Universidade de Lisboa

Instituto de Geografia e Ordenamento do Território

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Relatório de Estágio orientado pelo
Prof. Doutor Luís Manuel Costa Moreno

Mestrado em Políticas Europeias

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2017

A todas as vidas que a nossa fome sem limites ceifou

To all the lives reaped by our never ending hunger

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Abstract

This internship report – following a study period at the Institute of Management Science (IMS), the host institution for the internship, in the Humboldt University, Berlin – represents neither an institutional report of a typical internship nor does it aim at being a thesis of sorts. This report is the result of months of basic and exploratory research surrounding the topic of methane emissions, particularly from the standpoint of livestock emissions and the way EU policy tries to tackle the issue. But it also aims at exploring the broader identity of methane both as a greenhouse gas and as a possible renewable energy, how it interconnects with other energy types, and how limiting its emissions and capturing, or even producing it artificially, can represent not only a necessary environmental solution but a sound economic opportunity as well. This would be in line with the type of research being made at the IMS, which looks first into the focus of the research and then to how it behaves within a systemic context, and what can be deduced from this interaction, identifying any possible conflicts, but especially looking for possible opportunities for development from an utilitarian point of view.

Such type of basic research was seen particularly beneficial taking into account recent findings that place methane emissions far above what many authors thought, including the emissions from fossil fuels and microbes, both connected with livestock production and export. Methane is still object of study because not all its causes are completely understood, being perhaps most dangerous in the way it acts in the natural production of ozone and how it can easily cause a positive feedback effect strengthening its own emissions further.

This exploratory research tries to show, to some extent, taking into consideration all the limitations in the field, how important it is to address methane not only focused on livestock, from which its generation seems to be the greatest, but also from all other sources, that can actually be used as renewable energy providers, as it happens in several countries, most notably in China, United States, Norway and Sweden. Further considering all the practical and methodological limits of this basic research, it might be used in a more successful way as a draft prior to a more in depth research.

Resumo

O estágio acordado no Instituto de Ciência de Gestão (*Institute of Management Science* – IMS, da Universidade de Humboldt, Berlim) resultou no planeamento de um projecto de pesquisa que liga as preocupações ambientais com as inerentes à elaboração de políticas. O que começou como um caminho de entendimento complicado, devido à especificidade dos temas que o Professor Franz Hubert, o coordenador da instituição de acolhimento, estava disponível para dirigir, terminou com um acordo mútuo sobre a discussão das emissões de metano da pecuária, e as respectivas implicações em termos de políticas europeias. As razões que levaram a esta decisão são, principalmente, o foco do IMS na análise de políticas e de desenvolvimento sustentável, em conjunto com energia renovável e emissões.

O objectivo do projecto de pesquisa focou-se na exploração de um tema actual, em que muito já foi escrito, mas que tem sido alvo de descobertas inovadoras que podem transformar completamente a noção que muitas pessoas têm do aquecimento global e da indústria animal. Para uma melhor compreensão do tema e para mostrar a necessidade de abordar as emissões da pecuária, uma grande parte deste trabalho centra-se em discutir as consequências da criação de gado por meios industriais, ilustrando efeitos secundários e impactos. Este trabalho exploratório procura ilustrar e problematizar estas questões, não dispensando a atenção na relação entre as emissões de metano e as medidas de política e de legislação, envolvendo dificuldades inerentes à força dos *lobbies,* incluindo o dos produtores de carne e os próprios dos intervenientes na regulação do mercado de alimentos.

Foi um grande prazer ser recebido como estagiário no Instituto de Ciência de Gestão sob a direcção do Prof. Franz Hubert. A cadeira de Ciência de Gestão foi criada em 2000 com a ajuda de uma bolsa da Fundação Heinz-Nixdorf e com o apoio da *Stifterverband für die deutsche Wissenschaft*. O objectivo era desenvolver uma cooperação mais estreita em ensino e pesquisa nas áreas de economia e gestão entre Berlim e Moscovo. O seu principal parceiro na Rússia é a universidade publica *Higher School of Economics* (HSE), que foi fundada em 1992 para oferecer um ensino sobre a economia moderna, de acordo com as normas internacionais e que, desde então, tem criado novos departamentos em gestão, direito, ciência política e outros, sendo hoje a principal universidade da Rússia em economia e ciências sociais. O IMS oferece, em cooperação com o HSE, um programa de dupla licenciatura e organiza eventos científicos como o Seminário Europeu sobre o Gás Natural e a reunião anual da Associação Europeia de Finanças. Após a fundação Heinz-Nixdorf renovar o apoio para o seu trabalho em 2008, o IMS estendeu os seus programas de cooperação à *Urals State University* em Yekaterinburg, ao *Kazakhstan Institute of*

Management, Economics and Strategic Research (KIMEP) em Almaty, no Cazaquistão, e mais recentemente à *International School of Economics* em Tbilisi (ISET) na Geórgia. [1]

O objectivo do estágio era valorizar as nossas próprias capacidades de pesquisa e organização, ao olhar para um tema com uma infinidade de informação, e ser capaz de apresentá-lo objectivamente, com uma visão sistemática e compreensiva, fazendo conexões com as dimensões da economia que são o foco do IMS. Sendo as emissões de metano o tema geral a considerar, foi deixado à nossa própria discrição a melhor forma de abordagem e pesquisa sobre o assunto, sendo possível recorrer à ajuda do departamento com quaisquer dos seus recursos à disposição.

Após uma busca intensiva, tornou-se evidente que o metano, principal componente do gás natural, não deve ser apenas considerado um gás de efeito de estufa mas também um recurso renovável que pode ser usado em abundância e que, quando não utilizado, contribui para o efeito de estufa; por outro lado, ao ser utilizado poderá ser (muito mais) uma óptima fonte de energia alternativa, tanto do ponto de vista de diminuição do uso de combustíveis fósseis como também da segurança energética.

O relatório de estágio é composto por uma recapitulação da ciência de base que rodeia o aquecimento global e os gases de efeito de estufa – metano, CF4 e dióxido de Carbono (CO2) – discutindo as consequências de não se resolver o problema que são as emissões excessivas. Efetua-se alguma ilustração sobre as emissões provenientes do gado e as principais perspectivas da discussão sobre as mesmas.

Apesar de serem limitadas as políticas orientadas para um decréscimo das emissões de metano, estas serão apresentadas, em conjunto com algumas das políticas referentes às energias renováveis. Abordam-se as políticas directas e indirectas, a forma como estas contribuem para alterar a nossa presente realidade, de que modo estão a ser planeadas e como serão implementadas, numa perspectiva de futuro. Apresentando embora um breve enquadramento sobre as energias em geral, tanto na óptica dos seus pontos mais fortes como dos problemas que originam, aborda-se o metano enquanto energia renovável, parecendo ser a que apresenta menos desvantagens ou pontos negativos ao ser utilizada, podendo até a sua utilização ser considerada uma forma de reduzir as emissões de metano para a atmosfera, além de encerrar ainda outras potencialidades.

Este relatório de estágio foca-se mais em analisar a informação existente sobre a ciência das energias renováveis, gases de efeito de estufa e políticas ambientais (análise bibliográfica e documental) do que no tratamento de dados, ao qual é dado apenas um pequeno espaço, dadas as opções de investigação encetadas, como se descreve na componente metodológica.

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[1] Mais informações sobre o IMS podem ser encontradas em http://www.ms-hns.de/research-gas.

O estágio representou uma excelente oportunidade para desenvolver as capacidades intelectuais do autor, dada a interacção deste com uma equipa internacional com diferentes caminhos académicos e métodos de trabalho. Deu também a possibilidade de viver e sentir o sistema universitário alemão, em considerável parte da sua complexidade. Pensamos que as dimensões de “Estudo” e de “Estágio” do programa Erasmus, como quaisquer outros programas de intercâmbio, são altamente benéficos, tanto para os estudantes e professores como para as entidades de envio e de acolhimento, representando uma oportunidade nunca antes possível para a troca de conhecimentos e experiência, elevando o mundo académico a outro nível. Não só pela experiência académica, viver noutro país fornece também uma experiência de vida e de cultura, tornando evidentes não só diferenças como também semelhanças entre vários países, pessoas e lugares, levando a uma melhor compreensão de diferentes realidades sociopolíticas e culturais.

Palavras-chave: Políticas Europeias, emissões de metano, Impactos do Gado, Sustentabilidade

1 - The receiving Institution – Institute of Management Science

The chair for Management Science was established in the year 2000 with the help of a grant from the Heinz Nixdorf Foundation and with support of the *Stifterverband für die deutsche Wissenschaft.* The objective was to develop a closer cooperation in teaching and research in the fields of economics and management between Berlin and Moscow. Their main partner in Russia is the State University Higher School of Economics (HSE), a university that was founded in 1992 to offer a modern economic education according to international standards and has since then established departments in management, law, political science and others, being today the leading university of Russia in economics and social sciences. The IMS offers in cooperation with the HSE a dual degree program and organizes scientific events such as the European Seminar on Natural Gas or the annual meeting of the European Finance Association. After the Heinz-Nixdorf foundation renewed its support for their work in 2008, they extended their cooperation programs to the Urals State University in Yekaterinburg, to the Kazakhstan Institute of Management, Economics and Strategic Research (KIMEP) at Almaty in Kazakhstan and more recently to the International School of Economics at Tbilisi (ISET) in Georgia[2].

The Heinz Nixdorf Foundation, Munich, and the Stiftung Westfalen, Paderborn, are two company-independent charitable foundations of civil law, which have emerged from the estate of the entrepreneur Heinz Nixdorf, who died in 1986. The assets of the foundations originally consisted of the shares of Nixdorf Computer AG held by Heinz Nixdorf. The current foundation is derived from the sale of this shareholding. The Heinz Nixdorf Foundation and the Stiftung Westfalen are today two of the largest private foundations in Germany. Although both foundations are legally independent, they are closely connected because of their common roots, their largely equivalent foundations, and their parallel administrations. The Heinz Nixdorf Foundation provided, according to the IMS website generous funding to the Humboldt-University in Berlin to establish the chair for Science Management and finance a professor's leave for five years during which he/she would lecture and conduct research in Moscow. Later extending it for another five years, to increase support teaching in Russia, a student exchange program and support for scientific cooperation were created[3]. The Deutsche Bundesbank (Berlin) – the central bank of the Federal Republic of Germany – supports the IMS cooperation with Russia.

The Stifterverband backed up and took care of the management of funds for the Heinz Nixdorf Foundation, which motivation and support provided to the IMS. Its work in Moscow would have been impossible. The Stifterverband is the community initiative of

[2] All the basic information about the IMS has been available at http://www.ms-hns.de/welcome (accessed 2-01-2017).

[3] Information about the Heinz Nixdorf Foundation gathered in http://www.stiftung-westfalen.de/home (accessed 2-01-2017)

companies and foundations, which is the only one holistic in the fields of education, science and innovation. The Wirtschaftswissenschaftliche Gesellschaft (Economic Society) supported annual meeting of the chair at the European Finance Association in 2005 in Moscow and with its efforts to create the Berlin Doctoral Program in Economics & Management Science. The Economic Society at the Humboldt-Universität zu Berlin. was founded in February 1995 and has until today about 130 personal members and about 25 company members. The members are made up of business executives, faculty members and a small but steadily growing proportion of graduates of the faculty. The objective of the company is to promote a better cooperation of science and business practices, while at the same time supporting the international orientation of research and teaching. The infrastructure for the transfer of know-how from the economy to the faculty and from the faculty to the economy is established and maintained[4]. The Haniel Stiftung has given scholarships to exchange students from Russia. The Haniel Foundation aims to achieve the greatest possible impact with its projects. To this end, it relies on networking and cooperation with - but also between - cooperation partners. It gives impetus to the development and accompanies projects up to the sustainable establishment. In its two focus areas, educational opportunities and the promotion of young talent, the non-profit foundation currently grants around two million euros of funding annually[5].

Specialized Seminars

The Institute of Management Science over watches several courses at the Faculty of Economics of the Humboldt University. Here is provided a listing of the current courses that best describe the teaching activities and areas of economics on which the IMS focuses on lecturing and overseeing[6].

Network based Energy Systems

The course revolves at first in a broad overview of the gas and power industries in relation to energy markets, defining the most important basics of energy industry on an international level: most important energy sources and markets and their interconnections, historical analysis on prices and production including reserve ratios, problems deriving from resource production and those which can impact the environment. On the second phase of the course a focus is done on electrical power looking at the sector from three different aspects: the power generation, its transmission and management from a reliability standpoint, always considering two problematics: the correct use of current assets and the investment in more

[4] Information on the Wirtschaftswissenschaftliche Gesellschaft https://www.wiwi.hu-berlin.de/de/wwg (accessed 2-01-2017)
[5] Information on the Haniel Stifung gathered from https://www.haniel-stiftung.de/ (accessed 2-01-2017)
[6] Partial list of courses offered by the IMS http://www.ms-hns.de/study (accessed 2-01-2017)

effective and productive new assets. One a first analysis these are address from an operations research view, taking into consideration which problems must be overcome in order to guarantee an efficient power supply. On a second analysis a suggestion of possible solutions is made using decentralized markets, assuming these were perfectly competitive. On the third and last step an analysis is made on the problems derived from the market power made using non-cooperative game theory: In market power the various participants try to bend the rules in their favor. On the last part of the course the investment and regulation on the international pipeline system will be addressed, and how it can shape the power structure, using methodology from the field of cooperative game theory to derive conclusions.

Energy Systems

A generalist class oriented towards improvement of individual research and presentation skills, in which students must execute a presentation covering a different aspect of energy systems, in which they must include: Basic structure of a given energy sector, institutional framework of the sector, empirical study and/or theoretical model.

Gaming and Designing Energy Markets

The electrical sector in many countries has developed from a vertical structure where everything was heavily regulated into systems that are primarily market based, leading to a reformulation and adjustment of the business strategy of many companies operating in the energy industry. One the main ongoing challenges is the need to design and regulate energy markets in order to prevent abuse or exploitation of market power. The seminar examines the problems that exist when designing markets of energy generation, transmission and auxiliary services, when market power is am influencing variable. Students are expected to actively participate in the seminar discussions, make a research presentation and work on a seminar paper in one of the topics available on the syllabus.

Energy Policy

The broader topics relating to energy policy are discussed in this seminar, making use of economic theory insights to try to understand the trade-offs involved and make a quantification of their effects. Students are expected to actively participate in the seminar discussions, prepare and make a presentation and write a research paper on one of the available topics. Students will be able to report on their progress in a small group and get feedback to better understand what is expected of them.

Research Seminar: Electricity Markets

This seminar, oriented towards master and PhD students writing their thesis in this field, provides no credit points. Students must present and discuss the selected articles and current research project being developed in the area of electricity markets, in order to gain a better understanding on them so they can better develop their own thesis work.

Financial Contracts

In the seminar of theory on financial contracting an analysis is made on the situations in which markers are not perfect and cash flows are influenced by financial decisions, therefore the value of companies, in which for example, the fisher separation does not work, which will be pertinent especially when the information is asymmetric and when contracts are incomplete. The description of financial arrangements and their components will be made, like debt and equity, allocations in control rights, including others, which are considered take for granted in the more traditionalist finance theories. The theory gives reasons for which companies should worry about the structure of their capital and their policy on dividends, both of which would become irrelevant under a perfect capital market, and tries to explain the exact role of intermediate actors such as banks. The theory can be executed by stressing on the results, in the same way as practiced in finance literature or by stressing on the assumptions and modeling strategies as practiced in microeconomics and contract theory. An approach made based on the application usage has the advantage of allowing the material to be sorted based on practical issues like capital structure and dividend policy, among others, but may create some confusion in the students by showing logical foundations that can be sometimes contradictory. The seminar was planned therefore around a smaller number of basic models which can be used as the building blocks to construct more complex theories, being oriented towards doctoral students or advanced master students who have a keen interest in the field of corporate finance, consisting of lectures and tutorials and those participating are expected to already possess an advanced knowledge on microeconomics and experience with game theory.

Thesis Seminar

To make it possible for students to write a thesis they have to make an appointment for office hours and turn in (possibly by post or email): A grade transcript from the examiners office containing all courses and seminars and a one page draft proposal on the topic for the thesis. Based on the proposal, it will be discussed during office hours taking into account current research being done by the IMS, topics related to energy systems design and regulation networks and energy policy in general being preferred, but being possible for students to treat topics in other areas such as corporate finance, industrial organization, and real estate economics.

One of the conditions to be accepted for thesis supervision at the IMS is the participation in one of their seminars with good results. After students are accepted into the thesis seminar, where they will be provided with the framework for the supervision of their work, where they have to make three presentations in seminar format: the first at the beginning of term where they outline their project motivation, results they expect to obtain and methodological approach. Only after the first presentation can they make the official registration for the thesis at the examination office, and have between three and five months to finish the thesis. About half that time they will have to make a second presentation where they report preliminary results, open problems and changes in the approach. The third and last presentation is three weeks before the deadline and they must report progress and new problems and discuss any eventual last minute changes.

Dual Degree Programs

The dual degree program prepares attending students for leading positions in international business, public administration and research, covering advanced economics, finance, management, and quantitative methods according to very high international standards. The majority of participants start at the Higher School of Economics (HSE) in Moscow, where they remain for the first year and some come from the Urals Federal University (UFU) in Yekaterinburg or other partners. Students then have to spend two semesters in Berlin learning in English (optionally in German). Participants need a high knowledge of English and a solid background in mathematics right from the start. The program in its entirety should be finished, including the examination and the internship, in between four to five semesters.

