The relationship between climate change and agriculture is a contentious, complex and important one. In this series of twelve blogs, UCD Adjunct Professor Frank Convery will explore the context, challenges and potential solutions for dairy, beef and sheep farming in Ireland. Each blog presents key evidence to underpin informed debate and the series seeks to help plot a sustainable future for the sector.

Responses are invited via earth.institute@ucd.ie and the UCD Earth Institute will host a workshop in association with the UCD School of Agriculture and Food Science and the National Economic and Social Council at the end of the series in December 2022 to discuss the evidence and its implications.

Professor Tasman Crowe, Director, UCD Earth Institute

2. Climate Performance by Irish Ruminant Farming (Dairy, Beef, Sheep) - The Coming Metrics Revolution

Frank Convery, Adjunct Professor, University College Dublin

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*"Ireland will become a **world leader** in Sustainable Food Systems over the next decade. This will deliver significant benefits...and will also provide the basis for the future competitive advantage of the sector".*
Food Vision 2030 *[1]*

"What gets measured gets done"
Steve Ballmer, former CEO, Microsoft

Some Key Points

News & Events


Luke Casserly's Distillation artwork at IMMA

Launch of Talking Towns seminar series


Institute members awarded IRC research funding to tackle societal challenges

Metrics matter: recent developments connote a seriousness of purpose in this regard. From 2023, we are likely to have our first satellite (MethaneSat) designed specifically to measure methane emissions. It will be followed (2025) by the launch of an EU-sponsored satellite. We do not know whether either will provide credible farm-based emissions from pasture-based systems, but we do know that technology is often a surprise, it will provide information in real time, and be a constant source of media commentary. At farm level, the EU hopes to be the global leader as regards measurement of both emissions and removals. In Ireland, Teagasc (Agriculture and Food Development Authority) has made impressive progress: given parity of esteem to climate performance in its national farm survey; developed farm-based measurement of emissions ('Carbon Navigator') and provided estimates (per ton of CO2e) of the costs of abatement and carbon removal options. Development of emissions measurement and carbon removal at farm level are underway in the UK, NZ, US and elsewhere. As regards product labelling, Denmark is a leader in this regard and the EU has big ambitions (see Blog 3). California could emerge as a global leader (see Blog 5). New Zealand has pioneered the use of the spit gas approach, whereby methane, as a short live gas, is treated separately from long lived gasses (nitrous oxide and carbon dioxide).

Introduction

On July 28, 2022, the Irish government announced the specifics of its sectoral greenhouse gas emissions targets for 2030:

Table 1 Sectoral and Aggregate Greenhouse Gas Emissions Targets 2030, Ireland

Sector	**Baseline 2018**	**Reduction (rounded)**	**2030 Obligation**
Unit	Million tons CO2eq	%	Million tons CO2eq
1. Electricity	10.5	75	3
2. Transport	12.0	50	6
3. Buildings			
Commercial & Public	2.0	45	1
Residential	7.0	40	4
Total Buildings	9.0		5
4. Industry	7.0	35	4
5. Agriculture	**23**	**25**	**17.25**
6. Other	2	50	1
TOTAL	63.5		36.25

Notes:

- 5.25 MtCO2eq of annual emissions reductions are currently unallocated on an economy-wide basis for the second carbon budget period (2026-2030).
- Finalising the Sectoral Emissions Ceiling for the Land-Use, Land-Use Change and Forestry (LULUCF) sector has been deferred for 18 months to allow for the completion of the Land-Use Strategy
- These two notes help explain why the aggregate obligation for 2030 amounting to 36.25 million tons (Table 1) is 57% of the 2018 baseline rather than the 51% reduction required by the Climate Action and Low Carbon Amendment Act, 2021.

Source: gov.ie - Government announces sectoral emissions ceilings, setting Ireland on a pathway to turn the tide on climate change (www.gov.ie)

The extent to which the emissions target for agriculture (17.25 million tons of CO2eq) will be met or exceeded depends very significantly on the quality of the policy instruments that are mobilized and the skill with which they are implemented. I regard these issues as

so important that I devote four blogs (Numbers 9-12) thereto. The remainder of this blog focusses on the carbon footprint (Kgs CO2e per Kg of product), a metric which is likely to emerge in our key markets as a commercially important consideration.

