Effects of genetic gains in the Irish beef Maternal Replacement Index on greenhouse gas emissions

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Greenhouse Gas and Beef

- Beef cattle farming is a significant contributor to global greenhouse gas (GHG) production
- Selection to improve production efficiency can also reduce GHG emissions per animal and GHG intensity

$$System\ GHG\ intensity = \frac{system\ emissions\ (kg\ CO_2e)}{system\ production\ (kg\ meat)}$$

Beef Data and Genomics Program (BDGP)

- Aims to breed more profitable, sustainable, carbon efficient cows in Ireland
  - Tagging, data collection, genotyping, breeding requirements
  - €uro-Star Maternal Replacement and Terminal Indexes

  Cromie, ICAR 2016, *Beef Genomics Developments*

- Genomics with increased use of AI and elite animals → Potential to increase rates of genetic gain by 400%

  Hely et al, EAAP 2016, *A benefits model for a maternally focused beef breeding program in Ireland*

Objectives

- Predict improvements in GHG emissions intensity expected from genetic progress in Maternal Replacement Index and BDGP breeding strategies

1. Develop system model to quantify effects of trait change on kg CO_2e emissions and kg meat produced by average breeding cow

2. Predict industry-level long-term effects of index selection and BDGP breeding schemes

€uro-Star Maternal Replacement Index

Calf (Market Offspring) Traits 29%	Cow Traits 71%
Calving Difficulty	Cow Survival
Gestation Length	Calving Interval
Mortality	Age at First Calving
Carcass Weight	Maternal Weaning Weight
Carcass Conformation	Maternal Calving Difficulty
Carcass Fat	Cow Live Weight (maintenance)
Feed Intake	Heifer Live Weight (replacement)
Docility	Cull Cow Carcass Weight
	Docility

Approach

1. Estimate effects of change in each Index trait on **gross GHG emissions** = kg CO_2e / cow / year / trait unit

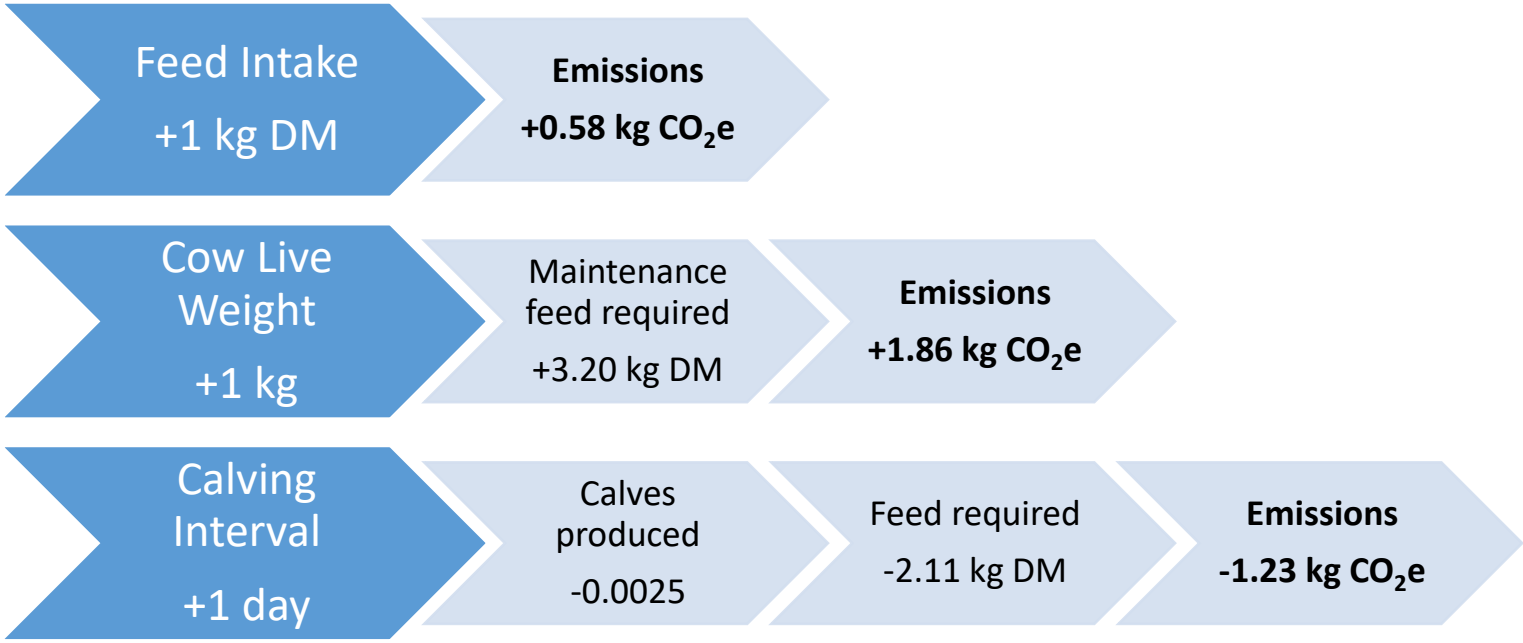
2. Estimate effects of change in each Index trait on system **GHG emissions intensity** = kg CO_2e / kg meat / cow / year / trait unit