When students successfully finish the program they are awarded the degree MSc in Economics and Management Science (MEMS) from the Humboldt-Universität zu Berlin and they also obtain a Master’s Degree from the Higher School of Economics referent to their specialization. Participants have to be admitted into a master program at the Higher School of Economics in Moscow and into the MEMS at Humboldt-Universität zu Berlin. Because the program is very demanding, only candidates with a very high academic potential will be admitted. The application deadline for the MEMS is 31 March every year. The tuition is free in both institutions and when compared to other big cities the cost of living in Berlin is relatively low being reasonable estimate around 600-700 € per month. The university assists accepted students in obtaining third party support for their study period in Berlin and in the past, students have received several scholarships from the European Union, DAAD, Ford Foundation, among others. The faculty will assist in networking among exchange students and maintain contact with alumni through regular events held in Moscow and in Berlin.

Doctoral Studies

Soon after starting teaching in Moscow, Dr. Hubert was asked by some of his best students to write them recommendation letters for PhD Programs at top Universities all over the US and Western Europe but not for Germany or Berlin. It was easy for him to see why because at Humboldt University the doctoral research was done in the traditional German way where most students worked for a particular professor as an employee of the University. The post graduate training was not well structured and the available job offers were posted in the German newspaper *Die Zeit* which was not very popular among graduates in Russia. During his visits to Berlin he initiated some discussions with his colleagues with the objective of stablishing a clear access road for talented students into their system and to improve the quality of the doctoral education, being for him obvious that Berlin offered a huge potential for doctoral education and research, but at the same time most universities lacked critical mass to compete with programs of international renown. So objective became apparent, a joint program would have to be created and the support of the most prestigious scholars in Berlin would have to be gathered.

In 2003 the Berlin Doctoral Program in Economics & Management Science (BDPEMS) was established being organized as a cooperative project including the participation of leading researchers from all the major universities and research institutions in Berlin so as to ensure the quality of the program and international competitiveness. The institutions working together were the Humboldt University, the Free University, the Technical University, the German Institute for Economic Research (DIW), the International Science Center (WZB) and the European School of Management and Technology (ESMT). For students interested in serious research and in building an academic career Dr. Hubert recommends them to apply to the program, but he will only accept to supervise doctoral research after prospecting students achieve an average of good or better in the core courses during the first year of the BDPEMS[7]. The Berlin Doctoral Program in Economics and Management Science (BDPEMS) attracts excellent young academics by offering a course program oriented towards research, having a close student-faculty interaction, and providing good research opportunities. The cooperation between all the institutions in Berlin allows for a broad curriculum from different areas in economics, finance, and management sciences. The main objective of the program being to train its students in conducting internationally competitive research, generate a productive research environment, and ensure their students have the capacity for a successful career in academia or in any other research-oriented professions. Students who graduate can expect internationally renowned careers in academia, research departments and businesses all over the world.

[7] For more information on structure, faculty and research opportunities visit the Berlin Doctoral Program in Economics & Management Science (BDPEMS).

Main Areas of Research

The main research project being executed by the IMS in on Natural Gas, in which they develop a quantitative model of the pipeline system in the Eurasia area and use cooperative game theory derived solutions to analyze the impact of certain investments in strategically placed pipelines, such as the ones in NordStream, SouthStream and Nabucco, and their impact on bargaining power for the players involved. They are also investigating the effects of a possible opening of the intra-European pipelines to investors from third parties.

Table 1 – Major research themes from IMS publications

	Categories of research work
2010 – 2016	Network Economics; Game Theory; Spatial Economics; Asian Energy Market; Energy Market Access; Gas Market Competition; Pipeline Power; International Transport Networks; Transport Networks Investment; Eurasia Bargaining Power ; Energy Supply Chain
2000 – 2009	Baltic Sea Pipeline; International Gas Transport Systems; Strategic Investment; Hold-up Problem; Russian Economy; Russian Electric Power Tariffs; Infrastructure Regulation and Financing; Eurasian Supply Chain for Natural Gas; Multilateral Bargaining; Investment Options; Eurasian Gas Market; Rent Control; Cross subsidies; Russian electric power tariffs; Russian Economy; Reform of the Russian Power Industry; Modernization of the Russian Economy; Multiple Source Lending; Risk-taking and Investment
1990 – 1999	Investment and Risk-taking in Procurement and Regulation; Financial Contracts; Investment Policy and Competitiveness; Capital Structure; Institutional Economics; Corporate Finance; Competitive strategy; Housing markets and policy; Private Housing Market in Germany; Free Cash Flow; Rental Contracts; Rent Volatility; Housing Reform; Taxation and Funding in the Housing Market; Housing Policy; Tenancy Law; Privatization of Municipal Housing; Rent Control; German Social Housing; Housing Finance; Occupational Rights; Long Term Rental Contracts; Housing Promotion

For a complete list of the IMS publications consult annex A.

Objectives of the internship

The main objectives of the internship identified in the internship agreement were: collection, treatment and presentation of information on methane and EU policies. What this really means, is that during our stay at the IMS we had the freedom and at the same time responsibility to maneuver my own research in the direction of our will, taking into consideration that the whole approach was supposed to be a self-learning process into the workings and mechanisms of conducting research in an independent and not strictly overseen way. The collection phase is perhaps the most essential and 'dangerous' at the same time, as there is so much information that it becomes easy to lose track of it or simply getting overwhelmed by the sheer amount of it. In our own experience, the biggest difficulty was dealing with outdated information on which most academic papers and even online publications are based on. Everyday there is new data coming in which must be processed, often resulting in different perspectives forming on top of previously held assumptions. The collection phase was exactly this, dropping with our own machinations, in the 'sea of information' and enabling to learn in the hard way how to best achieve a compromise between the knowledge produced in the past and the new data which is not even yet taken into account, never forgetting either, because both are essential in the process of research.

The second phase, the handling, can be made on many levels, but the most basic and essential one is in trying to tie in together information gathered from different sources and try to come up with explanations to facts and new data based on already proven methods of perceiving reality. The process of putting together data can be especially arduous considering different sources have often disparaging views on data and the reasons and conclusions that can be taken from the available data, which itself has limited reliability due to outdated values or different sources having data on different years and conditions. Normally this phase would include the use of quantitative methods and statistical analysis, processes that some experience has made us consider as friendly and with them feel fairly comfortable, but which require too much time and resources to be accomplished reliably and perhaps not so much in the spirit and during the time of fulfillment of a master internship of this kind.

The third and last phase, the presentation, on which we sin, not so much due to lack of presentation skills but, on the contrary, on one side for the need of simplicity and on the other because of the latent dissatisfaction with the limitations of the research process and the available data and the hassle to get to it, and the will to continue researching and finding meaningful data. Regardless, even this can be taken as a lesson into how to develop research, on how to manage its inherent limitations and how to deal with time and methodological constraints. The making of this exploratory research report represents at its core the hard German pragmatism of clashing head on into the data, and the struggle to try to obtain something meaningful and useful out of it.

2 - Introduction of the exploratory research work

The agreed internship at the Institute of Management Science (IMS) resulted in the planning of a research project which connects environmental concerns and policy making. What started as a complicated 'negotiation' due to the specificity of topics that Professor Hubert, the receiving institution coordinator, was comfortable to direct ended with a mutual agreement on discussing methane emissions from livestock and implications of European policy on them. The reasons that led to this decision are, on the one hand, the focus of the IMS in policy analysis and sustainable development together with renewable energy and emissions. On the other hand, it was necessary to meet both the principles of the master course in European Policies (IGOT, University of Lisbon), which frame institutionally this M.A. Internship Report, and the scientific areas of comfort of the supervisor in the IGOT, around public policies and agriculture and rural / territorial development in Europe.

The aim of the research project was to make us delve into a current topic, on which much has been written already, but which has been having ground breaking discoveries which can turn completely the notion people have of global warming and the meat industry. To make sure the topic is well understood and to show the necessity of addressing livestock emissions, a great deal of this project focuses on explaining the consequences of raising cattle by industrial means, illustrating secondary effects and impacts. This exploratory work intends to elucidate and discuss these issues, paying attention to the relationship between methane emissions, policy measures and legislation, involving difficulties inherent to the strength of lobbies, including those of meat producers and those of regulation of the food market.

The primary aim of the basic research work was to identify how are methane emissions from the livestock sector measured and dealt with within an EU context. The possibility of capturing these methane emissions creates the grounds for addressing methane not strictly from a pollutant point of view but also as an energy source, being of note that natural gas itself is composed normally of around 75% methane and other gases. This suggested the necessity of comparing it with other energy sources. After some research into the topic, it was evidenced that they are themselves methane emitters, especially coal mines, oil or gas wells and transportation, with the special addition of dams which have been proven "recently" to be major emitters of methane, which is now assumed to be common knowledge.

The objective of the internship was to promote our own research and organization skills, by looking at a theme with a plethora of information, and being able to present it objectively with a systematic and comprehensive view, making connections with the dimensions of economics which are the focus of the IMS. Being methane emissions the topic, it was left at our own discretion how to best approach and research the topic, being possible to resort to help from the department by any available means. At the start, the main objective of this report was to delve into the ‘policies of methane’, which unfortunately area almost non-existent. After some research, it became apparent that methane can and should be considered a renewable resource, not only because of environmental concerns, but also because it would be, from the standpoint of economics and energy security, a sound investment.

A combination of factors, arising from both the personal interests and of the host institution (internship), and also from the supervision at IGOT, has led us to delineate a guideline for research, according to Figure 1.

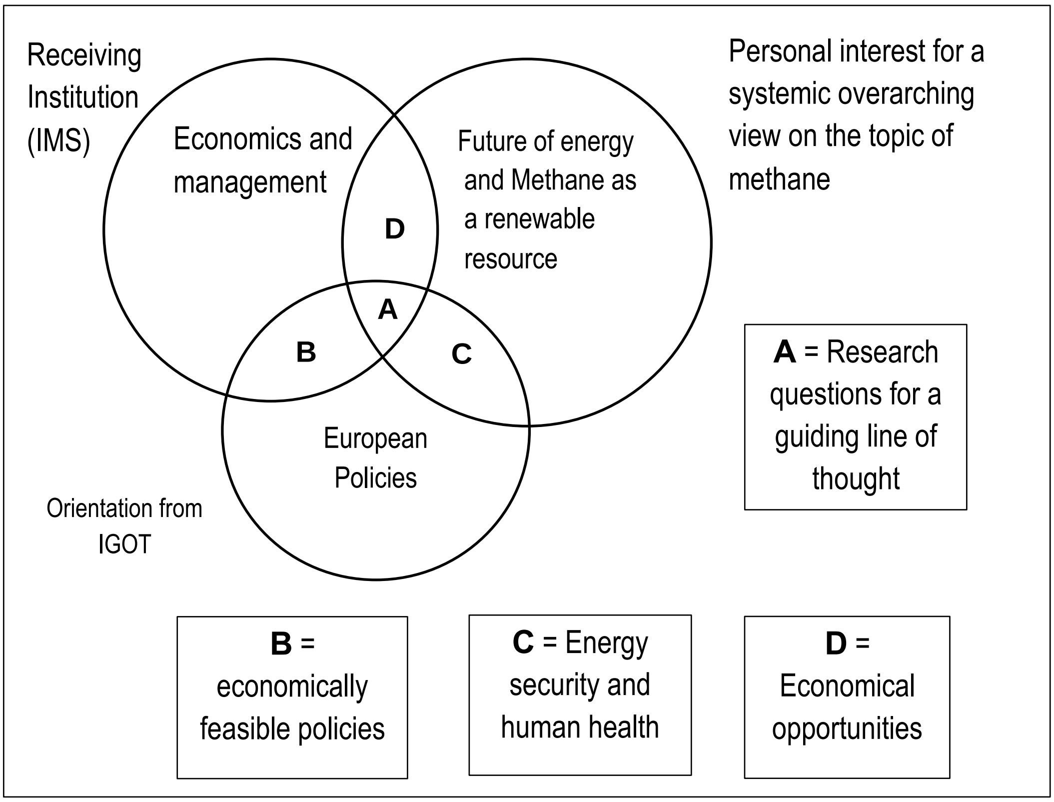

Figure 1 – The rationale behind the choice of the research topic

The work carried out sought to follow a common thread in response to some essential research questions, which are not exactly represented by the title. Indeed, “the influence of European and state policies on methane emissions from livestock” is the theme that leads us to explore some questions which arose from the readings on major contributions for the theme:

1) What is the expression of methane emissions from livestock in Europe, in a global context?

2) Which political choices have favored the current situation and which phases have been more critical?

3) To what extent is the emission of methane from livestock a problem?

4) How have the EU and several Member States responded to the challenge of tackling the problem?

Other much more complex questions have arisen and will be addressed to some extent, both as context issues and in a spirit of possible future research, due to their complexity and reach.

5) Can methane be considered a renewable resource? Is it economically viable?

6) Is there a possibility for a common methane policy? Methane tax?

7) How to treat Africa and South America considering 88% of CO_2 emissions come from Europe, Asia and US?

8) How far are we from an irreversible spiraling positive feedback effect?

The following work unfolds as a process of answering or discussing these questions. In order to do so, we present the logical sequence of the development of the whole report, so comprising also the previous and the present chapter.

Following the detailed presentation of the host institution, involving its dimensions / components, but also including the objectives of the internship (point 1), this Introduction was also prepared to present the guiding rationality of the work performed. Complementarily, the methodological considerations are the next focus (point 2.1).

In point 3 we make a small 'state of the art' on strategies and policies, which fits our approach to the various aspects that are our focus in point 4 and its subpoints. In this fourth point, the case of European policies is particularly highlighted, alongside some correlated aspects, including impacts.

Points 5, 6 and 7 present illustrative case studies documenting the research of different experts or scholars carried out in different parts of the world, which open perspectives to the relevant discussions we have considered.

In the point 8 we only present pre-conclusive notes, since the conclusion (right after) is just focused on a balance (self-assessment) of the internship carried out.

The bibliographic references are complemented with some documents which were important as resources used to access data.

Finally, the annexes contain elements that have been the subject of complementary work of their own, having sustained some elements of analysis and discussion in the body of work.

2.1 - Research methodology

For any academic work to be developed there must be a framework on which it is built, in order for a certain degree of consistency and complexity to be achieved, which in itself in more represents more of a need for conscious development of the research process, and not so much the need for strict lines of reasoning. E. Nuijten in his paper “Combining research styles of the natural and social sciences in agricultural research” (2011, p. 1) argues that there has been a constant increase in the need of interdisciplinary in agricultural and development-oriented research, a fact that became widely recognized. In his paper a research framework is suggested, to be able to integrate methods from both social and natural sciences, and argues that the context-mechanism-outcome based on critical realism allows for a more comprehensive understanding of available mechanisms that can be used that have a social, technical or mixed basis, regarding any research question, and which aim when being chosen is to have the maximum potential for explaining a particular phenomenon and should help researchers choosing the best available mechanism to tackle and individual research question. Nuijten identifies four research styles (Fig. 2) which, once combined with the context-mechanism-outcome (CMO) configuration, may help in identifying the best mechanisms, and he proposes a framework which should optimize the organization and methodology of an interdisciplinary research project. He argues that by understanding the best combination of disciplines and research styles can allow interdisciplinary research to go beyond triangulation, providing more consistent and clear possibilities for integrating research methods and different data sets (Fig. 3). He also argues that by making a conscious decision of having no clear strict methodology in interdisciplinary research can have the advantage of more easily making bridges and establishing different paths in science (Fig. 4).

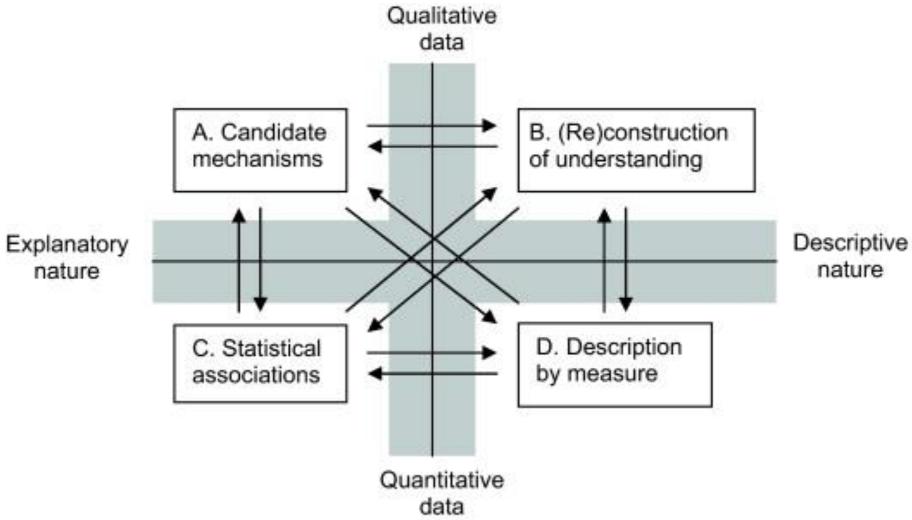

Fig. 2 - Four basic styles of social science research.