As climate performance has emerged as a key preoccupation of governments, businesses, households, consumers and communities, measurement reporting and verification (MRV) has become a central task. For various reasons, MRV for agriculture and land use is not yet at the same level as other sectors, and this has resulted in a variety of independent efforts to fill the gap. At national level, Denmark is eager to provide consumers with information on the carbon footprint of the food that they purchase, while at corporate level, Walmart has decided to reduce emissions from its supply chains by 1 billion tons of CO2e annually by 2030. In both cases, they are or will be using metrics to measure performance.

Locally, Glanbia's [1] Sustainability strategy is rooted in the Science Based Target initiative, which drives ambitious climate action in the private sector by enabling companies to set science-based emissions reduction targets. The SBTi is a partnership between CDP [2], the United Nations Global Compact (UNGC), World Resources Institute (WRI) and the World Wide Fund for Nature (WWF)

Below, I note some of the evidence on metrics that are in prospect at farm and market level, followed by an assessment of what it means.

Evidence

Farm Level

From Space – Satellites

A flagship programme of the Environmental Defense Fund (EDF) in New York has been finding ways that work to reduce methane emissions globally by 45% from the oil and gas industry.[3] Two key challenges in doing so are: a lot of the emissions come from thousands of small wells (both abandoned and active), and monitoring these to quantify emissions at acceptable costs is very challenging; secondly, a high proportion of emissions happen in jurisdictions where emissions monitoring is uneven. While I was chief economist at EDF (2014-2018) the organization secured funding to design, deliver and operate a satellite which will be customized to help fill these gaps. It expects to launch in 2023.[4] While its focus is on measuring emissions from oil and gas, it will also measure surface-level methane emissions from other major sources of human-caused methane emissions and help discover and quantify previously unknown sources; it is designed to measure regions at intervals under seven days. The data generated will be in the public domain. The European Union also has plans to launch a satellite in 2025 which will measure methane emissions as part of Copernicus.[5]

Ground-Based

EU Level: For energy, transport and buildings, there are well developed procedures for the measurement, reporting and third-party verification (MRV) of greenhouse gas emissions from industry and energy, at installation level.[6] In parallel, MRV procedures have been put in place to measure emissions from transport (including flights) and buildings. MRV is what allows the application of performance-based policies such as the European Union Emissions Trading Scheme (EU ETS), the Building Energy Ratings Scheme (BER) and the Regulation setting EU fleet-wide CO_2 emission targets and a mechanism to incentivise the uptake of zero- and low-emission vehicles. There is no comparable MRV system in place at EU level to address emissions and removals in agriculture.[7]

In December 2021, the Commission adopted Communication "Sustainable Carbon Cycles " in which it commits to addressing this asymmetry between the MRV already in place for greenhouse gas emissions and removals for other sectors of the economy, vis-à-vis the level of MRV available for agriculture: It proposes that the gap will be filled by 2028: "every land manager should have access to verified emission and removal data."

As regards *removals*, the Commission has announced as a first step to develop 'an effective regulatory framework for the certification of CO2 removals by the end of 2022'. On January 26, 2022, the School of Transnational Governance, European University Institute organized and hosted a workshop on 'Operationalising Land-Based Carbon Removals in the EU' to which I was invited to contribute. This was animated by the Commission's commitment to develop an effective regulatory framework for the certification of CO2 removals by the end of 2022; this was triggered by the finding that, for the EU's mitigation pathways to be compatible with the goal to stay below 1.5°C warming, an estimated contribution of land-based net removals of around 500 million tonnes of CO2 per year by 2050 would be necessary. Key insights from the workshop have been summarized by Runge-Metzger et al, 2022[8] who propose four principles:

1. Mirror as closely as possible the key characteristics of land-based CO2 removals. Thus, each certificate will have to accurately reveal in a transparent manner information about key quality characteristics
2. Be consistent with the overall national land use, land use change and forestry inventory system, and the associated nationally determined contributions as pledged under the Paris Agreement. In this way, any artificial inflation in the issuance of certificates or double-counting should become quickly detectable
3. Be capable of recognising and promoting synergies and co-benefits and identifying trade-offs with other important policy objectives, notably biodiversity protection and increasing ecosystem resilience. It should help avoiding 'quick sugar fixes', by, for example, ensuring that the right tree species is planted in the right place for the right purpose
4. Be governed by robust institutional arrangements ensuring an effective and efficient functioning of the system, including the development of methodologies, accreditation, verification and validation, and minimising administrative costs