3. Estimate **change in overall GHG emission intensity due to genetic gain** = kg CO_2e / kg meat / cow / year / € Replacement Index value

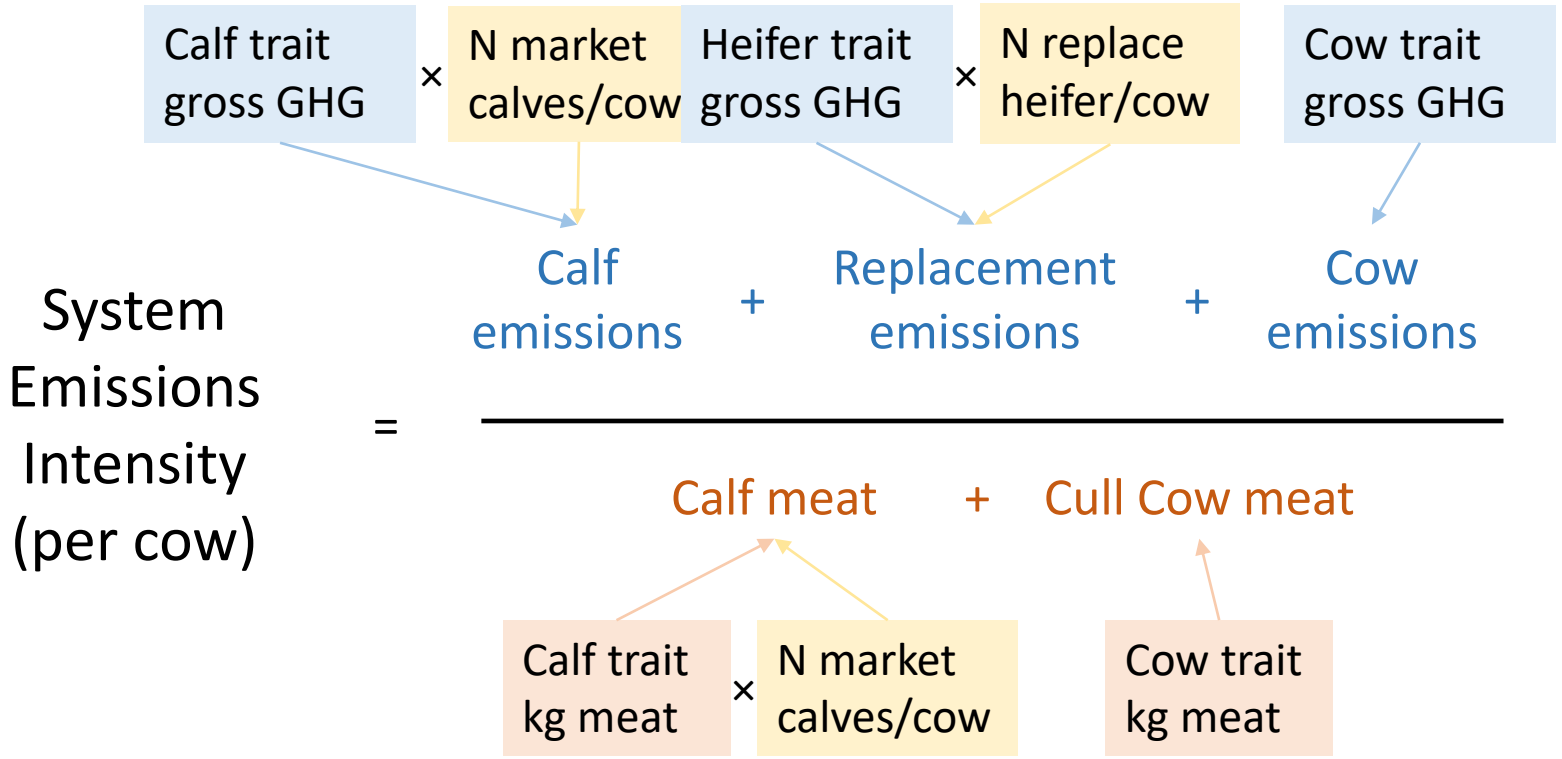
4. Predict **industry-level change in GHG emission over time** resulting from proposed BDGP beef breeding strategies

