Greenhouse Gas Emissions in Beef Supply Chains

Significant Opportunities for Reductions and Supply Chain Leadership

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Beef supply chain contributions to global GHG emissions need to go down, and they can

- All sectors and supply chains need to reduce emissions, and the beef supply chain is no exception.
- Beef supply chains account for about 6% of global greenhouse gas (GHG) emissions, of which about half are accounted for by the cattle production stage of the supply chain.
- New and emerging technologies and management practices, covering feed production, cattle breeding, cattle feeding, and soil and pasture management, all offer significant opportunities to reduce emissions.
- Global beef supply chain emissions can also be reduced significantly by implementing the best practices from the efficient beef supply chains to less efficient chains.

The market will be the most effective driver of GHG emissions reduction

- Food and agribusiness (F&A) company commitments to lower the supply chain GHG emissions of beef and other animal proteins are on the rise.
- Rabobank believes that in most regions these initiatives are likely to be more effective drivers of action to lower GHG emissions in beef supply chains than government regulations.
- The voluntary goals set by F&A companies offer greater flexibility and clearer recognition for reducing emissions. Systems are being established to increase the credibility of these actions.
- In contrast, regulatory approaches often encounter measurement and reporting problems.
- To remain the driving force, market-based approaches will need to demonstrate progress. Otherwise, they will be replaced by regulation.

Beef supply chain emissions can be reduced by more than 30% by 2030 in major markets

- Rabobank sees scope to reduce GHG emissions by more than 30% in Europe, North America, Brazil, Argentina, and Oceania by 2030.
- This would amount to a reduction of beef supply chain emissions by at least 0.6gt CO2 equivalent (CO2-eq) by 2030.
- The highest reductions are expected in the cattle production and upstream feed production and inputs stages of the chain.
- If action can be accelerated through technology developments or clearer incentives, we believe emissions could be reduced by about 40% by 2030 in these major markets.
- We believe that actions to reduce emissions in major markets will also have spillover benefits in other beef markets, leading to reductions of about 5%.

Leadership is needed to unlock opportunities in beef supply chains

- The misalignment of benefits and costs along beef supply chains is holding back progress in emissions reduction.
- But, leadership at F&A companies active in beef supply chains has the ability to unlock latent opportunities.
- To do so, F&A companies need to set ambitious goals to reduce emissions, promote innovation, and enable supply chain partners to work together to achieve their goals.
- There is also a need for explicit recognition and reward for emissions reduction. This should not be seen solely in terms of higher prices – other benefits of reducing emissions will include productivity gains, improved risk management, access to new markets, and enhanced brand and reputation.