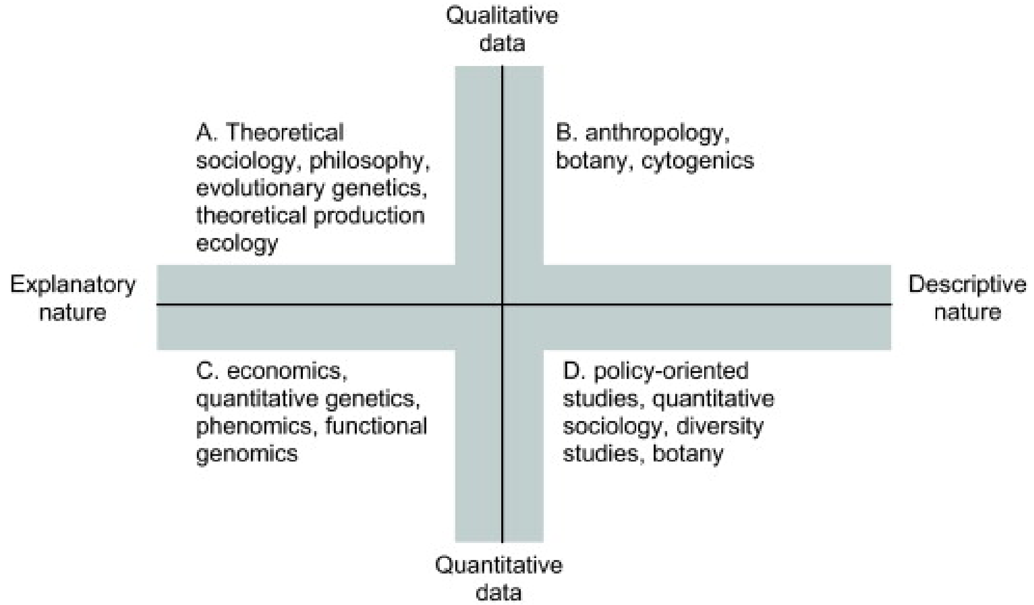

Fig. 3 - Examples of social and natural science disciplines with a perceived bias towards a particular research style.

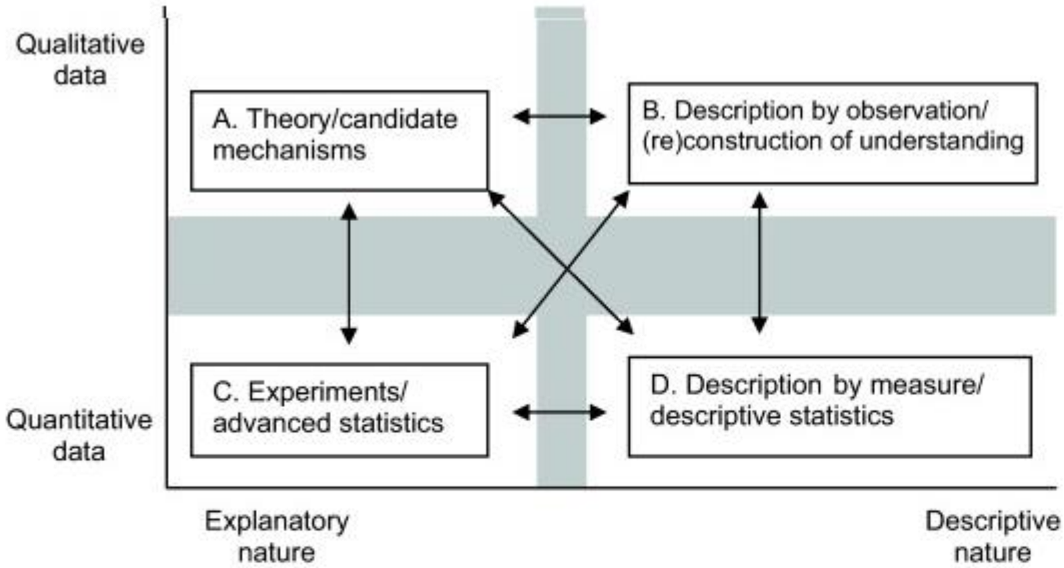

Fig. 4 - Four basic research styles in the natural and social sciences, and humanities.

Certain kinds of agricultural research, especially those oriented towards development, because of the complex nature of agricultural systems, need to integrate methods from both social and natural sciences. By identifying the four research styles existent in both social and natural sciences, it can help in bridging the gaps between both fields and allow for a better integration within a single research project, which combined with the CMO configuration, can lead to a better understanding of the shortcomings of each research style when applied in an interdisciplinary research context and can also reduce the misunderstandings between the fields of social and natural science. Nuitjen argues that at the moment the disciplines of natural sciences may not be in touch with the "real world out there" and mistakenly overlook the research style B (See figs. 2 and 4) and at the same time research in the fields of anthropology and development studies tend to ignore the need for the research style C, which is need to understand underlying realities. The most adequate share of which given style to use can change over time and it is important to realize that no single research style if superior to the other, and ideally all of them should be used and integrated in order to produce well thought viable research projects.

The share of research styles to use depends on the particularities of a given question and there is no given best set of styles, which means for each interdisciplinary research project the researchers have to take into consideration the different styles and methods and evaluate which ones are best to answer their question, taking into consideration time and methodological limitations. The need to always build a different configuration based on the basic styles can lead to interdisciplinary research being able to stimulate creativity in scientific research and in building bridges and better develop alternate paths in science (Nuitjen,2011, p.1).

The present research project can be said to be more developed on the styles A (theoretical), B (observational) and D (descriptive), sacrificing C (statistical) to some extent due to the inherent methodological and time constrains. Regardless, the research tries to make use of both qualitative and quantitative data to support the claims here being made and in the end if the project somehow contributes even in a small degree to the pool of knowledge of any eventual reader we will consider it to have been fruitful.

3 - Methane Policy - State of the Art

Methane (CH4) is a chemical compound mainly present under the earth as the main component of natural gas and is created through methanogenesis a process similar to the creation of oil, basically dead animals and plants get trapped in the soil and their decomposition mixed with high pressures over millions of years results in its formation. It is hard to use the resource due to its basic gaseous state, but among fossil fuels it is the most energy efficient and it also pollutes the least, as evidenced by Fig. 5.

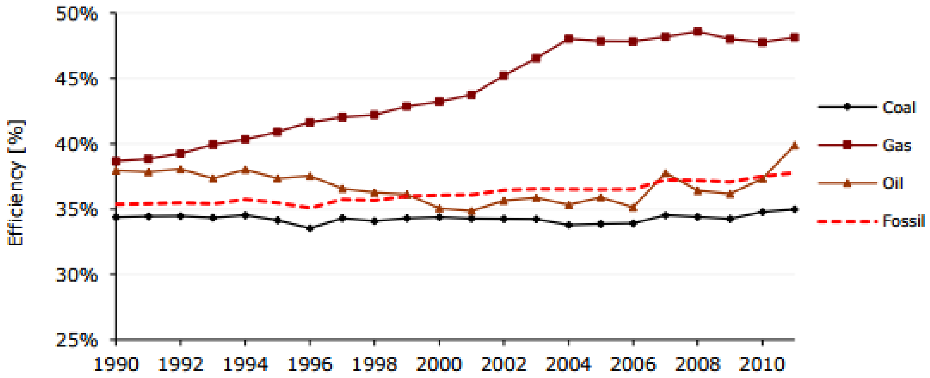

Figure 3 Weighted average energy efficiency for included countries.

Fig. 5 - Weighted average energy efficiency (Ecofys p. 5, 2014)

Methane is heavily used as fuel for ovens, homes, water heaters, kilns, automobiles, among others, being especially important for electrical generation by burning it as a fuel in a gas turbine or steam generator. The problem with it, is when it is released into the atmosphere, when it becomes known as atmospheric methane, because it becomes a strong greenhouse gas with a very high global warming potential GWP, a unit that compares any given GHG to a CO2 equivalent measure. Methane has a lifespan of circa 12 years, and over a 20 year period it creates 86 times more global warming than CO2 (see Table 2). Methane is "responsible for nearly as much global warming as all other non-CO2 greenhouse gases put together" (TGG, 2016).

GWP values and lifetimes from 2013 IPCC AR5 p714 (with climate-carbon feedbacks)[7]	Lifetime (years)	GWP time horizon	
		20 years	100 years
Methane	12.4	86	34
HFC-134a (hydrofluorocarbon)	13.4	3790	1550
CFC-11 (chlorofluorocarbon)	45.0	7020	5350
Nitrous oxide (N_2O)	121.0	268	298
Carbon tetrafluoride (CF_4)	50000	4950	7350

Table 2 – Global warming potential of different GHG (IPCC, 2014)

Aside from gas deposits, methane can be obtained by other much less controllable means. It can be obtained through biogas generated by the fermentation of organic matter including manure, wastewater sludge, municipal solid waste (including landfills), or any other biodegradable feedstock, under anaerobic conditions. Rice fields and some other human wetland plantations also generate large amounts of methane during plant growth. Large amounts or methane are excreted by cows during enteric fermentation, gas which goes to into the atmosphere becoming a greenhouse gas instead of being used as an energy source. Livestock also generates large amounts of manure daily that are usually treated in large waste treatment systems or left aside in pools, both producing the anaerobic conditions for the creation of more methane. Methane emissions from landfills and waste are very important accounting for 16% of human methane emissions, circa 55 million tons of methane per year. Methane gets generated by the decomposition of solid waste in landfills and animal and human waste streams. Landfills even after closed and open garbage dumps contain enormous amounts of organic material that gets decomposed and generates methane for several years. Wastewater can also be a big source of methane if it is stored and treated in an oxygen free environment, where bacteria that cause the fermentation can thrive. All these microbial sources of methane put together can be considered today as the major methane emitters at circa 400 mtons (Pearce, 2016, p.1).

The largest sector of methane emissions used to be fossil fuel production, distribution and use, meaning not the use of fossil fuels, but the leakage and "unavoidable" methane that is released into the atmosphere. Methane is released every time fossil fuels are extracted from the earth, especially from pockets in coal and oil deposits, transported in stages, refined and used, previously amounting to circa 110 million tons of methane per year (WYI, 2016).Now after satellite readings correctly evaluated at circa 200mtons (Pearce, 2016, p.1) Incomplete combustion of fossil fuels in machines and vehicles also produces methane emissions because no system is 100% efficient.

Biomass burning which is the burning of dead or living organic matter, like open fires to clear forest and fields, causes a large amount of methane emissions, 11% of human methane emissions amounting to circa 38 million tons of methane per year. Biofuel, the burning of biomass for domestic purposes especially in developing countries also contributes somewhat significantly 4% or 12 million tons of methane (WYI, 2016).

Methane which is at least the second most important and dangerous greenhouse gas has been subject to many attempts at understanding its impact as a whole, in the search of possible policy solutions that may lead to a decrease in emissions. The main GHGs associated with agricultural activity are methane and nitrous oxide, mainly deriving from fertilizers and the raising of livestock (Froggatt, A, 2013, p. 9). Livestock agriculture has a cogent appulse on all-around abating with about 10% of the absolute GHG emissions in the EU-27. This allotment would be even beyond if emissions from acreage use change as an after-effect of soybean agronomics in Latin America and those associated with transport, processing and packing were included (Lesschen, 2011, p.2).

Methane is one of the gases that contribute to a low air quality which poses a major health risk, being the cause of lung diseases, cardiovascular diseases, and cancer. It can also have destructive economic impacts with increased medical costs and lower productivity due to sick leaves. Air pollution also has impacts on the environment, affecting the quality of fresh water, soils, and ecosystems". (European Commission, 2016a, p.1). A 2016 report from the EEA on air quality estimates that in 2013 more than 450 000 people have died prematurely from air pollution in the EU (p.11). More than half of EU land area is constantly exposed to excess nutrients which are above safe levels. Air pollution also contributes to the degradation of materials and buildings and some air pollutants contribute to global warming through the greenhouse gas effect they have. "The economic cost of the health impacts alone is huge, estimated at EUR 330-940 billion (3-9% of EU GDP)". (European Commission, 2016a, p.1).

A review of the EU air policy conducted in 2011-2013 by the Commission resulted in the adoption of the Clean Air Policy Package which contains a proposed Clean Air Program for Europe which updates the 2005 Thematic Strategy on Air Pollution setting objectives for EU air policy for 2020 and 2030. The most important policy to achieve the 2030 objectives of the Clean Air Program is the Directive 2016/2284/EU about the reduction of certain atmospheric pollutants at national level emissions which came into force in 31 December 2016. The Directive sets national reduction targets for five main pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and fine particulate matter) which are responsible for acidification, eutrophication and ground-level ozone pollution leading to significant negative impacts on human health and the environment. The new Directive negates and substitutes the Directive 2001/81/EC, the National Emission Ceilings Directive (NEC Directive) making sure that the ceilings on emission for 2010 set in it apply until 2020. "Directive 2016/2284 also transposes the reduction commitments for 2020 taken by the EU and its Member States under the revised Gothenburg Protocol and sets more ambitious reduction commitments for 2030 so as to cut the health impacts of air pollution by half compared with 2005" (European commission, 2016c, p.1).

The package will include three main components: 1- A New Clean Air Program which aims at achieving several short term goals and also sets objectives to be met up to 2030. It contains measures to diminish air pollution, especially in cities, to support research and innovation and promote international cooperation. 2- New more strict emission ceilings for the main pollutants. 3- Proposal for new policy to diminish reductions from medium-sized combustion installations like those in energy plants for buildings and small industries. The package is expected to contribute by 2030 to a reduction of 58 000 in premature deaths, preserve 123 000 km2 of ecosystems from nitrogen pollution, preserve 56 000 km2 protected Natura 2000 areas from nitrogen pollution, preserve 19 000 km^2 forest ecosystems from acidification. These measures should result in net saves to the EU of circa 40-140 billion Euros and provide circa 3 billion Euros in direct benefits resulting from lower costs in health and higher workforce productivity, lower damages to buildings and higher farming productivity. The measure will add the equivalent to 100000 job positions due productivity gained through less workdays lost and should have a direct positive impact on economic growth (European Commission, 2016d, p.1).

The new National Emissions Ceiling Directive applies to the pollutants: 1- Primary particulate matter (PM) which can cause respiratory and cardiovascular diseases and lung cancer. It is emitted primarily by vehicles, ships, power generation from burning fuel or biomass. I can also be naturally occurring from sea salt, airborne soil and sand. 2 – Sulphur dioxide (SO2) which through secondary PMs causes the acidification of soils and water deposits, and is emitted by power generation, industry, shipping and households. 3 – Nitrogen oxides (NOx) which as well through secondary PMs can harm health and contribute to acid rains, as well cause eutrophication (excessive nutrients in water deposits). It can also create dangerous ground level ozone (O3). It comes mainly from vehicles, shipping, power generation, industry and households. 4- Ammonia (NH3), which can harm health and contribute to acidifications and eutrophication of soils and water deposits, generated mainly from manure and fertilizers. 5 – Volatile organic compounds (VOC) which are very important components in the generation of dangerous ground level ozone, emitted from solvents in products and industry, vehicles, household heating and power generation. 6 – Methane which was taken out from the directive (European Commission, 2016a, p.1).

The original proposal from the commission "ensured coherence with climate and energy policy in part by addressing two of the main air pollutants which are particularly relevant from a climate policy perspective – methane and black carbon" (2016a, p.1). Black carbon is inserted now within the PM measures, which should account for a robust abatement in emissions. As for methane, due to pressure from some countries including the UK, France, Italy and Poland, it was taken out of the directive (Neslen, 2016, p.1). The majority of meat from bovines in the EU comes from four Member States: France (34.4 %), Spain (15.2 %), the United Kingdom (12.8 %) and Ireland (8.7 %), together hosting around 70 % of the total European meat herd (Eurostat, 2015, p.1).

Even though the commission itself considers there is a strong case for air quality to keep methane emissions under check, in order to reduce ozone concentrations in the EU and to promote methane reductions internationally. The commission will continue to assess the impacts and possibilities for methane reductions in the future, after analyzing national data and taking into account new studies being made to understand better the nature of methane and the proper emission numbers form all source types, so that it can make better more elaborated future proposals (2016a, p.1).

In 2010, the United Nations proposed a "global levy on livestock methane emissions," or as the press dubbed it, "the fart tax." This didn't pass… but it is something that has continued to be discussed.

3.1 - Direct policies on methane emissions

It might be interesting to discuss the current policies that are aimed specifically at methane emissions, but for some not entirely clear reason, a policy that would require governments to reduce their methane emissions by 30% until 2030 was stricken down from a bill in 2014 (Crisp, 2015). This puts Methane emissions inside the strategy EU 2020, but at the same time does not guarantee that methane emissions will even be addressed, although the EC European Commission joined the GMI Global Methane Initiative back in 2007, of which the Steering Committee would give directives and guidance to their partners to develop their GMI Partner Action plan with the purpose of advancing project implementation, facilitate investment and creating appropriate policy frameworks that support methane abatement, recovery, and use (GMI, 2013).

The EU tackles methane emissions Indirectly together with other GHG emissions through the Climate and Energy Package, which was agreed by the European Parliament and Council in December 2008 and brought into law in June 2009. The package aims at reducing the emissions of greenhouse gas in the EU by 20% by 2020 compared to 1990.

On this package two main elements address methane to some extent a remake of the Emissions Trading System and the creation of an Effort Sharing Decision which would regulate emissions from sectors not covered by the ETS, such as transport, housing, agriculture and waste (GMI, 2013). Under this agreement members states agreed on binding emissions limitations for 2020 based on their relative wealth, the richest member having to cut its emissions by 20% and the poorest being free to increase his by 20%, with an overall aim of reducing GHG emissions from non-ETS sectors in the EU by 10% by 2020 in comparison with 2005 levels, covering the following gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorcarbons (HFCs), perfluorcarbons (PFCs) and sulfur hexafluoride (SF_6) (GMI, 2013).