1. Trait effects on Gross GHG

- Estimate how change in each trait affects feed intake and resultant CO_2e emission



2. Trait effects on GHG intensity



Trait effects on GHG & system

	Trait (unit)	Gross GHG kg CO_2e/trait unit
Calf	Feed Intake (kg DM)	0.583
	Carcass Weight (kg)	
	Carcass Conformation (score)	
	Carcass Fat (score)	
	Mortality (%)	
Cow	Heifer Live Weight (kg)	5.483
	Cow Live Weight (kg)	1.864
	Cull Carcass Weight (kg)	
	Age at First Calving (d)	3.167
	Calving Interval (d)	-1.232
	Survival (%)	

Trait effects on GHG intensity

	Trait	DGE/y	GHG intensity (kg CO_2e/kg meat/trait unit)
Calf	Feed Intake	0.54	0.0011
	Carcass Weight	0.54	-0.0250
	Carcass Conformation	0.54	-0.1483
	Carcass Fat	0.54	0.1086
	Mortality	1.1	0.1452
Cow	Heifer Live Weight	0.614	0.0038
	Cow Live Weight	2.204	0.0234
	Cull Carcass weight	0.288	-0.00001
	Age First Calving	0.614	0.0111
	Calving interval	2.204	0.0643
	Survival	2.204	-0.2072

Emissions Intensity Index

3. Replacement Index effects on System-wide GHG intensity

	Trait	DGE/y	GHG intensity (kg CO_2e/kg meat/trait unit)	Trait response to Index selection (trait unit/€ index)	GHG intensity response to Index selection (kg CO_2e/kg meat/€ index)	
Calf	Feed Intake	0.54	0.0011	0.0005	0.000001	
	Carcass Weight	0.54	-0.0250	-0.0205	0.00051	
	Carcass Conformation	0.54	-0.1483	-0.0017	0.00025	
	Carcass Fat	0.54	0.1086	0.0013	0.00015	
	Mortality	1.1	0.1452	-0.0023	-0.00033	←
Cow	Heifer Live Weight	0.614	0.0038	-0.1147	-0.00044	
	Cow Live Weight	2.204	0.0234	-0.1147	-0.00268	
	Cull Carcass weight	0.288	-0.00001	-0.0777	0.0000004	
	Age First Calving	0.614	0.0111	-0.0454	-0.00050	
	Calving interval	2.204	0.0643	-0.0283	-0.00182	←
	Survival	2.204	-0.2072	0.0193	-0.00400	←
					Total = -0.0089	