Sources: Rabobank 2021

1 Beef Supply Chain Emissions Will Need to Decline to Meet Global Ambitions on Climate Change

The Global Beef Supply Chain Can and Should Reduce GHG Emissions

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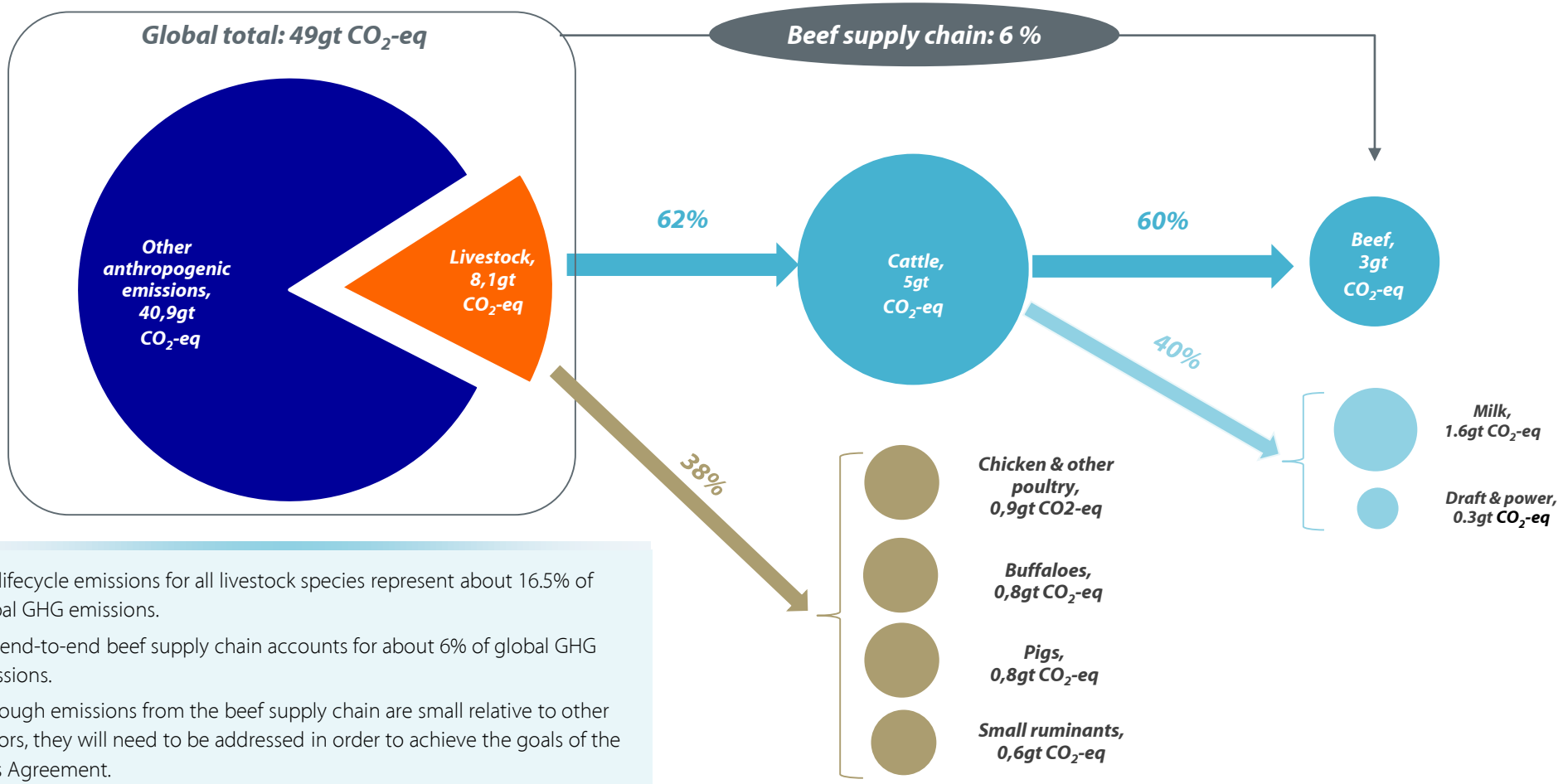
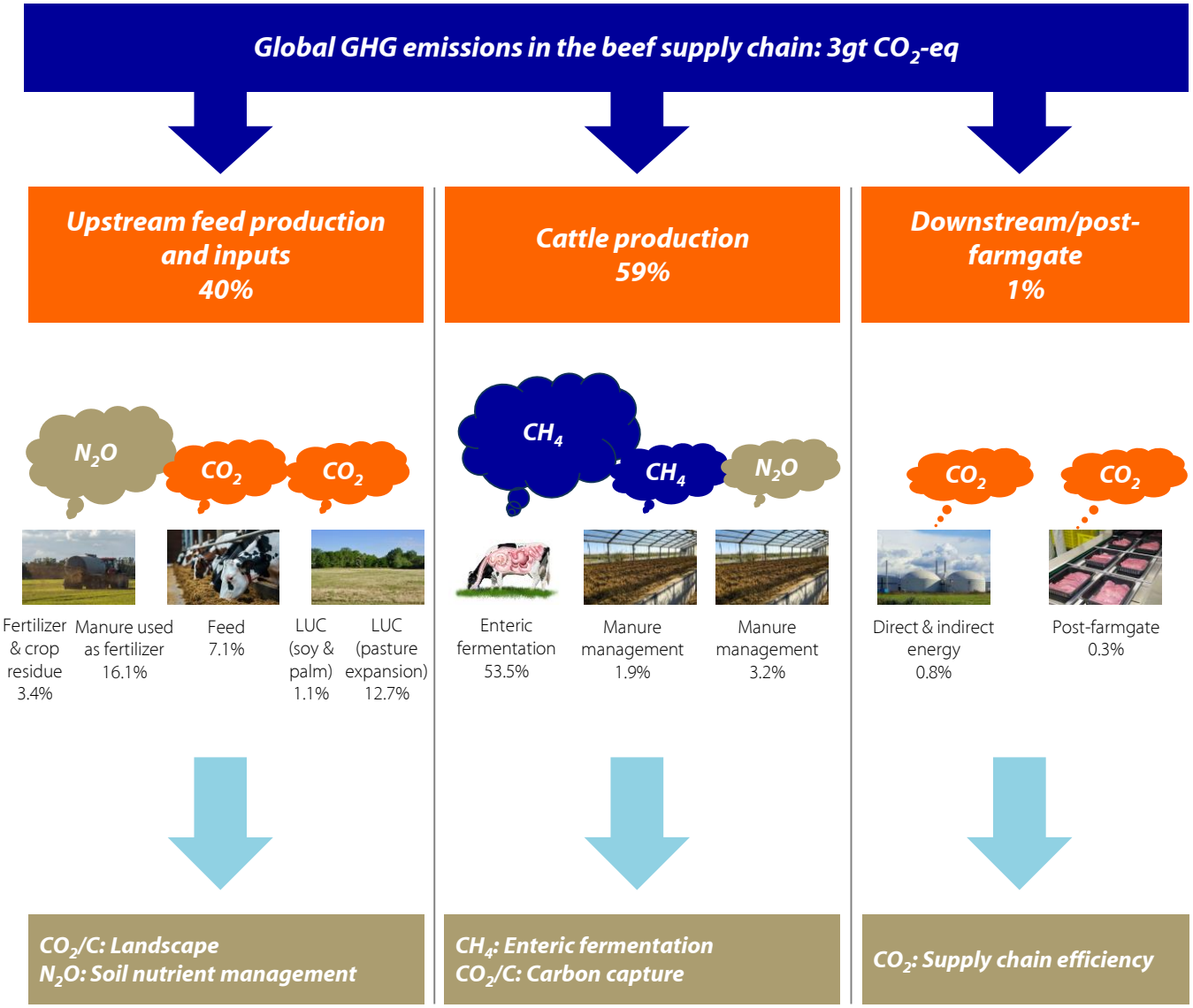
GHG emissions from the end-to-end beef supply chain represent about 6% of global anthropogenic emissions