Another indirect policy is the Landfill directive, which proposes a reduction of the volume of biodegradable waste that is landfilled by 65% by 2018, having already suffered a sharp drop of 35% between 1990 and 2010. On the long term the commission wants to completely eliminate landfills for untreated waste.

A policy that could have a tremendous direct impact is the Best Available Techniques (BAT) for agro-industrial installations that fall under EU legislation (the Industrial Emissions Directive), "such as power plants, refineries, large scale rearing of pigs and poultry and waste water treatment plants" (GMI, 2013). Yet for reasons that are unclear, there are no policies aimed directly at methane emissions from cattle, oil, coal or gas extraction and processing (GMI).

3.2 - EU 2020 Climate Strategies

The three targets the EU decide to strive for, known as the "20-20-20" targets, set three key objectives to be achieved by 2020 (Fig. 6):

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- A raise the share of EU total energy consumption produced from renewable resources to 20%;
- A 20% improvement in the EU members' energy efficiency.

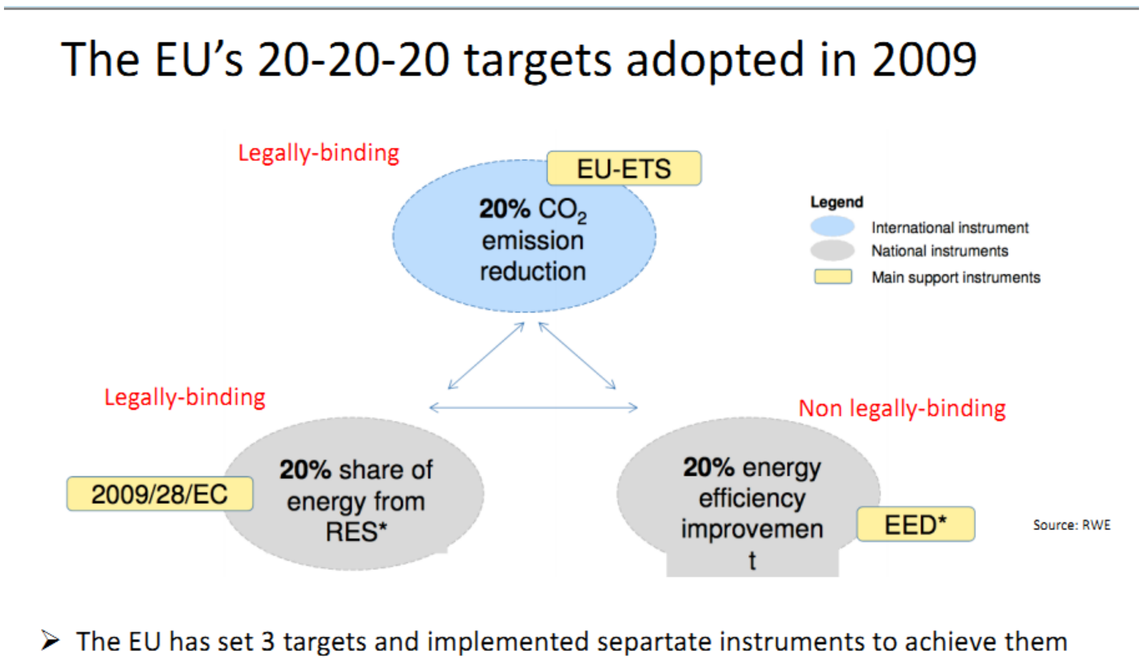

Fig. 6 – 20-20-20 targets (RWE, 2015)

With several measures taken both at European level and by Member States at national level, the EU is already close on meeting its targets for cutting greenhouse gas emissions both under its own internal target in the Europe 2020 Strategy and under the Kyoto Protocol's second commitment period (2013-2020). It is regrettable that the current Kyoto agreement was cancelled in 2014 because ratifications to the treaty didn't get enough votes to pass, although there is going to be another attempt to reach an agreement and ratify it next December at the United Nations Climate Change Conference in Paris. By reducing emissions since 1990 and still being able to expand its economy, the EU has successfully demonstrated that economic growth and emission cuts can go hand in hand.

The 20-20-20 targets represent an integrated type of approach to climate and energy policy with the aim of combating climate change, increase the EU's energy security and strengthen its competitiveness. They are also represent the most important aims of the 2020 strategy for smarter, more sustainable and inclusive growth which reflects in the conclusion that solving the climate and energy challenge can contribute to the creation of employment, the creation of a "green" growth and a strengthening of Europe's competitiveness. An estimate of reaching the 20% renewable energy target could mean the creation of around 417 000 additional jobs, and the 20% energy efficiency improvement in 2020 is predicted to create another 400 000 jobs. The EU also proposed to reduce emissions by 30% if other countries commit themselves to reduce theirs significantly.

3.3 - European ETS

The European Union Emissions Trading Scheme (ETS) is the largest cap-and-trade scheme in the world so far. The ETS regulates about half of EUs CO_2 emissions which include more than 11,000 factories, power stations, and other installations in 30 countries: all 28 EU member states plus Iceland, Norway, and Liechtenstein. The caps for 2020 were agreed at 21% below 2005 emissions, and expected to go down to as much as 43% by 2030. The first ETS trading period was from 2005 to 2007 (Fig. 7). The second trading period was five years coinciding with the first Kyoto commitment period from 2008-2012. The third is eight years, from 2013-2020. Participating entities receive European Emission Allowances (EUAs), being able to emit 1 tone of CO_2 for each grant. If their CO_2 emissions exceed the number of allowances, a factory can purchase EUAs from other installations or countries. But if the facility performs well in reducing their carbon emissions then it can sell their extra EUAs. Participating entities can use CDM (Clean Development Mechanism) and JI (Joint Implementation) projects to gain credits.

The ETS has been severely over-allocated in the first and second trading period which led to a collapse in the price at the end of the first and second trading period. In late 2012, the EU ETS was oversupplied by about 2 billion subsidies. The options for dealing with the excess supply include temporarily removing Grants (back-loading), retiring permanently subsidies or raising the emissions reduction caps.

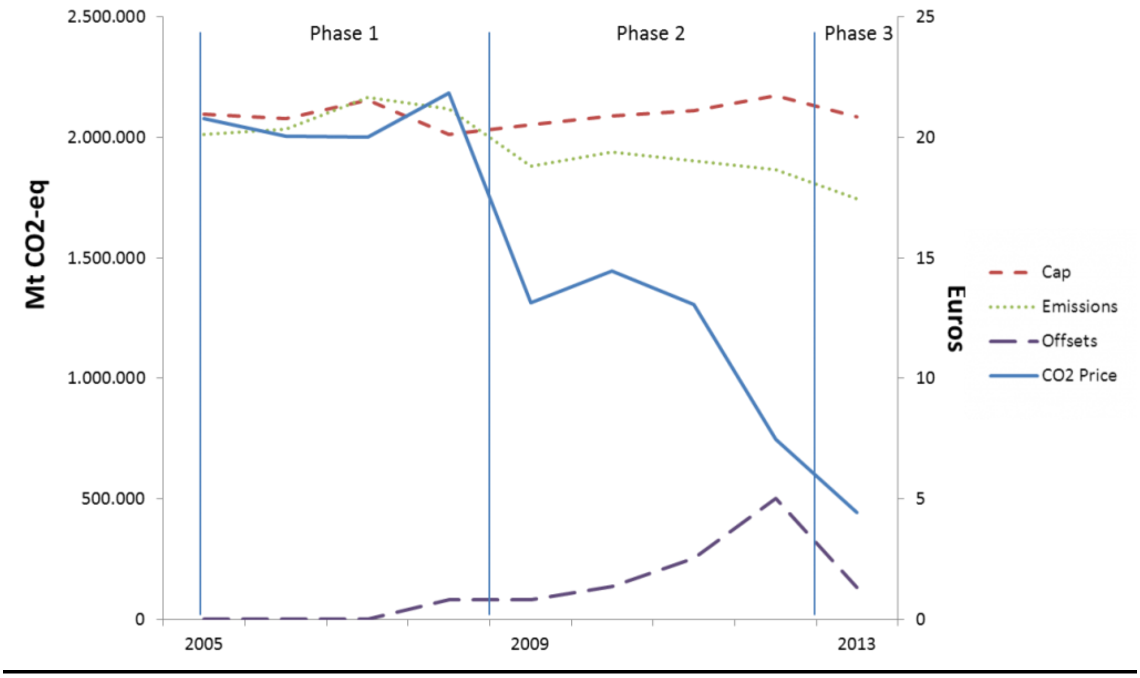

Fig. 7 – Phases of the ETS (EnergyPost, 2015)

One of the main reasons why the emissions didn't match the cap was due to the 2008 crisis and subsequent recession, which led to a decrease in industrial activity. Then because the emissions were below the cap, credit process plummeted. The violet line represents credit gains from other projects, which surprisingly grew quite well until around 2012, but after that followed the credit price trend. Some regard the drop in price as a sign the whole ETS was a failure, yet, considering emissions were actually below the expected cap, means the ETS was at least a partial success. One of the reasons why the EU may have chosen not to drastically change this cap to accommodate to the emission and credit price fall, may have been due to the need of economic recovery, while the EU is trying to put economic performance and sustainability together, not wanting to sacrifice one for the other.

3.4 - EU Effort Sharing Decision

Under the EU Effort Sharing Decision, EU Member States have taken on binding annual targets for reducing their GHG emissions from the sectors not covered by the ETS, such as housing, agriculture, waste and transport (excluding aviation) (Fig. 8). Around 50% of the EU's total emissions come from sectors outside the ETS. The overall EU target under the

ESD is a 10% emission reduction in 2020 compared to 2005. Each Member State has an ESD target determined according to its economic capacity. Significant differences exist between Member States and some need to reduce emissions compared to 2005 whilst others are permitted a limited growth in emissions. MS can use international offsets up to 3% of their 2005 emissions in the effort sharing sectors.

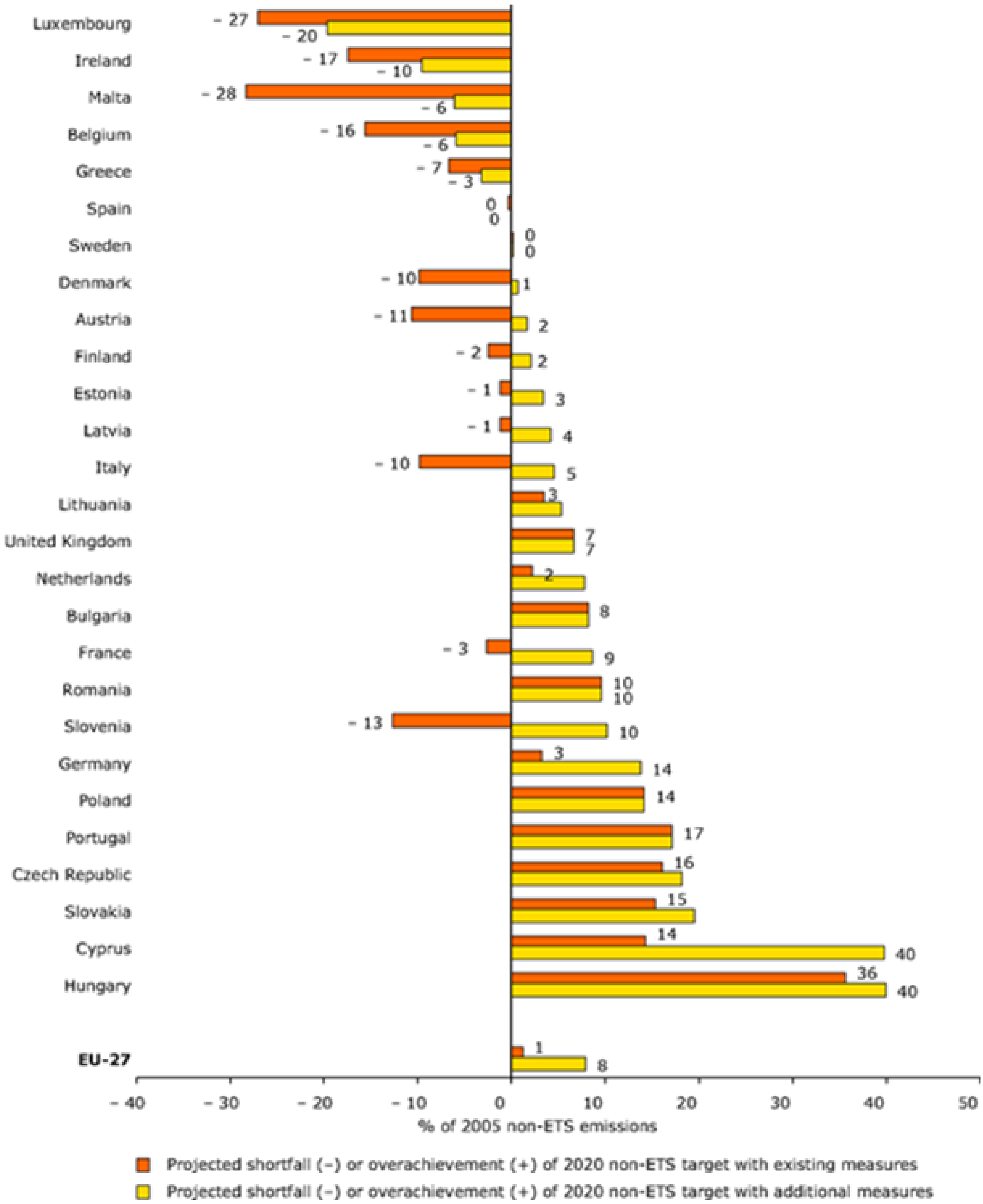

Fig. 8 – Percentage of 2005 non-ETS emissions (EEA, 2012)

3.5 - Carbon capture and storage

The fourth element of the climate and energy package was a directive creating a legal framework for the environmentally safe use of carbon capture and storage technologies. Carbon capture and storage involves capturing the carbon dioxide emitted by industrial processes and storing it in underground geological formations where it does not contribute to global warming. The directive covers all CO2 storage in geological formations in the EU and lays down requirements which apply to the entire lifetime of storage sites (Fig. 9).

Two tranches of deployment before rollout of CCS

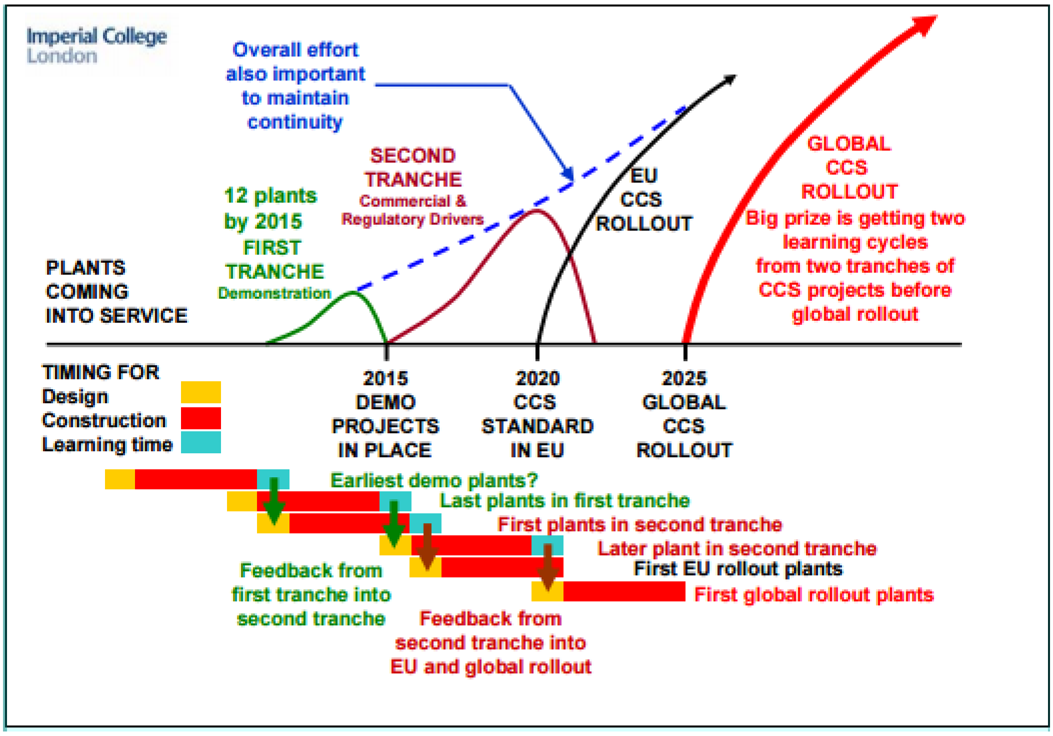

Fig. 9 – Carbon capture storage phases (CEC, 2008)

4 – Research and results

The research was conducted mostly online and only partially directly in the library, at a ratio of approximately 50 to 1. This is due to two main factors: on one side most academic material is available almost only online and on the other hand due to the sheer volume of useful information that sometimes can only be gotten from public mediums like reputable newspapers and news agencies. In a world that is constantly moving and changing, where data is constantly coming in and developments take place at an unprecedented pace, information becomes easily outdated. I conducted my research as best as I could but knowingly that some of what is here described is already outdated if new data, not readily available, was to be taken into consideration. Such should actually be a clear sign that research methods and policy making should adapt to the influx of information and allow for a more dynamic approach which can be steered in the right direction in the face of barriers and constraints brought in by new data, something which would require more complex reactionary mechanics.