There are also developments at EU level to address the measurement of carbon removals and greenhouse gas emissions at farm level. As regards measurement of *emissions*, there is a commitment to provide a digital carbon navigator and guidelines for the calculation of GHG emissions and removals at farm level in 2022, and for every land manager to have verified emission and removal data by 2028

In its Communication on *reducing methane emissions*, the Commission proposed as follows[9]:

"In the first half of 2021, the Commission will support setting up an expert group to analyse life-cycle methane emissions metrics. This group will look at livestock, manure and feed management, feed characteristics, new technologies and practices and other issues. It will also work in setting up a life cycle methodology on the overall emissions for livestock"

"To encourage carbon-balance calculations at farm level, the Commission will by 2022 provide a digital carbon navigator template and guidelines on common pathways for the quantitative calculation of greenhouse gas emissions and removals" with every land manager to have verified emission and removal data by 2028.

Farm Level in Ireland: The evidence gap as regards quantification of greenhouse gas emissions and removals at farm level is beginning to be addressed in Ireland. Carbon Navigator has been developed by Teagasc and Bord Bia as an advisory tool to do so, designed initially to support the Sustainable Dairy Assurance Scheme (SDAS), but has since also been applied to beef systems[10]. It estimates the % reduction in enterprise GHG emissions that will result from the achievement of the targets which are set.[11]

Marginal Abatement Cost Curve (MACC): The Marginal Abatement Cost Curve MACC developed by Teagasc (Lannigan and Donnellan, 2018) is a very important 'first cut' at where value is to be found: It also helps identify where investment is likely to be needed.

Table 2 No Regrets Measures (return more than they cost in financial terms) ranked by cost per ton of CO_2e, Irish Agriculture, 2020-2030

Rank	Measure	Cost per ton of CO_{2e} abated (€)	Impact K tons abated
1	Improved Beef Maternal Traits	-602	25
2	Energy efficiency on farm	-359	29
3	Beef Genetics: Optimised live-weight gain	-215	61
4	Dairy EBI (Economic Breeding Index)	-200	430
5	Nitrogen-use efficiency	-124	112
6	Extended grazing	-96	65
7	Improved animal health	-46	131
8	Grassland Management	-41	262
9	Wood Biomass for energy generation (thinnings)	-31	759

10	Short Rotation Coppice & Miscanthus Biomass for Heat Production	-20	179
11	Short Rotation Coppice for Electricity Production	-10	187
12	Inclusion of Clover in pasture swards	-7	69
TOTAL			2309

Table 3. Regrets Measures (revenue yield does not cover costs)

Rank	Measure	Cost per ton abated (€)	Impact K tons abated
1	Fertiliser Type (Reducing N emissions)	8	521
2	Water table manipulation of organic soils	11	440
3	Reduced crude protein in pigs	12	50
4	Draining wet mineral soils	16	197
5	Sexed Semen	27	24
6	Afforestation at a rate of 7,000 ha per year	45	2100
7	Slurry amendments	49	27
8	Adding Fatty Acids to dairy diets	76	35
9	Tillage Management – Cover crops	86	108
10	Oil Seed Rape for Biodiesel	90	174
11	Anaerobic Digestion	115	224
12	Low-emission slurry spreading	187	117
13	Sugar beet for bioethanol	200	29
14	Tillage Management – Straw incorporation	279	61
15	Digestion of slurry and grass for the production of gas which is processed further to methane which is injected into the natural gas grid.	280	150
TOTAL			4257

Source: Lannigan, Gary, Trevor Donnellan (Eds.), 2018. An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-2030 (the 'MACC') Based on the work of the Teagasc Greenhouse Gas Working Group. June.

Developments in the US: "COMET-Farm uses information on management practices on an operation together with spatially-explicit information on climate and soil conditions from USDA databases (which are provided automatically in the tool) to run a series of models that evaluate sources of greenhouse gas emissions and carbon sequestration. By integrating NRCS SSURGO database and site-specific climate data, locality-specific results are presented to COMET-Farm users". In a submission prepared by the Food and Agriculture Climate Alliance before the US Presidential election in 2020, "Provide NRCS funding to improve USDA's COMET tool" was a recommendation.[12] Since, then, in the Inflation Reduction Act 2022, $300 million is allocated to improve measurement.[13]

Farm level in New Zealand: New Zealand has developed its own farm-based emissions measurement system (OVERSEER). This was critiqued in 2018 in a report commissioned by the Parliamentary Commissioner for the Environment, [14] after which further developments were proposed.[15]