- Full lifecycle emissions for all livestock species represent about 16.5% of global GHG emissions.
- The end-to-end beef supply chain accounts for about 6% of global GHG emissions.
- Although emissions from the beef supply chain are small relative to other sectors, they will need to be addressed in order to achieve the goals of the Paris Agreement.
- Reductions in beef supply chain emissions are feasible through the application of new technologies, improved production practices, improved land management practices, and other scientific discoveries.

Sources: IPCC 2014, FAO-GLEAM 2017, Rabobank 2021

Most GHG Emissions Occur in the Upstream and Production Stages of the Beef Supply Chain



- Globally, 99% of GHG emissions in beef supply chains occur in the upstream and production stages.
- Methane (CH_4) is the single biggest source (55%) of GHG emissions in beef supply chains, and is mainly released during enteric fermentation (part of the digestive process).
- In the upstream stage of the supply chain:
  - N_2O is emitted from fertilizer applied to feed crops and from the decomposition of crop residue. Similarly, N_2O is released from manure applied to feed crops as organic fertilizer and from manure deposited directly by grazing animals.
  - CO_2 is emitted during the production, transportation, and processing of feed and in the consumption of energy for manufacturing fertilizer and pesticides and for field operations, such as tillage or fertilizer application.
  - CO_2 is released during land-use change (LUC), for example the expansion of cropland for crop production and the expansion of pastures.
- Different gases require different mitigation approaches:
  - In the upstream stage, the focus is on capturing carbon in the soil, optimizing fertilizer use, and limiting LUC.
  - In cattle production, more efficient enteric fermentation and capturing carbon in the soil are the goal.
  - In the downstream stage, increasing supply chain energy efficiency offers opportunities.

Sources: FAO-GLEAM 2017, Rabobank 2021

Emission Intensities Differ (Significantly) by Region, Signaling Opportunities for Reductions by Sharing Best Practices

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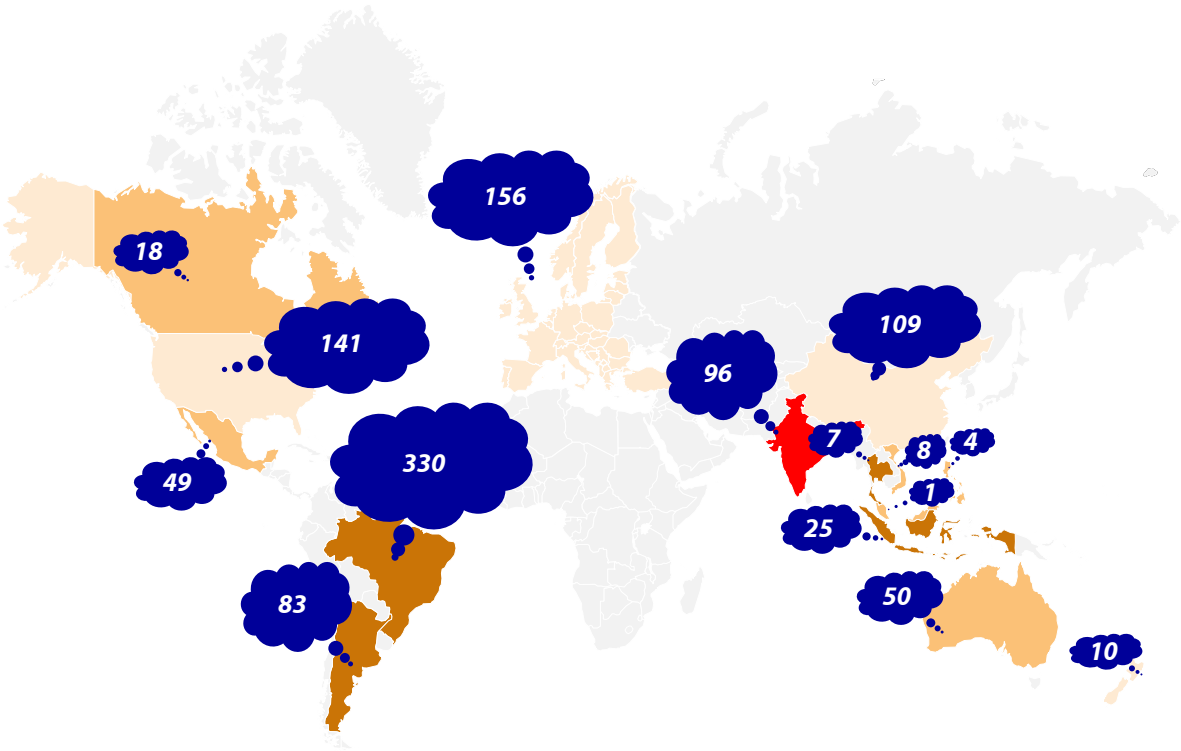

