution of these factors are individually recognised by the USDA[3] as a measure of economic value to the farmer and a measure of production sustainability, measured by individual weighted traits such as feed saved, heifer liveability, early first calving and mastitis.

3 https://www.ers.usda.gov/

DAIRY

OUR DAIRY TARGETS

OVER THE NEXT 3.5 YEARS (1 GENERATION) AN INCREASE OF

231 NM DOLLARS

(1 GENETIC STANDARD DEVIATION)
and a 0.01155 point (1.115%) decrease in the carbon footprint for Energy Corrected Milk ('ECM'). In FY21, ECM carbon footprint was 0.5639 kg CO_2e/kg ECM

APPLYING THIS REDUCTION, THE TARGET FOR THE NEXT GENERATION IS EQUIVALENT TO

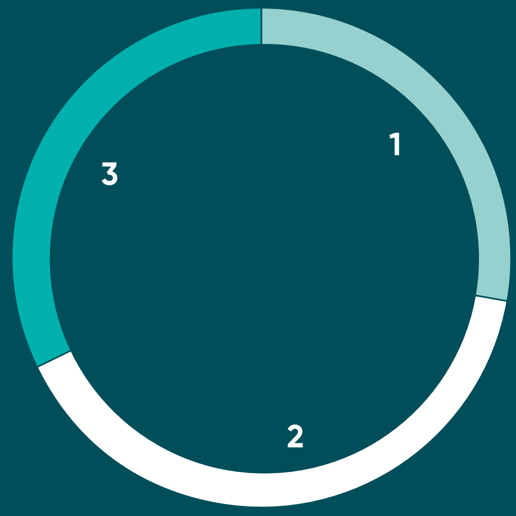
0.5576 KG

CO_2e/kg ECM

DAIRY

HOW WE CALCULATE OUR DAIRY TARGETS

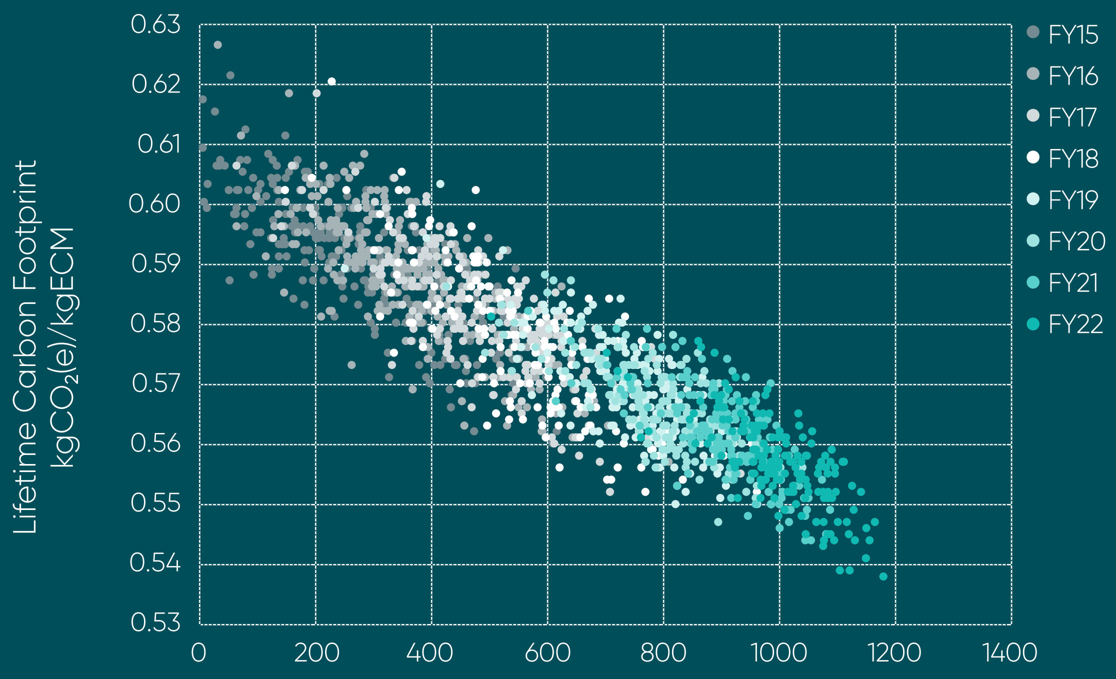
1	PRODUCTION	28%
2	LONGEVITY	40%
3	FEED	32%



LINKING LIFE CYCLE CARBON EMISSIONS TO GENETIC PROGRESS:

Life cycle carbon emissions result from a combination of improvements achieved through our breeding programme. The breeding trait of most significance is longevity, followed by feed efficiency and production (the quality and quantity of milk produced).

ABS SIRES CARBON FOOTPRINT



HOW WE CALCULATE OUR DAIRY TARGETS

THE RESULT – REDUCED FEED MEANS REDUCED EMISSIONS ACROSS THE ENTIRE LIFE CYCLE

Over the last 7 fiscal years ABS's improved sire genomics has resulted in a 4.7% carbon footprint decrease (see the chart on the previous page). Our target over the next 3.5 years (1 generation) is an increase of 231 NM dollars (1 genetic standard deviation) and a 0.01155 point (1.115%) decrease in the carbon footprint for ECM. (In FY21, ECM carbon footprint was 0.5639 Kg CO_2e/Kg ECM). Applying this reduction, the target for the next generation is 0.5576 Kg CO_2e/Kg ECM.

LIMITATIONS AND ASSUMPTIONS OF OUR MODEL

ABS developed a dairy model that uses the Council on Dairy Cattle Breeding's and ABS's trait evaluations with industry-standard IPCC methodology (2019 refinement) to determine a sire's daughter's lifetime carbon footprint based on body weight, health, residual feed intake, total lactation months, ECM, and heifer liveability (summarized in the pie diagram on the previous page). Reported carbon footprint units are Kg CO_2e/Kg ECM.

Emissions have been included for enteric fermentation (direct emissions from livestock), manure methane, and manure nitrous oxide emissions estimated using a standard US split of slurry, solid storage, and pasture storage. Emissions for heifers that would have died before lactation and for the first 3 months of a male dairy calf were included.

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