Ina Caroline Solum Larsen

The likelihood for artificial meat production in Norway:

A comparative case study of two actors

Master thesis 2020

MASTER DEGREE IN
Energy, Environment and Society

MASTER THESIS

Candidate Number: 5636

Semester: Spring 2020

Author: Ina Caroline Solum Larsen

Supervisor: Reidar Staupe-Delgado

Master Thesis title: The likelihood for artificial meat production in Norway: A comparative case study of two actors

Subject words/key words: Artificial meat, in vitro meat, cultured meat, meat industry, meat substitutes, sustainable production, climate change, mitigation, adoption, feasibility, wicked problems, Paris agreement, food security, energy, society, socio-technical transitions, Multi-Level Dynamics, Multi-Level Perspective, narratives, discourses, regulations, market acceptability, willingness, agriculture, environment, microcarriers, aggregated cells, packed bed bioreactor, cell culture

Pages: 84

Stavanger: 30. August 2020

Abstract

As the meat industry cannot respond to increases in demand and the emerging climate changes, the industry must find solutions to issues regarding sustainability, health, and animal welfare. Further, they will have to do so in spite of competition from emerging non-traditional meat products in an increasingly complex regulatory environment. In order to meet the issues facing the traditional meat industry, these novel meat products, otherwise known as 'artificial meat', are utilizing ground-breaking technologies. However, there is no real capacity for these artificial meats, in vitro or cultured meat, as well as meat from genetically modified organisms, to compete with conventional meat production in the present environment.

Artificial meat is a promising, but early-stage, technology with different technical challenges. Recognizing the importance of the political and regulatory forms an artificial meat industry might take is also crucial. Thus, this thesis investigates the likelihood of artificial meat production in Norway, as well as enhancing our knowledge about how artificial meat can be produced, by looking at the necessary implementations needed and how it can serve as a mitigation pathway for combating climate change. Based on the problem statement and research questions proposed, an abductive and qualitative methodological approach was applied to the case study of two actors.

The findings throughout the research of this thesis showcase many factors that must be in place for a feasible and sustainable rapid large-scale artificial meat technology – the biggest one being able to scale up production. Such large-scale production is significantly more challenging, having a key issue of producing effective culture media. Through the research, findings and discussions of this thesis, it becomes evident that having artificial meat production on a scale that makes an impact on global climate change would likely take many decades. Thus, a rapid large-scale production might seem unlikely as of today

Acknowledgements

Although this thesis marks the end on my master's degree in Energy, Environment and Society, it is at the same time the start of a new personal era. This journey has been rewarding, uplifting, demanding and has taught me to think differently.

As said by Albert Einstein "the value of an education is not the learning of many facts, but the training of the mind to think something that cannot be learned from textbooks". Thus, I would express a thank you to all my professors for sharing their knowledge with me. A special thanks to Oluf Langhelle for creating the master's program – an interdisciplinary master's looking at the interlinkages of energy, environment, and society, which is sorely needed.

Furthermore, I would like to give a big thank you to my supervisor Reidar Staupe-Delgado for the constructive feedback and guidance, you have been very supportive and helpful since day one. In addition, a special thanks to each and every informant for providing me with data and sharing their valuable knowledge and time for my research.

I also want to thank my good friend and study partner Tor – you have been so positive and helpful.

Finally, I would like to thank my family and friends for all the encouragement and support. I love you so much!

Thank you,

Ina Caroline Solum Larsen

Table of contents

1. Introduction

The likelihood for artificial meat production in Norway: A comparative case study of two actors.

The problem statement and research questions aim to explore a social phenomenon. An exploratory research design has been chosen in order to provide understanding and insight. Blaikie (2010) describes a problem statement as an intellectual puzzle that the scientists want to solve. He also stresses that it is not always possible to formulate a complete problem statement at the very beginning of a research design. And the problem statement often needs to be reformulated several times before the final submission (Blaikie, 2010, p. 16).

Further, researchers may, according to Yin (2014), be tempted to try understanding everything, which is impossible. Thus, the research questions have been formulated in order to define the main goal for this research, as well as keeping focus on what is interesting. These questions have been used as a tool to keep and refine the attention throughout the research process.

Due to the scope of uncertainty surrounding the technology of artificial meat, not only in Norway but in general as well, it can be challenging for data analysis and reduction. Such uncertainty is, however, the motivating principle this thesis aims to reduce. The problem statement can be formulated as follows:

In light of deep uncertainty and the ever-growing and urgent environmental problems, can artificial meat be considered a feasible and sustainable technology for rapid large-scale production in Norway?

Thus, this thesis aims to investigate the likelihood for artificial meat production in Norway by exploring the possibility of integrating with existing traditional meat production or, if possible, take over the industry altogether. This thesis will also look at similarities and differences between the two chosen actors' perception of the technology. In addition, it will explore the future profitability of artificial meat, food security and agricultural impact.

The main research questions will include the following main themes: 1) the feasibility for artificial meat production, 2) agriculture, food security and the environment, 3) the necessary and sufficient conditions needed and 4) investments and economy in the meat industry. The

following research questions can, based on the emerging theme, problem statement and uncertainties evident within the literature, help in achieving the overarching objective:

1. *What is the feasibility for artificial meat production in Norway from the perspective of producers?*
2. *What will artificial meat production mean for agriculture, food security and the environment?*
3. *What necessary and sufficient conditions need to be in place for artificial meat production?*
4. *How may investments and economy in the meat industry in Norway affect the likelihood for artificial meat?*

This thesis will, when answering these questions, hopefully serve to enhance our knowledge about how artificial meat can be produced in Norway. In addition, it also serves to enhance decision-making capabilities in strategies regarding policy and economy in the industry. Finally, the role artificial meat can play in mitigation pathways will hopefully also be enhanced and highlighted in this thesis.

Climate change and meat production

Climate change has, within the last few decades, emerged as perhaps the biggest threat to any human civilization, and the most pressing political issue of modern time. The term climate change has become an umbrella term for environmental degradation, global warming, and an existential threat to the biosphere of the planet. A response in all levels of society is required to meet this emerging and increasingly more apparent disaster. Small and large lifestyle changes are needed on the individual level, as well as businesses and industries need to find a way to reinvent the way in which resources are consumed and cut emissions on the market level. Multilateral institutions and government have to lay the foundation of rapid socio-technical and socioeconomic change on the political level, by implementing policies and defining frameworks in line with a world of low emissions.

The transition needed is, at every level, immense in terms of the scale and pressing in relation to the timeframe required to stop climate change. A vast and deep transition of our society is what is needed to mitigate the effects of climate change. Hence, social science is, in the context of climate change, increasingly concerned with the studies of transitions (Geels, 2011; Grin,

Rotmans, & Schot, 2010; Markard, Raven, & Truffer, 2012; Meadowcroft, 2009, 2011; Smil, 2016; Smith & Kern, 2009; Sovacool, 2016). The global community has, through the Paris Agreement, committed to this transition. Stating that almost every country has ratified the agreement, shows at least some global purpose for meeting the challenge of climate change. Norway for example, has pledged that by 2030, it will cut national emissions by 40% compared to the 1990 level (MCE, 2016-2017).

However, we can already feel, see, and report on different consequences related to climate change. In Norway 2018, the summer was characterized by heat records, wildfires, and droughts all over the country. Many farmers were forced to slaughter their cattle due to droughts making it impossible to grow enough food for their stock. In addition, the droughts caused the poorest grain crop harvest in almost 50 years, which lead to record high import of straw and hay (Gangstø, et al., 2018; SSB, 2019; NTB, 2019). In addition, there are almost 8 billion people on this planet, and is the population of the world is predicted to exceed 9 billion by 2050. This will lead to a considerable increase in the demand for food worldwide. The increasing food demand and climate changes will cause the meat industry to make a big shift towards a more sustainable production, where artificial meat production might play a major part in feeding future generations. However, in order to do so, the artificial meat production is required to use fewer resources and with minimal environmental footprint. Technology could be important to enable the transition to a non-animal diet, and in the future, we might be able to produce many different animal products in the laboratory, such as milk, eggs, and leather.

The livestock sector is one of the most significant contributors to urgent environmental problems, and conventional meat production is considered a major challenge to world sustainability, while demand is growing. Approximately 30% of total greenhouse gas (GHG) emissions in Europe are caused by food consumption, and due to increase per capita global consumption of meat and population growth, meat production is projected to double by 2050 (Petrovic et al. 2015). Such growth, however, poses some significant sustainability challenges. Among other things, around a third of the world's arable land contributes to the production of animal feed. In addition, consumers are increasingly concerned about the ethical aspects of industrial animal husbandry and meat production. One way to reduce the impact of meat production is to eat less meat - either partially or by switching to a total vegetarian or vegan diet. In response to this situation, more and more plant-based alternatives to meat are being

developed, making it easier for the consumer as the selection of plant-based products in the store improves.

Research is making great progress on many different fronts, and the food industry is also working on new technology that can have major consequences for society and the environment. One of these new technologies is artificial meat production. To produce artificial meat, a few stem cells are taken from a limited number of animals and then multiplied and differentiated into muscle cells, which then fuse and build muscle fibers. They are, once the muscle fibers are mature and harvested, assembled into a patty creating minced meat. This opens the way to potentially producing artificial meat in very large quantities with very few animals. Some of the benefits obtained are the reduction of greenhouse gases produced by livestock, a reduction in slaughtering farm animals in order to feed humanity, and also maintaining a significant potential in meat production, providing food for more and more human beings (Post, 2012).

Artificial meat received in August 2013 a large amount of publicity following the production and tasting of first burger patty ever made from stem cells grown in tissue culture medium (Goodwin and Shoulders 2013). The burger, made by the researchers behind MosaMeat, consisted entirely of muscle cells grown in a bowl. It had been a complicated process - stem cells were first isolated from bovine muscles, and then gradually developed into muscle cells that then clump into long muscle fibers. To get them "in shape," they were also "trained" with the help of small electric shocks. Finally, all the 10,000 fibers were put together into one burger, by hand. The pricetag? About NOK 2.5 million or $335 000 USD (Mattick et al. 2013). Thus, it is necessary to reduce costs for artificial meat to become a commercial product.

It sounds undeniably tempting to be able to completely take the animal out of meat production - while being both cost-effective and tasty. But are there any potential downsides to this? If we have fewer grazing animals and harvest less grass for use in animal feed, it could have a great effect on biodiversity. The meat industry needs, in line with evolving challenges and the expected increase of production demand, to invest in technology development to improve the solutions we have today. Even so, we must remember that the production of artificial meat also requires energy and other input factors that affect the climate. The final climate accounts are, therefore, not that simple. The question is; Can we produce meat in other ways than we do today? Meat grown in the lab can be the solution. Thus, this thesis investigates how this technology trend can impact the meat industry and climate change.

1.1 Delimitation

There are a few topics and issues this thesis touches upon, but do not discuss or explore in great detail. It is necessary to delimit the study to understand this study's objective better and further discuss what will not be done in this thesis. Besides, this could perhaps inspire further discussions or research. First of all, the thesis's major theme is what the likelihood for artificial meat production is in Norway, meaning that the research questions are first and foremost being addressed to key informants in Norway. As there are a large number of literatures on artificial meat in general, I had to limit the thesis by only looking at the topics that I chose to explore. This due to the fact that the thesis does not have the capacity, nor time, to explore all the existing literature on the topic. Further, the technical aspect of artificial meat is not being explored in-depth, as I wanted to map out the feasibility of artificial meat by looking at the perception of the chosen key informants have towards artificial meat, as well as what it can do for mitigating climate change. However, the technological aspects, being the upscaling of production, are explained and looked at in the discussion section, as it is one of the main challenges for artificial meat to become a commercial product. In addition, the thesis explores topics such as biodiversity, mitigation, adaption, and meat substitutes. Nevertheless, these topics are not explored in-depth but rather presented to get an overview of the complex problem that climate change and the meat industry is.

1.2 Structure of the thesis

Chapter two presents a literature review of existing literature on 'climate change and food security', 'meat substitutes' and 'artificial meat production,' before presenting the theoretical framework focusing on the framework of Multi-Level Dynamics, The Multi-Level Perspective, wicked problems, and Discourse analysis. These frameworks give an understanding of the need for new technology and pathways in the meat industry in Norway, as well as how different regimes co-exist. In addition, they help draw attention to the complexities and challenges of addressing social policy problems and can further capture different and similar storylines from the utilities to analyze the perceived interests in the technology of artificial meat production.

Chapter three describes the methodology of this study by exploring its research design. A comparative case study was chosen to gain in-depth knowledge with a qualitative research strategy. Further, an abductive approach to the research was applied as a means to try understanding and explaining a phenomenon through conceptual frameworks. The techniques

used for how the data is collected, and data sources are shown, as well as the qualitative research methods; documents and interviews conducted is identified and discussed. The trustworthiness of the research is also addressed to allow the readers to critically evaluate the validity and reliability of this study.

Chapter four presents the findings that are built around the research questions. The four research questions are answered with the aim to gain an understanding and enhance our knowledge about how artificial meat can be produced in Norway.

In **Chapter five**, the findings are brought together and discussed from different viewpoints presented in the literature review chapter from the theoretical framework and gathered primary data, arguing that there are multiple factors that must be in place for artificial meat production to become feasible and sustainable rapid large-scale technology.

Chapter six presents a conclusion based on the findings, and my understanding from this study is then presented before the implications and limitations are mentioned. Finally, some further research recommendations are suggested.

2. Literature review and theoretical framework

This chapter will look at the existing literature on 'climate change and food security,' 'meat substitutes,' and 'artificial meat production' before presenting the theoretical framework of the thesis, which forms the basis for the proposed problem statement. The theories must serve the development of my research, which can further help me generating specific predictions. To examine the different perceptions of artificial meat production as a mitigation response and its impact on traditional meat production and climate change, I will implement relevant theories that can help model my research. The aim with the choice of the theoretical angle is to frame how artificial meat production can help provide for future food security and mitigate climate change while reducing carbon footprint in the meat industry.

2.1 Climate change and food security

Roughly a billion people live their lives in chronic hunger around the world, and the inability of humanity to offer them sustained improvements has been one of our most heartless shortcomings. Even though there have been rapid improvements in economic growth and agricultural productivity bringing food security to broad swaths of the developing world over the second half of the twentieth century, other regions did not share in this success and remain no better off today than they were decades ago, and even worse in some cases (Lobell & Burke, 2010).

Due to food security having multiple and complex determinants, with varying consensus on which causes are more or less important, there has been controversy raised. However, confronting this complexity is argued by Lobell and Burke (2010) to be central to any understanding of the potential impacts of climate change on food security. Knowledge of the impacts of climate change on crop yield is, for instance, not enough to understand the impacts of food security due to food security being a product of complex natural and social systems in which yields play only a part of it. Understanding the full impact of climate change will rather require knowledge of its potential effects on both the more fundamental causes of poor economic progress, such as low education levels, poorly-functioning markets and institutions, and high disease burden, as well as the proximate causes of food insecurity, such as low rural incomes and low agricultural yields.

The term “food security” is defined by the Food and Agriculture Organization (FAO, 2001) as “a situation that exists when all people at all times have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. Food security consists, under this definition, of having the food one wants and needs on an individual level. This definition is further conventionally subdivided into three main components: *food availability*, *food access*, and *food utilization*. First, *availability* refers to the physical presence of food. Secondly, having the means to acquire food through purchase or production refers to *access*. Thirdly, *utilization* refers to the proper nutritional food content and further the ability to use it effectively (Lobell & Burke, 2010). Climate change is argued by Lobell and Burke (2010) to be impacting food availability, access, and utilization through many pathways. In agricultural productivity, climate-induced changes will likely affect the food prices faced by poor households, being with the net effect on food security and function of the particular set of livelihood strategies of each household, in addition to the incomes earned. Health impacts associated with climate change could also hamper the ability to utilize food effectively by individuals.

All agricultural practices have been found to having varying effects on the environment, such as water and land consumption and pollution through fossil fuel usage. Further, agriculture has long been recognized as a significant contributor to global greenhouse gas emissions in terms of CO2 and especially nitrous oxide and methane (Rosenzweig and Hillel, 1998). Thus, a major reduction in emissions of these gases from agricultural activities could contribute to climate mitigation. Regarding adaption to climate change, mitigation could even present an opportunity.

Table. 1 The environmental impacts of crop and livestock products and cultured meat

Project	FU[1)]	Energy use (MJ)	GWP (kg CO_2-eq)[2)]	Land use (ha)
Potatoes	t DM	1 232	217	0.03
Rice	t DM	1 170	203	0.15
Wheat	t DM	2 460	804	0.15
Beef	t carcass DW	27 410	15 920	2.35
Pork	t carcass DW	16 300	6 350	0.73
Sheep	t carcass DW	23 100	17 200	1.33
Cultured meat	t WW	32 710	1 794	0.02

[1)] FU, functional unit; DM, dry matter; DW, dead weight; WW, wash weight.
[2)] GWP, global warming potential.

(Source: SUN Zhi-chang et al. 2015 p. 237)

There is suggested a broad and pressing need for adaption by Lobell and Burke (2010), due to the rapid pace of climate change and its anticipated large adverse effects on many agricultural systems. The nature of these responses will, for farming households, depend on their recognition that climate is changing and their ability to adjust their behavior in response. This can perhaps be through diversifying into off-farm income-generating activities or altering farm management practices. Such responses argued by Lobell and Burke (2010) must happen in the context of climate variability, which further can obscure longer-run climate trends and make the adoption of various adaption measures riskier and more unsafe.

There is no doubt that production practices will evolve in response to climate change. They will, however, evolve with environmental regulation, technological developments, market conditions, and other factors as well. Thus, while it will be of great value how possible adaptions in the meat industry might affect the climate change impacts, one must keep in mind that among many processes that will affect future agricultural systems, climate change is only one of those. The most logical answer to climate change or any other problem for that matter is probably mitigation, as we should, if knowing what is causing the problem, stop doing whatever that is, and the problem will then be solved. There are many efforts of mitigation around the world, such as in Germany, that are, as a move away from fossil fuels, working on phasing out their coal-fired power plants by 2038 (Wacket, 2019). In addition, the Paris Agreement and the Kyoto-protocol can be viewed as mitigation efforts, since there are clear goals and targets in both the agreements about strengthening clean energy alternatives and cutting greenhouse gas (GHG) emissions. Having said that, as these agreements have no "real" legal power to enforce their goals and targets, there have been debates about how productive and efficient these agreements are.

Mitigation faces different limitations and challenges, one being that it might simply not be enough to prevent the adverse effect of climate change (Knittel, 2016). Many of the limitations and challenges are, in addition, related to challenges faced by renewable energy technologies. The maintaining and upfront costs of building the plant are, for example, one of the biggest issues with renewable technologies. In addition, other issues are public perception, intermittency in the energy-production, and "longstanding dependence of markets and institutions on fossil fuels" (BBC, 2014). Being that mitigation requires "not only change in policy but an underlying change in culture" is another issue with climate change mitigation. (Brown, 2012). Mitigation requires, in other words, more or less a regime change of, for

example, the incumbent fossil fuel industry and meat industry. In addition, a "regime change" in the life choice and lifestyles of people is required. This is a huge challenge, to say the least.

Mitigation is furthermore about long-term issues and solutions. Corporate leaders, the politicians, and the industry, in general, are, however, more focused on the short-term gains. An example of this is the politicians who are elected for a short period of time, which influences policies and their politics, being that their position of power depends on current issues and affairs. Further, even if we stopped all our emissions today, the earth would still continue to warm for years. This means that some impacts of climate change are irreversible and inevitable. Hence, to deal with the adverse climate change impacts, the mitigation efforts are not enough on its own.