Emission intensity
kg CO_2-eq/kg carcass weight (farmgate)

- <16
- <26
- <53
- >100

Total GHG emissions from beef in CO_2-eq million metric tons

- At the farm level, there is significant variability in the emission intensities of beef production.
- High variability signals ample opportunities to reduce emissions by transferring the best genetics and management practices from lower-emitting countries to higher-emitting countries.
- The FAO estimates that closing the emission-intensity gap (the difference between the highest and the lowest emission intensities) could cut global emissions by 30%.
- Emission intensity largely depends on production efficiency:
  - The US has a highly efficient beef production system, and hence low emission intensities. The high efficiency results from finishing beef cattle on a corn-based diet, which results in more efficient feed conversion, reduces the days to market, and leads to a more efficient metabolic process and lower methane emissions.
  - Brazil has relatively high emissions, mainly because a pasture-based system is prevalent, leading to a longer production cycle. Recovering degraded pastures, supplemental feeding of cattle, improved animal health and reproductive management, and integrated crop-livestock-forestry systems can all contribute to lowering emissions in these pasture-based systems.
  - In India, the intensity of emissions is seven times higher than in the US. In some parts of the world, such as India, cattle are kept because of religious beliefs or as a form of family wealth. These animals substantially contribute to emissions but often have very low productivity. The prevalence of these so-called 'idle cattle' is highest in southern Asia, northern Africa, and South America.

Sources: FAOStat 2019, Rabobank 2021

2 Opportunities Exist to Reduce GHG Emissions Along the Beef Supply Chain

We See Potential to Reduce Global* Beef Supply Chain Emissions by More Than 30% by 2030, Creating a Multibillion Euro Opportunity

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Global beef supply chain emissions in 2030 can be reduced to 1.4gt CO_2-eq (from 2gt CO_2-eq)

	Upstream feed production and inputs	Cattle production	Downstream/post-farmgate
Business as usual	1gt CO_2-eq	1gt CO_2-eq	0.03gt CO_2-eq
	-0.27	-0.35	-0.02
Emissions reduction scenario	0.73gt CO_2-eq	0.65gt CO_2-eq	0.01gt CO_2-eq

In the emissions reduction scenario, we have assumed the implementation of a range of technologies will match the availability of technical and financial capital in each region.

In general, the technologies that we assume will deliver the greatest reductions are highlighted.

Emissions reduction will be driven by the following developments and technologies

Practices to reduce land use change for feed production	Genetics/genomics/breeding	Increased use of renewable energy at plants and during transportation
Reduced use of mineral fertilizer	Feed additives	Efficiency gains
Precision agriculture technology	Production-system efficiency gains/management	
Renewable energy use on arable farms	Soil and vegetation management	

An accelerated technology and incentive scenario would unlock emissions reductions closer to 40%.

Genetics/genomics/breeding, feed additives, soil and vegetation management, and reduced LUC would be the main contributors to the accelerated scenario.

** Global emissions calculations in this slide refer to Europe, North America, Latin America, Australia, and New Zealand*

Source: OECD-FAO, FAOStat, Rabobank 2021

Five Promising Technology and Management Areas for Reducing GHG Emissions in Cattle Production

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1

Genetics, genomics, and breeding

1. ***Beef on dairy***
   Crossbreeding beef breed bulls with dairy cows to optimize genetics in beef supply chains.
2. ***Genomics***
   Genetic selection, enabled by the collection of cow data, could lower methane emissions by selecting for traits that reduce emissions or identifying cows that are low emitters.
   Selecting best-performing sires can also reduce methane emissions by +10%.
3. ***Dual-purpose dairy breed***
   In countries where beef and dairy systems are closely linked, breeds that balance milk and meat yield can reduce overall methane emissions.