Index effects on System-wide GHG intensity

- Summing all Maternal Replacement Index trait responses, **GHG intensity reduced by 0.009 kg CO_2e/kg meat/breeding cow/year/€ index value**
  - both age- and weight-constant slaughter systems
  - Gross GHG reduced 0.810 kg CO_2e/breeding cow/year/€ index value

- Similar approach to estimate effects of Terminal Index
  - Calf (market offspring) traits only
  - **GHG intensity reduced by ~0.02 kg CO_2e/kg meat/breeding cow/year/€ index value**
  - Gross GHG reduced 0.018 kg CO_2e/breeding cow/year/€ index value

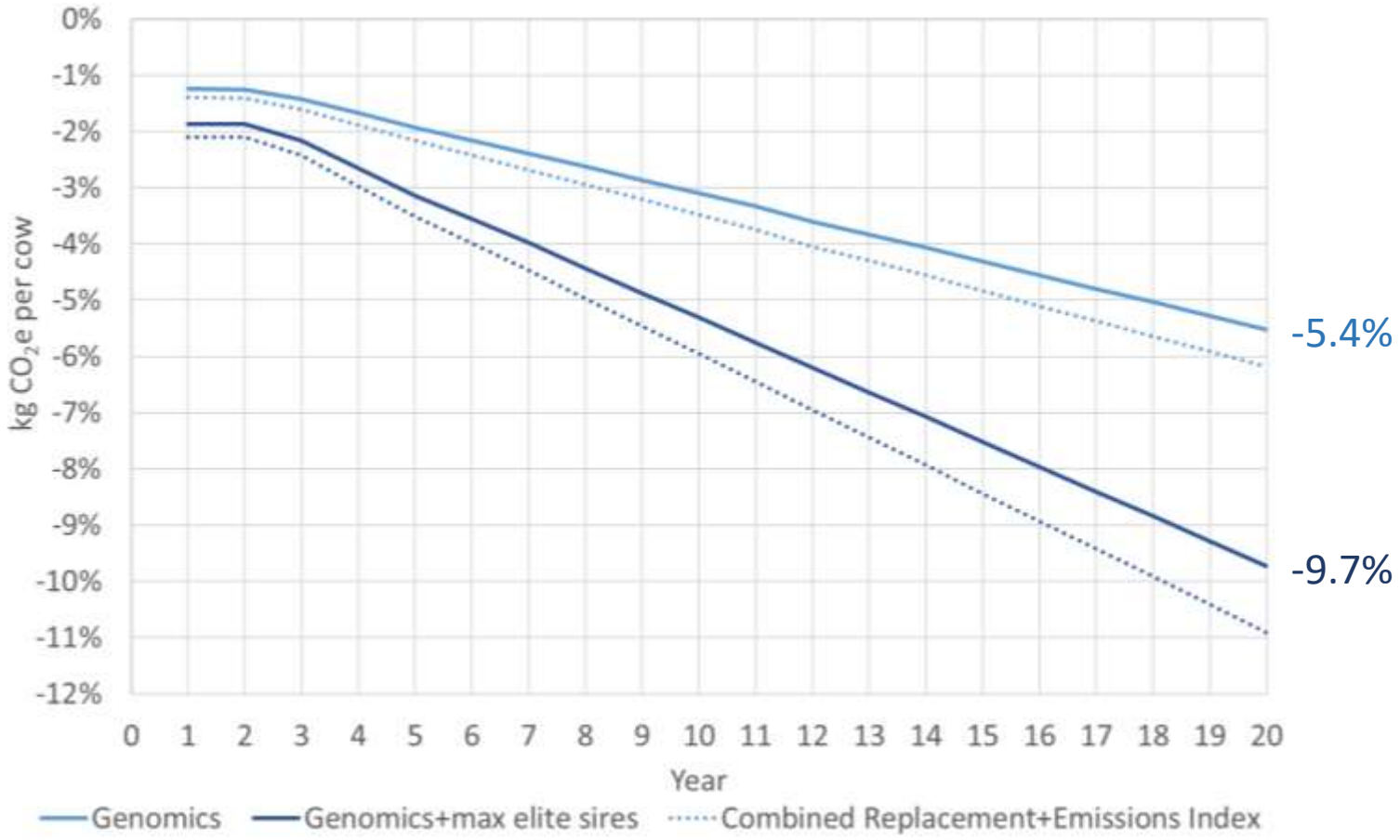
4. Industry-wide effects of BDGP breeding strategies