The time for a change of focus to adaptions is argued by Brown (2012) to be now, saying that it is past time to begin adapting to climate change with specificity and the same effort that communities invest in preparing for a coming flood or hurricane. Instead, Brown (2012) argues that there is a need to be prepared for rising sea levels, melting ice, droughts, floods, weather extremes, in addition to stressed and changing ecology. Adaption is about taking advantage of possible opportunities that come with climate changes, as well as reducing the consequences and impacts. Adaptation means "anticipating the adverse effect of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise." (EU, Adaptation to climate change).

As climate change intensifies, adaptation might sound like an easy route to take in order to stay on top of things. Brown (2012) argues that there is a need to breed and genetically engineer crops that are able to handle extremes and build needed infrastructure or shift how the land is used where anticipated water shortages will arise. Most of all, Brown (2012) argues that we need to fasten our political will to act now, saying that if we accept the realities of adaptation, the picture might be so ugly, vivid, and expensive that we will address mitigation too (Brown, 2012). Adaptation faces challenges regarding climate change being a super wicked problem, meaning that we have to be prepared for flooding one day and for droughts the next. As it can be hard to know what specific events to adapt for, as well as at what location and time, adaptation to climate change become extremely challenging. In addition, the uncertainty about future impacts is another challenge adaption faces.

Lobell & Burke (2010) argues that there are numerous questions regarding how effective and fast adaption measures will be. At the farm level, examples such as how well farmers can perceive climate trends amidst substantial variability, how quickly they can implement and learn new technologies, and what the likelihood of success and the risks for these adaptions might be. Furthermore, adaption approaches are largely dominated by economy, technology, and/or policies. Four categories are proposed by Smit & Skinner (2002), when looking into influences on adaption strategies in agriculture. First, there are technological developments. Secondly, there are government programs and insurance, thirdly there are farm production practices and finally farm financial management (Smit & Skinner, 2002, p. 85). Technological adjustments consist of, in order to cope with further changes in climate, changing the physical agricultural land. These alternations depend on what type of cultivation the farm is managing, and which climate changes are predicted to happen in the future. Technological adaptions could be plant protection, drainage, good soil management systems, and water control (Seehusen et al.,2016).

In addition, policies are a large part of adaption strategies. The "relationship between potential adaptation options and existing farm-level and government decision-making processes and risk management frameworks" (Smit & Skinner, 2002, p. 85) is an important aspect. Furthermore, government decisions can have a huge impact on the feasibility of adaption strategies and on farmers' decisions. Governmental levels, such as the municipality and county, can in order to provide support for the agricultural business activities in various ways. For example, by giving advice and being in dialogue with the farmers, in addition to having a kind of management and supervisory role, the municipality can act as a council for the agricultural sector (Westskog, et al., 2018).

The county might furthermore be able to develop projects in cooperation with agricultural sectors and other regional sectors. Too much input by a local government could, on the other hand, put pressure and further weaken the relations between producer and state. Thus, it could be difficult knowing whether or not adaption strategies should be managed and maintained on a local, regional, or national level. Government officials might want to have a certain level of influence on farmers' decisions in order to secure future food supply due to people being dependent on food. Lastly, Eriksen and Selboe (2012) argue that social relations and local strategies are essential in order to adapt to climate change in the long run.

2.2 Meat substitutes and artificial meat production

There have been developed several meat substitutes over the years, made entirely of vegetable components, which have gained a small market share that is slowly increasing (Egbert & Borders, 2006). The total sales of frozen meat substitutes in 2010 reached 267 million USD in the US (Salvage, 2012), as opposed to 74 billion USD in beef sales alone (Mathews & McConnell, 2011). Most products are based on soy, such as tofu and tempeh, but also milk protein, mycoprotein ("Quorn"), and wheat proteins ("Seitan"). All these fit the criterion of a beneficial carbon footprint and efficient protein production (Hoek et al., 2004).

Table. 2 The different product categories of artificial meat

Types of artificial meat	Definition
Meat substitutes	Plant and myco-proteins used as meat alternatives, e.g., quorn, tofu
Cultured meat	Produced though the *in vitro* culture of tissues or cells (stem cells, myocytes)
Modified meat	Meat derived from genetically modified organisms

(Source: Bonny et. al. 2015 p. 256)

Two key requisites for a meat alternative to be industrialized and accepted are efficiency and mimicry. Even though the technology of texturization to improve the taste and feel of these products is continuously improving, it appears difficult to closely mimic meat with fats, sugars, and proteins from vegetable origin (Elzerman, 2006). Thus, meat substitutes of vegetable origin are mainly being used in processed meats such as sausages, burgers, or other types of minced products. A new meat substitute needs to be exactly mimicked or even better to be widely adopted, recreating conventional meat in all of its physical sensations, being the smell, texture, visual appearance, and taste (Bredahl, Grunert, & Fertin, 1998; Verbeke et al., 2010).

Further, Post (2012) argues that there are at least three motivating factors to intensify the exploration of alternatives to livestock meat production, the first being that we will quickly run out of production capacity as already a large portion of arable land is dedicated to livestock management and feeding, with the predicted substantial increase in meat demand. There is secondly, a growing concern about the environmental impact of livestock management and breeding. Lastly, societal concerns about public health and animal welfare have sparked due to the high-volume slaughtering and herding of livestock.

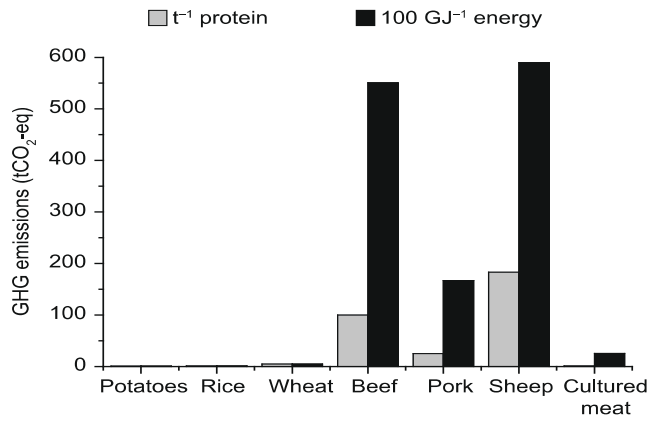
Artificial meat production

There is not a great amount of literature on artificial meat production in relation to Norway, but there is a lot on artificial meat in general. However, Nofima, one of Europe's largest business-oriented research institutes that conducts research and development has developed a project called GrowPro. They seek to develop innovative technology to produce muscle proteins for food using bioreactors instead of traditional livestock in a new and environmentally friendly way. The project will form the basis for the industrial cultivation of muscle proteins for food, thereby helping to solve the protein needs of the future. It will by showing that they work innovatively and forward-looking, also increase the industry's reputation. The project has a great environmental potential, both by using by-products from the food industry for new purposes and also reducing the use of cattle (Nofima, n.d).

In addition, Ruralis, which is one of the leading professional communities in Europe in the field of multidisciplinary rural studies, has created a project called PROTEIN 2.0. This project looks at the transition to biosynthetic protein and evaluation of the effects, outcomes, and opportunities for Norway's post-animal bioeconomy. The main goal of the project will be to help Norway by considering the probable consequences, results, and opportunities the technology provides, prepare for the possible introduction of synthetic animal proteins in the coming decades. Furthermore, the project focuses on evaluating protein technologies, assessing consumers' responses to the concept of synthetic animal protein, and understanding the likely impact of technology on global food systems. This technology is argued to have the potential to increase food security, reduce greenhouse gas emissions, reduce the need for industrial agriculture, promote environmental sustainability, and create new knowledge-based industries for food production in Norway (Ruralis, n.d).

Further, there is a wide consensus that agriculture has direct GHG emissions, as well as large indirect emissions from fossil fuel used and agrochemicals production (Smith and Gregory, 2013)—changing demands on agricultural production has, therefore, the potential to substantially alter GHG emissions (Bustamante et al., 2014; Havlík et al., 2014). In addition, Humpenöder et al. (2014) argue that climate change mitigation measures options are provided by the sparing of agriculture, including afforestation or bioenergy.

Figure. 1 Comparison of greenhouse gas (GHG) emissions of producing different food products allocated per ton of protein and 100 gigajoule (GJ) of food energy.



(Source: SUN Zhi-chang et al. 2015 p. 237)

Another agreement was that large-scale production is significantly challenging. Moritz et al. (2015) indicated that in vitro techniques still need to be more efficient than currently available techniques for large-scale production. In addition, they argued that there is a need for technical research on artificial meat to increase the efficiency of large-scale production. Orzechowski (2015) also concluded that for artificial meat to be commercialized, it should be produced at an affordable price. However, he argued that if there is not a new type of alternative low-cost technology to be discovered, this will not be achievable. This opinion is also confirmed by Kadim et al. (2015), Bhat et al. (2015), and Sharma et al. (2015), who believe that artificial meat technology is still at an early stage. Even though there has been huge progress made during recent years, they argue that important issues still need to be solved, such as technical, ethical, and social problems.

Most of them, however, are rather optimistic that the optimization of large-scale production can result in a low cost and efficient production of artificial meat. Even so, there are numerous challenges. Orzechowski (2015) argues that the most important ones are economic issues and epidemiology. Stephens et al. (2018) argue, in addition, that the success of an artificial meat sector will also depend on government policies and complex social apparatus, including subsidy regimes, tax, and regulation. Considerable economic, political, and social implications for various and multiple stakeholders will be conducted if this sector is continued to grow. Therefore, continued critical analysis of these factors is much needed to fully understand who and in what ways will be impacted.

Conventional meat production is suggested by Bonny et al. (2015) to not continue to respond to an increase in the demand for animal protein. Le Mouël et al. (2015) shares this point of view by arguing that current trends will be associated with global and local environmental problems linked to food production. Gerber et al. (2015) argue that there must be found a new solution regarding sustainability, health, and welfare. However, many new technologies, including artificial meat, cannot be, for the different reasons mentioned above, an immediate substitute to conventional meat production at their present stage (Hocquette 2016).

To summarise, even though many scientific authors recognize the potential benefits of artificial meat production, such as reduction of GHG emissions, nutrition-related diseases and reduction in animal suffering, there are different views on whether artificial meat production will have a low carbon footprint or not (Bhat et al., 2015; Hocquette 2016). It is, however, clear that it is difficult to evaluate the environmental impact artificial meat has since it is only based on speculative analyses. Public perception of artificial meat is, in this context, diverse. The potential benefits, such as food security, animal welfare, and environmental impact, are in the focus of some people (Laestadius and Caldwell, 2015; Laestadius, 2015; Verbeke et al., 2015).).

Other consumer groups are, on the other side, not convinced by the projected environmental benefits (Laestadius, 2015; Hocquette et al., 2015) and are worrying about the fate of farm animals that would be less needed (Laestadius, 2015; Marcu et al., 2014), as well as feeding artificial meat to poor populations (Laestadius, 2015; Laestadius and Caldwell, 2015). In addition, they worry about the potential problems concerning rural livelihoods, open landscapes and loses of culinary traditions (Marcu et al., 2014; Verbeke et al., 2015). One major point, however, is the personal health risks consumers are concerned about when consuming artificial meat (Hocquette et al., 2015; Laestadius and Caldwell, 2015; Verbeke et al., 2015). Verbeke et al. (2015) argue that the majority of educated consumers do not think artificial meat will be the solution for the future. Finally, an interdisciplinary collaboration between the social sciences and biological sciences is argued by some authors to be needed to discuss all these ethical questions, even if the public may or may not agree with it (Goodwin and Shoulders, 2013; Dilworth and McGregor, 2015).

2.3 Theoretical framework

The theories used in the thesis are the framework of Multi-Level Dynamics and Multi-Level Perspective (MLP), wicked problems, and the theory of discourse analysis. It will help outline how I have chosen to apply this in order to look at how artificial meat production can frame the problem and solutions of climate change and food security. The frameworks will be helpful in the analysis in different ways. First, the Multi-Level Dynamics show us that different regimes co-exist, and even though one regime does not encompass the whole of other regimes, it refers to the rules that are aligned to one another. Further, The Multi-Level Perspective (MLP) gives an understanding to transitions from "one socio-technical system to another," which in this case can give an understanding about the need for new technology and pathways in the meat industry in Norway. Thirdly, wicked problems help draw attention to the complexities and challenges of addressing social policy problems, as they lack clarity in both their aims and solutions. Finally, the discourse can capture different and similar storylines from the actors to analyze the perceived interests in the technology of artificial meat production.

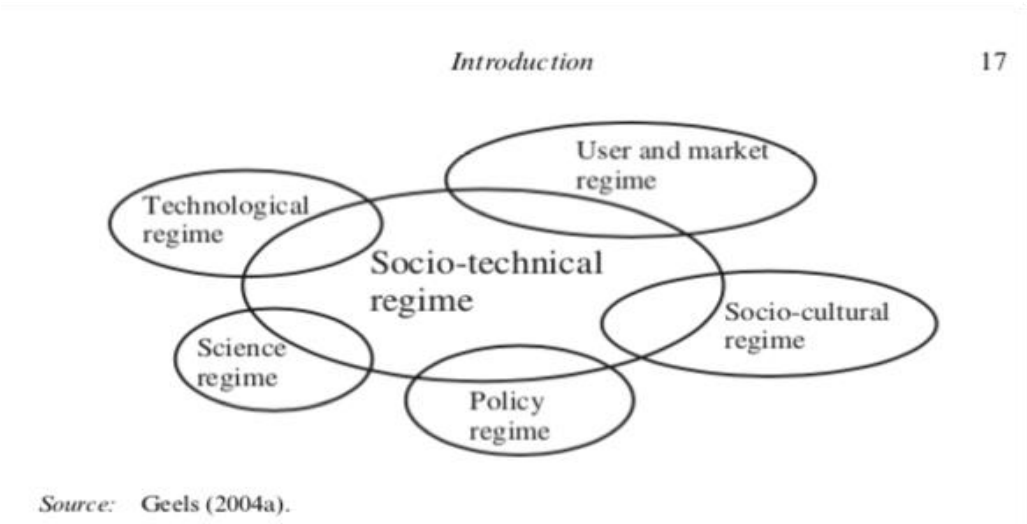
Multi-Level Dynamics

Modern society is today facing some structural issues in different sectors, and when we think about the meat industry, there are issues linked to climate change, CO2, oil dependency (in transport), water and land usage, pollution, and NOx emissions. Such social issues are elements within a socio-technical system, and these systems are actively created and maintained by human actors in which they are embedded in social groups. In addition, these specialized social groups are elements within a socio-technical system (Geels, 2005, p. 8).

Particular perceptions, norms, problem agendas, and preferences are shared by social groups within a socio-technical system. These groups are further explained by Geels (2005 p. 15) to be sharing a particular language, telling similar stories, having professional associations, and meeting each other on specific fora. In addition, there is coordination within groups due to these members sharing cognitive, normative, and formal rules. Thus, this means that different regimes co-exist, such as technological regimes (design, production), policy regimes, socio-cultural regimes, and science regimes (Geels, 2005, p. 15). Different groups interact with one another as well, forming networks with mutual dependencies. Groups have their characteristics of rules, such as beliefs and cultural values. Even so, they are interdependent and interpenetrative as well, causing the social group activities to be aligned to one another (Geels 2005 p. 16).

A meta-coordination through socio-technical regimes that propose the concept of the "socio-technical regimes" is shown in figure 2 under. Even though one regime does not encompass the whole of other regimes, it however, refers to the rules that are aligned to one another.

Figure. 2 "Meta-coordination through socio-technical regimes"



The bases of a socio-technical analysis are made by these interactions, taking into account that technology influences the society on the one hand, while social actions influence technological change at the same time (Geels, 2005 p. 18). This dynamic of social shaping is further explained by Geels (2005) to be accompanied by the technical shaping of society.

The Multi-Level Perspective

The Multi-Level Perspective (MLP) framework analyze and describes socio-technical transitions (Geels, 2011; Geels & Schot, 2007). The MLP help show the complexities of the socio-technical system, how they might operate, and also what forces that might drive change within the system. The MLP is described by Geels (2010) as a framework for understanding sustainability transitions, which provides an overall interpretation of the multi-dimensional complexity of transformations in socio-technical systems (Geels, 2010 p. 495). Thus, the goal of this section is to enlighten the reader on the complex nature of socio-technical transitions and the conflicting attitudes within studies of transitions regarding the potential scale and pace of sustainable transitions.

The MLP consists of three levels, and these are understood as analytical concepts which can help to explain how systems work and change. Hence, the MLP is first and foremost a heuristic

tool (Kuzemko, Lockwood, Mitchell, & Hoggett, 2016, p. 97). First, the regime level account for the "deep structures" and "stability" of the system and refers to the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems" (Geels, 2011, p. 27). The regime includes the incumbent actors, infrastructures, and mechanisms within the system. Furthermore, the regime consists first and foremost of actors that operate with common rules, and these rules create stability inside the regime. This gives a predictable trajectory that leads to lock-in, making it hard to change. Technology, industry, science, markets, culture, and policy are the architecture of the regime (Grin et al., 2011). They are, in the context of this thesis, translated into meat production, utilities, research practice, producer and consumers´ behavior towards meat prices, sustainability and environment, money flow, and food waste. Furthermore, the regime makes up a 'paradigm' where shared core beliefs, schemas, cognitive routines, institutional and lifestyle practices, and competence make up the regime 'rules' (Geels, 2011, p. 27).

Secondly, the niche level consists of novelty actors that pursue a place in the regime or desire to replace the regime. The niche actors work on "radical innovations that deviate from existing regimes" and are thus important to transition as they "provide the seed of systemic change" (Geels, 2011, p. 27). Niches are often, in sustainable transitions, represented by renewable energy actors that seek a large share of the energy system and the market through working in coalition and acquire public legitimacy and acceptance. Thus, niches can be new technological solutions that can change the socio-technical system by entering into the regime (Grin et al., 2011). They are in this thesis defined as artificial meat, and there needs to be a landscape change for niches to be part of the regime. In addition, there has to be a disruptive force that puts regimes under pressure to be a landscape change (Geels, 2002). Landscape pressures can, in this case, be climate change concerns and environmental destruction, policy, hunger problems, and the ever-decreasing health condition.

Thirdly, the socio-technical landscape constitutes the "wider context, which influences niche and regime dynamics" and encompass "not only the technical and material backdrop that sustains society but also includes demographical trends, political ideologies, societal values, and macro-economic patterns" (Geels, 2011, p. 28). The landscape level is slow to change and is, in addition, not influenced by the niche or the regime. Landscape development put, however, pressure on the regime, which may create windows of opportunities for niches to capitalize on. Politics is argued by some scholars to generally take place within the exogenous landscape level

(Kuzemko et al., 2016; Rosenbloom et al., 2016). Simply put, the landscape incorporates the political, economic, environmental, and cultural contexts that influence on the niche and regime level (Rosenbloom et al., 2016, p. 1276).

In addition, it influences the epistemological and ontological axioms that might shape different cognitive assumptions within the system. By interacting with each other, the three levels create room for transitions. Artificial meat production can, in this case, solve the problem within the regime. Artificial meat production can, however, due to mismatch with the regime architecture, still remain a niche for a long time (Grin et al., 2011). For instance, technological capabilities cannot be possible to combine with the existing market, policy, infrastructure, and the perception from the public (Grin et al., 2011). For that reason, niches depend on the landscape to put pressure on the regime, and this pressure creates windows of opportunity for niches and tensions inside the regime. Tensions can lead to strategic games, and "when strategic games heat up, this may lead to domino effects that suddenly accelerate the breakthrough of the new technology" (Grin et al., 2011 p. 26).