2

Feed and feed additives

1. ***Adjustments to the basic diet***
   - Increasing corn silage
   - Tannin-rich forages
   - Increasing the level of concentrates to forages
2. ***Feed additives and nutritional supplements***
   - Adding nitrates to the diet could lead to reduced methane emissions and improved animal performance.
   - Adding eligible additives to increase fat content .
   - Adding different feed additives to the diet – for example, algae or botanical compounds.

3

Smart technology

1. ***Wearable technology to capture methane***
   Wearable devices placed on the cattle's head can neutralize livestock methane exhalations at the source.
2. ***Optimization of animal performance and trading***
   Farm management software can improve productivity and optimize supply chain performance, thereby improving the sustainability of beef production.

4

Soil and vegetation management

1. ***Carbon sequestration***
   - Soil and pasture management (regenerative agriculture).
   - Grassland carbon sequestration: preliminary estimates indicate a reduction potential of 0.6gt CO2-eq/year, but the science is still developing.

5

Manure management

1. ***Converting waste and natural resources into methane***
   - Biogas installations
   - Using methane as feedstock to manufacture alternative proteins.

Source: Gastelen et al., 2018, Vellinga and de Vries, 2018, Pryce and Haile-Mariam, 2019, Zelp, Genus, Breedr,, DSM,, WRI, Rabobank, 2021

New Technologies and Improved Practices Can Significantly Reduce GHG Emissions

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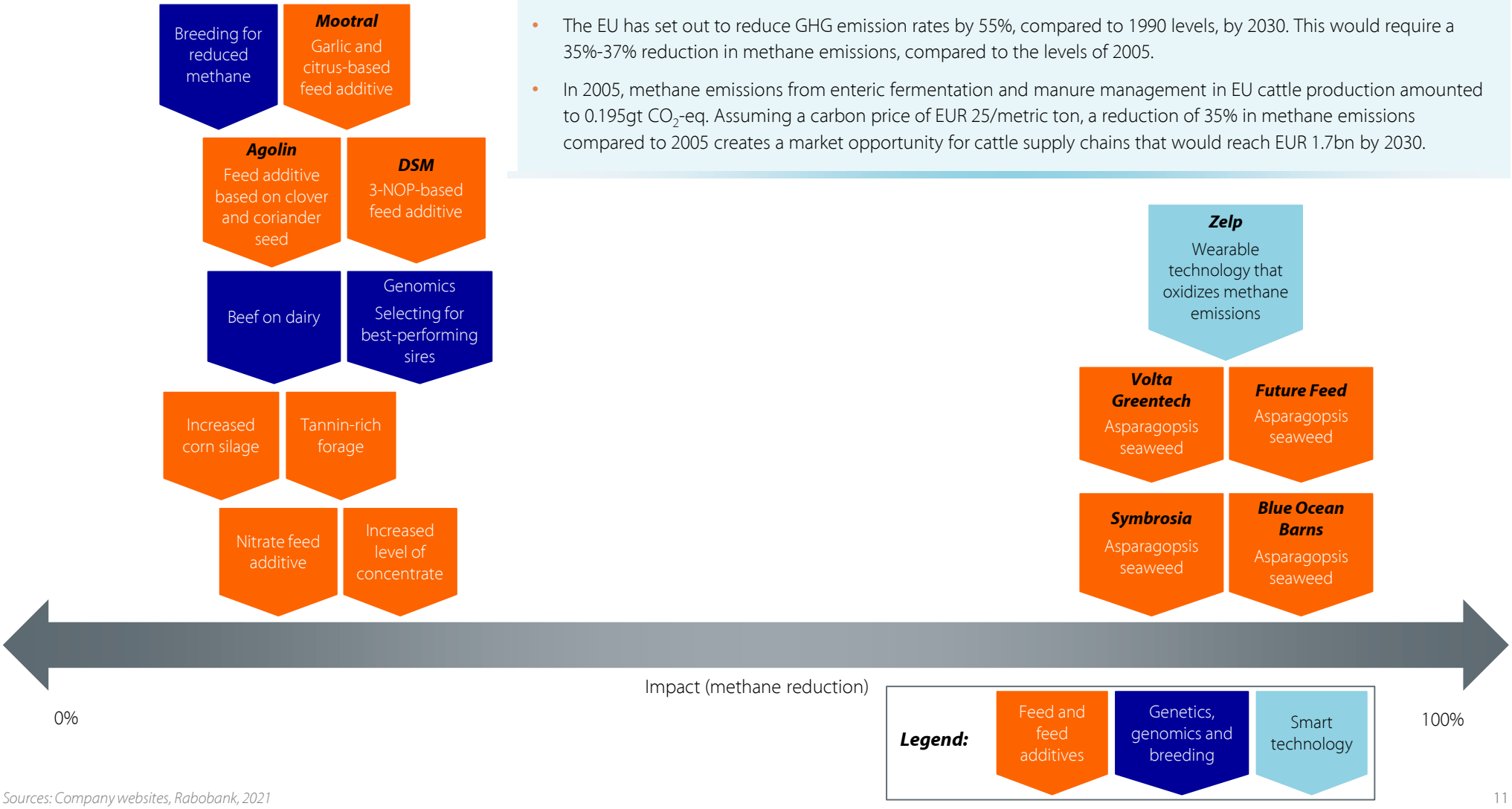
The potential of various technologies to reduce emissions ranges from 10% to 90% reduction, which shows that it is possible to significantly reduce emissions without limiting herd numbers

GHG emissions reduction in cattle could represent a EUR 1.7bn market opportunity in the EU by 2030.