A significant development by New Zealand has been separate treatment of methane, a short lived gas which accounts for about 25% of today's global warming.[16]

At global level, the convention, following guidance from the intergovernmental Panel on Climate Change (IPCC), is to aggregate all gasses based on their global warming potential (GWP) over a 100-year period, where the GWP of CO2 is 1. In its sixth assessment report released in August 2021, the GWP for CO2 is shown as 1, for nitrous oxide 273, for methane of fossil origin 29.8 and of non-fossil origin 27.2. These coefficients are then applied to the emissions of various gasses, summed, and the total a single number for all greenhouse gas emissions, called 'CO2 equiv.', or 'CO2e'.[17] This approach has great attractions for policy systems, because aggregation hugely simplifies presentation and communication of emissions' performance globally, by country, city, company, farms and households etc. and for this and other reasons, there will be resistance to changing to gas specific metrics.

In its target setting and abatement ambition for greenhouse gas emissions from agriculture, New Zealand separates their treatment based on the length of time they stay in the atmosphere, with particular reference to methane emissions (short lived) and nitrous oxide and carbon dioxide (long lived).

The underlying logic for a different treatment of methane is that cows eat grass and other vegetation that previously was capturing and storing carbon via photosynthesis. As this is consumed and digested, the carbon cycle is temporarily interrupted by a new pathway; some of the CO2 gets converted to methane (CH4) by fermentation of carbohydrates by microbes under anaerobic conditions in the rumen, and emitted, via cow burps and manure, into the atmosphere, before it breaks down into CO2 again. For the dozen or so years that the methane is in the atmosphere, it is trapping more heat than the CO2 would have. If we kept the stock of cows (and manure management practices) constant, the system would eventually find a balance with methane in the atmosphere. This does not mean that there is no warming impact from the cows existing, just that the warming impact from these cows would not be increasing. NZ's Interim Climate Committee expressed the challenge as follows[18]:

"If methane is emitted at a constant rate, methane concentrations will stabilise within about 50 years, as each new emission simply replaces a previous emission that is decaying naturally. Therefore, because methane does not accumulate methane, emissions do not have to drop to zero to stop them adding to global warming. However, if methane emissions continue at or near their current rates, they will keep the Earth a lot warmer than it would be without those on-going emissions. The less methane we emit in future, the less we will contribute to global warming. How much methane should be reduced is a value judgement about how much total warming we are prepared to cause. Natural science alone cannot answer this question or tell us how to prioritise methane reductions now relative to reductions in long-lived gases."[19]

Company Level - Environmental Social and Governance (ESG)[20]

ESG has emerged as a metric for evaluating a company's performance across these three criteria, and ESG rating is used to help investors who want to take these three considerations into account in their decisions. Many questions arise as regards the 'Who' (who does the rating, and monitoring reporting and verification?), the 'What' (what is included, the weighting given within each element?), 'When' (timing and frequency of update?), 'How' (the methodologies used to develop the coefficients, their accuracy, replicability and cost?), Language (e.g., the use of 'energy' to describe drinks which are mainly sugar), Presentation (what appears on the pack of butter or meat?), Displacement (where a company meets very high standards for supplies delivered to ESG sensitive markets but has another company that delivers the opposite to markets that are not).

Markets

The EU

Consumers: Whenever you go to buy a house, a car, or an appliance in the EU, you are very prominently made aware of the relative carbon performance of the choices you face. We invested in both solar water heating and wrap around insulation of our suburban home in Blackrock, County Dublin, which was built in the early 1960s, when energy efficiency and housing in Ireland was an oxymoron. The EU's mandatory Building Energy Regulation (BER) requires that the carbon-efficiency of new and refurbished housing units be independently determined and prominently displayed to prospective buyers and renters. There are 19 levels in the statutory rankings, ranging from A1 (<25 kWh/M2/Yr) to G (>450 25kWh/M2/Yr), with the equivalent CO2 emissions in kg CO2/m2/Yr. ranging from 0 (best) to 120 (worst). After the retrofit, our house was rated C1 (34.9 Kg CO2/M2/Year). A similar template is used to assess appliances and cars.

The next logical step is to provide a similar CO2e independently assessed performance ranking for food which will be available to consumers. The EU is proposing future legislation on sustainable food and related labelling (2023)[21]. At member state level, in anticipation of EU action, Denmark is pressing ahead with a voluntary carbon rating scheme[22].