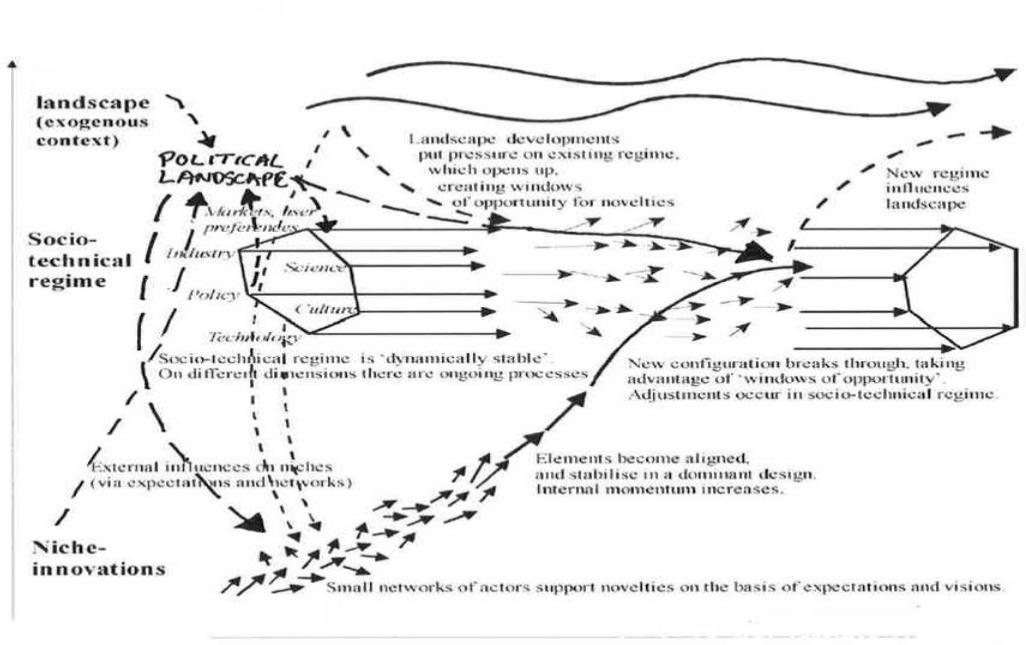
Furthermore, the MLP is described by Sovacool (2016) as a theoretical manifestation of the idea to alter political and legal regulations, technologies, economies of scale and price signals, and social attitudes as central parts of socio-technical innovation and transitions (Sovacool, 2016 p. 205). I will, in my research process, narrow the observation directed to the existing regime, as the meat industry is already "stabilized by lock-in mechanisms that relate to sunk investments, behavioral patterns, vested interests, infrastructure, favorable subsidies and regulations" (Geels, 2010 p. 495). Socio-technical transitions can be studied from various angles by different disciplines, as they are multi-dimensional phenomena. Transitions are understood as:

> Processes of structural change in major societal subsystems. They involve a shift in the dominant 'rules of the game,' a transformation of established technologies and societal practices, movement from one dynamic equilibrium to another—typically stretching over several generations (25– 50 years). (Meadowcroft, 2009, p. 324).

The concept of « sustainable transitions» has, in relation to the present climate issues, emerged. These sustainable transitions are, within the transition literature, separated with historical

transitions by a wide range of characteristics. First and foremost, in relation to addressing environmental problems, they are "goal-oriented", rather than being "emergent" – or more random or driven by commercial opportunities explored by entrepreneurs. Hence, rather than the commercial gain of individual actors, the process is initiated by a drive for an outcome that serves a "common good" (Geels, 2011, p. 25). Secondly, obvious "user benefits" are not offered by sustainable transitions. Therefore, it is "unlikely that environmental innovations will be able to replace existing systems without changes in economic systems (e.g., taxes, subsidies, regulatory frameworks). These changes will require changes in policies, which entails politics and power struggles because vested interests will try to resist such changes" (Geels, 2011, p. 25). Thirdly, powerful incumbent actors, such as food processing companies, supermarkets, oil companies, and electric utilities, might be both key to and hinder breakthroughs in environmental innovations as they monopolize the "empirical domains where sustainability transitions are most needed, such as transport, energy and agri-food" (Geels, 2011, p. 25). Geels (2011) argues that sustainable transitions, therefore, involve an interaction between "technology, policy/power/politics, economics/business/markets, and culture/discourse/public opinion" (Geels, 2011, p. 25). This could encourage an inquiry into the complex and multi-dimensional nature of such transitions.

Figure. 3 The political landscape and the interlinkages to regime and niche levels. Showing the frequently used and well-known illustration of the Multi-Level Perspective, but being somewhat modified, where the political institutions of the political landscape and the arrows to and from it are added:



(Source: Adapted from Geels and Schot, 2007, p. 401)

Sovacool challenges in his 2016 article "a 'conventional truth' in the field of transition studies: that transitions take at least 30–50 years, if not centuries as some historical examples show" (Kern & Rogge, 2016, p. 13). Thus, the idea of a rapid energy transition is argued by Smil (2016) as "wishful thinking" (Smil, 2016, p. 194), and further goes on presenting 12 points to exemplify his argument, based on historical transitions. This can be summarised as follows:

> We now have a truly global energy supply system relying overwhelmingly (~85% in 2015) on fossil fuels. Replacing it by new arrangements based on (mostly liquid) biofuels and intermittent (mostly wind and solar) electricity generation is—even after ignoring all environmental and social problems associated with the requisite up- scaling of biofuel production, and all technical challenges associated with mass-scale reliance of generating electricity with low capacity factors—a task that will necessarily occupy us for generations to come. (Smil, 2016, p. 196).

However, Sovacool (2016) claims that if the political know-how and will were to be in place, the potential for a faster transition into a decarbonized energy system is feasible. In addition, Kern & Rogge (2016) argue that "at the heart of the pace of low carbon energy transitions is firm political commitment at all levels of governance" (Kern & Rogge, 2016, p. 16). Thus, they proclaim, in hope to halt dramatic climate change, that political determination is the only way a socio-technical transition of this scale can take place within the timeframe needed. Furthermore, Kern & Rogge (2016) argue that the Paris Agreement is a testament to a political paradigm shift that "has the potential to significantly accelerate the decarbonization of the global energy system" (Kern & Rogge, 2016, p. 16). Sustainable transitions are nevertheless still within the current economic paradigm, dependent on incentives and frameworks that make them beneficial for actors to accept. It seems, therefore, that the only way for a relatively quick transition to occur is through political steering and determination.

Thus, a key role in the accomplishment of these socio-technical transitions is played by politics. Politics is, according to Meadowcroft (2011), to be understood as "the constant companion of socio-technical transitions, serving alternatively (and often simultaneously) as context, arena, obstacle, enabler, arbiter, and manager of repercussions" (Meadowcroft, 2011, p. 71). In addition, Meadowcroft (2011) notes that politics does not only include the behavior of political actors but all those actors within a coalition, including those outside of the political setting as

well. This implies to a preferably complex political system, where a huge variety of actors struggle to gain control through discursive mechanisms and other intricate systems where actors are to cooperate, coexist and compete (Dryzek, 2013). Politics alone are nevertheless not the "driver" of transitions, and Geels (2011) argues that "(t)here is no single 'cause' or driver. Instead, there are processes in multiple dimensions and at different levels which link up with and reinforce each other ('circular causality')" (Geels, 2011, p. 29). In other words, with this MLP framework, Geels (2011) find that socio-technical transitions occur as a result of interactions between processes on different levels of the "hierarchy" within the socio-technical system.

The foremost essential part of my research is understanding the issues that the existing regime, being, in this case, the meat industry, is up against. Geels (2010) describes this as a dilemma: The strategy literature sees sustainability transitions as strategic dilemmas for firms, who have to balance the risks and opportunities associated with (sometimes multi-million dollar) investments. On the one hand, it may be rational to postpone 'green' investments because of future uncertainties in government regulations, price fluctuations, the degree to which environmental concerns translate into a willingness to pay more for green products, and the emergence of 'green' markets (Rugman and Verbeke, 1998) (Geels, 2010 p. 497). Geels (2010) continues to describe these uncertainties to complicate calculations of return-on-green investment, arguing that it might be rational to wait for more clarity:

> On the other hand, 'green' technology leaders may benefit from first mover advantages (such as brand recognition, creation of market positions, technology lead, creation of patent barriers) that create favorable positions in future 'green' innovation races. Firms that have a 'green' lead may also convince policy makers to issue stricter regulations and thus impose 'imitation costs' on competitors (Puller, 2006). Environmental sustainability thus forms a dimension of strategic and competitive games. (Geels 2010 p. 498).

Furthermore, being that sustainability transitions is a normative goal is one aspect of this, including a collective global issue. In the time of sustainability transitions, the importance of environmental issues is going to be full of debates, which involves deeply rooted beliefs and values. The public and the civil society will be crucial drivers for sustainability transitions, and

the civil society, as well as the Government, is further explained by Geels (2010) to having to change consumer practices and frame conditions. The process of changing from an industry based on a strong carbon footprint towards a more sustainable way of producing meat can be seen as a long-term transition, as well as being highly complex in any society. In addition, the meat industry can be seen as deeply rooted in culture, social structures, and routines. Socio-technical transitions can be based on the analytical insight the MLP gives into the subject, arguably occur through a process of complex political, socio-economic, and cultural mechanisms where a variety of actors provide the process with the schemes and wills of either struggling niches or powerful incumbents. This apparently makes for a somewhat "messy" and complex process which is not steered easily, even though there are many actors who try to do so (Kuzemko et al., 2016).

Lastly, the Multi-Level Perspective of Geels has, in socio-technical transitions, been readily criticized for downplaying the role of politics (Genus & Coles, 2008; Meadowcroft, 2011; Osunmuyiwa et al., 2018). Hopefully, this thesis can help contribute to explaining the role of politics within transitions. Due to the fact that political determination is one of the key drivers of transitions, I aim to stress the importance of swift political action by mapping out how complex the problem is and how deeply we are established in the system that constructed it, as well as understanding how difficult and prolonged a transition might prove.

Wicked problems

Wicked problems are complex and interdependent problems that arise in the public sphere while involving high levels of uncertainty as well. As climate change is being recognized, additionally we know that it is an issue that is not simple as its nature, starting to realize that these problems involve many interrelated factors such as our cultural and psychological attachment to finances, economics, impacts of social relations and environmental issues such as air quality. A wicked problem is further explained by Camillus (2008) as having innumerable causes, being tough to describe, and lastly, does not have a right answer. Classic examples of wicked problems are terrorism, environmental degradation, and poverty. Such problems are the opposite of ordinary problems, which people can solve by applying standard techniques in a finite time period.

Thus, wicked problems are termed as highly complex issues, being that they are unstructured, open-ended, and multi-dimensional systems having no known solution. In all cases of different types of wicked problems, such as environmental degradation and climate change, it cannot be

separated and isolated from the system. Rotmans et al. (2010 p. 139) further explain that adaption is about changing practices, as the traditions and culture of the regime might become less optimal when other landscape conditions and subsystems start to change. The regime may or may not try to change its practices, and there is a chance not to succeed if they decide to change. It is assumed, within this adaption mechanism, that an external event can be defined based upon which adaption response of the regime is triggered. The representation of the emergence within the subsystem of an adaptive response is what the decisions and actions of the multiple individual actors that make up the regime are based on. In the transition´s multi-level phase, the following internal transition logic is what it is being yielded by (Rotmans et al. 2010 p. 139).

Further, Rotmans et al. (2010) argue the regime often acts as an inhibiting factor in the pre-developed phase, being that it will mostly seek to maintain social norms and belief systems while trying to improve existing technologies and policies at the same time. This is argued to be a strategy aimed to fight off new and threatening developments. Often the take-off phase is caused by series of external disturbances because of too many attempts to change the system in the pre-development phase, which is further reached when modulation of developments takes place at the micro- and macro-level. This meaning that certain innovations at the micro-level, such as technology, policy, and behavior are discussed by Rotmans et al. (2010), to be reinforced by changes at the macro-level, such as changes in worldviews or macro policies. They further describe that the regime, in the acceleration phase, has an enabling role through a large amount of capital and the application of innovation. Thus, the result of a regime change is based on either response to bottom-up pressures from self-examination or micro-level, or as a top-down pressure on the regime at the macro level.

In addition, they discuss that situations can change rapidly and irreversibly, describing the system as an "unstable situation because revolting elements of a new regime compete with established elements of the existing regime. In the stabilization phase the acceleration slows down, due to a new regime that has been built up, again resisting new developments" (Rotmans et al. 2010 p. 139). They further explain that the stabilization phase represents a dynamic equilibrium being that it could accommodate potential seeds of change for another transition (Rotmans et al. 2010 p. 139).

Discourse analysis and coalitions

The thesis includes some concepts from discourse analysis, to separate the actors perceived interest in artificial meat, and will look into different discourses in order to understand the many ways one can look at an issue. First of all, it is important to separate the definition, and every-day use of the word 'discourse,' which one can say is more or less a synonym for 'discussion' or 'debate,' with the analytical 'discourse' that is being used in various strands of social science. A 'discourse' in the analytical context is, according to Hajer & Versteeg (2005), defined as:

> An ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of practices. The 'discussion,' in other words, is the object of analysis; discourse analysis sets out to trace a particular narrative regularity that can be found in discussions or debates... Discourse analysis illuminates a particular discursive structure that might not be immediately obvious to the people that contribute to the debate. (M. Hajer & Versteeg, 2005, pp. 175-176).

In addition, a discourse can be understood as a shared viewing of the world, dictated by how culture, language, historical development, belief systems, and norms interplay in creating a context wherein individuals exist together. Discourse can also be seen as political commodities, being bound to political power and practices in the way that they condition the prescription on values to those that subject to them. This may, especially in a democratic model, result in a political outcome (Dryzek, 2013; Foucault, 1980). Hence, ideas, biases, beliefs, knowledge, and language can, through discourses, generate and coordinate policy outcomes, being that the discourse narratives rise high enough on the political agenda.

Discourse analysis is, in the context of climate change, environmental issues, and sustainability, an ideal analytical tool and will contribute to stimulating fruitful discussion on the topic. The intricacy, multifaceted nature, and complexities that these themes require makes for a rather complex portfolio of preferred paths-of-action and perceived causes to mitigate the issues related to climate change (Hajer & Versteeg, 2005). The researcher will be given insight into political mechanisms, through a discursive analytical approach to an environmental-policy inquiry, partially through revealing the role of language in politics and the embeddedness of language in political practices (Hajer & Versteeg, 2005, pp. 176-177). Discourses do not,

however, always affect governments and policy in a direct way, but rather indirectly through becoming embodied in institutions, thus shaping "informal understandings that provide the context for social interaction, on par with the formal institutional rule" (Dryzek, 2013, p. 20). Discourse might, in other words, influence the way in which institutions respond and perceive issues, such as how a political institution responds to environmental issues, for example.

The strength of discourse analysis lies partially in the emphasis placed on language as an important element in politics and social phenomena. Nevertheless, a lack of emphasis seems to exist on the role that actors play in conventional discourse analysis, making it possibly weaken as an approach to political inquiry. Even so, there are supplement perspectives existing within discourse theory, which implement the role of actors in its analysis to a greater extent. Discourse coalitions serve to this end and are a key concept in the discursive approach to environmental policy by Hajer. The discourse coalition concept presumes that;

> In any policy field, there are different coalitions competing for policy influence of which one is normally dominant. What glues the coalition together is the use of a shared discourse. The framework is used to analyse how discourse coalitions form around shared storylines. (Kern & Rogge, 2018, p. 108).

Discourse coalitions, being one of several theories that offer a methodological approach to the study of narratives in political change, plays an important role in political change. The framework of discourse coalition can discover knowledge into political change through an analysis from a variety of sources in collected storylines, such as interviews, speeches, whitepaper, and documents (Smith & Kern, 2009). Several different ways of looking at environmental issues have argued by Dryzek (1997) in the last four decades been included. The impact of discourses can, according to Dryzek (1997), often be felt in the intergovernmental of government bodies (Dryzek,1997 p. 19). Thus, it provides a good tool for analyzing the approach towards climate change taken by the two chosen actors.

3. Research design

This chapter describes the methods used in this study, presenting and discussing the methodological approach employed to study the concept of artificial meat production in Norway, concerning the research questions proposed.

3.1 Methodological stance

> Methodology means understanding the entire research process – including its social-organizational context, philosophical assumptions, ethical principles, and the political impact of new knowledge from the research enterprise. Methods refer to the collection of specific techniques we use in a study to select cases, measure and observe social life, gather and refine data, analyse data, and report on results. The two are closely linked and interdependent (Neuman, 2011, p. 2).

I will start with the choice of research strategy, before continuing with how the data for my study has been obtained. Furthermore, I will explain the methodological challenges, as well as the validity and reliability of the study. In this study, key informant interviews have been used as my primary sources for data collection. In addition, I have used document analysis of existing documents related to the chosen research questions. I will, therefore, apply a theoretical approach and focus on analytical theory. I will establish, through academic readings and comparative analysis, an understanding of how the chosen actors frame the topic of artificial meat production. In addition, the logic and strategy behind the methods will have to be explained. Hence, the strategy and categorise the method of inquiry to be pursued will be presented in the next two sections, before establishing the methodological and logical approach for the analysis.

The purpose of this chapter is to describe the process of collecting data, followed by an analysis of said data for this thesis and proposed research questions. I will present the methods being used and why and how they were used. In addition, what ontological and epistemological approaches the methodology is based on will be addressed.

3.2 Research strategy

There are many ways to approach a problem, and in order to answer the problem, the choice of the research strategy is crucial (Blaikie, 2010). This thesis methodology will mainly follow the logic of an abductive research strategy to identify the feasibility for artificial meat production in Norway. Trying to understand and explain a (social) phenomenon through conceptual frameworks are some of the principles of an abductive strategy (Danermark, et al., 2002). This strategy can interpret and recontextualize the likelihood for artificial meat production within a theoretical framework (Danermark, et al., 2002). The framework has a significant role in an abductive research strategy to determine the understanding of the feasibility for artificial meat. Thus, in this thesis, it is going to guide the understanding of the role of the artificial meat industry in the future.

Further, by applying theoretical knowledge, it takes an observable phenomenon and implies a universal context or general structure to them. Hence, the theory in the analysis becomes an essential part. I presented a collection of theories in the theory chapter above, which will serve as the conceptual lens through which the data will be analyzed (Danermark et al., 1997). However, the aim is not to justify the truth of the theories, but rather relate empirical evidence to the theories to "give meaningful interpretation" (Dey, 2004, p. 91).

This thesis analysis will rely on the understanding and interpretation of data, which will be categorized and compared, and the conclusion made will be based on the observation of the various theoretical perspectives gathered. Further, being that it is difficult not to consider the context around a contemporary phenomenon, this will be the main reason to use an abductive strategy, as the interpretation from actors can change and be different depending on circumstances and time. Thus, by recontextualizing and bringing it up to a higher level with a theory, abduction has the potential to give a sensible analysis of a contemporary phenomenon, where inference depends on a theory, which can give serval understandings depending on the used theory (Dey, 2004).

Abduction will force my interpretation of the theories in the Multi-Level Perspective (MLP), wicked problems, and the theory of different discourse analysis. My understanding of the phenomena will then depend on the ideas form these theories (Danermark et al., 2002). The attention will, by the concepts, move to the most relevant evidence to answer the research

questions. Even so, uncertainty in the conclusion is an issue abductive inference has since there are no fixed criteria to make them valid (Danermark et al., 2002). Abduction guidance the analysis of the data through the perspective the researcher chooses and places it further into a bigger context. Nevertheless, according to Danermark et al. (1997), the weakness is that there is no specific set of criteria for deciding the validity of abductive reasoning. The conclusion being seen as reasonable, given the theoretical point of departure is the criteria.

However, Danermark et al. (2002) argue that abduction guides interpretation by putting them into a larger context. The thesis can, therefore, have a holistic perspective by putting the finds into a larger context, being the evidence represents the likelihood for an artificial meat production in Norway. Thus, the goal of the research is, in line with Dey (2004), to end up with an interpretation of what the role of an artificial meat industry has in the future and the different perceptions the two actors have towards artificial meat production. This recontextualizing comes from the theories and provides meaningful reasoning.