- The EU has set out to reduce GHG emission rates by 55%, compared to 1990 levels, by 2030. This would require a 35%-37% reduction in methane emissions, compared to the levels of 2005.
- In 2005, methane emissions from enteric fermentation and manure management in EU cattle production amounted to 0.195gt CO_2-eq. Assuming a carbon price of EUR 25/metric ton, a reduction of 35% in methane emissions compared to 2005 creates a market opportunity for cattle supply chains that would reach EUR 1.7bn by 2030.



Sources: Company websites, Rabobank, 2021

Swing Factors That Will Determine the Speed and Level of Emissions Reductions That Are Achieved

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Opportunities and risks for the uptake of emission-reducing technologies and practices vary from one country to another. In general, two major and two minor barriers and issues – or swing factors – that will determine progress in reducing emissions in beef supply chains can be identified.

Managing costs for reducing emissions

- Most GHG emissions reductions occur before the farmgate or on-farm, while recognition of emissions reductions closer to consumers is greater.
- Sharing risks and rewards along the supply chain will be critically important if GHG emission-reduction potential is to be realized.
- In part, this will depend on an acceptance of additional production costs along the chain. It will also rely on recognition for emissions reductions in terms of adding value rather than only in terms of price.

Measuring on-farm emissions

- Livestock emissions are inherently difficult to measure, and as a result, averages are often used. These provide limited scope to recognize specific changes made by farmers.
- In addition, estimates of soil carbon sequestration are currently not well defined or agreed. Also, the positive contribution of cattle in grassland management, such as the fact that grazed or growing grass absorbs more carbon than mature grass is usually not considered.
- Improvements in tools and techniques to measure on-farm GHG emissions in beef supply chains will help accelerate action to reduce emissions.

F&A companies' commitment to beef

- Most downstream F&A companies have goals to reduce their supply chain GHG emissions, but are not specific about beef supply chain emissions.
- Some F&A companies may not be committed to reducing any specific commodity's GHG emissions, including beef's.
- Instead, F&A companies may choose to adjust product formulation, recipes, and menus to reduce the share of higher-emitting commodities like beef in favor of lower emitters to achieve their goals.

Metric for methane measurement

- Adjusting the global warming potential of methane to reflect its relatively short time in the atmosphere would have a significant bearing on cattle's contribution to global GHG emissions.
- GWP100, the accepted metric for measuring the warming impact of different GHGs, does not fully account for methane's short-lived nature.
- GWP* is an alternative metric that is expected to be defined in more detail in the IPCC Sixth Assessment Report in 2021.

Source: Rabobank, 2021

3 What Drives Action to Reduce Emissions?

A Market-Based Approach Is More Likely to Unlock Opportunities to Reduce GHG Emissions in the Near Term