4.1 - Emissions caused by Livestock production

The scope of this research project focuses directly on the methane that is created through the raising of livestock, especially cows through enteric fermentation, the fermentation of organic material inside the animal that is released in the form of methane though belching 95% and flatus 5%. Cattle production has more than doubled since the 1960s (WYI, 2016), with it came not only the methane emissions from the animals, but also from manure and waste water, and many other indirect means, forest clearing for growing feed, transportation of feed and animals, and the creation and use of all the necessary machinery and processes Involved.

It can be argued that there is no clear scientific consensus on how much total GHG emissions the raising of livestock creates. In 2009 two researchers from the world bank argued in a paper for the Worldwatch Institute that it accounted for 51% of all man made GHG (WWI, 2009), whereas a report from the UN food and agriculture organization FAO, stated in 2007 that it accounted for 18% (FAO, 2007) and later in 2013 merely for 14,5% (FAO, 2013). Although it can be argued that since FAO is not an independent organism like the Worldwatch Institute, it can be more prone to political mannerisms, especially lobbying. Samuel Jutzi, director of the animal production and health division of the FAO, said “powerful lobby groups were able to delay decisions, sometimes for many years, and "water down" proposed improvements. Their job was made easier because the FAO works by consensus, so persuading as few as two or three national governments to oppose an idea was enough to block it” (Jowit, 2010). Tim Lang, a professor of food policy at City University in London, said there have been concerns about corporate lobbying of UN organisations including the FAO and the World Health Organisation for decades, a problem made worse by the widespread acceptance of the power of private companies (Jowit, 2010). Robert Goodland, one of the world bank researchers, argues that the models used by FAO are outdated and that it is underplaying the role of the livestock industry in the creation of man-made GHG by ignoring the 45% of all landmass on earth used for growing feed for livestock that had to be cleared and could otherwise be used for forest, also ignoring the respiration factor of livestock (Goodland, 2013).

Goodland and Anhang argue that there are many uncounted, overlooked and misallocated livestock-related GHG emissions in the 2007 FAO report (Table 3), a total of 22048 million tons that are not part of the inventory of world atmospheric GHG, and which when put together would raise this inventory from 41755 million tons to 63803 million tons (WWI, 2009, p.11). If they are right, this means that the total GHG production from Livestock would be equal or above 51% of the total man-made GHG in the world. They argue that livestock should be treated as a commodity in terms of their breathing, which FAO considers natural, comparing them to cars (considering them man-made), in part because a major part of the world population consumes little to no animal products and “no livestock respiration (unlike human respiration) is needed for human survival” (WWI, 2009, p.12). When the CO2 from livestock is included an extra 7516 million tons of GHG are added to the inventory, and with all relevant GHG added comes to mean 13.7% of GHG.

Uncounted, Overlooked, and Misallocated Livestock-related GHG Emissions

	Annual GHG emissions (CO_2e)	Percentage of worldwide total
	million tons	
FAO estimate	7,516	11.8
Uncounted in current GHG inventories:		
1. Overlooked respiration by livestock	8,769	13.7
2. Overlooked land use	≥2,672	≥4.2
3. Undercounted methane	5,047	7.9
4. Other four categories (see text)	≥5,560	≥8.7
Subtotal	≥22,048	≥34.5
Misallocated in current GHG inventories:		
5. Three categories (see text)	≥3,000	≥4.7
Total GHGs attributable to livestock products	≥32,564	≥51.0

Table 3 – Uncounted, Overlooked, and Misallocated Livestock-related GHG Emissions (WWI, 2009, p. 11)

They argue that the FAO report doesn't count the "annual GHG reductions from photosynthesis that are foregone by using 26 percent of land worldwide for grazing livestock and 33 percent of arable land for growing feed, rather than allowing it to regenerate forest" (p.13) terrains which if were left to regenerate forest could potentially absorb more than half of all anthropogenic GHG. If this land was used to produce biofuel it could replace half of the coal used in the world, and net saving of 3340 million tons GHG. They argue that the FAO uses the 100 year methane GWP of 25 to calculate its impact whereas they use the 20 year one of 72, which raises the GHG from livestock by another 5047 million tons. They also call to attention that other timeframes should be worked on; perhaps denoting the strange fact that methane having a lifespan of between 8 to 12 years must have its impact calculated on a 20 year frame.

They argue that the FAO has undercounted or overlooked four other factors that contribute 5560 MTons of GHG: 2560 MTons from the increased tonnage of meat products from 2002 to 2009; Several discrepancies in FAO studies regarding the number of animals in the world, which would increase GHG by more than 10%; the FAO quotes many aspects of GHG dating as far back as 1964; and it counted livestock-related deforestation and farmed fish in other sectors; having also ignored the increased use of fluorocarbons in meat products refrigeration, higher energy needed for cooking; disposal of livestock remains; production, distribution, and disposal of byproducts, like leather, feathers, skin, and fur, and their packaging; Production, distribution, and disposal of packaging used for livestock products; Carbon-intensive medical treatment of millions of cases worldwide of zoonotic illnesses (WWI, 2009, p. 15).

4.1.1 - Positive feedback effect from agriculture

The term "positive feedback effect" has in the past been used most often to describe the artic methane release which can happen after global temperatures attain certain levels, which could theoretically free enough methane concentrations in the ice to create a positive feedback into the atmosphere that would by itself drive temperatures up even further and release even further methane, in a spiraling process (Svoboda, 2006, p. 1).

Current research warns about microbial activity and methane production of which livestock is most likely its biggest contributor, but not yet existing a proper method to identify how much exactly of the methane in the atmosphere comes from livestock, rice cultivation or waste management. Something is certain though, the fact that methane emissions from microbial sources increase with temperatures gives a whole new dimension to how methane emissions have to be treated and tackled, especially considering expected temperature increases in the next decades which will drive these numbers up (Pearce, 2016, p.1).

4.2 - Terrain occupancy impacts and trends

Cattle production needs massive land use, both for pasture and feed production (Table 4). To get these terrains, forests are often cleared away, especially in developing countries, since developed countries don't have forests anymore or have strict laws in place. In Brazil for example one of the most recent census shows that 91% of its forest destruction was due to the creation of grazing fields for cattle (Margulis, 2003, p. 36)

TABLE 1: EVOLUTION OF LAND USE IN LEGAL AMAZONIA IN CENSUS YEARS (PERCENT)

	1970	1975	1980	1985	1995
Deforested areas	3.0	4.0	6.2	7.7	9.5
Total cropland	0.3	0.6	1.0	1.2	1.1
Planted pastures	0.7	1.4	2.6	3.8	6.6
Unused and fallow areas	2.0	2.0	2.6	2.7	1.8
Non-deforested areas	97.0	96.0	93.8	92.3	90.5
Public and protected areas	87.9	84.5	79.6	77.3	76.3
Natural pastures	4.0	4.5	5.1	4.7	3.6
Private forests (a)	5.1	7.0	9.1	10.3	10.6

(a) The areas covered by planted forests are 2 to 3 orders of magnitude smaller than the areas covered by natural forests.

Source: IPEA/DIMAC based on IBGE Agricultural Censuses.

Table 4 – Land use in the amazon in the last census years (Margulis, 2003, p.9)

As it can be seen in Table 4, the increase in pastures follows closely the deforestation trend. At the same time the number of public and protected areas goes down, as the number of private forests increases. The Amazonia is one of the best examples, not only because it is the most bio-diverse tract of tropical rainforest in the world but also because most forests at risk are in developing countries where for the most part there are no census, a strange exception would be Australia. The World Wide Fund for Nature (WWF) predicts that the big brunt of deforestation in the world will happen in the next 15 years – Fig. 10 (WWF, 2015)

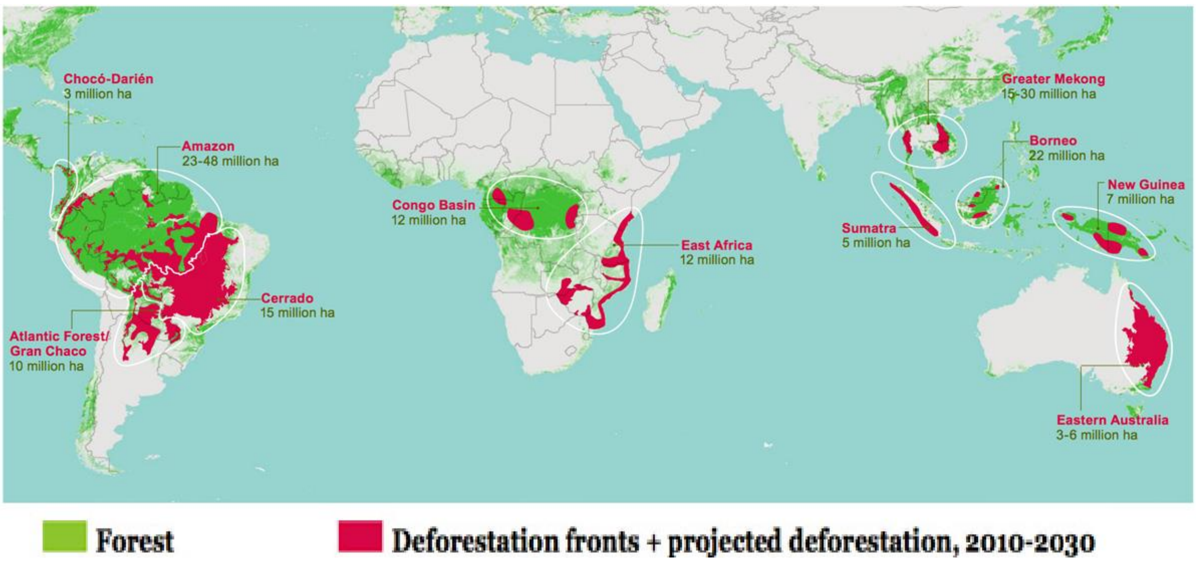

Fig. 10 – Predicted deforestation 2010-2030 (WWF, 2015)

4.3 - Livestock direct and indirect emissions

It is very hard to make a concrete calculation of emissions from livestock and all the associated variables. Expert estimates of global greenhouse gases (GHG) emissions attributable to livestock "range from 8 to 51%" (Herrero, 2011). This problem starts at the animal level (Fig. 11), because there are many different breeds, which are fed different diets and treated with different antibiotics. Housing and the degree of freedom given to animals also has a huge impact on their emissions. Geographical location is perhaps one of the most overlooked variables, but which can have the greatest impact, considering that the warmer and humid the environment, the better the conditions for fermentation of organic matter into methane.

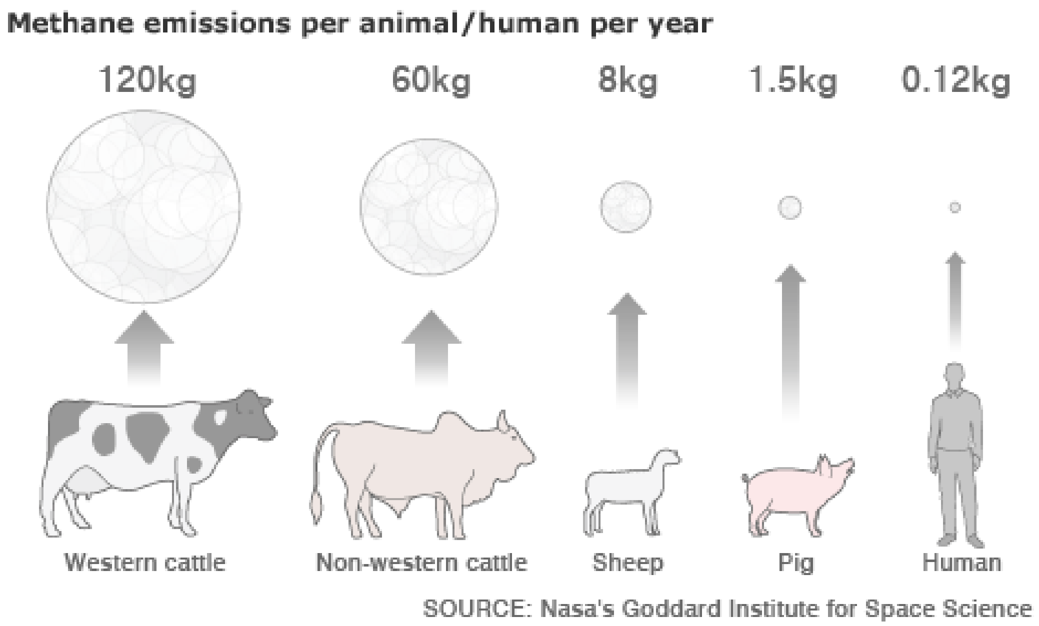

Fig. 11 – Methane Emissions estimate by animal/human (Bell, 2009)

4.4 - Increase in consumption habits

Not only forests which are a major carbon sink are at risk; the human population is predicted to grow exponentially over the course of the next years (Fig. 12), and with it will come a much higher demand for meat products, driven not only by the raise in population but also by the development of poorer countries that start to adopt to a western diet with fish and meat[8].

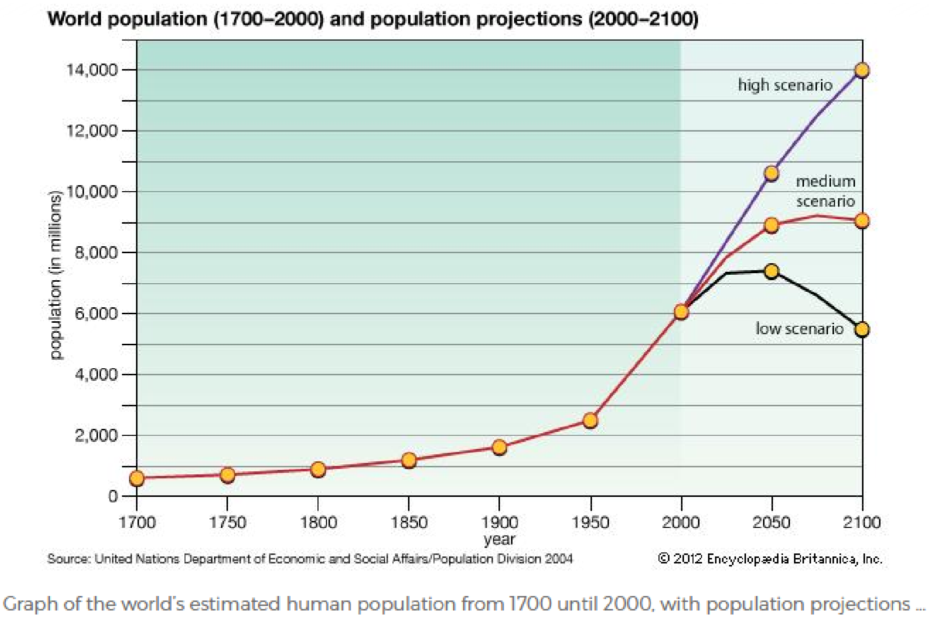

Fig. 12 – Population growth in the world between 1700 and expected to 2100 (Telterbaum, 2015)

When we look at the latest numbers of meat consumption, we can see a sharp rise all over the world, but especially in developing countries, which import the lifestyle and diet of the western world as they grow and become more 'developed' themselves (Fig. 13). Development in a sense that means destruction of our environment and future of the planet for a short moment when a couple of generations can have all they desire and doom future generations to live in a barren world.

[8] This diet only had its great impulse with the industrialization of agriculture, after the Industrial Revolution. Thinking in some relevant kinds of meat, for our concerns, "only in the nineteenth century did the commercial production of beef for the rapidly expanding and relatively well-off urban populations of Europe and North America become viable" (Higman, 2012:74). This author further adds that "the invention of continuous refrigeration", in the same century, was crucial to enable "long-distance trades in highly perishable foods such as meat and dairy products" (idem: 132). The combination of this and the diffusion of household refrigerators (fridges) since the 1940s were stimuli for greater stock-farming, with the development of large-scale supply.