3.3 Comparative case study and qualitative research

Comparative case study

A comparative case study is used to investigate the likelihood of artificial meat production in Norway, as one can go in-depth with a contemporary problem in a case study, understanding the context around (Yin, 2014). In this term, artificial meat production would be the social phenomenon, where the focus was on the perception of the two actors as companies to potentially adapt to a new way of producing more environmentally friendly meat. I have chosen Nortura AS (& Norilia) and Kjøtt- og fjørfebransjens landsforbund (KLF) as the two actors, since they are the biggest competitors in the market, and there are also similar characteristics between them. In addition, I have looked at the project GroPro by Nofima and their results so far.

The strength of a case study is the use of multiple sources of evidence, and the research is pulled towards a direction that provides a meaningful conclusion with a variety of sources (Yin, 2014). The data collection is repeated by a comparative case study, and then the analysis can compare the similarities and differences in perception from actors to understand the needed conditions for investing in artificial meat. The reason a case study was selected for this thesis is that the purpose of the study is to understand how artificial meat production in Norway works in

practice. By doing so, qualitative research has to be conducted in order to understand the variables present in such projects.

Findings based on the proposed research questions will be of importance in order to be able to support any recommendations or conclusions derived from the finding from the case study, both for dissecting the research questions and further when providing any final statements regarding artificial meat production in Norway. Thus, in order to provide recommendations or conclusions with regards to artificial meat production, based on the research question proposed, the purpose of this case study is to collect data through the case study, being followed by an analysis of the findings, to achieve an understanding of artificial meat production.

Qualitative research strategy

Qualitative methods have developed from aspects of sociology and anthropology, and the aim is understanding human affairs (Holliday, 2002). The thesis will have a qualitative focus mainly based on text analysis and theory, as the intention is to apply the framework of Multi-Level Dynamics, the Multi-Level Perspective, wicked problems, as well as discourse analysis.

The research questions in this thesis aim to gain a thorough understanding of artificial meat production in Norway, and from findings through the case studies, possibly present a conclusion regarding the viability of artificial meat production to have any impact on the climate changes we are facing today. A qualitative methodological approach has been chosen to do so, as this is considered to be the most appropriate approach. Qualitative research uses, according to Golafshani (2003), "a naturalistic approach that seeks to understand phenomena in context-specific settings, such as "real world setting [where] the researcher does not attempt to manipulate the phenomenon of interest" (Patton, 2001, p. 39).

Qualitative research, broadly defined, means "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Corbin and Strauss, 1990, p. 17) and instead, the kind of research that produces findings arrived from real-world settings where the "phenomenon of interest unfold naturally" (Patton, 2001, p. 39). Unlike quantitative researchers who seek causal determination, prediction, and generalization of findings, qualitative researchers seek instead illumination, understanding, and extrapolation to similar situations (Hoepfl, 1997)." (Golafshani, 2003, p. 600).

Thus, the purpose of a qualitative research strategy is to understand human experiences, social phenomena, and structures. I found that using a qualitative research strategy was highly applicable to studying issues related to the concept of artificial meat production in Norway, as it allowed me to gain a thorough knowledge of the concept itself. This being combined with insight into social phenomena related to the concept through the particular case studies presented in this thesis.

3.4 Ontological and epistemological assumptions

An inclusion of meta-theory will be of significance in order to discuss and provide any possible conclusions or solutions to the research questions proposed in this thesis. "Meta-theory is concerned with discerning underlying ontological and epistemological assumptions that a body of theory or a theoretical perspective uses." (Blaikie, 2010, p. 138), meaning that the concept of artificial meat production is looked at in an ontological and epistemological manner. Ontology is, according to Neuman (2011), "An area of philosophy that deals with the nature of being, or what exists; the area of philosophy that asks what really is and what the fundamental categories of reality are." On the other hand, epistemology is "An area of philosophy concerned with the creation of knowledge; focuses on how we know what we know or what are the most valid ways to reach truth." (Neuman, 2011, p. 94 - 95).

Reviewing the concept of artificial meat production in an ontological manner means stating what findings, in relation to the research questions, are present from the case studies. For example, what does my case study reveal about the concept of artificial meat production in Norway? Further, are there any pros and/or cons? Lastly, are the findings sufficient and applicable to be able to discuss the research questions? I am stating the facts that have been discovered. Reviewing the concept in an epistemological manner, on the other side, concerns in what way the findings will be applied. The importance is, based on findings from the case study, put on sourcing applicable information in other to produce knowledge and, in addition, consider the best implantation of such information to be able to present recommendations and/or conclusions in a scientific manner.

3.5 Access to data and data collection

Access to data

The collection of data, such as documents, scientific journals, and webpages were accessible through the Internet. For the interviews, there was sent a mail to the different actors, asking to talk to key informants with high competence and knowledge about the topic, preferably persons that have worked with artificial meat before. However, since it is a relatively new technology, it can be difficult to get relevant information. The informants should, therefore, have a more holistic view on the topic, rather than technical expertise. The purpose of the interview and information about the project was here given, in addition to the theoretical framework and my background. However, information about the research question was not mentioned in the email since the informant could prepare clever answers about the topic presented.

Data collection

The primary qualitative source comes from interviews with the two actors Nortura AS (& Norilia) and KLF, as well as an interview with Nofima about their project GrowPro. It is possible to get information about the two actors' experiences and meanings towards artificial meat by doing interviews (Sovacool, Axsen & Sorrell, 2018). However, it is important to note that the goal of the interview is not to collect information about the experiences and feelings the informants´ has towards artificial meat. The aim is rather to get information, address the research questions, and get evidence, which can be used to understand the case (Rapley, 2004).

The interview was done in a semi-structural format with key questions that answered the proposed research questions, being designed after these and theory to make sure that relevant data was gathered. The flexibility of the interview would increase by structuring the interview in a semi-structured way containing relevant and important topics. Subsequently, the questions could then be followed up and adjusted accordingly to the specialization of the informant, and the interview with research questions can further go more in-depth and find unexpected data. Some of the questions would, however, be the same, being that this would make it possible for the interview to be comparable (Ringdal, 2013). Such an approach made it possible to discuss differences and similarities in perceived interest towards the technology and provided in some degree of insight into the strategic thinking of key informants and stakeholders as well. In addition, this should allow for a better understanding of how artificial meat is viewed and framed in discussions. This should further help us to better interpret and understand qualitative

data regarding current actions that are being taken within the political and industrial spectrum by various stakeholders and actors.

The data collection started in March and ended in April 2020. The interviews, however, were started at the beginning of May and ended in the middle of June, as there was a need for additional understanding of artificial meat production before doing the interviews, making me more prepared before the interviews. I wanted to preferably interview the informants at their office, but due to the situation with Covid-19, this was not possible. The interview was therefore done over Microsoft Teams and via mail, lasting for about 30 minutes. During the semi-structural interviews, I used recording equipment and then transcribed the interviews. This is to ensure that I did not miss key information and to ensure that the data was reproduced correctly (Brinkmann and Tanggaard, 2012). The transcription provided me with a better basis for systematizing and ensuring a comprehensive perspective on my data. The data from the interviews and document analysis are further categorized and structured according to my research questions and my analytical framework to provide a more structured overview of my data (Yin, 2009; Blaikie, 2010). In the context of this structuring, I extracted the parts of my data set that were relevant to the study, thus reducing the amount of data (Thagaard, 2013).

In addition, the qualitative secondary sources were collected in newspapers, reports, webpages, and scientific articles, as these provide information about environmental movements, artificial meat production, politicians, and so on. In addition, the documents can also give information about the past understanding from the actors towards artificial meat. The quantitative data comes further in a secondary form; being the second-handed data is collected by other research and made for a different purpose. Collecting data is, however, an expense, and one can save recourses and time by using others' work. Even so, one should be aware that the data might have errors and biases from other researchers and thus carefully deciding the material (Blaikie, 2010).

Further, the codebook Nivio was used to gather data inside, giving a better overview of all the collected data and opportunities for another researcher to replicate the findings. By doing this, I was able to recontextualize the data and put it into a larger context with an abductive research strategy (Danermark et al., 2002). However, this can make it difficult for others to get the same conclusions, as informants can change their opinion, and technological changes will give a completely new understanding of artificial meat production. The contextual factor can, in the

future, influence the development of artificial meat and sustainable developments in general, which was not discussed in detail in this thesis. Thus, it might be challenging for researchers to find the same evidence. The aim was, however, not to produce generalizable results but rather to understand a contemporary phenomenon by applying a framework.

Lastly, the different documents and interviews were placed into different theoretical concepts, which will give a holistic view of the likelihood for artificial meat in Norway. The interviews served, however, as resources to answering the research questions, and not only about the informants´ perception in general. Documents and findings on artificial meat were placed into the niche and then compared to the regime to see if there was a need for this new technology. The two actors, which operate inside the regime as incumbents, might have similar and different perceptions towards artificial meat production. Finally, the modelling of future meat prices and the economy was put as a pathway, in terms of more renewable and sustainable technology.

3.6 Data collection limitation

For this thesis, the discussions around the research questions proposed will be based on knowledge gained throughout this master program, followed by the findings from the case study as proposed. Data for a study can be collected in many ways, and in this case, the collection of qualitative data will be conducted with the common interviewer-participant interaction. I consider this chosen method to enable me to present a good case and final recommendations/conclusions. In addition, articles and books contributed by other researchers are other important sources for this thesis. To critically choose amongst a large amount of written work available is here the main challenge. As well as theoretical stance, they have provided me with empirical evidence for how the two actors perceive the idea of artificial meat production as a mitigation path towards climate change and issues.

The data collection method applied to this thesis can be seen as "limited to the perspective, agenda, and biases of those who produced the documents" (Sovacool et al., 2018, p. 29). This might be so, however, if one takes into consideration that the two actors to be discussed through the case study are available for scrutiny and open for the public, as well as in combination with this thesis author's understanding of the concept of artificial meat production, the data collection method in this thesis should be sufficient, trustworthy and applicable for the discussing around the research questions and any final recommendations/conclusions.

Sovacool et al. (2018) state, in addition to the limitation discussed above, that they confirm the authors' assumptions being that the chosen method of data collection is a sufficient and valid method of collecting qualitative data for this study, further producing applicable findings to be able to answer any research questions. They consider the final category to be "analysis of documents, such as reports, letters, websites and news media. Such data sources can provide insight into the information, frames and storylines presented by different actors, as well as the social interactions among them" (Sovacool et al., 2018, p. 29).

3.7 Validity and reliability of the data

The validity of research is, according to Fisher (2007), concerned with the truth of the interpretations made and further determines how truthful the research results are or whether the research accurately measures that it was intended to measure. I have used terms and concepts adopted from the theory in order to secure this. Furthermore, I have aimed to look, through my adaption of the abductive strategy, at the different documents through a theoretical framework. Thus, I have been provided with a tool to re-contextualize text and further identify how the actors have adopted different framings and discourse elements to the issue of dealing with the complexity between climate change and traditional meat production.

In line with how Danermark et al. (2002) describes the abductive research strategy, I have seen the case in the matter through the context and theory provided. Thus, my findings are subjective to the framework or circumstances I have set. I am not considered being objective as a researcher, as I, according to discourse analysis, are subjective in nature. The results are most certain colored by thus ambiguity, even though I have attempted to be objective. As a different framework and theory in abduction research have been used to analyze the data from both interviews and literature, there is not necessarily one conclusion for the problem, being that the problem can be studied from different angles and often are about how good you argue your point. As there can be different interpretations of the same problem, this can, therefore, challenge the validity and reliability (Blaikie, 2010). Thus, having a clear explanation and definitions of theories and concepts being used, as well as clear research questions, is important.

By using different methods, such as combining interviews and peer-reviewed literature, can contribute to securing both validity and reliability. As the interviews can be of

misunderstandings or interpretations of what is said, one can avoid this by asking a couple of the same questions to all the participants in the interview. In addition, a draft was sent to the participants to ensure that there were no misunderstandings between the interviewer and the interviewee. Further, Merriam and Tidsell (2016) explain that member checking can be a strategy to ensure credibility and internal validity, describing this as an idea to ask for feedback on the emerging findings from the interviewed key informants. They explain it as:

> This is the single most important way of ruling out the possibility of misinterpreting the meaning of what participants say and do and the perspective they have on what is going on, as well as being an important way of identifying your own biases and misunderstanding of what you observed. (Merriam and Tidsell, 2016, p. 246).

Thus, I used member checking as a strategy to help increase the quality of my qualitative study, as it reduces the researcher bias and respondent bias, as well as it substantially increases the validity of the study. I sent an email to the participants after I completed transcribing the interviews, asking them to review their answers. They all gave me detailed corrections of the quotations that should be implied in the data further. They corrected some of the sentences and clarified their expression in writing, and further verified and validated the actual interpretations of the transcription, which provided me with more insight and clarity based on their feedback. Lastly, finding consensus in the peer-reviewed literature show, there are validity and reliability in their studies.

I hope that the reader, in order to gain transferability, has been provided with enough information and data about the context of the study so that they can decide if the results are valid to their own project (Blaikie, 2010; Shenton, 2004). Examination of trustworthiness is crucial when ensuring reliability in qualitative research. Seale (1999) states that the "trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability" (Seale 1999: 266). It is furthermore suggested by Strauss and Corbin (1990) that the "usual canons of 'good science'...require redefinition in order to fit the realities of qualitative research" (Strauss and Corbin 1990: 250). Therefore, I have evaluated the research and participant bias, as well as their errors after the interviews. It is, however, important to underline the threat of over interpretation and ambiguity, and as I am not fully objective, the work will always be affected by this.

3.8 Ethical considerations

The project was reported to Norsk senter for forskningsdata" (NSD), being that the data collection identifies individual persons through name and the organization they are connected with. To make sure that the project is in line with ethical principles, projects containing information about personal data downloaded on equipment such as interviews, need to be reported (Wadel, 2014).

4. Empirical findings

This chapter covers findings from responses from the interviews conducted from selected actors, which will be presented in categories related to my research questions. The collected data are based on the four research questions, as well as the four sub-questions, in which these questions are suitable to shed light on my problem statement. The purpose of the data collection was to understand and enhance our knowledge about how artificial meat can be produced in Norway, what the challenges might be and map the level of interest and willingness to invest in artificial meat production.

4.1 Findings from interviews

The main research questions included the following main themes: 1) the feasibility for artificial meat production, 2) agriculture, food security, and the environment, 3) the necessary and sufficient conditions needed, and 4) investments and economy in the meat industry. Thus, these themes are presented in the findings from the interviews with Nofima, Nortura & Norilia, and KLF. In addition, when interviewing the chosen actors, some sub-questions have been asked in order to look at similarities and differences in the perception of the technology.

First Nofima, which is already mentioned to be one of Europe's largest business-oriented research institutes conducting different research, was interviewed about their project GrowPro. Furthermore, Nortura AS was chosen as one of the actors as it is one of Norway's largest food producers, as well as being the farmer's company, a cooperative owned by over 18,000 Norwegian farmers (Nortura, n.d). As they focus on developing in a health-friendly and sustainable direction and continue to create food enjoyment and great values that remain in Norway, they seemed like a natural choice to interview. In addition, a key informant from

Norilia, who is an owned subsidiary of Nortura, was present during the interview. Norilias purpose is to take care of and utilize the by-products of the meat and egg industry to contribute to profitable and sustainable agriculture. Further ensuring that all resources, being the whole animal, are utilized in the best possible way for products that the world benefits from and enjoys (Norilia, n.d). Thus, it seemed natural for them to participate, as well. Lastly, Kjøtt og Fjørfebransjens Landsforbund (KLF), which is an interest and industry organization that represents the privately owned, independent part of the meat, egg, and poultry industry in Norway, is the second chosen actor for this thesis. As they have three main focus areas, being politics, food safety, and commercial activity, they seemed like a natural choice (KLF, n.d).

The feasibility for artificial meat

Research question 1: "What is the feasibility for artificial meat production in Norway from the perspective of producers?"

In the interview, I wanted to map out what each key informant associated with the issues around artificial meat technology and production, emphasizing the potential and challenges this technology is facing and what it can mean for a decarbonized society. The key informants in Nortura & Norilia explain that they are partnering with Nofima´s GrowPro project, explaining that:

> This is due to us wanting to be informed about the development and to gain more knowledge about lab meat and further discussing whether to produce meat products of lab-grown meat in the future.

For Nortura and their subsidiary Norilia, their key informants say that their entrance is learning about the technology and knowing what they are facing, having an opportunity to produce this type of meat in the future if they want to and if their owners will. However, the key informants clarify that it is the owners who will decide whether to adapt to such technology, explaining that:

> If and when the owners want to, is argued to perhaps be our biggest challenge, as we have the machines, equipment, and knowledge of meat as raw material, having everything arranged. Still, it is a challenge with our owners who produce ordinary meat. Already, there have been quite a few disputes about it.

Therefore, one of the main challenges they are facing concerning this technology is that artificial meat has the potential to eradicate traditional agriculture, and that is something farmers do not want to happen as it is their livelihood. Further, when asked how they see the possibilities for artificial meat production in Norway in the future, they argue, based on their knowledge from the project, that it will probably not be on the market before ten years or longer. Some of the reasons for this, they argue is whether consumers want it or not, considering local food trends and health and not additives, saying that:

> One might think that consumers may not want to buy it. However, if there is a business opportunity here, Nortura should be in the driver´s seat.

When further asked what they think of artificial meat production as key informants, they argue that artificial meat technology is relevant today and technology development is always positive, saying that:

> All new possibilities should be considered, especially when it is considered to be an immediate technology development, as well as having the machines, technology, and the knowledge available to produce products.

Further, the key informants argue that there is no doubt there will be a production of small-scale in the beginning. Thus, the biggest challenge will be scaling up the production to large-scale. Also, the price must be reasonable, whatever the market.

However, the key informant at KLF argues that everything will depend on the regulations first, there are large groups that test different methods, explaining that:

> How it is regulated and whether this becomes paternalized solutions or whether it becomes open to everyone are the most significant moments of uncertainty. I am curious about whether it will be only a few chosen companies that can use this technology, or if it becomes commercially possible to get at a reasonable cost. However, if one is to go in for large-scale production of artificial meat production, then it should happen here in Norway.

The key informant further explains this to be so that one is not made dependent on imports. When further asked what she thinks of artificial production, she has divided thoughts on this question, seeing that there is potential and being a technology supporter as well, explaining that:

> I do not see the technology of artificial meat as something freaky and would try or buy it if possible. At the same time, seeing that agriculture has a value, I become very ambivalent. On the one side, it is nice that technology has come so far and can make it happen. On the other side, the thought of agriculture employing many thousands of people who could potentially lose their livelihood and everything they have worked for is scary.

Even though the meat industry itself will have a significant role and still create jobs, it is the agriculture the key informant is most concerned about. The key informant from Nofima has divided thought on what she thinks of artificial meat production as well, saying that:

> It is one the one hand very interesting in terms of work and science, feeling like it is science fiction almost. On the other hand, it is difficult to think that you are part of something that can completely eradicate cultural landscapes and the workplace of people.

It may well be that this is phased out if one finds that it is not possible or that it is not cheap enough or good enough and loses 5-6 years. However, the key informant argues that they would still have generated essential knowledge about the technology. If one is to make a meat product such as beef, the key informant believes that this will be far in the future, being that it is difficult to make a steak and not as an ingredient in sausages or minced meat.

Further, the key informants were asked about the production process and if they were in the process of producing a finished product. First, the key informant from Nofima says that there has been more focus on sustainability and how to produce enough food for people over the last ten years, as well as how to use all the raw materials available, explaining that:

> As Nofima researches on food production and works a lot with meat and food quality, the step was very short for researching artificial meat as well, being that we have worked with cellular systems and muscle cells for many years.

> In addition, we have used it as model systems to look at various ingredients and factors that affect muscle and meat quality.