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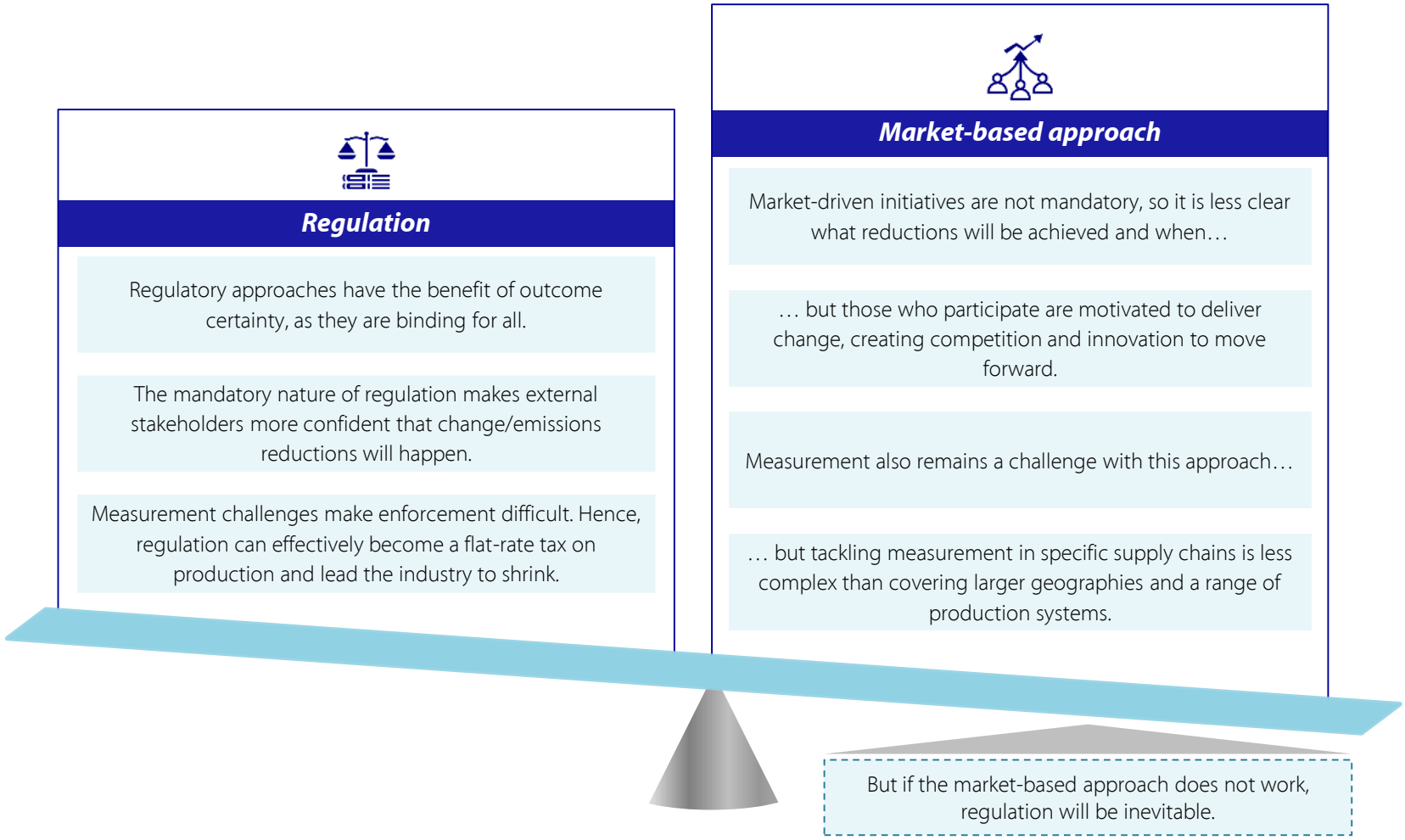
Regulators have been reluctant to act

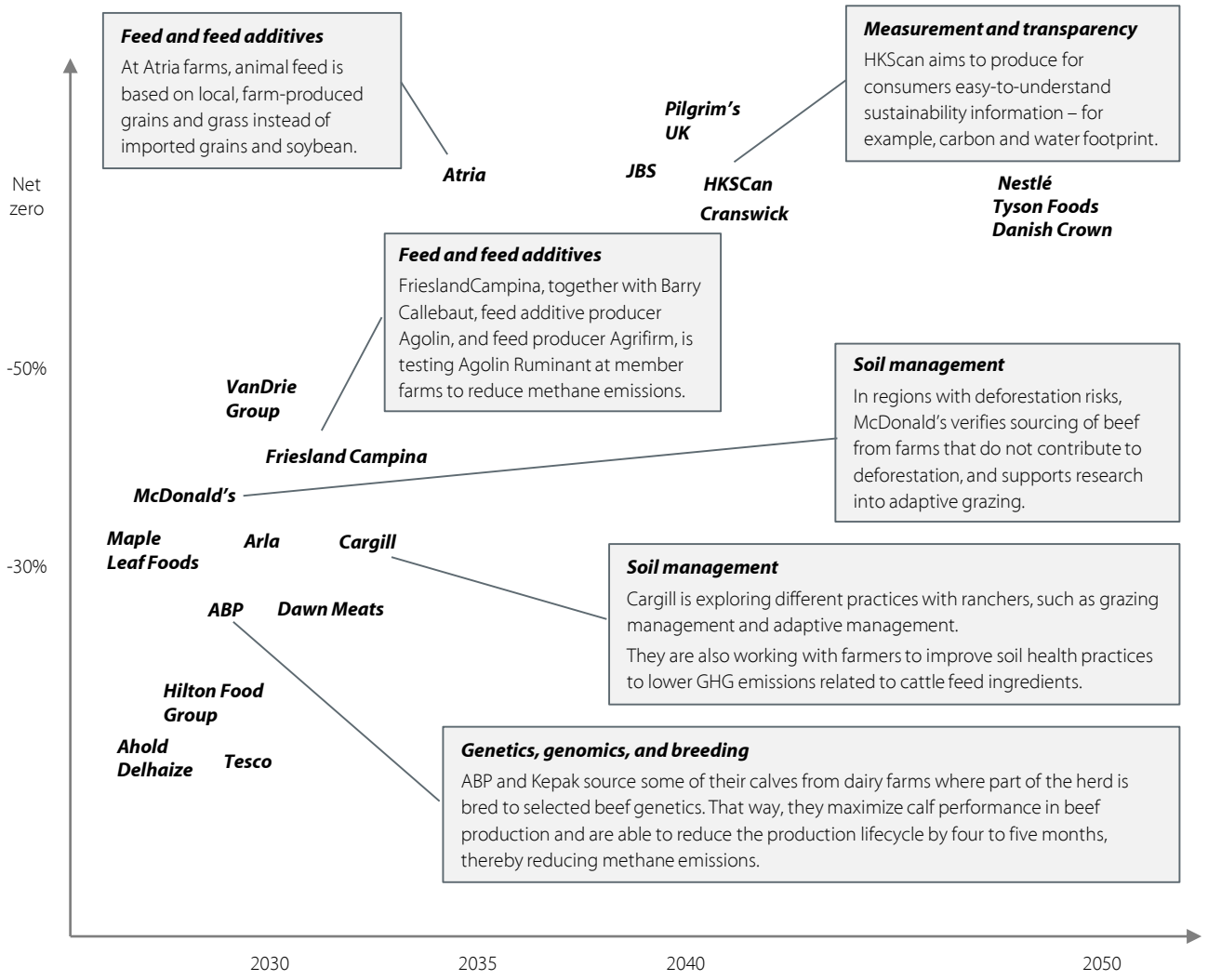
- Rising pressure along the supply chain could drive chain captains and participants apart, at a time when they need each other to achieve change.
- Alternatively, it could force a re-working of how chain participants are recognized and rewarded for the value they create.
- Leading companies will be thinking of the latter rather than the former.
- Supply chain participants could increase their leverage towards captains, through DTC models and more transparent reporting of rising costs.
- Supply chain models also need to engage the inputs companies, as they will be needed for achievement of chain sustainability goals.