Investors: In June 2020, REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 was issued. The following 6 performance indicators (Article 5) are specified: climate change mitigation; climate change adaptation; sustainable use and protection of water and marine resources; transition to a circular economy, waste prevention and recycling; pollution prevention and control; and protection of healthy ecosystems.

In April 2021, led by Commissioner Mairead McGuinness, the European Commission issued its proposal for a Corporate Sustainability Reporting Directive requiring all large and all listed companies to report sustainability information in a consistent and comparable manner[23]. These new reporting requirements will apply to most Irish food exporters, applying the 6 performance indicators listed in the regulation.

Key Actor: A key actor in the development of the evidence and processes at both farm and market levels is the Joint Research Centre (JRC)[24]. This is the EU's very highly regarded internal science body which helps the Commission design its policy proposals and often prepares the technical annexes for its legislation. It is at the forefront of developing the evidence and systems that will apply at both farm level and in markets. [25]

There is also important activity underway or in prospect on metrics at both farm and market levels in the UK, US and New Zealand. These are touched on in Blogs 4 (UK), 5 (US) and 7 (NZ).

Assessment

Satellite Measurement of emissions

This is the new frontier. We do not know whether and to what extent it will provide credible farm-based emissions from pasture-based systems, but we do know that technology is often a surprise, that it will provide information in real time, and be a constant source of media and public commentary

Farm Based

At present, the EU is shaping up to be the global leader as regards measurement of both emissions and removals, but the UK, US and NZ could catch up and then lead. It is essential to keep abreast of such developments.

Due to the great efforts by Teagasc (Agriculture and Food Development Authority) Ireland has the potential to become a world leader in the design and delivery of metrics that inform climate decisions at all levels (farmer, investors, communities, retailers, consumers). These efforts include:

- Giving parity of esteem to climate performance in its national farm survey
- The development of farm-based measurement of emissions
- The first effort to cost abatement and carbon removal options per ton.

Without these efforts, Ireland would be in a very challenging situation as regards climate policy credibility on the world stage or in a court room. It comprises a hugely valuable coherent and credible basis from which to make progress.

It is essential that it be resourced to maintain and enhance its leadership. Biodiversity needs to be integrated into the sustainability strand of its national accounts, and staff have made it clear that farm-based emissions accounting requires considerable additional investment

I recognize the case for treating methane differently from nitrous oxide and carbon dioxide, but, given that every ton reduced helps to cool the planet, I struggle to convert that recognition into normative recommendations:

- The world is likely to continue to use the aggregation or gasses expressed in the form of CO2e because it is now anchored into how many understand the issue and act thereon.
- However, there may be a willingness in specified cases, under the Paris Agreement or otherwise, to accept the validity of a parallel accounting of methane.

Company Based

Investors who want to be climate-responsible are aware of the challenges involved in interpreting the currently available ESG metrics, and struggle to ensure that what the invest in will indeed deliver what they aspire to achieve. In Blog 8 (companies) I touch on their strategies, which include looking for reports today that are consistent with the Task Force on Climate-related Financial Disclosures (TCFD) pending the development of government standards that would ideally be global in scope and acceptance.

Marginal Abatement Cost Curve (MACC)

A key weakness of opt-in subsidy schemes is that they typically provide a list of 'acceptable' activities for which funding will be available, which means that new ideas not on the list struggle for acceptance. The European Innovation Projects managed to overcome this limitation by being responsive to new ideas emerging from learning by doing and insights emerging from the grass roots. The MACC needs constant updating that reflects new knowledge, and this in turn needs to inform policy design and delivery.

Markets

Denmark is a leader in regard to climate performance-labelling of food products which would be analogous to nutrition labelling which emerged in the 1980s. The EU has big ambitions. California could emerge as a global leader [more in Blog 5 (US)]. So far, there seem to be no moves to follow Denmark's lead and inform Irish consumers about the carbon footprint of what they buy. It would be useful if at least one company took on this challenge.

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See https://libguides.ucd.ie/academicintegrity on how to cite in other formats.