The key informant further explains the process by saying that:

> The muscles of all living animals consist of long fibers, and between these fibers lie small muscle cells, which are resting cells. These cells can be collected in the lab, is that one can take a sample from a living animal or, as we in Nofima does, is; collecting cells from sirloin from newly slaughtered cattle. These cells are additionally broken down by the fibers, extracting only the muscle cells, causing them to grow further in the lab.

As of now, Nofima works in small vessels at the lab, but if this is to feed the world, they have to have billions of cells scaled up and made into many. However, the problem with extracting cells from living animals is due to the cells only being able to divide a certain number of times before they die, further explaining that:

> The challenge here is that you have to take these cells into large tanks, making them grow there and further take them out and create a muscle fiber structure. This can be done in different ways; one example can be to grow them in various types of large tanks that cause them to fuse together and form the proteins you are interested in. With regard to the question, if we are in the process of producing a finished product, the answer is that we have not come this far.

However, they are not meat to do so either since they are only researching this topic. Nofima has been able to grow small pieces but not beef due to the problems mentioned about extracting cells, only dividing a certain number of times.

As for Nortura & Norilia, the key informants say they are involved as far as possible, being most in meeting activity and gaining information about what is happening, and not so much involvement in the practical lab work. However, Norilia supplies some raw materials for the project and looks on how an alternative growth medium for these cells can be made, explaining that:

> This is due to the growth medium used as of today is too expensive and therefore, cannot be scaled up to a large scale. In addition, it is unsustainable because we still have to use unborn fetuses from animals, and this creates a lot of problems from an ethical standpoint as well.

Therefore, Norilia is involved in getting alternative products into the growth medium. Furthermore, they argue that even if one does not move on with artificial meat production, they still would have learned a lot about growth media and how their raw materials and ingredients can contribute to it. Regarding KLF, they are not involved in any process of producing artificial meat. However, they are stakeholders in the research project protein 2.0 of Ruralis, which will look at artificial meat and the consequences and possibilities.

Agriculture, food security and the environment

Research question 2: "What will artificial meat production mean for agriculture, food security and the environment?"

Further, the key informants were asked about the relationship between artificial meat production and agriculture, food security, and the environment, in which all the informants agreed to it having both positive and negative impacts. The key informant from Nofima argues that artificial meat production can have a negative impact, considering the ethical and moral aspects, explaining that:

> It has the possibility to eradicate cultural landscapes, traditional meat production, and the workplace of farmers. However, if one manages to achieve coexistence, it can have a positive impact, especially is aquaculture is included in this, as it can be used as an ingredient instead of importing soy.

Lastly, the key informant says that if produced locally and in coexisting with traditional Norwegian agriculture, it can have a positive impact. The key informants from Nortura & Norilia argue further that there is no doubt that artificial meat production will likely have a positive environmental effect, since there is a big challenge with cattle especially, saying that:

> There is a big opportunity for short-lived food, being that this can be produced domestically. With regards to artificial meat production compared to traditional meat production, the emissions from Co2 and methane are completely different. However, the differences in water consumption are still not entirely certain, being that there have been some studies that show the total footprint is not that much lower.

In addition, the key informants say that there is a matter of technology development, arguing that the better it evolves, the more focus can be on optimizing it. They are still a little uncertain about how the end product will be. However, they believe it to be more small scale at first. They further argue that:

> The ones who might be the first to produce such a product will perhaps be a farmer who is young and interested in new technology, as well as wanting to do things differently.

Further, the key informant from KLF believes it to depend on where the production will happen, saying that:

> If we get to produce it in Norway with our resources, then it can be beneficial for food security. However, if we depend on the production to happen elsewhere, it can have a negative impact on food security in Norway. We depend on import and trade and always will be; however, the question is at what level then.

There are possible benefits and advantages, when it comes to energy usage and the environment, if that you are able to produce artificial meat with a lower climate footprint and further being that this guarantees a safe way. However, the key informant argues that:

> The downside, being that this play out the traditional agriculture will be to lose an enormous amount of knowledge about agriculture that will be difficult to reclaim.

In addition, the key informant argues that we can lose cultural landscape, biodiversity, and grazing, as well as Norwegian food traditions. The key informant hopes that there is a possibility that these two productions can coexist in the same way as vegetarian products and meat products exist side by side today.

Necessary and sufficient conditions

Research question 3: "What necessary and sufficient conditions need to be in place for artificial meat production?"

The key informants further discussed what necessary and sufficient conditions need to be in place for artificial meat production, which they had different views on. First, the key informant from Nofima argues that one must have land in order to develop big tanks for large scale production of muscle cells, in addition to water usage. However, it will probably require less land area than today´s traditional meat production. What kind of energy usage will be important as well, arguing that:

> It might pay of placing the production in another industrial area, with an aim to utilize existing energy flow and not having to build new infrastructure. In addition, the regulation should be in place as well. However, it is not within reach at all today.

As Norway is cooperating with the EU, being in the EEA agreement, the regulatory of artificial meat production must be approved in the EU. For this to happen, it has to be through a regulation that no one has applied for today. Such an application is sent within the EU, taking at least 18 months to be approved. Furthermore, this must be approved in Norway as well. In the process, a new set of rules might follow if gene editing has been used. Thus, the key informant argues that the regulations and infrastructure must be in place, as well as financial will. The question of who will produce it and what kind of products it will be, in addition to who the target group is will be important to answer as well. When further asked about what the potential and challenges of artificial meat production can be, the key informant argues that the challenges are technical, being where you get the cells from, explaining that:

> If you get primary cells, they divide only a certain number of times. Therefore, some want to create a cell line with a tank of cells instead of going to the slaughterhouse and obtaining them. The challenge with this is that you have to use gene editing, which is strictly regulated as GMOs in the EU. The source of the cells is one thing, but further, there is the question of the food of the cells. The cells need sugars, minerals, and amino acids to grow, as well as growth factors.

Serums obtained from cow fetuses is purchased as it contains everything needed for the cells, and this is a very common practice that is practiced in almost all laboratories in the world. In addition, this works well in the lab. However, the key informant argues that the point of all this is that you should not have to rely on so much from animals. As it is hard to find something else that the cells like, they have been working with by-products, such as blood from slaughterhouses, which contains proteins. The key informant further argues that:

> The blood collected at slaughterhouses has worked just as well as fetal serum. Those who think that one should not have animal production at all question this method; however, I believe that it still will be animal production in the future, as the production will contain surplus material.

As for Nortura and Norilia, the key informants argue reputation and consumer acceptance to be the most important, explaining that:

> If the consumer does not want it, then it will not be a product worth investing in. However, there is always someone interested, being the question then is how big it can be. Nevertheless, there is a lot that still remains in technology development; however, we believe it to become a niche product in the future.

There will most likely have to be some kind of subsidies for implementation as well, due to the requirement of investments in a facility, this even if everything is in place to rebuild. In addition, there must be some kind of political support to convince people to do things completely differently, as well as having financial support. Further, when asked about the potential and challenges of artificial meat production, the key informants believe that upscaling is the biggest challenge in getting it done today, and this has not yet been solved, saying that:

> When it is resolved, it will be relevant as there are actors who think it is smart to operate and work on it, and this can be Nortura. However, one thing is the process and finding a good way to produce it, as well as making it taste good, but a lot also relies on the acceptance side.

They argue that one has to get consumer acceptance, in addition to the big question being who the target group for artificial meat is, saying that:

> Will it be flexitarians or those who eat huge amounts of meat already? Or maybe vegetarians and vegans? What channels do we sell it through? These are questions we ask our self, being that everything is linked to who the actual target audience is.

They further argue that is has to do with trust in agriculture and the market as well, saying that it varies greatly. However, confidence in Norwegian agriculture is quite high today.

The key informant from KLF argues that, in addition to all the practicalities, such as raw material source, an energy source, and the permission to produce it, the regulation and consumer reaction is what they are most uncertain about. In comparison, GMOs have been strictly regulated, however being a technology that could be imagined providing many beneficial improvements. The key informant mentions Clustered Regularly Interspaced Short Palendromic Repeats (CRISPR) technology in regards to protection against disease, being that this technology describes a system found in a number of bacteria and most often refers to a genetic engineering method in which targeted changes are made to DNA in cells and organisms – so-called gene editing, explaining that:

> One could imagine the CRISPR-technology being used in a cow to reduce methane emissions; however, this is strictly regulated and political, with much consumer skepticism. Even so, this might be changing now. Thus, the uncertainties will be the regulatory aspect, as well as consumer acceptations and attitudes.

As Norway is part of the EEA agreement and everything concerning food regulation and food production, except for agriculture itself, we are obligated to follow EU regulations. The key informant argues that:

> The EU regulates this strictly and is not the most forward-thinking or innovative. Even though researchers might not care about that part, I see this as a major obstacle. Whether it should actually be allowed and how it should be labeled are discussions that quickly take 5-10 years.

As for the potential and challenges concerning artificial meat production, the key informant argues that there is a potential, but access to production is important, as one should not become too dependent on imports. There are many actors in the meat industry who believe that artificial meat will never be what consumers want. However, the key informant believes that there are some potential, explaining that:

> This will perhaps most be as an alternative to minced meat and burgers. As a substantial amount of a cow goes to minced meat today, this can quickly have further negative effects when replaced by artificial meat, as we end up with pieces of beef that the consumer probably will not buy. Thus, one might end up with a mismatch of what is produced and what is sold.

The key informant further argues that this can have major effects throughout the meat industry but hope that the meat industry sees itself as a natural role as they are those who know meat production best.

Investments and economy

Research question 4: "How may investments and economy in the meat industry in Norway affect the likelihood for artificial meat?"

The last question that was asked was if investments and economy in the meat industry in Norway might affect the likelihood for artificial meat, in which every key informant agreed that there was a lot of resistance from the owners. First, the key informant from Nofima finds this question interesting, explaining that:

> One meets a lot of resistance. After all, Nortura is owned by the farmers, and why should the farmers be involved in investing in something that can have the potential to eradicate Norwegian agriculture as we see it today, being that this is a typically disruptive technology. In addition, one does not know the willingness to invest in the meat industry today.

On the other hand, the meat industry has begun to turn towards seeing itself as a protein producer and not just a meat producer, being that Nortura, for example, is the largest supplier of vegetarian products that are meat-free in Norway. In the United States, where the largest cultivated meat producer called Memphis meat is, Tyson Foods and Cargill, which are two major meat producers, have stepped in and invested. The key informant further says that there is a lot of discussion about this, saying that:

> On the one hand, it can destroy the industry, and on the other hand, it can manage to coexist. However, I hope to have both in the future, if possible.

Further, the key informant was asked if they had any plans for getting artificial meat out in the market. The key informant says that due to Nofima being a research institute conducting research and development for the food industry, they have no plan on getting artificial meat out in the market, explaining that:

> Our aim is to complete the project, and if further research is wanted after GrowPro is finished, we want to make prototypes ready for testing the taste and how it behaves. So far, our goal is to get so far that the product contains the wanted amino acids and tastes like traditional meat. The industry must then determine whether they want to take this further or not.

Regarding Nortura & Norilia, the key informants say that it is doubtful that Nortura will invest much in this technology as of today, explaining that:

> So far, there has been so much opposition among the owners of Nortura that Nortura will not invest in it to any great extent, being that it is a matter of control internally in Nortura whether to proceed with it or not. Instead,

> Nortura is a partner in the project GrowPro to learn and get an overview of the possibilities.

However, they think that there will be farmers out there who might be interested in this technology and that it is very likely that the support will come from the outside, from those who are concerned about the alternative. Further, the question will be from which corner it should come from, saying that:

> The investments in The United States comes from commercializing and those who see the market and not necessarily from the community. If one sees that there might be a possibility of money here, there will be an investment.

As for their plan in getting artificial meat out in the market, the key informants argue that if artificial meat was to be launched in the market, it would be like all other ordinary products, saying that this might have benefits for Nortura, as well as some challenges, especially to the owners. They further explain:

> The benefits might be a whole new product on the market that we make a profit on and further increases revenue. The challenge can be that artificial meat has the potential to eradicate traditional agriculture, and that is something farmers obviously does not want to happen as it is their livelihood.

The key informants further say that they have launched vegetarian products, and this has been a challenging case against the owners as well. However, a part of the owners and farmers produces vegetarian products, such as different vegetables, at the same time. The farmers in Norway is as nuanced as the population in general, being that they have all sorts of opinions. Some believe this is the future, while others completely disagree. The key informants further argue that:

> It is not unlikely that it starts at the restaurant, based on the price people are talking about, saying that when launching new products, it is often that chefs would like to have their own specialties in restaurant markets. Further, it will then appear in grocery stores afterward if the market is there.

Lastly, regarding investments and the economy, the key informant from KLF argues that:

> If there is a market and an opportunity here, then you should invest in it, being that you have the possibility to turn around fairly quickly - the question is therefore more about what people want and what is possible to make.

Many of the meat companies have invested heavily in vegetarian production today, using the same equipment, as well as the knowledge about hygiene and the production technology. Thus, it should be natural that they do it. For the key informant, it is mostly seen as market-driven if it becomes an opportunity. In addition, the big food chains decide a lot here as well. The key informant further says that they do not have any plan on getting artificial meat out in the market, explaining that:

> We look at artificial meat production as a premature technology and still sit a little on the fence, not having any plans on getting it out in the market as of now.

Further, if any of their members had any plan on it, the key informant would know. However, given the whole premise, the key informant imagines some of the biggest meat companies could be willing to invest in it, being especially if it comes as a requirement from the different food chains.

5. Discussion

In this chapter, my empirical findings presented in Chapter 4 will be seen in connection with and discussed in the light of the theory presented in Chapter 2. The chapter is structured according to the four research questions with the aim of answering the overall problem statement of the study; *"In light of deep uncertainty and the ever-growing and urgent environmental problems, can artificial meat be considered a feasible and sustainable technology for rapid large-scale production in Norway?".*

In order to elaborate on the problem statement, the mentioned four research questions will in the following provide the base for discussing and analyzing the findings. In the first part, I will discuss what the feasibility for artificial meat production is in Norway. Then I will discuss what artificial meat production will mean for agriculture, food security, and the environment. Further, I will discuss what necessary and sufficient conditions need to be in place for artificial meat production. Lastly, I will discuss how investments and the economy in the meat industry in Norway may affect the likelihood for artificial meat. By systematically answering the research questions, one guides the readers through the findings and simultaneously stay focused on what is relevant to the task, hoping to gain an understanding of what are the key factors that are needed to address the challenge posed by the problem statement.

Due to the increased environmental pressures to reduce carbon emissions is putting the future of existing meat production as risk, where the growth of alternative sustainable methods is encouraged by a more environmentally conscious society. There is no doubt that the traditional meat industry is reaching the limits of its production capacity, forcing them to face a seismic shift. Such a shift might be new techniques and technologies – possibly artificial meat production. However, there are still some obstacles hindering such a production; resistance from actors and owners, social, political and institutional impacts, being dependant on regulations, the potential to eradicate traditional agriculture, consumer and market acceptance, as well as technical challenges, being as it only can be produced in small-scale as of today. These challenges will be accounted for in the next sections while answering the research questions.

5.1 The feasibility for artificial meat production

Before embarking on the challenges artificial meat production is facing, it is considered appropriate to look at the potential artificial meat could deliver, as this was one of the sub-questions in this thesis.

The potential of artificial meat technology

Compared to conventional livestock meat production, artificial meat could deliver reduced greenhouse gas emissions, water, and land use, as well as reducing eutrophication potential. Such potential has been assessed in a number of Life Cycle Assessments, even though all these are based upon hypothetical models of what form artificial meat production might take. As Tuomisto et al. (2011) calculated in their superficial life cycle analysis, they found that artificial meat could, depending upon what meat product is it compared to, reduce approximately 82-96% of water usage, land usage by 99%, greenhouse gas emissions by 78–96%, and energy consumption by 7-45%. A second comparative study was produced by Mattick et al. (2015) by using a different model for artificial meat production. The most notable difference here being the media production method used and the inclusion of a cleaning phase. Artificial meat is suggested by these results to involve some trade-offs, with significant energy use leading to lower global warming potential than beef, while retaining significant gains in land use. However, artificial meat would have a greater global warming potential than poultry or pork.

Smetana et al. (2015) conducted a cradle-to-plate assessment, by using a different field of comparison, comparing artificial meat to a range of meat alternatives, such as dairy-based, mycoprotein-based, plant-based, as well as chicken – being the least environmentally problematic conventional meat. They found, across a set of environmental categories, that artificial meat had the highest impact, due mostly to its requirements of high energy levels, with terrestrial and freshwater ecotoxicity and land use being the only exceptions. Artificial meat could, in the overall picture, have a bigger environmental impact than chicken and plant-based protein, but less than beef, and possibly pork as well. All these three Life Cycle Assessments notes, however, that artificial meat technology has significant scope for innovation, which could reduce the energy requirements below those used in these assessments, and further could subsequently deliver better environmental outcomes than these models predict.

Resistance within the regime

Regarding this thesis, the framework of Multi-Level Dynamics and MLP can help show the complexities of the socio-technical system, how they might operate, and what forces might drive change within the system as well. As the regime consists of actors operating with common rules, which further creates stability inside the regime, it leads to lock-in and makes it hard to change. The illustration of MLP shows us that a regime might be unwilling to change. There are new entrants and innovations at the bottom level, where there is a lot of learning included in this process, and a transition might further occur. Thus, one can portray the incumbent firms, such as Nortura AS and KLF, as the main part of the problem because they are a part of the regime, and therefore might be "resistant to change" as well.

However, as Nortura AS is partnering with Nofima's GrowPro project, learning about the technology and knowing what they are facing, having an opportunity to produce this type of meat in the future, they might go towards a potential pathway, called reconfiguration. This involves breaking of established linkages while creating new ones (Geels, 2002, p. 3). Such a process is explained by Geels (2002) as appearing to be a revolution due to the fact that there is an outcome of a "series of small, incremental adaptions over time." Such a dynamic is explained to be an “effect of these steps can be at least as substantial as the effect of abrupt innovations. Reconfiguration entails that multiple elements coevolve. "Complexity and structural change can be explained only as historical developments, as co-evolutionary processes." (Geels, 2002, p. 3).

Thus, Nortura AS and KLF might have to imply new combinations between old traditional meat production procedures with a new, more sustainable production, which in this case can be artificial meat technology and production. However, a regime does not consequently have to have a disruptive pattern where new entrants fully replace the traditional corporation, but rather a coalition between the new and the old. A green reorientation is a gradual process, and as the key informants all agreed on is that it needs to happen incrementally, due to sudden changes being highly challenging both socially and economically to deal with. When a wicked problem occurs, such as climate change, there are fuzzy boundaries, being that there are different issues connected to this complex subject. Problems emerge from different perspectives, due to no specific answer to these issues. Thus, some see it as a challenge, while others might see it as an opportunity initiated from these challenges.

Furthermore, the society establishes rules, regulations, and laws in which we conduct our lives, whereas Nortura AS and KLF can be seen as business organizations that work within the society and thus influence the socio-technical landscape. Being that these two utilities are not isolated organizations, they are designed within multi-level dynamics in which they further closely communicate with other socio-technical systems. These systems can be other business organizations such as their customers, the Government, and stakeholders, as well as international restrictions such as those the EU passes. Thus, this means that these two actors are intertwined with all these social entities, as well as there are being a rift in interaction and dependency between these layers. Therefore, it is important to think holistically about these two actors' positions and how they interact with the broader socio-technical systems.

In addition, one can see these two actors as systems with a collection of interrelated components that work together in achieving a common objective, including business processes and people that interact and collaborate with each other. As all the key informants explained in the section above, it is easy to change the system, but managing the people and owners is the difficult part. Some people do not respond to output as one may require when change is coming, in the context of transition. This can be seen due to underlying behavior, being that it always will be subjective due to the position in the jobs of people. As the key informants explained, why would the farmers be involved in investing in something that can have the potential to eradicate Norwegian agriculture as we see it today, as well as jeopardizing their jobs?