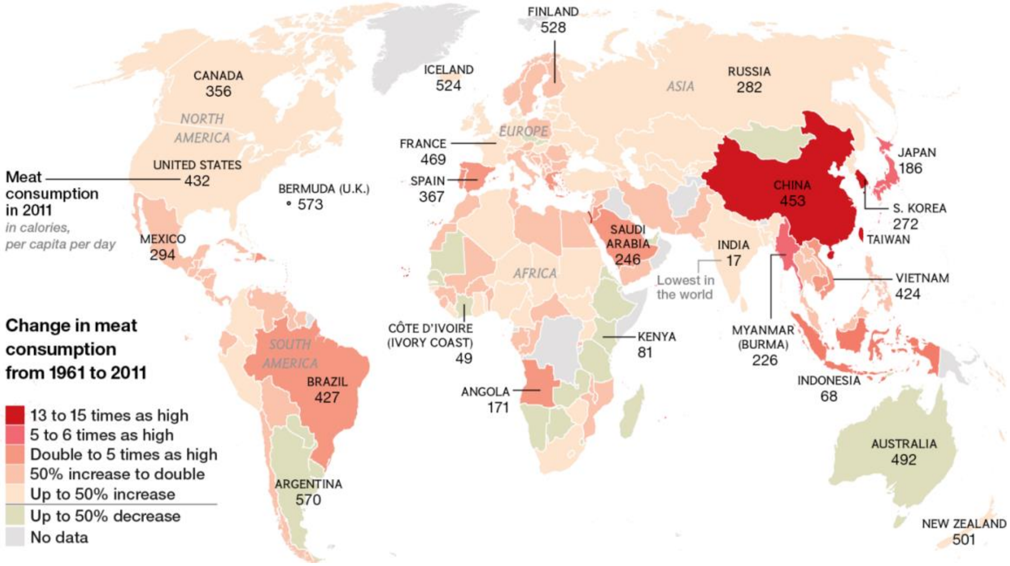

Fig. 13 – Change in meat consumption by calories per capita from 1961 to 2011 (Kunzig, 2014)

4.5 - Impact of methane emissions coming from livestock in Europe

The Typology of the Livestock Production System in Europe in Europe is characterized by six main sectors: dairy cattle for milk production, meat production from bovine livestock, meat production from poultry, egg production, meat and milk production from sheep and goats and pig production (meat and raising). Description of the Livestock Production System was at the regional level using 8 groups of descriptors: animal assemblage, climate, intensity level, productivity level, cropping system, manure production, feeding strategy and environmental impact, for which the quantification was made based on the CAPRI database in conjunction with data from the JRC Agri4cast action (climate), INRAtion© (feeding strategy) and Eurostat (farm types) (Pérez, 2016, p. 9).

The quantification for the methane emissions from enteric fermentation and manure management has followed the IPCC 2006 guidelines, with a Tier 2 approach for cattle activities and with a Tier 1 approach for swine, poultry, sheep and goats (Fig. 14). The feed digestibility was calculated on the basis of the feed ration estimated with CAPRI and existent literature. Nitrogen emissions were calculated using a mass flow approach which considered emissions from grazing animals, manure management, manure and mineral fertilizer application, nitrogen delivery of crop residues and N-fixing crops, indirect N2O emissions from volatilized NH3 (Ammonia) and NOX (nitrogen oxide) as well as from leaching and runoff (Pérez, 2016, p. 12).

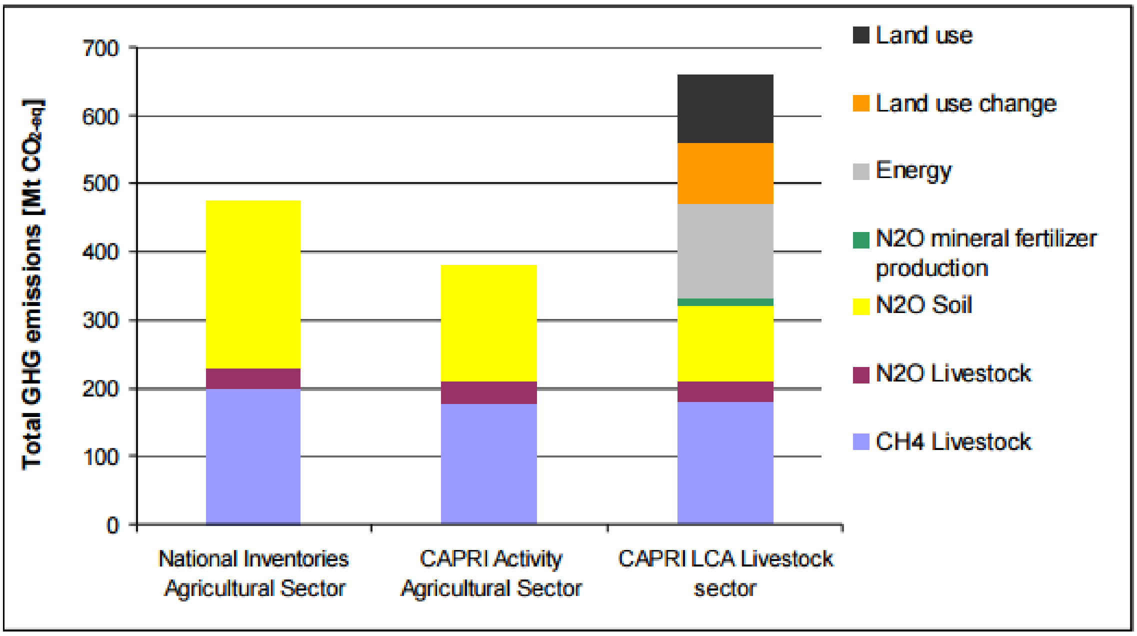

Figure ES9. Total GHG fluxes of EU-27 in 2004 of the agriculture sector as submitted by the national GHG inventories to the UNFCCC (left column, EEA, 2010), calculated with CARPI for the IPCC sector agriculture with the CAPRI model (middle column), and calculated with a cradle-to-gate life-cycle analysis with CAPRI (right column). Emissions from livestock rearing are identical in the activity-based and product-based calculation. Soil emissions include also those that are 'imported' with imported feed products. The LCA analysis considers also emissions outside the agriculture sector.

Fig. 14 – Quantification of methane emissions from agriculture in the EU (Pérez, 2016, p. 20)

Such estimates are very conservative since especially for soil emissions and enteric fermentation, there is much more research needed for assessing trade-off and feed-back effects. There have been several reductions in emissions due to the implementation of the nitrate directive on nitrate vulnerable zones and a future complement to this regulation could hold a positive result on agricultural lands. The is a sizeable amount of knowledge on possible actions that can be taken in relation to manure management, especially from the standpoint of animal waste management systems, and it is feasible for the methane emissions from these systems to be captured and used for energy or others ends. It is not certain how much methane and nitrous oxide emissions could be abated, but by making full use of current available technology, the potential seems to be at circa 30% of current emissions from manure management could be captured and used for energy purposes, in systems that allow for controlled anaerobic digestion and composting (Pérez, 2016, p. 22).

There is a discrepancy between the levels of production systems and emission systems, based on how the several characteristics of the systems interact, for example some countries with the lowest emissions per kg of beef like Austria (14.2 kg CO2-eq/kg) and the Netherlands (17.4 kg CO2-eq/kg), shows that some like the Netherlands minimize emissions of methane and N2O which indicates an efficient and industrialized structure of production with strict environmental regulations, while Austria which has much higher emissions is able to balance them by having lower emissions from land use and land use change which is a sign of self-sufficiency in the production of feed and high amount of grass used in feed. Both countries have high yields of meat, but de defining factors are on one side the imposing of limits to emissions and on the other proper use of land and self-reliance (Pérez, 2016, p.29). According to FAO, the total emissions from livestock in the world amount to circa 7.1 Gigatonnes of Co2-equiv per year, which represents 14.5 percent of all anthropogenic GHG emissions in the world (2017, p.1). That would mean the circa 650 Mton emissions from livestock in the EU would represent at least 9 percent of all the emissions from livestock in the world. Considering Fig. 16 represents data from 2004, this value would be ramped up if a similar assessment is made on current data.

4.6 - Political choices and phases of development

The treaty of Rome was established in 1957 creating the European Economic Community ECC (the precursor to the EU) between six western countries (Belgium, France, Italy, Luxembourg, the Netherlands and West Germany). The treaty foresaw the Common Agriculture Policy (CAP) as a way to provide secure and affordable food for to EU citizens and allow farmers to have a fair standard of living. The Common Agriculture Policy (CAP) itself was created only in 1962 and the core policies were to provide good prices for farmers, which led a large increase in production which secured the first objective of the policy which was food security[9]. Between the 1970s and 1980s the CAP faced the problem of overproduction[10], with the EU producing much more food than it needs, much of it going to waste[11]. Several reforms were made which brought production levels closer to market needs.

In 1992 the CAP shifted from market support to products support, with price support being scaled down and replaced with direct aid payments to farmers, at the same time also encouraging them to become more environmentally friendly. At the same time the Rio de Janeiro Summit took place, launching the concept of sustainable development. In the middle of the 1990s the CAP started focusing on food quality introducing policy to support farm

[9] Pursuing the balance of national interests (including to keep or develop some previous systems of farm-price support), the creation of the Common Agricultural Policy (CAP) was a boosting factor for a considerable intensification in the agri-food sector, in a great extent because of food security concerns, mainly in former times. Indeed, objectives of the CAP comprised – according to the Article 39 of Treaty of Rome – the increasing of agricultural productivity; ensuring a fair standard of living for farmers; the stabilization of markets; the assurance of food supplies; to provide consumers with food at reasonable prices (Staab, 2011).

[10] Because of productivist public policies, under a modernization paradigm. This is why Sinabell & Schmid (2009:1-2) refer that “the policy instruments had remained untouched during the first three decades of the CAP, except the introduction of milk quotas in 1984”. In the same way, Garzon (2006:21) refers this period as the “thirty years of immobility”.

[11] A situation sharply characterized by Andreas Staab: “In the 1970s the increasing financial burden of the CAP left the EU facing the prospect of bankruptcy. With unlimited market guarantees and increased productivity, and prompted by technical progress, expenses grew as high as around 70 percent of the EU’s budget by 1984. Overproduction reached obscene proportions. In the early 1990s, for example, the EU of twelve member states produced 20 percent more food than it could consume, resulting in the infamous wine lakes and the butter and sugar mountains.Clearly something had to be done” (Staab, 2011, p. 118).

investment, training, improved processing and marketing. Also creating measures to protect traditional and regional food and creates the first policies on organic farming. In 2000 the CAP shifts part of its attention to rural development, putting more energy into the economic, social and cultural development of rural spaces in the EU. The reforms from the 1990s were continued and aimed at making farmers more market oriented. In 2003 the CAP shifts yet again, but this time, from product support to producer support providing new income to farmers that fulfil the preconditions of looking after the farmland, and achieving standards for the environment, animal welfare and food safety.

In the middle of the 2000s the CAP created a policy of openness which led to the EU becoming the largest importer for developing countries, importing more than US, Japan, Australia and Canada combined. From 2004 to 2007 after the enlargement with 12 new countries, the farming population in the EU doubled, creating a whole new paradigm for farming in the EU and its over 500 million inhabitants.

In 2008, the CAP 'Health-Check' consolidated the measures of the 2003 reform process, and involved further changes and environmental implications, e.g. the abolition of set-aside, improved rules on the identification and registration system of animals. Moreover, they included "an extension of cross compliance requirements; and increases in the rates of compulsory modulation, which were to be targeted towards 'new challenges' of biodiversity, water management, renewable energies and the dairy sector" (Allen & Hart, 2013. p. 11).

After 2011 new reforms try to strengthen the agricultural sector, economically and ecologically from a competitive point of view, giving special relevance to the areas of innovation, climate change suppression, and empowerment of rural areas through higher rates of growth and employment. The following chronogram shows a short summary of the main objectives tackled since the creation of the CAP (Fig. 15).

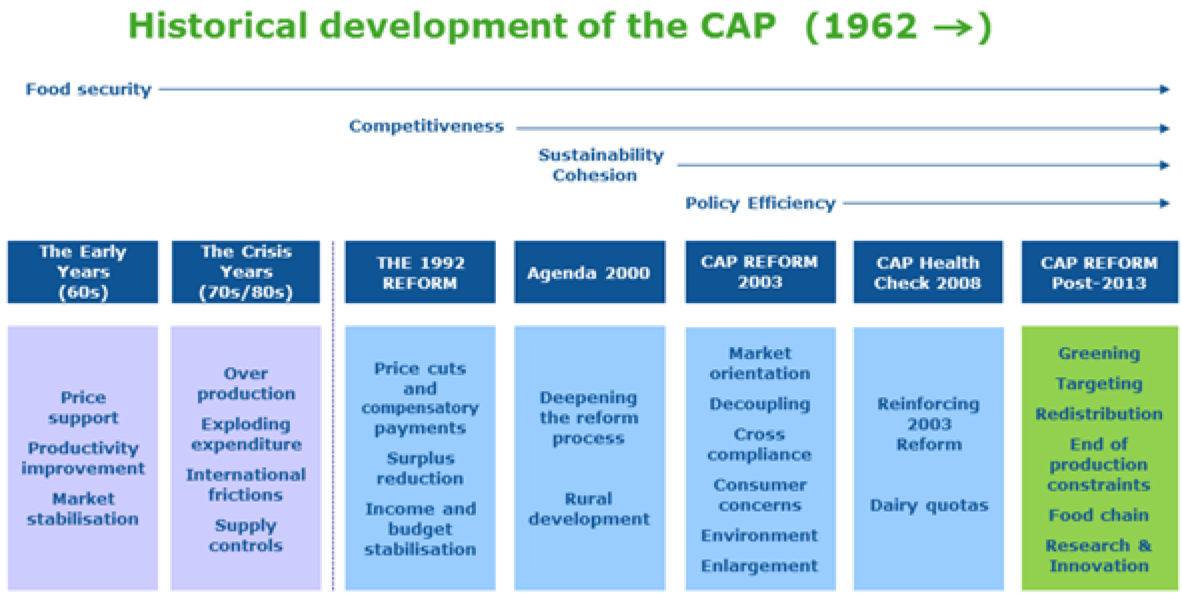

Fig. 15 – Historical development of the CAP (European commission, 2017, p.1)

According to Allen & Hart (2013, p. 9), “the 2014–2020 reform proposals have, for the first time, incorporated payments for carrying out environmental management practices beneficial to climate and the environment within Pillar 1”. The authors further add that this, known as ‘greening’, is “partly in response to calls for the CAP to do more for the environment” and “could mark a significant turning point for the CAP, whereby the environment and the delivery of public goods is placed firmly at the centre of the policy”.

Focusing on livestock, the most recent CAP reforms have meant an increase in environmental legislation and also oriented towards animal welfare, as mentioned before, which reflects “socio-economic factors such as human health concerns and changing socio-cultural values” (Thornton, 2010, p. 2853). Some of these measures were accompanied by the application of innovations and improved technologies, and there are examples of great potential for dairy products, where “innovative approaches could reduce methane emissions by 40%”[12].

A study was made in 2014 to assess the possible impacts of stopping CAP subsidies and the expected resulting increases or decreases in livestock, which the researchers themselves see as possibly highly biased information, since the predictions were made based on surveys, which reflect present agricultural conditions which could have led to some influence in the responses (Vischeccia, 2014, p.138). The results obtained showed that discontinuing CAP subsidies would not have an overwhelming effect, 60% of farmers would not change their behavior, 11% showed indecision, and only 30% would change their behavior with 6% increasing their livestock and 24% decreasing it. Their results showed that the variables that would change their response to a decrease in livestock numbers would mainly be the ones related with size of land, rented land and organic rearing. While the variables that would influence an increase in livestock would be the ones associated with renting (in) land and dairy livestock typology, which would be in close association to milk quotas (p.138).

They found however discrepancies between the new Member States and the EU-15 as new Member States were more likely to decrease livestock numbers without CAP support. The defunding of the CAP will most likely never happen, but some conclusions from the study were that, for example the option of removing milk quotas would trigger an increase in

[12] More information and sources in www.elancoeurope.com/pdfs/sustainable_livestock_a4_aw_290915_dps.pdf (access in 12-02-2017). Some of those innovations, plus the disincentives for less efficient farmers, may explain the continuing overall decrease, in the EU, in both the gas emissions from livestock and the weight of livestock emissions in the agriculture as a whole (Annex 2). Nevertheless, the weight of the enteric fermentation in the total cattle (idem) has been growing, which seems to translate some increasing weight of the ruminants and inspires later investigations on this subject. Countries like Sweden, Ireland, United Kingdom, Romania, Austria, France and Latvia are among the greater providers for that weight. Something that may be connected with this reality is the persistent importance of the dairy sector. Indeed, “More than 2/3 of total production value of all commercial farms in the EU are generated by milk and dairy products (60 bln €) and 1/3 by bovine meat production (27 bln €)” (Ihle et al., 2017, p. 32).

livestock from specialist dairy farms, and that, organic farms and those located in hard to get places, are much more dependent on subsidies to continue operating (Vischeccia, 2014, p.138).

4.7 - Problems deriving from livestock emissions

Methane is more often addressed as being a greenhouse gas but it a pollutant as well, being one of the main contributory gases necessary for the formation of ground-level ozone, which is created naturally in low concentrations and normally poses no risk. It can also be called tropospheric ozone because it occurs within the lower boundary of the stratosphere, above which we have stratospheric ozone which is vital to life on earth due to it blocking ultraviolet radiation from the sun. Tropospheric ozone, unlike stratospheric one, does not bring any advantages, and in higher concentrations, formed by high emissions of CO2, Methane, Nitrogen Oxide, among others in conjunction with high temperatures, can actually have severe impacts in human health even with short exposure times (Mathews, 2015, p.1).

Ozone in the troposphere can cause damage to crops and forests, and causes injury and destruction of living tissue. Concentrations near the surface in the form of smog can cause respiratory problems, worsen heart disease, increase numbers of bronchitis and emphysema, and even bring about premature death. It is also a very potent greenhouse gas, being third in degree of contribution to greenhouse radiative forcing after CO2 and methane (p.1). The highest contributor to premature death due to air pollution is the concentration of fine particulate matter (PM2.5) in the form of smog of which ozone is also a component. According to the 2014 air quality report from the European Environment Agency's (EEA) PM2.5 was responsible for circa 430,000 premature deaths in the EU-28 in 2011, through long-term exposure and estimates for ozone concentrations were circa 16,160 premature deaths per year in the EU-28, but through short-term exposure (p.1).