Biography

Frank Convery has degrees [B. Ag and M.Ag (Forestry)] from UCD. Encouraged by the late Seamus Sheehy, he went to the US and took a PhD in Forestry Economics (State University of New York). After a distinguished academic career in the US (Duke University) he returned to Ireland as research professor at ESRI before being appointed as Heritage Trust Professor of Environmental Studies at UCD where he led the successful application for the funding of the UCD Earth Institute. He chaired the boards of the Sustainable Energy Authority of Ireland (SEAI) (2002-2007), Comhar Sustainable Development Council (2006-2010) and served on the Climate Change Committee (2016-2020) chaired by John FitzGerald, and the AgriFood 2030 Committee chaired by Tom Arnold. The latter produced *Food Vision 2030*. From 2014 to 2018, he was chief economist with the Environmental Defense Fund, New York. His passion is finding ways to bring the weight of learning down to where things are done; his ambition for the sector is the same as Food Vision 2030's: "Ireland will become a **world leader** in Sustainable Food Systems (SFS) over the next decade. This will deliver significant benefits...and will also provide the basis for the future competitive advantage of the sector".

Footnotes and references

[1] Following the Co-op's agreement with Glanbia plc last year to acquire the full ownership of its dairy and grain operating business, this is now trading as Tirlán

[2] Home - CDP

[3] It has since added emissions from agriculture and land use to its work programme

[4] How MethaneSAT is different from other satellites | Environmental Defense Fund (edf.org). New Zealand's Space Agency is a partner in this endeavour.

[5] https://www.copernicus.eu/en

[6] EUR-Lex - 02018R2066-20210101 - EN - EUR-Lex (europa.eu)

[7] This is in part a challenge of numbers – there are ~17,000 installations (power and heavy industry) across the whole EU included in EU ETS, while Teagasc includes ~90,000 farmers in Ireland in its national farm survey - but it is also a product of the variability across farms in soils, drainage, topography, vegetation, farming systems, weather etc

[8] Runge-Metzger, Artur, Linde Zuidema, Peter Vis, Jos Delbeke, 2022: *STG Policy Papers ISSUE 2022/11*, April School of Transnational Governance. Policy Brief: Certifiying land-use based carbon dioxide removals – outline of a strawman proposal : Carbondioxide Removal (carbondioxide-removal.eu)

[9] European Commission, 2020. Communication - an EU strategy to reduce methane emissions, eu_methane_strategy.pdf (europa.eu) pp 13, 14

[10] In the Beef Data Genome Programme (BDGP), over 24,000 beef suckler producers had their farms assessed by Navigator (a tool developed by Teagasc to estimate greenhouse gas emissions), with consultants who were paid €160 per assessment. [Cawley, A., and A. Cronin. 2019. *Spending Review 2019: Beef Data Genomics Programme*. Irish Government Economic and Evaluation Service – IGEES]. 4092b0f1c806495485644360f489c63c.pdf (assets.gov.ie)

[11] Bord-Bia-Dairy-Carbon-Navigator-LR5.pdf (teagasc.ie)

[12] Layout 1 (agri-pulse.com). The co-chairs were Zippy Duval (American Farm Bureau Federation), Elizabeth Gore (Environmental Defense Fund), Chuck Conner (National Council of Farm Cooperatives) and Rob Larew (National Farmers Union).

[13] To address climate change, U.S. makes historic investment in rural America | Growing Returns (edf.org)

[14] 2018_07_27 PCE OVERSEER Review

[15] Overseer | NZ Government (mpi.govt.nz)

[16] Based on the data in IPCC AR5 WGI 2013 – Chapter 8 SM, Table 8.SM.6. Methane emissions are responsible for +0.97 W/m2 warming from preindustrial to present-day, and you divide that by the total positive radiative forcing in the atmosphere from emitted components (+3.95 W/m2).

[17] Source: IPCC Sixth Assessment Report (AR6) Global Warming Potentials - (ercevolution.energy), August 26, 2021 and Table 6 from Blog 1 (Looking Back)

[18]FINAL ICCC - Embargoed - Action on Agricultural Emissions report.pdf, p. 25

[19] FINAL ICCC - Embargoed - Action on Agricultural Emissions report.pdf, p. 25

[20] What Is ESG Investing? – Forbes Advisor for more detail

[21] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13174-Sustainable-EU-food-system-new-initiative_en, p.6

[22] Denmark to introduce voluntary climate labelling ahead of a planned EU-wide roll out - Retail Insight Network (retail-insight-network.com)

[23] Sustainable finance package | European Commission (europa.eu)

[24] https://joint-research-centre.ec.europa.eu/index_en

[25] See its work on food labelling methodologies: https://joint-research-centre.ec.europa.eu/science-areas/environment-resource-scarcity-climate-change-sustainability/sustainable-production-and-consumption-and-circular-economy_en