Further, the behavior of one individual can be affected by age as a factor as well, being that older people can be more emotional to changes and might have a different interpretation of the real world, compared to the millennials who have been growing up in a dynamical reality. As the key informants from Nortura AS and Norilia explained, the ones who might be the first to produce artificial meat would perhaps be a farmer who is young and interested in new technology, as well as wanting to do things differently. Thus, the notion of subjectivity might help explain why some people are prone to changes, while others seek changes as an opportunity, in contrast, trying to understand why some are prone to change as the key informants were discussing in the section above.

Moreover, the question of why some might be prone to future changes, are explained by Deloitte Insights (2016) in an article to be perhaps mental exhaustion experience because of a

distant and unclear future, as well as juggling between multiple complex options. One can have a lack of a sense to urgently decide, when it comes to outcomes in the future, due to the human tendency to overinflate the here and now, which they further describe as the present bias. Thus, to tip, the balance in favor of making decisions benefitting one in the short term is made more preferable. This paralysis is further explained to arise from conflicting values between the future selves and the presence of people, being in which, the future is seen as uncertain and difficult to plan for and "the now" is more concrete. Some people might, therefore, choose to focus more on choosing a path that is the least resistant and thus staying in their comfort zone. However, the world is changing, making behavior that might have been acceptable at one stage become less acceptable at a later stage. Cultural changes must therefore happen through human interactions where employees encourage each other to grow and evolve with the emerging climate changes.

Issues concerning social responsibility are no longer an isolated phenomenon. Nevertheless, it is something that passes through daily work, as well as it reflects how the outside world perceives a company. This applies not at least by its customers, being that all companies, both large and small, are dependent on consumer demand. Consequently, they are the ones who need to adapt to the requirements of ethics and the environment most quickly, being that they are increasingly imposed. Thus, taking social responsibility means that the two actors would try to minimize the adverse effects the traditional meat production does on the environment and people.

When Nortura AS and KLF as companies are being responsive and thoughtful, this will hopefully help to reduce the gap in their realistic opportunity to influence in the right direction and the demand for responsibility in the world. By listening to their stakeholders, as well as the customer's demand, might help them get an insight into what further expectations are predicated upon the two companies. Having new implementations of technology, systems, and ideas can help break with old traditional routines and practices where they have open up the possibility of changes. New technological innovation and ideas based on expectations from external forces in the niche, impact the change in the established regime, due to the fact that they being to destabilize the traditional pattern occurred because of the occurred wicked problems and its consequences in the whole socio-technical system.

The regime must furthermore be understood as a confluence of socio-technical systems that is distinguished by its stability. A configuration of technologies, actors, and institutions for the fulfillment of social functions that are a fundamental part of modern civilization is what socio-technical systems can be defined as, including market prices, regulations, infrastructure, cultural meaning where they cover consumption, distribution, and production. Thus, a socio-technical system can be seen as a set of relationships between different institutions and actors and a set of technologies that fulfill a social function, consisting of a diversity of elements and resources encompassed in the use and distribution of technology, the production of artifacts and refers to the links between different elements necessary to fulfill a certain social function as well.

An approach towards a more sustainable environment is about long-term and complex transformations, as well as involving the social, economic, and ecological perspective. Artificial meat technology and production involve many actors, such as users, non-users, and social groups affected by the proposed change. The reconfiguration thus arises through processes of interaction in specialized niches. This is a dynamic process in which Nortura AS and KLF would be learning while the reconfiguration occurs, as well as at the same time negotiate and interpret. As the transition requires a radical innovation to become predominant, the process involved does not happen quickly nor easily, considering that infrastructure, regulations, user practices, and even symbolic meanings are aligned with existing technologies. The niches, which are the spaces in which it is developed and where the two actors can begin to be destabilized, are required by these innovations. Whether or not a transition accelerates, would depend all on the accumulation of the internal learning processes and the external pressures, which includes rising public attention that strengthens policies.

Understanding incumbent firms such as Nortura AS and KLF as a potential solution concerning the green orientation is vital. Thus, we should be focusing on trying to work with companies like them and not portraying them as the "bad guys" due to the fact that these companies see the opportunities and have the resources, skills, and an ethical context that can help the green shift accelerate faster. The resources and skills of the companies are essential in helping the technology of artificial meat to mature. Qualities available to the industry is required when increasing the reach of such technology, while at the same time reduce its costs. Such qualities can be large-scale production and project management capabilities. However, as we have seen in the section above, the biggest challenge is to scale up production so that the cells can be

grown in large tanks, and not on a two-dimensional surface as they must today. To succeed in this, biotechnological innovation and engineering are required. Thus, each sector of the industry has to think about how to react, being that doing nothing is not an option.

Further, the question is if artificial meat technology and production would be adequate for the future – and only time will tell. We do not only depend on the meat industry today but on oil and gas to provide us with sufficient energy supply within the production and transport as well. If the two actors are to invest in artificial meat production and redeploying capital towards such a low-carbon business, it will require new capabilities within the companies and attractive investment opportunities in the meat industry markets. All these issues should furthermore lead the companies to rethink their investment strategies because there is uncertainty by not knowing how or when an inevitable political response will occur.

Political, social and institutional impacts

Politics plays a key role in the accomplishments of socio-technical transitions. In the landscape level of the MLP, landscape development puts pressure on the regime, which may create windows of opportunities for niches to capitalize on. However, the landscape level is slow to change and not influenced by the niche or the regime, but instead incorporates the context of political, social and institutional impacts that influence on the niche ad regime level. Thus, the three levels of MLP create room for transitions by interacting with each other. Nevertheless, politics alone are not the driver of transitions, being that there is no single cause or driver. Instead, there are processes in multiple dimensions and at different levels, being in social and institutional levels as well. As a result of interactions between processes on different levels of the "hierarchy" within the socio-technical system, transitions then occur.

Being that is it unlikely that environmental innovations will be able to replace existing systems without changes in economic systems, such as regulatory frameworks and taxes, it would require changes in policies, due to vested interests resisting such changes. Thus, being that political determination is one of the key drivers of transitions, swift political action by mapping out how complex the problem is and how deeply we are established in the system that constructed it is therefore important to stress, as well as understanding how difficult and prolonged a transition might prove.

Powerful incumbent actors, such as Nortura AS and KLF, might be both key to and hinder breakthroughs in environmental innovations. This is because they are monopolizing the empirical domains where sustainability transitions are most needed, such as agriculture and agri-food. Thus, a sustainable transition involves an interaction between different branches, such as technology, politics, business, and discourses. As implications related to political, social, and institutional might occur due to artificial meat, it is vital that they are inspected collectively, as they inform each other. As we have seen, numerous narratives have in favour of artificial meat, and other alternative proteins emphasized the ability for these foods to disrupt and further overcome the negative impacts associated with traditional livestock production. However, as of today, artificial meat has existed predominantly in promissory narratives, rather than in physical and material forms (Jönsson, 2016; Stephens & Ruivenkamp, 2016; Stephens, King, & Lyall, 2018).

Such narratives, fuelled largely by media and corporate actors, has made for an ambiguous and at-times prematurely optimistic discourse around artificial meat. As of today, there is not certain what an artificial meat sector will look like, whether it is a few large-scale producers or many small-scale. In addition, what inputs will be required, being synthetic growth media vs. animal, and lastly, what their respective ethical and environmental footprints will be. Thus, as a consequence, there is much need for continued assessments of the diverse range of impacts, both positive and negative, that might come with artificial meat as it further develops. In addition, the question of how these might reconfigure or contribute to exiting political economies in the global food system is important.

There is a need for a broad-based engagement on these impacts across a diverse range of policy experts, academics, and practitioners working at the front line of food security, environmental and animal issues. Such analysis should, in particular, consider who might potentially be the "losers" and "winners" of the artificial meat sector as it emerges. For artificial meat to be realized as an ethically acceptable solution, Pluhar (2010) argues that it would need to be accessible as a consumable product for "people from all economic backgrounds and cultures ... if that is their wish" (Pluhar, 2010, p. 464). In addition, the attention on economic and social equality is required at the production level, with key questions such as who will produce artificial meat and is already enabled to adopt and potentially profit this technology, as well as where the production will take place.

As the key informants argued in the chapter above, a farmer who is young and interested in new technology might be the first to produce artificial meat. In addition, regarding the question of where the production will take place, the key informant from KLF argued that it could be beneficial for food security when producing it in Norway with our resources. The import dependence means that we are dependent on others being able and willing to share, thus being able to produce it, our self makes us less dependent on import from other countries. As we know that climate in the future will create major challenges for food production, it will be cheap insurance to invest more in our own food production and build up stocks of food, making ourselves less vulnerable in the future, and rather try to increase the degree of self-sufficiency. Further, for understanding the ability of artificial meat to realize the promises its proponents currently claim, it is of critical importance to understand how the different scales and geographies of food consumption and production, and the politics of sustainable and healthy eating will become situated within existing socio-political relations regarding the commodification of nature (Birch et al. 2010, Sexton, 2016). Thus, this is a task that must be conducted of the technology´s current early stages, as well as over the coming years as it develops.

It is further vital to identify their underlying assumptions when considering these potential future relations. It is clear that implying that rising consumption of artificial meat would equate to declining consumption of conventional meat is being some of the narratives on the potential benefits of artificial meat implicitly assumed as a 'substitution effect.' This is further agreed upon by the key informants, as they argue that artificial meat production has the potential to eradicate Norwegian agriculture as we see it today. All traditional meat production would, under a full substitution effect, be replaced by artificial meat leading to dramatic falls in land use, animal-related emissions, and slaughters. Thus, reductions in environmental impact and animal suffering would have a significant reduction in global livestock populations as well. This assumption is however unsubstantiated as of yet, leading us to instead consider a thought experiment the impact of an 'addition effect' might have, in which artificial meat productions lead to an increase of the total global meat consumption (of conventional and artificial meat combined) and not works to reduce conventional meat production.

Traditional meat production would, under a full addition effect, not decrease at all, and neither would the numbers of animals slaughtered nor its environmental impacts. As opposed to substitution, the potential for adding in an under-considered aspect of this work (Stephens et al.

2018). The concern that rising incomes and population is the core of these animal suffering and environmental narratives, meaning demand for meat that will outstrip global supply. As Stephens et al. (2018) argue, it seems reasonable, in this circumstance of significantly increased demand and insufficient supply, to at least consider that traditional meat production might not fall dramatically. This especially if artificial meat products were considered less desirable, leading us to consider how an additional effect might be avoided and further what the conditions of future adoption might be. Nevertheless, it will require a more complex engagement with the political aspects of delivering artificial meat, as well as an ongoing questioning of underlying assumptions within existing accounts (Stephens et al. 2018).

In addition, consideration must be given to the role of governments in providing financial, such as grants and subsidies, how artificial meat workforce will materialize, as well as training support for smaller-scale producers who wish to transition to artificial meat production. Thus, it is anticipated that there will be a need for a workforce with a range of knowledge and skill levels that extend beyond the more conventional roles, such as veterinarians and agriculturalists, to include technicians, chemists, cell biologist and different types of scientists as well (Stephens et al. 2018).

Anticipated regulatory pathways

There is no doubt that conventional meat production is reaching the limits of its production capacity and that any further increases in output will require new techniques and technologies (FAO, 2009). There are currently only certain types of meat replacement products and conventional meat that are present in the marketplace. Artificial meat, cloning, and agroecology might, in the future, provide techniques and technologies which would allow the meat industry to meet the increasing consumer demands. Hopefully, this will be the case in Norway as well. However, due to the complexity of the marketplace and the vast assembling of different consumer groups, expecting artificial meat to completely replace conventional meat would therefore be unrealistic (Hou et al. 2008).

It is further likely that, as climate change begins to have more and more influences on government policy, the push for sustainable production methods may come through increasing government regulations and not directly from the consumers (NIAA, 2012). Regulatory bodies, such as the European Union, are passing legislation requiring companies to act in a more environmentally sustainable fashion (Anon 2003; Carlarne 2007). The Swiss government has,

for example, discussed a possible 'meat tax' as a result of concerns regarding the greenhouse gas emissions of livestock (Lerner et al. 2013). This shows that, in determining the course of technological innovation, regulatory systems are among the most important influences. Regulatory frameworks differ across countries and continents, and since Norway is a part of the EEA agreement, everything concerning food regulation and food production must be followed by EU regulations. Thus, the regulatory of artificial meat production must be approved in the EU. Petetin (2014) argue that the regulations were inadequate to appropriately deal with artificial meat technology at the time of writing, without significant development. Petetin (2014) further argues that artificial meat would be subject to novel food regulations; however, notes at the time of writing that it does not easily fit the framework.

The benefits of draft 2013 proposals are further speculated by Petetin (2014), a version of this was subsequently approved as Official Journal of the European Union (2015), which removed the consideration of substantial equivalence issues that existed current FDA regulation and in previous EU (Schneider, 2013). Via a European Food Safety Authority (EFSA) risk assessment, these new regulations prioritize the precautionary principle. However, there can be a possible error in Petetin's (2014) analysis, being that she assumes that artificial meat is not a genetically modified product. Yet, a key issue of contestation within the field is the potential for genetically modifying the cells, with several laboratories pursuing this route. The relevance to this point is that genetically modified foods from the new EU 2015 Novel Food regulations remit, pointing instead towards the regulation on genetically modified food and feed specifically designed for this type of product (Official Journal of the European Union, 2003, 2015). Thus, this shows that different regulatory pathways are implied by different production methods and that further identifying a clear pathway of current uncertainties around both the regulation and the technology remains a task of dealing with ambiguity.

Further, using the pre-Brexit UK context as an example regulatory system, there are key regulatory issues that require attention. As Petetin (2014) argues, the EU Novel Food Regulation will most likely be the pathway in the UK mediated by the Food Standards Agency (FSA). However, establishing if artificial meat is a product of animal origin will be a key issue. Considering my findings, I would argue that it most likely will be. However, one must remember that compared with the culturing media (which may or may not be animal-based), the animal cells are a small proportion of material used when culturing begins. In addition, cell lines may be considered a processed product. Assuming artificial meat is understood as of

animal origin, then regulation would, however, involve a range of organizations. As there might be keeping of a donor herd and extracting muscle biopsies, it would likely include different departments, as well as local authorities. As artificial meat products would require food regulation through such governments, it shows the importance that local authorities are heavily involved. A 'primary authority' model might be advocated due to its complexity, in which, on behalf of all other authorities, one local authority with expertise in the area acts.

The regulatory framework for artificial meat has in the EU been in place since 1997 and was further updated in 2018 (Post et al. 2020). Either the EU Novel Foods Regulation or the genetically modified organism (GMO) legislation (embodied by the GMO Directive and GMO Regulation) will be applicable, depending on the starting cell types used. Genetically modified foods are, however, excluded by the EU Novel Food Regulation, and thus the use of iPSCs for artificial meat production will most likely be covered by the EU GMO legislation (Post et al. 2020). The EU novel foods regulation further aims to ensure the "the effective functioning of the internal market while providing a high level of protection of human health and consumers' interests" (European Commission, 2015). The regulatory system requires, in order to achieve this, prior market authorization. Such an authorization application of artificial meat "should be made via the e-submission system operated by the European Commission, who will subsequently distribute the application to all EU member states" (Post et al. 2020 p. 411). This applies to Norway as well, as we are part of the EU in the EEA agreement. Post et al. (2020) further explain this procedure to include:

> (1) the term for response for the member states (this was 60 days under the previous Novel Foods Regulation prior to 1 January 2018, but this term is not mentioned in the current Novel Foods Regulation); (2) the questions that EFSA can ask the applicant, resulting each time in a so-called stop-the-clock moratorium. (Post et al. 2020 p. 411).

Thus, this further explains the duration of such an application takes before it is approved. In addition, this must be approved in Norway as well. Therefore, regulations must be in place.

5.2 Agriculture, food security and the environment

Climate change can be seen as a wicked problem, being that it is a complex and unstructured issue that involves many interrelated factors and cannot be separated and isolated from the system. Thus, there has to be mitigation and adaption changing practices with new solutions regarding sustainability, health, and welfare. Artificial meat production aims to contribute in resolving problems related to agriculture and industrial livestock farming by bypassing some of its undesirable consequences. The need to substantially reduce our consumption of conventional animal products was stated by the Intergovernmental Panel on Climate Change, in order to avoid the worst effects of climate change (Sharma et al. 2015). Thus, the question will be; what can artificial meat do for agriculture, food security, and the environment?

Potential and challenges

Post et al. (2020) argue that a vast reduction in the amount of livestock needed to produce meat could be a result of harnessing the potential of stem cells to multiply and further form fat tissue and skeletal muscle. Artificial meat production is, in terms of land use and water consumption, and greenhouse gas emissions, anticipated to be far more efficient than conventional meat (Tuomisto & de Mattos, 2011). However, artificial meat production might be more energy-intensive, which further leads to some environmental benefits being dependent on a transition to clean energy sources (Lynch & Pierrehumbert, 2019). In addition, in terms of animal welfare, artificial meat presents advantages. 99 % of animals used for food are factory farmed are estimated by the Sentience Institute and further considered to be industrial products rather than sentient beings (Post et al. 2020).

There is further required an estimated 70 % of arable land to be used for growing livestock feed in the production of conventional meat. Thus, we will have insufficient planetary resources, with an anticipated 70 % increase in global meat demand, to provide meat to the world population by 2050. Food security is already affected by observed climate change through the greater frequency of some extreme events, changing precipitation patterns, and increasing temperatures. Thus, in order to combat climate change and land degradation that threatens food systems, it is critical for the world to make a shift of global diets away from red meat consumption and towards healthier plant-based alternatives while meeting the nutrition requirements of a growing population as well. Unless there is such a shift, food security could be jeopardized. Being able to produce artificial meat in an efficient way for large-scale

production, as well as at an affordable price, is therefore critical. In addition to being less reliant on climate, land area, and quality, it has been proposed by Stephens et al. (2018) that artificial meat could enable more of the global population to have consistent access to protein.

One of the main challenges with artificial meat are facing is that it has the potential to eradicate traditional agriculture. Land provides the principal basis for human wellbeing and livelihoods, including freshwater, the supply of food, and multiple other ecosystem services, as well as biodiversity. Grazing livestock is essential for our biological diversity, being that they keep the outfield landscape open and fertilize the soil here. In addition, they contribute to carbon storage in the soil. As humans cannot eat grass, we can, through livestock such as cattle and sheep, turn grass into human food. It is, from a sustainability perspective, essential to use all available resources we have to produce food. Further, artificial meat production will never be able to use the soil in the same way. Thus, a transition to few or no grazing livestock in Norway will mean overgrowth and fewer species, such as pollinating insects. In addition, it may be that our landscape will capture CO2 from the atmosphere to a lesser extent.

As artificial meat is an expensive product as of today, it can present ethical challenges as well and thus probably will not be available to everyone. However, from an animal protection perspective, as artificial meat production aims to use considerably fewer animals than traditional agriculture, it thus could appeal to vegetarians, vegans, and to those conscientious omnivores interested in reducing their meat intake on ethical grounds (Hopkins & Dacey, 2008). Further, the possibility of a higher return per animal is recognized by Stephens et al. (2018), saying that:

> While the precise economic value of harvested cells has yet to be determined, the potential to harvest large numbers of cells from a small number of donor animals gives rise to the possibility of considerably higher returns per animal than traditional agriculture. This level of profitability could provide a credible alternative to intensive farming systems such as Concentrated Animal Feeding Operations (CAFO). (Stephens et al. 2018, p. 158).