Source: Rabobank 2021

Beef Supply Chain Leaders Are Making Commitments and Taking Action

Targets are increasingly being set for Scope 3 (i.e. along the full supply chain) reductions by animal protein companies and by food retail and foodservice companies. Supply chain participants are now taking action to reduce GHG emissions in beef supply chains.



Other companies in beef supply chains are actively reducing their carbon footprint through specific, targeted initiatives.

Examples include:

- ***Marfrig Global Foods***

  By 2025, the goal is to achieve full traceability of Marfrig's supply chain in the Amazon. By 2030, the company will do the same in the Cerrado and other biomes, thus achieving ***zero deforestation***.

- ***Tyson Foods***

  Tyson is improving ***land stewardship*** to lower GHG emissions from grain production for feed.

- ***Vion Food Group***

  Vion Food Group is developing a ***CO_2 label*** to inform consumers about the environmental footprint of their products in 2022.

Source: Company websites, Rabobank 2020
Last refreshed: March 2021

It Will Be Possible (but Not Easy) to Build the Business Case for Reducing GHG Emissions in Beef Supply Chains

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Progress in emissions reduction is being stalled by the lack of a clear value proposition

- The ***case for reducing emissions is clear***.
- ***Technologies and practices*** that reduce emissions are available.
- But progress is held up by the question: ***"Who is going to pay?"***
- If beef supply chains ***get this right, they can move faster.***

Leadership is needed

- Leadership is needed to focus on the opportunities and ***to deliver on the potential*** to reduce GHG emissions along beef supply chains.
- Leaders need to ***set ambitious goals*** to reduce GHG emissions in beef supply chains.
- Leaders need to ***take early action to commercialize*** new technologies and management practices that reduce emissions.
- Leaders need to ***test consumers' willingness to pay*** for lower-emission beef and supply chain partners' willingness to collaborate on emissions reduction.
- Leaders need to ***develop and refine the value proposition*** for reducing emissions, working with participants in the supply chain.

Consumers' willingness to pay for lower-emission beef products needs to be tested

- Early movers could secure ***premium prices*** for lower-emission beef products.
- These beef products will likely be ***branded*** and include ***verification*** of lower emissions, and the number of consumers willing to pay premium prices for lower-emission beef products ***will be limited***.
- Ultimately, any investment made by a beef supply chain participant ***is paid for by the margin received*** for the product.
- Given the limited size of the market willing to pay higher prices, participants in the beef supply chain will need to think about the return on investment in lower GHG emissions ***that creates value for their business***, rather than solely thinking about higher prices.

The value proposition for reducing GHG emissions in beef supply chains needs to be refined

The value proposition for reducing GHG emissions along beef supply chains will be built on ***five pillars.*** Lower GHG emissions can:

- Drive ***innovation*** and improve ***productivity***
- Improve ***risk management***
- Provide access to ***new markets***
- Support access to ***capital***
- Enhance ***brand and reputation***

Source: Rabobank, 2021

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