Tropospheric ozone is considered the most dangerous air pollutant to vegetation, hampering its growth and decreasing crop yields, and reducing the CO2 abortion potential of plants in general, all of which can create a positive feedback effect and serious economical and health impacts. Statistics show that in 2011 circa 18% of agricultural land in the 33 EEA countries was exposed to levels above the ones necessary to preserve crops, with the highest impacts felt in Italy and Spain. Long terms objectives were exceeded in 87% of the agricultural area and the critical levels for forest protection were exceeded in 67% of the total forest area of the EEA as well as in 84% of the areas Natura 2000 in 2011 (Matthews 2015, p.1).

In the last 50 years the concentrations of tropospheric ozone have increased threefold in the northern hemisphere and are now very close to levels that can have serious impact in human health and vegetation in general. Future changes in the levels of ozone will be proportional to the changes in methane and nitrogen oxide emissions (both of which livestock in the main contributor). Bringing methane and nitrous oxide emissions under check on a hemispheric scale could reduce significantly the concentration of tropospheric ozone (p. 1). According to the latest reports from the EEA the concentrations of tropospheric ozone have exceeded the agreed standard during the 2014 summer, even though the number of exceedances has been slowly going down in the last 25 years, for reasons not yet known. Studies show that tropospheric ozone can only be properly controlled if there is global action and not only local action (p.1), especially considering that local methane emissions due to its dissipation nature cause a worldwide creation of ozone. The following graphic shows the sector share of the main ozone precursors (Fig. 16).

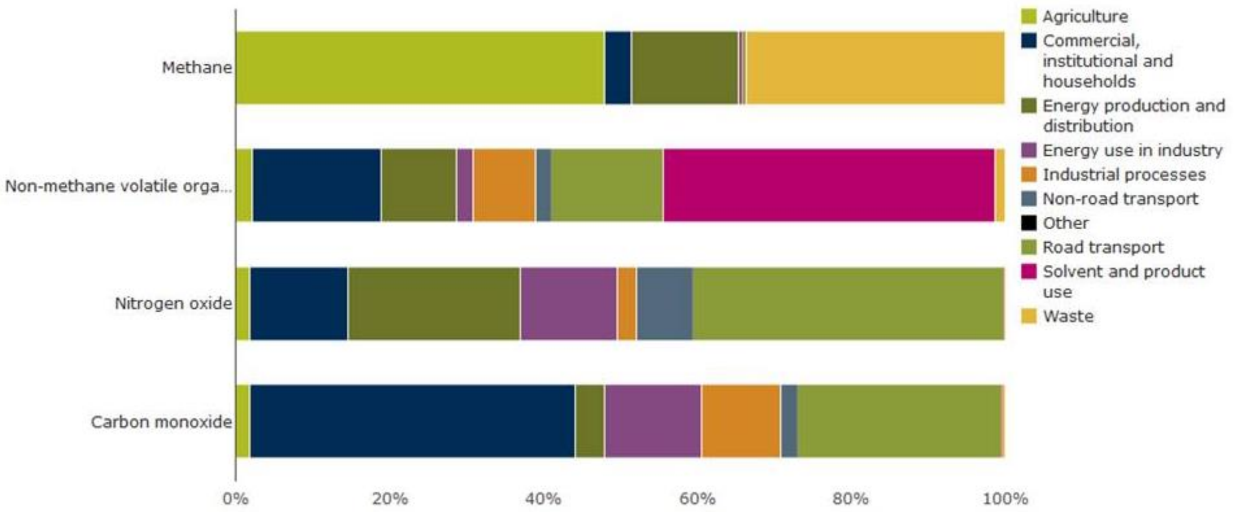

Fig. 16 – Sector split of emissions of ozone-precursor pollutants

4.8 - EU and Member States response

Methane emission limits were first mentioned in 2005 within the air quality legislation when the impact assessment for the Thematic Strategy from the commission reported that methane and nitrous oxide emissions on hemispheric scale could cause a large reduction of ozone concentrations. The consulting company ENTEC UK was contracted to support a review for the NECD 2001 (National Emissions Ceilings Directive) and one of its tasks was to ponder whether an emission ceiling for methane would be feasible. The conclusion was that putting a ceiling on methane would indeed result in the reduction of some tropospheric ozone concentrations, and could move Europe to a MTFR status (maximum technically feasible reduction), but they also warned that further research would be needed to establish cost effective measures (Matthews 2015, p.1). It also added that the inclusion of methane should be made on the basis of further research in order for the total significance of methane in ozone formation to be understood, but in its view the emissions from the EU members were too small to be significant, and that to be properly addressed, global action would have to be taken.

The commission put forward two main arguments to include methane in the NECD: methane would have a positive impact both at EU and international level and it would prepare the international stage by leading the change. A methane ceiling would also “exploit the substantial potential for low or zero cost reduction”, which would have complemented the reduction of nitrous oxide NOx and volatile organic compounds VOC. Opposition argued that the ceilings were not cost effective; Matthews shows this is not true (2015, p.1). The second argument from the opposition was that there was a danger of over regulation because methane emissions were already being tackled by the national emissions ceilings in the Effort Sharing Decision (ESD). Matthews argues that the commission should have argued that not all greenhouse gases under the ESD have the same impact when it comes to forming ozone, and it would create a two tiered approach that would have made it unavoidable not to tackle methane emissions (p.1).

The argument over whether it is cost effective still goes on, but the benefits for health and the environment from reducing methane and therefore ozone concentrations, even if it was made at a cost, would well compensate for them. The opposition to the creation of a methane ceiling gives no importance to the argument from the commission that a methane ceiling would promote international cooperation, thus considering it not important (p.1).

5 – Satellite data on types of methane emitters

The National Oceanic and Atmospheric Administration NOAA and the Cooperative Institute for Research in Environmental Sciences CIRES have conducted a study with satellite analysis of methane emissions and were able to identify its real levels and main sources. The study has shown that methane emissions from fossil fuels are 60 percent higher than previously thought. The study found that the fossil fuel industry accounts for 132 million to 165 million tons of the total 623 million tons of methane emitted worldwide from all sources every year, making up 20 to 25 percent of the total emissions and 20 to 60 percent more than previously thought (Fig. 17).

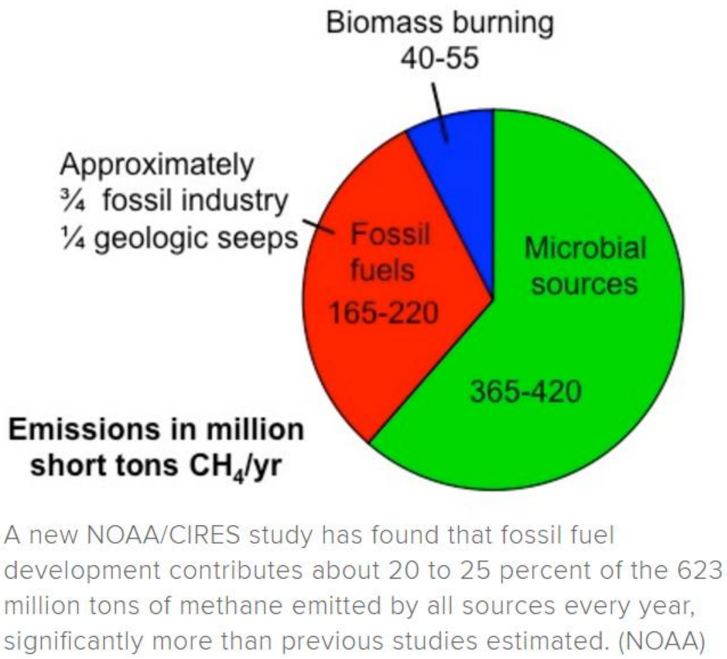

Fig. 17 – Total global methane emissions by source (NOAA, 2016, p.1)

The research was published in the journal Nature and its aim was to determine exact numbers for the methane emissions coming from fossil fuels, natural geologic sources, microbial activity, and biomass burning. The study used the largest database on methane emissions ever made, to determine as accurately as possible the total contribution from fossil fuels, being more or less 100 times larger than any previous databases, which improved the accuracy of their results, said Schwietzke, the leader of the scientist from the University of Colorado that put it together (NOAA, 2016, p.1).

The emissions of methane contain particular isotopes depending on their source, which can act as a signature to identify whether they come from fossil fuels, biomass burning or microbial sources. The study also supports research that was being done previously on the causes of the sudden surge in methane emissions since 2007. The isotopic analysis found that microbial sources (man-made and natural) are responsible for 364 million to 419 million tons of methane per year, which represents 58 to 67 percent of the total emissions. From 2007 to 2013 methane emissions increased by circa 28 million tons per year. Schwietzke said that microbial sources include cows, agriculture, landfills, wetlands and fresh waters, but that at this moment it is not possible to pinpoint the value for each of them, but that further research that accurately pinpoints the main culprits can be essential in finding a solution to abate methane emissions. He also argued that it is possible that these emissions are part of a self-reinforcing feedback loop leading to increasing climate change (p. 1).

For future research Schwietzke argues that it is important to add samples from microbial sources like cows, agriculture and wetlands, and important to increase the data to make more accurate assessments, which would eventually make it possible to identify emissions by individual sources at continental scale (p. 1).

It is highly likely that major culprit for methane emissions are cows considering past trends in methane emissions increase and increases in livestock production and size (Fig. 18 and 19), but without future research and data assessment it not possible to quantify it properly, but the NOAA methods are cutting edge and should prove as one of the best available tools in creating a systemic view over global emissions.

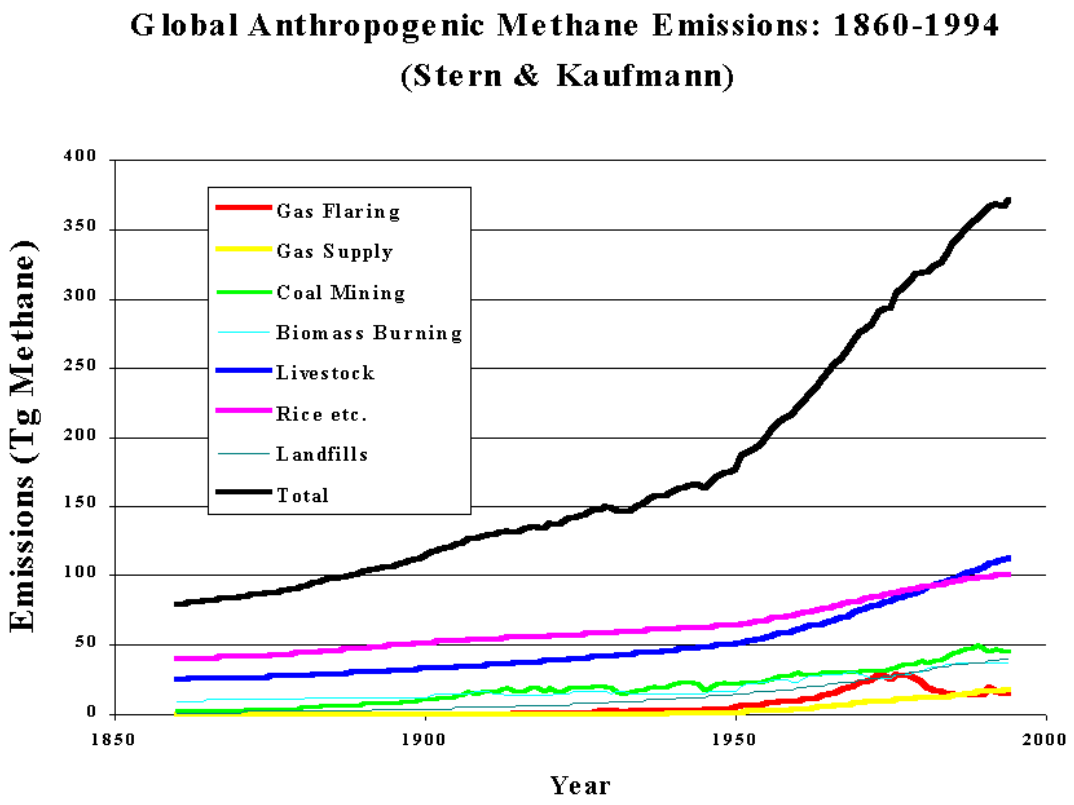

Fig. 18 -Global anthropogenic methane emissions 1860-1994 (Stern, 1998, p.1)

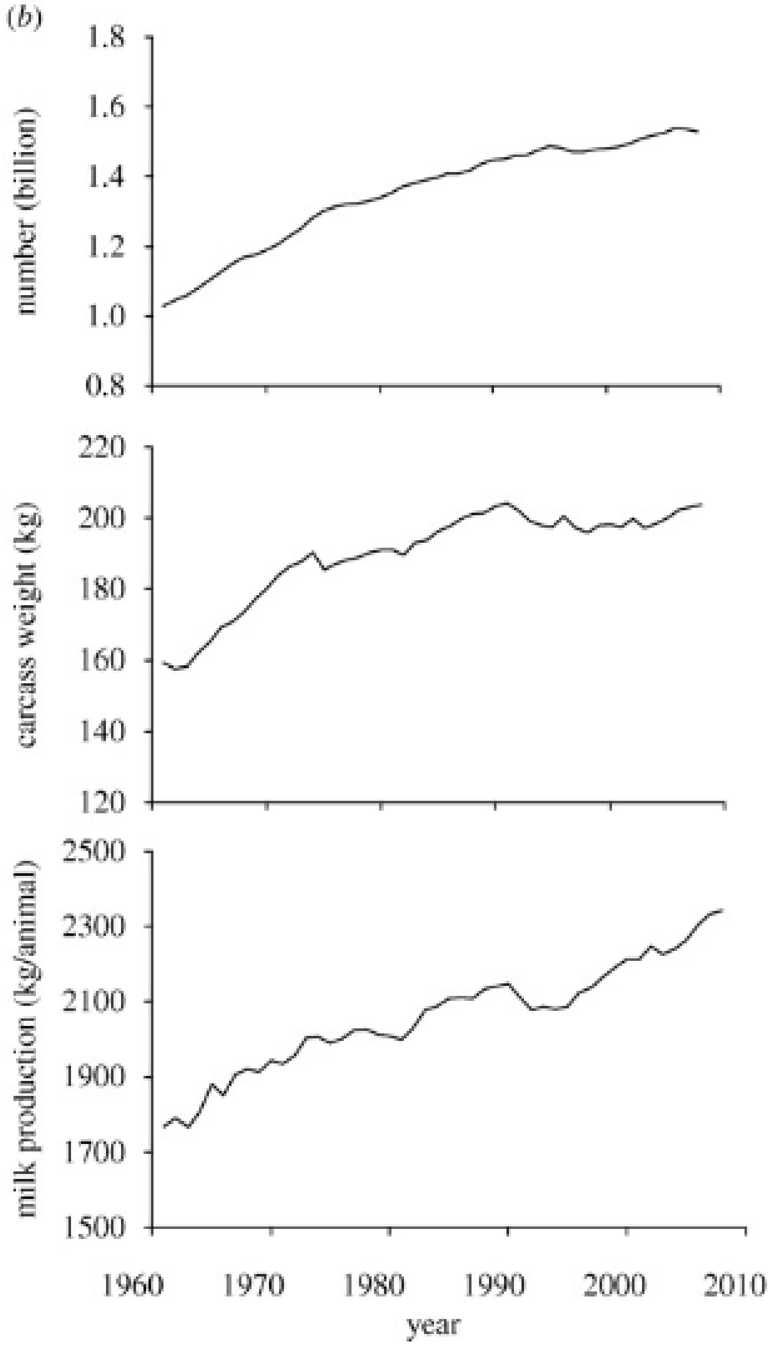

Fig. 19 – Production of bovines, increase in size and milk output/kg from 1960 to 2010 (Thornton, 2010, p.1)

6 – Methane as a possible renewable energy

6.1 – Case study from manure management in Huishan – China

A dairy farm of very large proportions in northeast China has created a lucrative business model by using methane resultant from the manure from their cows into a renewable energy. It installed a gas-powered system of generators that capture the methane from fermenting cow manure, being 10 times bigger than the normal cow manure methane capture programs. The power plant processes the waste from 60000 of 250000 cows from Huishan, producing 5,66 megawatts of power, which would be enough to feed around 3500 American-sized houses and therefore many more Chinese ones. The system includes an anaerobic digester that breaks down cattle waste into gases, which is then exposed to iron oxide to remove corrosive hydrogen sulfite, in a process called hydrodesulfurization. The biogas is then burned in GE Jenbacher engines to create electricity. The same engines are employed as well in some dairy operations in India and a wood gas plant in Austria. The project profitability may be due in part to its large scale, something that hampered methane capture systems in the US, where the largest system up to date produced two megawatts. Only 1 percent of US dairy operations capture methane. The energy produced at Huishan will go directly into the state grid, and the company Blue Sphere Corp, which built the system, argues that the plant can generate 619,770 tons of fertilizer and reduce carbon emissions by 180,000 tons per year (Boyle, 2010, p.1).

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6.2 – Case study from waste management in Denver United States

A project at the Denver Arapahoe Disposal Site (DADS) in Denver USA, uses a series of large sizedV-16 engines that run on collected methane gas resultant from anaerobic (no air) decomposition from landfills to power a turbine that generates enough electricity to supply a few thousand homes (Meyers, 2011, p.1).

The Waste Management runs DADS program in a long-term contract with the city of Denver, sending the generated electricity to the company Xcel Energy which then supplies homes directly. The city of Denver has a very arid and steppe climate, so the anaerobic process is not as good as it could be in other locations where moisture and high temperatures are present. Many landfills still burn the methane directly without a capture system to produce electricity, which already is advantageous from a climate perspective, but optimally in the future they will harness the methane to produce electricity as well (p. 1).