For those utilizing traditional native breeds of livestock within traditional agriculture, artificial meat could provide new opportunities as well. The move to cell harvesting from the carcass is further argued by Stephens et al. (2018) “could a shift change away from the genomic and

phenotypic selection of high yielding, hybridized breeds of livestock to the utilization of more traditional livestock who can thrive on low density, low input, extensive systems" (Stephens et al. 2018 p. 158).

They argue these benefits to be three-fold. First, it can have the potential to be highly profitable. Secondly, these low impact systems have a much lower impact on the environment. Thirdly, it might contribute to the retention of the genetics of traditional breeds and thus safeguard their biodiversity (Stephens et al. 2018). Standard carcass utilization within the commercial meat industry, when considering food waste, is the single biggest problem in the context of waste management. Here, artificial meat could provide a new opportunity, in which the prime cut alone is produced for consumption or processing rather than the whole carcass (Stephens et al. 2018).

Considering the challenges with artificial meat having the potential to eradicate traditional agriculture and the livelihoods of the farmer, Stephens et al. 2018 argue that there is an opportunity for each producer to create their own version of the product, thus "giving them diversity and competitiveness in the market, as well as engaging in higher-skilled jobs in a new knowledge economy" (Stephens et al. 2018 p. 158). The combination of new technologies and traditional agriculture will if developed in such a way as to support it, enable a circular economy. This being that the majority of waste products, such as metabolites and heat, from artificial meat production, can be upgraded for use on a farm or sold. Lastly, they argue that there is an opportunity to realize both the environmental and financial impact of the production of food through cellular agriculture by establishing a true cost accounting structure (Stephens et al. 2018).

The status of Norway

An important goal for the government is the development of a "bio-economy," as Norway is rich in bioresources both on land and in water. Thus, one can predict that agriculture, fisheries, and forestry may constitute the "new oil," in line with the sinking position of the oil. Regarding Norway, there are many possible future avenues where bio-resources can play an important role. The question is how the bioeconomy will characterize agriculture. A significant technology-driven upswing in conventional production is, in my view, unlikely for the reason being rapid development associated with artificially produced meat, fish, and milk we have seen in recent

years. We now have technology allowing artificial production of real meat proteins, as well as fish and milk. However, as we have seen, the technology is still at a premature level so far.

Further, the price tag will be of importance as well. If at the start, it is possible to compete with conventional meat on price, then one can only imagine the continuation. The potential for expanding production, improving technology, and establishing shorter value chains (without slaughter and livestock production) will affect the price of the final product. At the same time, the costs associated with conventional agricultural production are constantly increasing – and there are limited opportunities to reduce these. In addition, prices of imported animal feed are increasing, while limited availability of phosphorus can lead to major problems in maintaining intensive production in the future. As soon as the cost of artificial meat production is lower than the cost of conventional production, it is unlikely that the price benefits of artificial products will ever disappear. This indicates that it will be unwise to aim to industrialize agriculture even more, in order to compete internationally on price. Naturally produced, high-quality foods will probably always be a market for, and this is what Norwegian agricultural policy should be geared towards in the future.

In addition to the price, there are other benefits as well. Artificial meat is not affected by the same health and ethical concerns that intensive agricultural production is. The former can be produced without the use of valuable grain, animal welfare is irrelevant, the environmental impact, such as greenhouse gas emissions, water, and land use, is far lower. Furthermore, with a shorter value chain, food security is easier to maintain. In addition, religious and ethical reasons can be considered for not eating meat. While cultured cells from a live cow may give vegans and vegetarians the opportunity to enjoy a beef burger with a good conscience, the cultivation of cells from a halal-slaughtered cow may open the door to a future Muslim market as well.

This vision of the future has important political implications for Norway. There has, as we have seen, been maintained a small-scale production form in Norwegian agriculture, consisting of high quality and with relatively small negative consequences for the environment. Thus, one can argue that it would be a bad idea trying to change this, as there will always be interest in quality products carefully thought out, as well as there always will be people who can afford to buy such items. We must, with regards to the future role of agriculture in the Norwegian bioeconomy, continue with what we already do, but plan for a future where agriculture is not necessarily the main source of cheap animal proteins as well.

Production of artificial animal protein is a technology that will evolve and eventually affect Norwegian agriculture. Norway has good opportunities to develop its own industry based on synthetic production, by having a highly educated population, and rich access to natural resources. With that being said, we can either see the possibilities or sit on the fence. Nevertheless, artificial production of animal protein poses no immediate threat. However, it can lead to enormous upheavals in agriculture in the long term. Thus, it might be smart to be prepared.

5.3 The necessary and sufficient conditions needed

There is no doubt that artificial meat raises several social questions and challenges, such as the economic impact on communities that are dependent on animal farming, the implications of shifting power in the food system, as well as how the technology should be regulated. One major question though, is whether consumers will buy artificial meat or not. For the commercial success of artificial meat, consumer acceptance is a necessary component in the short term, as well as for its ability to bring about societal benefits in the long term. Thus, it is important to look at how the consumers and market frame and perceive artificial meat production. Discourse analysis can, in this case, contribute to stimulating fruitful discussion on this topic.

Market and consumer acceptability

First, as being primarily framed as a technological innovation, artificial meat can be seen as significantly less appealing than when the focus is on its similarity to conventional meat or on its societal benefits. In addition, one can argue that overtly technical descriptions can be less appealing than more straightforward names and descriptions, such as "lab-grown meat," being that it invokes unnaturalness and science that are significantly less appealing than names such as 'clean meat' which highlight the benefits relative to artificial meat (Post et al. 2020).

Further, artificial meat aims to avoid the primary environmental and ethical motivations for vegetarianism. It is, however, common for vegans and vegetarians to acquire an emotional disgust reaction to meat in general, which might replace rational reasons for avoiding meat. Nevertheless, as for the producers or advocate, this should not be a major concern, being that those who avoid meat are a small fraction of the market. In addition, they are not contributing to the problems of traditional meat production. Moreover, it is important that artificial meat is not viewed as a product that is 'for vegetarians' if artificial meat is to displace demand for

conventional meat in the long-term, being that this might limit its appeal to non-vegetarians and thus its ability to displace demand for animals (Post, et al. 2020).

However, a major limitation is, as there are no artificial meat products currently available commercially, all research on consumer acceptance is thus its hypothetical nature, making researchers unable to explore specific aspects of the product which are appealing, as well as observe consumer preferences in practice. Furthermore, Post et al. (2020) argue that in terms of demographic trends, consumer perceptions of artificial meat are similar to perceptions of genetically modified food. Thus, these technologies are viewed by some consumers as conceptually similar, and further that attitudes are often underpinned by similar sets of concerns.

Both advantages and barriers to commercial implementation that will affect the uptake of the technology are inherently contained by different forms of artificial meat (Table 3). As we have seen, adopting new products and technologies is only something producers and manufactures will do if there is a potential of increasing profit and turnover. In addition, there must be a capacity for mass production, as well as the capability of supplying a significant proportion of the marketplace. Being able to produce products with limited change to existing infrastructure would be ideal, being that this acts to reduce the initial risk for the industry and set up costs. In addition, a product similar to an existing product would be something the consumers more likely would purchase, as they can be seen as more familiar. Thus, artificial meat should recreate or closely mimic the position conventional meat has in the minds of the consumers in terms of convenience, meal solution, and appearance nutrition, for a product being able to compete (Verbeke et al. 2010).

Table. 3 The relative abilities of traditional meat production, types of artificial meats and alternative protein sources to meet the demands of the marketplace

		Traditional meat	Cultured meat	Manufactured meat (plant and mycoproteins)	Insect proteins	Modified meat (genetically modified and cloned organisms)
Sustainability	Resources used	High	Significantly reduced	Significantly reduced	Moderate reduction	Reduced, depending on the product
	Waste	High	Potentially reduced	Reduced	Reduced	High
	Greenhouse gas emissions	High	Potentially reduced	Reduced	Reduced	Reduced
Health		Unchanged	Potential improved fatty acid profile and reduced iron content	High in protein	High in protein and minerals	Improved fatty acid profile, improved vitamin and mineral content
Safety		Unchanged	Untested product Untested product	Reduction of food borne diseases Reduced cholesterol content	Safe with small scale production, untested with large scale production	Reduction or elimination of zoonotic disease
Market acceptability	Capacity for mass production	Yes, but reaching limitations	Marked technological barriers at present	Yes	Yes	Moderate technological barriers at present
	Need for further research	Moderate	High	Low	Moderate	Moderate
	Cost	Increasing	Very expensive	Cheap	Moderate	Expensive premium product
	Government regulation	Subsidies, but increasing regulation	Untested	Subsidies, standard regulation	Standard regulation	Severe restrictive regulation
Addresses welfare concerns		No	Yes	Yes	Yes	Moderate
Acceptability to consumers		Demand increasing	Neophobia and technophobia	Palatability problems	Neophobia	Technophobia

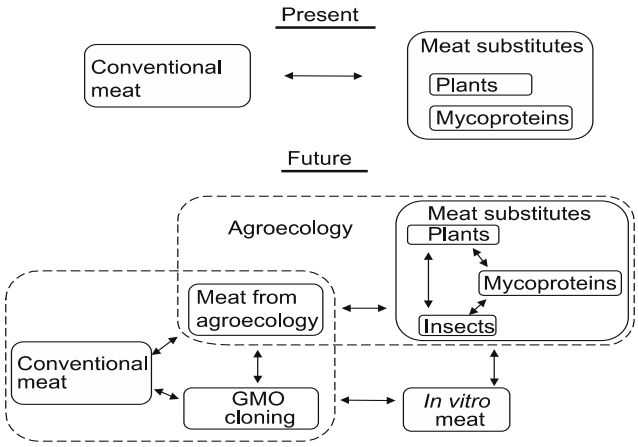
(Source: Bonny et al. 2015 p. 258)

There is, as we have seen, still significant regulatory and technological barriers to commercialization of artificial meat and genetically modified livestock. In order for artificial meat to enter the market, it has some significant technological barriers to overcome. Further, genetic modification has, before it is a viable option, to overcome some minor, as well as major technological issues and significant regulatory issues. Thus, the product is argued by some scientists to never see commercialization, while others think it will revolutionize the meat industry. (Chiles, 2013).

It remains, furthermore, to be seen if the majority of consumers will accept such new technology or not. It will be essential to deliver a consistent quality product, as well as keeping the consumer-focused when faced with competition from artificial meat (Grunert et al. 2004; Polkinghorne et al. 2008). The traditional meat industry has the capacity to harness and adopt accelerated genetic selection, genetic modification, and cloning technologies in order to improve its ability to satisfy consumer demands for sustainability, healthiness, and quality animal welfare, as well as increasing production capacity (Novoselova et al. 2007). In addition, it would, by increasing efficiency and production, improving the quality of the product offered to the consumer, give the industry greater capacity and flexibility. However, the passionate activism of certain consumer groups, as well as the strict regulatory barriers, would have to be addressed before this is successful (Bruce et al. 2013).

Furthermore, agroecological techniques to increase production can be embraced by conventional meat production, while simultaneously meeting consumer demands for sustainability, animal welfare, and quality. It is likely that consumers, which are attracted to agroecological produce, will in addition to reducing their meat consumption, increase their intake of alternative protein sources as well. Thus, more closely matching the outputs of agroecological systems. Bonny et al. (2015) argue that the "emergence of these products and techniques will lead to a complex marketplace with different products and groups of products all competing and appealing to different sectors of the consumer base" (Bonny et al. 2015 p. 261).

Figure. 4 shows the competition between alternatives and conventional meat products in the future and in the present time. The boxes, both dashed and solid, represent groups of products; arrows represent further competition between the groups; GMO means genetically modified products. Conventional meat products compete, in the present, with meat substitutes with are plants- and mycoprotein based products. New products may, in the future, become available to consumers as meat produced through agroecological systems, genetically modified and cloned meat, proteins from insects, and finally possibly artificial meat produced from stem cells. As some of these new products will be incorporated with meat substitutes or with conventional meat production, the market will, in the long-term future, thus become more complex with many interconnected groups competing with each other.



(Source: Bonny et al. 2015 p. 261)

Furthermore, a greater acceptance of artificial meat technologies will be led by consumer concern about the welfare of the meat industry or sustainability. However, another factor is the price. The price today is around NOK 500 per kilo, but it must fall further in order to become a competitive commercial product. Thus, when the price is lower, consumers are more likely to choose artificial meat. The prices of artificial meat can hamper the transition towards such new technology in Norway if it is not economical for producers. Economic factors will be consisting of an examination of ravenous, costs, and overall profitability of new and existing artificial

meat production. As predicting inflation, market development, and pricing would be extremely complex and challenging, economic feasibility will be assessed predominantly on earlier and current figures. Financing, meat pricing, costs, and profitability are parameters that should be considered when assessing financial feasibility. In addition, technical appraisal of artificial meat will be of importance, being that this determines potential capacity and efficiency in relation to mitigation pathways.

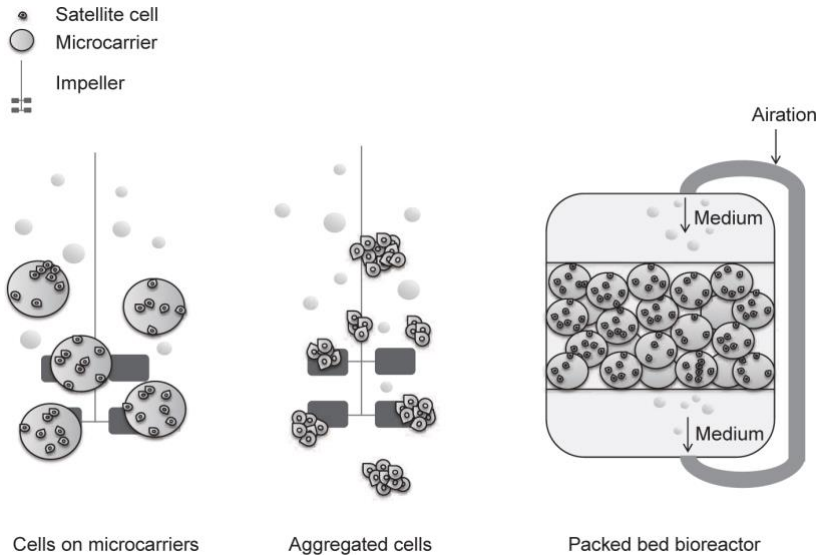
Upscaling challenges and efficiency

At present, it is not possible to make artificially produced meat in large-scale production. As of today, the production is both advanced and expensive. A number of institutes are researching artificial production of meat, and it will probably be available in the future. If researchers are able to find a production method for artificially produced meat that is suitable on a large scale, it will probably also be possible with artificial production of other foods. However, it is probably a long time until you and I can buy grown meat in the store.

Production has to become economical and scalable in order for artificial meat to become a viable alternative to conventional meat. Post et al. (2020) explain that the specifics of scaling depend on the number of doubling the stem cells can sustain, as well as the final intended product. Further, the goal of a large-scale cell production system is to generate a large number of cells with minimal handling and with the smallest possible amount of resources (such as culture medium), as well as preferably in a short time (Bonny et al. 2015). Suspensions cultures in bioreactors are required for the very large-scale cultivation of stem cells for food. Two alternatives to achieve high-density cultures in suspensions is 1) cultivation on microcarriers or 2) cultivation in aggregated form as cell aggregates (Reuveny 1990; Steiner et al. 2010; Abbasalizadeh et al. 2012).

First, microcarriers in suspension are beads where cells can attach and further grow by apposition, as being grown on flat surfaces. The medium is aggregated by gas flow, an impeller, or rotation of the bioreactor, to ensure a mixture of gases and nutrients (Moritz et al. 2015). In addition, microcarriers can be static in a bioreactor as well, being inside a system called packed bed bioreactor (PBR) with fluidized media. Further, cell aggregates are explained by Moritz et al. (2015) to be “clumps of cells that grow in 3D and serve as anchors for their neighbors, while the aggregates themselves remain in suspension” (Moritz et al. 2015 p. 209). In **figure 5** a basic overview of the three large-scale production systems can be seen.

Figure. 5 Overview of the three possible large-scale systems for cultured beef.



(Source: Moritz et al. 2015, p. 209)

For retaining the proliferation phase of satellite cells in the cell suspension, there are several factors that need to be considered. First, the interdependency of cells through their proximity is one important aspect. In addition to depending on growth factors that come from the medium, the cells in culture depend on the cells themselves. Neighboring cells are further triggered by the growth factors produced during metabolic activity, resulting in increased growth (Greene and Allen 1991; Tatsumi et al. 1998; Troy et al. 2012). This means, considering microcarrier cell culture, that a low initial seeding concentration, being cells per bead, can cause a lower growth rate compared to high seeding concentration.

However, there is a maximum density of cells as well, when they reach confluency on the beads. In addition, the cells seem to form aggregates, in which big clusters can be built on microcarriers (Molnar et al. 1997). New beads can, to overcome clusters, be added, making the cells transfer and colonize the new beads, so-called bead-to-bead transfer (Wang and Ouyang 1999a; Dürrschmid et al. 2003). A convenient scalable production of cells on microcarriers is offered by adding new beads for the bead-to-bead transfer of cells as well. Sart et al. (2013) argue that this type of production can be produced in large-scale by mesenchymal and pluripotent stem cells cultured on microcarriers.

Cell density is, for aggregated cells in suspension, the most important as the metabolic activities depend on the initial cell density with high initial cell densities being preferable to assure

colonization of all cells (Abbasalizadeh et al. 2012). This, in addition to parameters of mixing through agitation and medium composition (Abbasalizadeh et al. 2012; Chen et al. 2012). Further, an important determinant of successful culture is the size of the aggregates. Aggregates are ideally not too large, having a relatively homogeneous size distribution. Thus, size can, by changing the agitation of the medium, be contained, and shear stress on the cells decreased (Zweigerdt et al. 2011; Abbasalizadeh et al. 2012).

In addition, a combination of aggregated cells on microcarriers has been tested and is argued by Phillips et al. (2008) to be better than single cells on microcarriers. This even if the reported cell expansion still was lower than with aggregates or non-aggregate microcarriers alone (Amit et al. 2011; Park et al. 2014). However, it appears that aggregates on microcarriers could be an option for expansion to large-scale. This is due to the aggregated state protecting the cells from stress and thus decreasing the lag phase during bead-to-bead transfer (Boudreault et al. 2001). Further, there is required a synthetic, biodegradable scaffold that serves as a support for the cells for myofiber formation and differentiation. The cells have to be transferred, after having proliferated, to a second bioreactor system for tissue generation and differentiation. One option could be adding a scaffold where the cells can mature and organize (Neumann et al. 2003). Another option might be using added microcarriers for further tissue development after aggregate culture. The cells could still stay in the same bioreactor, due to aggregated cells being able to attach to microcarriers, by just adding microcarriers and changing the medium. As a result, both procedures could lead to less operational handling of the cells and thus less risk of contamination (Moritz et al. 2015).

Further, packed bed bioreactor (PBR) contains a bed of microcarriers, where the cells are immobilized. This type of reactor is explained by Moritz et al. (2015) to have a “flow of growth medium down-stream, up-stream, or radially across cells in a static position within the packed bed while the nutrients and gases are evenly distributed” (Moritz et al. 2015 p. 211). Such bioreactors have, due to the flow of nutrients and oxygen that can reach the cells, as well as static immobilization, proved to increase the viability of the cells (Park and Stephanopoulos 1993; Cong et al. 2001). A packed bed containing a flow of medium has the advantage that the medium is oxygenated before entering the bioreactor that further improves oxygen distribution to the cells (Chiou et al. 1991). The most promising type of such bioreactor seems to be the system of a continuous radial flow of growth medium (Bohmann et al. 1992).