- For a constant level of meat production:

- Genomic selection with Replacement index
  - Average Index progress +5 €/year
  - **Total GHG reductions 229 kt CO_2e after 5 years, 1952 kt CO_2e after 20 years**

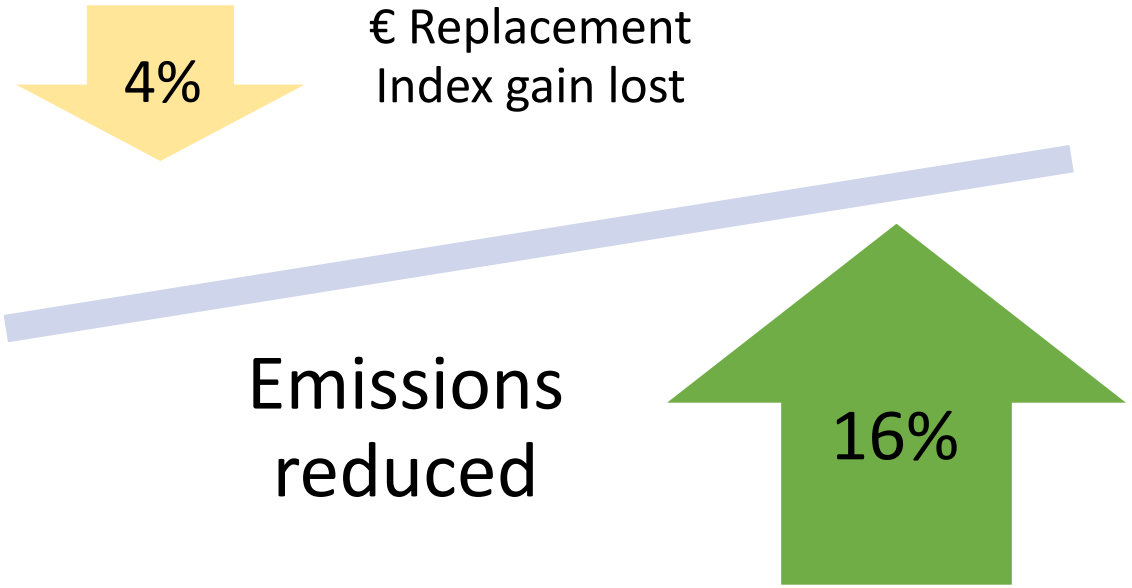
- Genomic selection plus maximum use of elite Replacement Index bulls by AI in pedigree herds
  - Average Index progress +9.5 €/year
  - **Total GHG reductions 350 kt CO_2e after 5 years, 3335 kt CO_2e after 20 years**

Industry CO_2e reductions



Selection for reduced GHG

- Combined Replacement + Emissions Index can balance trade-off of production vs. GHG reduction



Conclusions

- Genetic selection and genomics are effective tools to mitigate greenhouse gases in beef systems
- ICBF beef Maternal Replacement and Terminal Indexes can reduce industry-wide GHG emissions
  - Can improve production and further reduce GHG emissions intensity by combining production indexes with Emissions Index
- BDGP strategies to increase use of elite genetics through genomics and AI can improve genetic progress and associated GHG reduction
  - For a fixed product amount, total CO_2e reduced 5 - 10% after 20 years

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Thank you!