6.3 – Case study from Vermont Dairy Farm United States

A project at Green Mountain Dairy Farm is part of a growing alternative energy program that converts the collected methane from cow manure into electricity, and then sells it to the grid run by the Central Vermont Public Service, which supplies electricity to circa 158,000 customers in the state, and was among the first utilities in the country to generate electricity from cow manure in dairy farms. The project is funded partially by 4,000 utility customers who agreed to pay a premium for the electricity generated from this method. The aim of the project was to help solve the problem of manure management and at the same time make farmers more financially secure said Steve Costello the spokesman for the Central Vermont Public Service (Zezima, 2008, p.1).

At the time the article was written 4 dairy farms were participating in the project and two others were expected to join in later that year, and until 2010 the utility wanted to add another six farms to the project. The residents and businesses that agreed to the program pay an extra of 4 cents on top of the typical rate of 12.5 cents and most of the money goes to farmers who have to invest their own money in the program, and which can cost up to 2 million dollars (around 1.8 million Euros at the time) but most farmers expect to start making a profit of it after 7 to 10 years (p.1).

The project started when Bill and Brian Rowell, two brothers, owners of a farm with 1650 cows saw an economical opportunity in using the manure from their cows to something other than producing fertilizer. They made use of a grant of 750000 dollars (around 550000 Euros) from federal, state and utility company grants to create the project. The waste from the cows is diverted into a large drain by means of a mechanical scrapper, and then pumped into a sealed concrete tank which holds 21 days' worth of waste at the temperature of 38ºC to create the ideal anaerobic conditions to the generation of biogas (methane and others) which is then transferred to an engine that powers an electricity generator, producing 250 to 300 kilowatts every day, which is enough to power 300 to 350 houses (p.1).

The Rowells receive a payment of 7cents per kilowatt plus the extra 4 cents from participating customers, earning around 200000 dollars (Around 180000 Euros) every year from electricity, which could increase to 235000 to 240000 if they purchased additional cows. They also make use of commercial waste, processing around 500000 gallons (=3,78 litters) of "waste and outdated ice cream from Ben & Jerry's each year" lowering their disposal costs, and increasing the electricity generation from the farm (p.1).

It doesn't stop there. After 21 days the waste is pumped out into a separator, which leads the liquids into a silo and the solids into a barn. The liquids are used to make fertilizers and the solids to make cow bedding, saving the Rowells thousands of dollars every month in sawdust and they can even sell the excess to garden stores (p.1).

Several utility companies across the US have included energy from farms like this in their renewable energy portfolios, some charging premiums others not. The company Alliant Energy, supplies electricity to rural customers in Wisconsin, Iowa and Minnesota, gets power from four digesters and plans to add more in the future. Around 20 independent farms in Wisconsin have their own digesters and sell electricity to various utilities (energy companies).

In Ohio the company Buckeye Power went online with a digester at the end of August planning to turn waste from a chicken farm into electricity. The spokesperson for Buckeye said their aim was to find a green energy better than the existent ones, especially not intermittent like wind and solar, and does not even charge an extra premium (p.1).

The Marie Audet’s family farm was the first to join the Central Vermont system going online in 2005 and having invested 1.3 million dollars with a expectation of return over 7 to 8 years, saving money by not needing sawdust, reducing waste levels by recycling and generating income by selling electricity to the grid. Many customers have no problem in paying an extra premium for supporting local farmers and using a cleaner energy source (Zezima, 2008, p.1).

6.4 – Case study from Norway waste incineration to produce electricity

The Climate and Pollution Agency in Norway is importing as much rubbish as they can (at a fee) to produce electricity through the use of large scale incinerators. This results in lower costs for countries who want to dispose of waste and larger profits for Norway. They normally generate about 50% from the fees for accepting waste and 50% from the sale of electricity (Russel, 2013, p. 1)

Norway is not the only one. There are circa 420 plants in Europe that operate on a similar style, which together provide energy and heat to around 20 million people. Germany is the top importer ahead of Sweden, Belgium and the Netherlands. Norway is the leader in heating supply with the largest share of waste to energy (p. 1).

The waste incinerator in Oslo, also built in capacity for future growth, taking into consideration that more EU countries will move away from using landfills and seek better economic and environmental solutions, waste to energy being one of them. Oslo takes up to 410000of waste a year and imports 45000 from the UK, but Europe as a whole puts around 150m tons of waste into landfills every year, which represents a tremendous potential for this type of energy generation. The burning of waste to produce energy has gotten a good reception with 71% of the population supporting what they consider being a renewable energy source (p.1).

7 – Methane as a possible energy retainer for renewable energy

7.1 – Approach from the Karlsruhe Institute of Technology Germany

At the Karlsruhe Institute of Technology (KIT) in Germany researchers came up with an innovative way of producing and storing energy, by means of a new type of methanation plant smaller than a ship container, and which could be used as a means of energy storage for excess and intermittent supply which is characteristic of solar and wind energies, and could even serve as a means of backup when these have a down time. The new type of reactor uses the products of biomass gasification: hydrogen, carbon dioxide and carbon monoxide, together with a nickel catalyst to produce methane and water, by means of a honeycomb catalyst carrier, which is already often used in cars and know for high thermal conductivity and mechanical robustness. Connect to a grid which contains wind or solar power, it can use the excess power for electrolysis and production of additional hydrogen, which would mean that all the carbon stored from the initial biomass feed can be used, including the waste heat resultant could be used, giving it a very high efficiency (Levitan, 2015, p.1)

This novel concept would allow for a mix between the electricity and gas grids, turning biomass outputs into methane, and transporting it elsewhere through the gas infrastructure, and the renewable energy would not be wasted and would not need any expensive battery system, the methane itself becoming a battery of sorts, one which holds the energy potential indefinitely, unlike traditional batteries. The resulting methane could be used to supply clients directly or to power gas fired power plants. The pilot plant with the name of DemoSNG was tested at the KIT and transported to Köping, in Sweden to be connected to a biomass gasification plant that uses wood residues, being a way of storing green power and transporting it in the gas grids in the form of methane. All the biomass plants are small, and around 14500 exist in Europe, which by making use of this technology would be able to be paired with wind or solar farms in a decentralized way to produce methane. The process of burning the resulting methane does generate emissions, but these are taken from the biomass gasification process. The big issue with this technology is the often low reliably of gas pipelines due to leaks, which could be solved with higher scrutiny over pipeline efficiency (p.1).

7.2 – Approach from the Stanford and Penn State in the United States

Researchers from both universities are working conjunction with methanogens, colonies of microorganisms, which have the ability to turn electrical energy into pure methane. The aim of the researchers is to find a way to create large scale microbial factories that could transform energy from wind, solar or nuclear into other important chemical compounds. If such were possible, it would eliminate the need to use fossil fuels entirely. The microbial process is also emissions neutral and could be the solution for storing excess energy produced by wind and solar farms. To make it a reality they have to understand exactly how the metabolic process works so they can scale it and the scientists envision large bioreactors filled with methanogens to produce a green methane of sorts, without having to use traditional highly polluting means of obtaining natural gas. The methanogens live in an extreme environment, and do not grow in the presence of oxygen. They consume carbon dioxide and electrons from hydrogen and as a byproduct excrete pure methane which the researchers are planning on using in the future to fuel airplanes, ships and vehicles (Shwartz, 2012, p.1).

Yet there are still many challenges to be overcome before this technology can become viable, since not so much about it is yet properly understood. The first experiment in 2009 made use of a methanogen strain called Methanobacterium Palustre connected to a reverse battery with the electrodes placed in a beak of nutrient-enriched water. They placed a biofilm of the M. Palustre and other microbial species onto the cathode, and when they applied an electric current the M. Palustre began excreting methane, with an energy efficiency of 80 percent, remaining highly efficient as long as the microbial mix was intact. Isolating the methanogen lowered efficiency, so an ideal mix of microbes has to be developed in a type of microbial zoo, which consist of several different colonies of mixed strains of archaea and bacteria. Depending on the colonies they can produce several different resulting compounds. The Penn State is building and testing advanced cathode technologies that can be used to increase methanogen efficiency and researching new materials for the electrodes, in the hopes of making it unnecessary to use precious metal catalysts like platinum. The end goal is to reliably and efficiently produce methane from clean energy in scale, which they consider as high-risk high-reward research, and they see it as a need for energy storage (p. 1).

8 - Analysis and discussion of results

Methane and all the natural phenomena of which it can be part of and processes associated with it, are still largely not understood completely. A great deal of research is still needed to better understand this wonder particle. It can be considered at the same time a greenhouse gas and a pollutant but also a renewable energy that could serve the needs of energy security by working in conjunction with green energies. From the standpoint of climate change it can be considered highly dangerous due to its high GWP and capacity for positive feedback effects especially being one of the main precursors of tropospheric ozone.

From a policy point of view it is very hard to regulate, because it requires international action for meaningful results to be achieved, but its capture and use as a renewable presents a tremendous opportunity to develop newer technologies that could make use of it. In theory it could be used not only as a means of energy storage but also for lossless energy transmission over great distances.

The exact emissions from different sources have yet to be determined, but there should always be several solutions available to deal with methane. In regards to the livestock sector ideally methods for methane capture and storage should be researched and implemented, but in the lack of this, hopes may like in genetic engineering to create feed or antibiotics that bring down methane emissions from livestock or livestock with better more efficient gut systems which limit or eliminate methane fermentation.

Ongoing research on methane will most likely be the deciding factor in the future, after all its possible implications are understood, then can we start making more accurate assessments to its uses, limitations and risks.

We are at a point in history where population is growing at an exponential rate which will in the next decades create a need for ever increasing amounts of food and resources. All the solutions seem to rely on scientific advancements and research to come up with ways to design the future. Perhaps even more important than that at this point is to learn how to objectively perceive the reality that surrounds us and find ways to better understand nature and the repercussions of human action and inaction when it comes to climate change.

Conclusion

This exploratory research work was highly beneficial for the author's growth, to improve both his capacities as a researcher and his knowledge on environmental policy and also on the scientific issues behind. There is some regret for resorting mostly to bibliographic and documental content analysis, instead of using also extensive data treatment, but at this point there is simply not enough information available on the emissions for livestock suitable for our purposes. Anyway, it was also beneficial to understand that science and policy, even though the people working in them try their best, are fallible in nature and often contain contradictory information. Moreover, some questions involve politics too, which extends the challenges for the research.

The research work was way harder to tackle than the author expected at first, not only because of the technical and methodological limitations but also for the unreal expectations he had of being able to put much more time into the research and treatment of data. His own private life ended up being one of the factors that made it more difficult to properly deal with the project, especially considering that living in a foreign country is by itself hard, much more when the only way to work with the supervisor in Portugal was over the internet, through emails or the occasional skype meeting, all of which can never substitute in person meetings and planning.

Regardless of the difficulties, the author feel he was able to create a way of research that shows to some extent how complex 'the methane question' is, and how much of a danger and an opportunity it can be. We hope we can delve deeper in this topic in the future, not only because of its depth and interest but also for its ever greater importance in a planet with an ever growing population with ever growing demands and expectations for knowledge and scientific advancement.

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Tools and reference material

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FAO main findings http://www.fao.org/news/story/en/item/197623/icode/

Metric conversion tool http://www.metric-conversions.org/

NOOA annual emission index https://www.esrl.noaa.gov/gmd/aggi/aggi.html

Weight to volume converter http://www.thecalculatorsite.com/conversions/weighttovolume.php

WRI infographic GHG emissions http://www.wri.org/blog/2015/06/infographic-what-do-your-countrys-emissions-look

Databases

CIA world fact book https://www.cia.gov/library/publications/the-world-factbook/

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Annexes

Annex A - List of Publications of the IMS (by year of publication)

Franz Hubert, Onur Cobanli, 2016: Pipeline Power: A Case Study of Strategic Network Investment, Review of Network Economics (Published Online: 08/29/2016)

Roberto Roson, Franz Hubert, 2015, Bargaining Power and Value Sharing in Distribution Networks: a Cooperative Game Theory Approach, Networks and Spatial Economics, vol. 15 , pp 71-87

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Franz Hubert, Svetlana Ikonnikova, 2003: Strategic Investment and Bargaining Power in Supply Chains: A Shapley Value Analysis of the Eurasian Gas Market, Discussion paper

Franz Hubert, 2002: Rent Control: Academic Analysis and Public Sentiment Swedish Economic Policy Review, vol. 10

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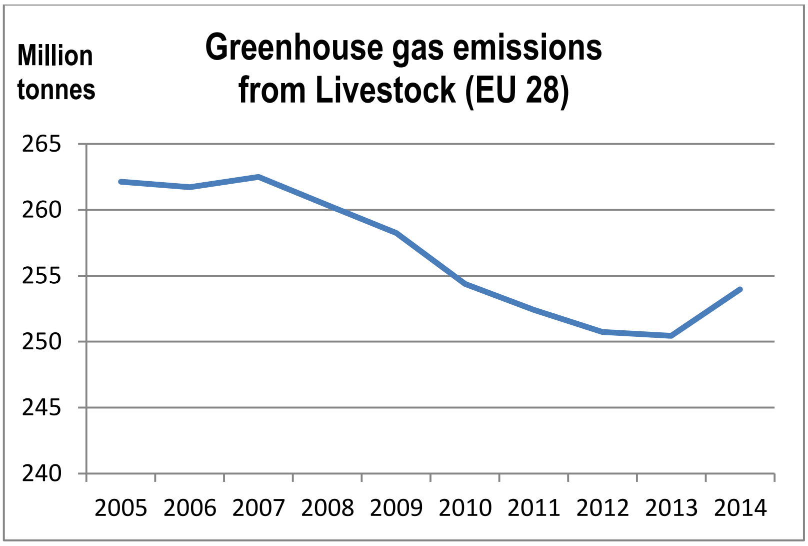
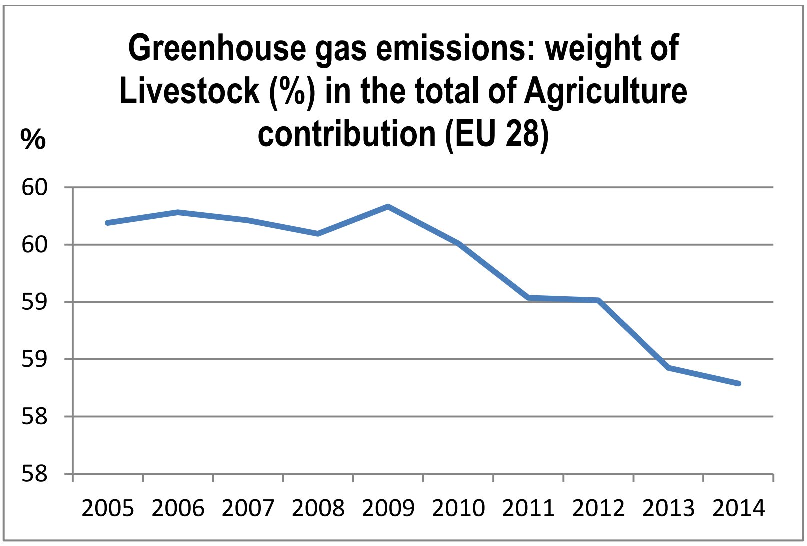
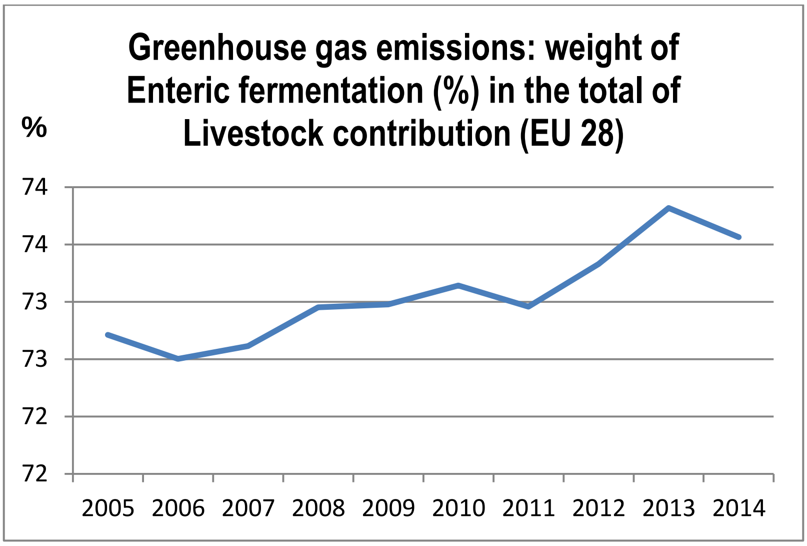
Annex B - Greenhouse gas emissions from Livestock in the EU



Evolution 2005-2014 of the Greenhouse gas emissions from livestock in the EU
(own calculation, after data in http://ec.europa.eu/eurostat/web/products-datasets/-/aei_pr_ghg)



Evolution 2005-2014 of the EU's weight of livestock in the total of Agriculture contribution for the GHG emissions
(own calculation, after data in http://ec.europa.eu/eurostat/web/products-datasets/-/aei_pr_ghg)



Evolution 2005-2014 of the EU's weight of the enteric fermentation in the total of livestock contribution for the GHG emissions
(own calculation, after data in http://ec.europa.eu/eurostat/web/products-datasets/-/aei_pr_ghg)