An important parameter which determines the efficiency of the production process is high cell density during the proliferation phase. There needs to be defined optimal conditions for each type of system for bovine satellite cells, due to these cells not being well studied for large-scale cell production. A possibility to recycle medium through the removal of waste products, such as ammonia and lactate, as well as replenishment of utilized nutrients, such as glutamine and glucose, can be seen in a comparison between the three possible scale-up strategies. Reusing part of the medium as growth factors might be beneficial in that cells can stimulate subsequent cell growth (Moritz et al. 2015).

Further, for large-scale production of artificial meat, the most important aspect is efficient production, being that this drives the potential environmental and food-security benefits over livestock beef. In addition, another important factor is resource efficiency, in order to keep the cost of production low due to materials being the largest cost component. The most important criterion in consumer preference is price and production cost will thus translate in consumer price. Culture conditions need to be optimized for culture medium utilization in order to reach high efficiency (Moritz et al. 2015). However, it is still likely, even with optimized medium utilization, that not all components of the medium are equally consumed. Thus, additional resource efficiency is suggested to be gained by recycling the medium and microcarriers (Wang and Ouyang 1999).

In large-scale production, culturing cells can be done by gradually increasing the size of the cell culture. This means that the cells are transferred to 2D surface plates and then to bioreactors after being isolated from a cow, going from small to large volume tanks. There is a need to optimize these transferring steps. A high density of cells can, for the cultivation of cells on microcarriers or in aggregates, be achieved by a gradual “increasing the number of beads and cells per bead or by splitting the aggregates during culture” (Moritz et al. 2015 p. 212). The efficient distribution of oxygen and nutrients are another condition that is required for high cell density. Culture medium agitation is here a factor of importance (Zhao et al. 2005).

Table. 4 Challenges and prospects of the three scale-up systems, microcarrier suspension culture, aggregated cells in suspension, and packed bed bioreactor (PBR)

System	Prospects	Challenges
Microcarriers	Many different possibilities of characteristics on microcarriers	Can aggregate and build clusters
	Reuse of microcarriers possible	Shear forces from microcarriers or clusters
	Easy to scale-up by adding new microcarriers	
Aggregates	Cheap because of no extra material needed	Could be difficult to achieve on satellite cells without any cell modifications
	Simple harvest	Hard to control aggregate size
PBR	Protective for the cells from shear forces	Difficult to scale up
	Good oxygenation	
	Easy recycling of growth media possible	

(Source: Moritz et al. 2015, p. 212)

To assume a new growth-promoting state, cells need to be further temporarily dissociated from their environment. Different methods for dissociation of cells, such as mechanical disruption, chemical treatment, and enzymatic treatment, have been developed (Collins et al. 2005; Suemori et al. 2006; Amit et al. 2010). Genetic stability and viability of the cells might be affected by each of these methods. Thus, there needs to be found a balance between potential side effects and efficient cell dispersion (Mitalipova et al. 2005).

5.4 Investments and economy in the meat industry

As we have seen, in determining the course of technical innovations, regulatory systems are among the most important influences. Even so, they are still actively supporting conventional agriculture at a local level, meat production included. As this support is firmly controlled, it might be restricted to specific geographical regions with a low production capacity or in the form of a quota system (Anon 2003). Further, plant protein substitutes might be able to access this existing support structure. However, other artificial meat products will have to compete with a subsidized product. In addition, if specific artificial meat producers or products can prove definitive reductions in greenhouse gas emission and other environmental benefits, they might receive encouragement and subsidies from regulating bodies and government as well (Dagevos and Voordouw 2013). Thus, the likelihood of the commercialization of artificial meat technologies would greatly increase by the support of government funds.

Willingness to invest

First, licensing requirements are the largest challenge with the commercial uptake of genetically modified meat technology. At the present time, for genetically modified livestock, such

regulatory hurdles are negatively affecting the likelihood of investment return. Genetic modification techniques are, if the regulatory hurdles are overcome, arguably rather suited to conventional infrastructure and production techniques. While it is not necessary with major infrastructure investments for the farming industry, there might be a need for new investments in infrastructure once new organisms are developed. This being that the major cost in this form is the dissemination of the new desired genetic material within the population.

Furthermore, the technology is at least 10-20 years away from being commercially available, being that the cell culture approach for artificial meat is in preliminary stages of development (Mattick et al. 2013). A significant commitment, as well as investments, are required from both industry and government in order to realize this technology. Thus, there is proposed a dilemma where firms have to balance opportunities and risks associated with investments. As Geels (2010) argues, there might be rational to postpone investments such as artificial meat due to future uncertainties in price fluctuations and government regulations. Thus, this translates into a willingness to pay more for such green products, and the emergence of 'green' markets (Geels, 2010 p. 497). However, Nortura AS and/or KLF might benefit from first-mover advantages, such as the creation of market positions, brand recognition, and technology lead, creating favorable positions in future 'green' innovation races. In addition, they might convince policymakers to issue stricter regulations as well and thus impose 'imitation costs' on competitors (Puller, 2006).

In addition, the importance of environmental issues, in the time of sustainability transitions, is going to be full of debates, as it involves deeply rooted beliefs and values. Thus, crucial drivers for sustainability transitions will be the civil society and the public. Such societies have to change consumer practices and frame conditions, subsequently leading to incentivize the private sector to reorient their commercial activities and innovation (Geels, 2010). However, such a process of changing to a more sustainable way of producing meat is seen as a long-term transition. Furthermore, the construction of an entirely new type of manufacturing facility with a number of untested technologies would be required by any artificial meat enterprise, presenting a significant risk for commercial organizations. The vast majority of media coverage for artificial meat has, however, been positive, where consumers have expressed hypothetical interest in the product, were it to become available (Goodwin and Shoulders 2013).

Lastly, if it comes as a request from the different food chains, some of the biggest meat companies could be willing to invest in it, given the whole premise. As we have seen, producers and manufacturers will only adopt new products and technologies if there is a potential of increasing profit and turnover. However, it will require significant investments and commitment from both industry and government for this technology to be realized.

Epistemic communities

One can argue that any given moment in history is defined and shaped by the dominant narratives of that time, which transcend all perceive barriers in society. In such a way, anyone can thus influence a group of individual or any other individual through narratives, leaving the power held by authoritative institutions, within an overarching discourse, as a mere expression and result of the dominant narratives and the rationales (Dreyfus & Rabinow, 2014; Foucault, 2012; Fraser, 1981; Olssen, 2003; Zembylas, 2005). The most dominant narrative will eventually become the paradigms within society, which can create stringent socioeconomic systems and further even influence the ontology of individuals, being the ways of relating to and seeing the world.

However, there can be some groups of individuals and other individuals that possess more power in a given context than others. Even though, these are not necessarily the bodies of judicial or political authority, but rather the communities and groups in a position to shape and justify narratives (Dreyfus & Rabinow, 2014; Fraser, 1981). These communities/groups can, in the climate context, often be so-called *epistemic communities* concerned with climate science and creating pathways for climate change mitigation and societal transitions. An epistemic community is defined by Haas (1992) as:

> A network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area...what bonds members of an epistemic community is their shared belief or faith in the verity and the applicability of particular forms of knowledge or specific truth. (Haas, 1992, p. 3).

The professionals within an epistemic community share causal and normative beliefs that are derived from their shared ideas and empirical knowledge of validity (Haas, 1992). In addition, a common idea of how policies are formed, and similar preferences are shared for policy

outcomes relating to their topic of expertise. Furthermore, common discursive practices are shared by members of an epistemic community and are generally engaged with the same narratives.

If there are uncertainties involved in the perception of both the origin and the abatement of a policy issue, scientific information and learning processes have in the development of regimes and policies been emphasized. For example, climate change tends to provide such uncertainties, being characterized by anything from doubt in its very existence, to which pathways to follow to mitigate the issue in the most beneficial manner or urgency of the issue. The demand for particular information is given rise by these sorts of uncertainties, untainted by the interference of states or other interest groups, as well as their intentions and unrestrained by political limitations. This sort of information representing the interpretations of an issue by experts might be proven by epistemic communities in consideration of physical and social boundaries. Ideally, this information can serve as advice on complex policy matters (Haas, 1992).

As the environmental policy is, to a large degree, dictated the international community and multilateral agreements, this can describe how epistemic communities may operate within an international or transnational setting. Epistemic communities are theorized by Haas (1992) to be able to affect both transnational and domestic policymaking as part of coalitions within a multilateral policy system:

> Members of transnational epistemic communities can influence state interests either by directly identifying them for decision makers or by illuminating the salient dimensions of an issue from which the decision makers may then deduce their interests. The decision makers in one state may, in turn, influence the interests and behaviour of other states, thereby increasing the likelihood of convergent state behaviour and international policy coordination, informed by the causal beliefs and policy preferences of the epistemic community. Similarly, epistemic communities may contribute to the creation and maintenance of social institutions that guide international behaviour. As a consequence of the continued influence of these institutions, established patterns of cooperation in a given issue-area may persist even though systemic power concentrations may no longer be sufficient to compel countries to coordinate their behavior. (Haas, 1992, p. 4).

Further, epistemic communities might be said to effectively reinforce established regimes and create opportunities for new ones to emerge, in addition to contributing to the dominant discourses. Also, they could be understood as actors within a wider discourse, having the ability to justify and form strong narratives and therefore contributing significantly to the discourse.

Such communities can arguably be represented by the IEA and the IPCC, as these epistemic communities can be seen to act as the key in changing narratives and producing new or locking in old ones (Fraser, 1981). Institutions such as these can, through the various future climate scenarios, thus both justify the incumbent socioeconomic paradigms and create narratives which the institution is subjected to. As these narratives represent the 'best available science' on climate change and communicate possible pathways for global climate change mitigation, they arguably become dominant in the political climate change context (Glen P. Peters, 2016). Regarding informing policy, the IPCC scenarios mostly play a central role, being that they attempt to map out 'feasible' ways of reaching the climate mitigation targets within a collection of expected future trajectories of changes in "demographics, human development, economy and lifestyle, policies and institutions, technology, and environment and natural resources" (O'Neill et al., 2017, p. 169).

Lastly, the economic growth assumption of the IPCC can be seen as an expression of the current scientific paradigm in which the IPCC subsist, where the economic growth narrative a defining role within the scientific discourse, being that it has been central since the emergence of the Sustainable Development concept (Wanner, 2015). In other words, the meat industry can be said to be underpinned by a paradigm of continued economic growth. In addition, the economic growth paradigm is resonated in the green growth narrative of the World Bank, UNEP and OECD (World Bank, 2012; OECD, 2011; UNEP, 2011), which exemplifies how the paradigm has appeared to dictate most of the multilateral institutions that are central in socioeconomic development and policymaking. Arguably, these global organizations hold significant power in a world where power comes from narratives within discourses.

6. Conclusion

This research aimed to seek in-depth knowledge of artificial meat technology and production in Norway while investigating the relationship between the technology and the matter of mitigating climate change. As a foundation for the research, the following problem statement was set forth; *"In light of deep uncertainty and the ever-growing and urgent environmental problems, can artificial meat be considered a feasible and sustainable technology for rapid large-scale production in Norway?".*

A comparative case study was chosen as a research strategy to gain the in-depth knowledge needed to propose any assumptions regarding the technology concerning the problem statement and research questions of this master thesis. An abductive approach to the research was further applied as a means to try understanding and explaining a phenomenon through conceptual frameworks, being that this strategy can interpret and re-contextualize the likelihood for artificial meat production within a theoretical framework while seeking empirical evidence to support or dismiss any assumptions regarding the problem statement and research questions. As a case study was chosen, a qualitative research strategy was deemed most appropriate, enabling an understanding of the social phenomena of artificial meat production. Through a case study of two actor's perception of artificial meat, studying in a real-world setting, presented non-manipulated findings providing valuable information of both understandings of the technology itself, while also acting as a supplement to discussions and support to any conclusions.

As we have seen, transitions generally take a long time many of the relevant incumbent systems have become locked-in to the socio-economic dynamics of society (Kuzemko et al., 2016; Smil, 2016; Sovacool, 2016; Unruh, 2000). Thus, regarding the problem statement, can artificial meat be considered a feasible and sustainable technology for rapid large-scale production in Norway? There are many factors that must be in place for artificial meat production to become a feasible and sustainable rapid large-scale technology. First, there is no doubt that reducing costs is necessary for artificial meat to become a commercial product. Today, the price is around NOK 500 per kilo but must fall further to be competitive. Besides, it will take time to get the necessary approvals from the authorities, for example, in the EU. However, the most significant challenges are technical; when growing cells in the laboratory, one must, among other things, add growth factors, which stimulate the cells to grow and divide. Currently, the serum must be

used from animals. The goal is that the product can be made entirely without the input factors from animals; being the cells can be grown serum-free. In addition, one can argue that the cell culture approach for artificial meat is still in preliminary stages of development and that it is least 10–20 years away from the technology being commercially available.

There is further no doubt that producers and manufacturers will only adopt new products and technologies if there is a potential of increasing profit and turnover. There must be a capacity for mass production of products and also be capable of supplying a significant proportion of the marketplace. Products would ideally be produced with a limited change to existing infrastructure, which acts to reduce the initial risk and set up costs for the industry (Verbeke et al. 2010). For this technology to be realized, it will require significant investments and commitment from both industry and government. Any artificial meat enterprise would furthermore require the construction of an entirely new type of manufacturing facility, containing several untested technologies. For any commercial organization, this presents a significant risk. The vast majority of media coverage for artificial meat has, however, been positive, and the product has seen consumer interest (Goodwin and Shoulders 2013).

Worthwhile, it is essential to remain mindful of the possibility that we could be seeing a situation where we have an economically viable artificial meat sector that does not deliver all of the environmental and social benefits that are currently associated with the technology. Net global reductions in animal slaughter or greenhouse gases might not be delivered if traditional livestock meat production is not being reduced as artificial meat production increases. Furthermore, if the organizations producing artificial meat prioritize other factors in their system, gains in energy use or health might not be delivered. The current set of artificial meat groups are motivated by environmental and social goals, seeking to develop innovative approaches that can maximize potential benefit. There is, however, no guarantee that such motivations will be shared and further pursued by future artificial meat producers, being that we are yet not convinced that the benefits are necessarily inherently embedded within the technology. However, I would urge the field and its stakeholders to remain attendant to supporting the delivery of the projected benefits.

Artificial meat could still be an essential technology for addressing a range of food security and environmental issues. However, I would argue to warn against perspectives that position artificial meat as the defining solution. Even so, the rising global demand for animal-derived

foods, as well as the contemporary context of planetary tipping points, presents significant challenges to existing meat production practices. However, one must take care in recognizing the systemic nature of these challenges and that technological approaches, such as artificial meat, should not be viewed as the only solution. Instead, I would argue for a multi-faceted response including a range of approaches, such as promoting plant-based protein and meat reduction, policy reforms that redress the systemic inequalities within contemporary protein and livestock food systems, as well as improved waste management strategies.

Nevertheless, technologies on artificial meat are utilizing ground-breaking techniques to meet the evolving demands of consumers, including health concerns, environmental sustainability, and animal welfare. Further, even though it is unlikely that conventional production of meat utilizing animals will ever be completely eliminated, the industry will face a regulatory environment as well as a challenging marketplace. This will lead to changes in the industry as a whole. I believe that artificial meat can be able to produce cost-effectively, with the possibility to not distinguish this meat from ordinary meat. With the exception of a small proportion of consumers who will continue to want traditional meat from animals, artificial meat might be the preferred choice for most people in the future. However, there must be made informed choices in order to achieve scalability and reduce cost, as well as avoiding regulatory hurdles. In addition, the impact on rural economies and power in the food industry should be considered, as well. However, it can be argued that this might prove difficult as long as narratives and climate policies are underpinned and subjected to the currently dominant socio-economical paradigm, as it is being defined by a pursuit of green economic growth. Thus, a broad paradigmatic shift brought on by narratives which will re-define the nature-economy relationship is what it will depend on, as it effectively changes the way in which the global community meets the challenge.

Finally, to answer the problem statement; even though I believe that artificial meat can be produced as a feasible and sustainable technology, the thesis has entangled many factors that must be in place for this to happen. The biggest challenge is to scale up production so that the cells can be grown in large tanks, and not on a two-dimensional surface as they must today. Such large-scale production is significantly more challenging, with the key issues being the production of effective culture media, as well as appropriately priced. Producing artificial meat on a scale that could make marked impacts on global climate change is, as we have seen, likely

to take many decades. Thus, this shows that rapid large-scale production seems unlikely as of today.

6.1 Implications

This thesis has shown that there are many factors that must be in place for artificial meat production to become a feasible and sustainable rapid large-scale technology, meaning that the findings might be important for the policymaking of authorities. In addition, the challenges in the technical aspect have been looked upon, hopefully giving the actors a better knowledge of how to produce artificial meat. Furthermore, I recognize the need for further analysis and research from a wider set of disciplinary stakeholder and academic positions, addressing these regulatory, technical, and social challenges by working together in interdisciplinary teams. I believe that a more nuanced set of understanding will emerge through a continuing emphasis on interdisciplinary engagement with such cellular agriculture and its possible results, leading to more robust socio-technical responses to these opportunities and challenges.

6.2 Limitations

There are some limitations to the study worth addressing. The most apparent weakness is that there could have been chosen a larger number of participants for a better representation of their perception and narratives on artificial meat technology and production, being that a more significant sample of answers could be collected. This could have improved the representativeness of the study, as well as the generalizability. Looking back at my work, I would have liked to interview different political parties, as well as looking at how those who do not consume meat perceive artificial meat. Besides, I would have wanted to interview a key informant from Ruralis to see if there was any difference in the research on artificial meat and comparing the answers from the key informant from Nofima. However, getting in touch with them was quite tricky; trying to reach multiple persons of interest without any luck. Another limitation could be such a lack of diversity amongst the participants. However, due to time and willing participants' limitations, this was not an option for this thesis.

Nevertheless, this thesis did not aim to achieve global representativeness but instead aimed to gain valuable knowledge about artificial meat technology and production. As the meat industry is a large contributor to climate change and being that the problem will most likely intensify,

this thesis further aimed to look at what type of mitigation pathways the industry can take – in this case, being artificial meat production.

6.3 Further research

This study has contributed to knowledge about artificial meat technology and production and how the actors perceive this technology. The study was motivated by a desire for increased insight into how artificial meat production can work as a mitigation pathway for climate change. Several factors have been highlighted that might be of significance for this technology to become both feasible and sustainable. Future research on the topic of framing new technologies could explore how the media frames are attempted crafted by producers, how successful they are in promoting the frames they prefer, and the downstream effect on consumers' attitudes. Furthermore, it would be interesting to look deeper into what consumers, especially vegans and vegetarians, think of this technology, for example, if they are willing to try it even if they do not eat regular meat products.

The field would, in terms of consumer research concerning artificial meat, specifically benefit from rigorous content analyses of frames used by both media and producers over the last 5-10 years. In addition, looking at what the dominant frames presented to consumers are, both by producers and media, and if these have changed over time, would be interesting. Further, future research on artificial meat could attempt to track consumer attitudes over time. Researchers could, in such a longitudinal design, be allowed to try observing the real effect of relevant news on consumer attitudes. This could provide a way to monitor the changes taking place when consumer attitudes shift over time and further be a method for measuring the master frame through which consumers interpret artificial meat. In addition, the idea that acceptance will increase over time would be possible to test, as people become more familiar with the product, as well as when products become commercially available. Finally, it would be interesting to carry out a comparative study of different political parties, comparing their perception of the technology.

7. References

Abbasalizadeh, S., Larijani, M. R., Samadian, A., & Baharvand, H. (2012). Bioprocess development for mass production of size-controlled human pluripotent stem cell aggregates in stirred suspension bioreactor. *Tissue Engineering*. *Part C, Methods*, 18(11), 831-851.

Amit. M., Laevsky, I., Miropolsky, Y., Shariki, K., Peri, M., & Itskovitz-Eldor, J. (2011). Dynamic suspension culture for scalable expansion of undifferentiated human pluripotent stem cells. *Nature Protocols*, 6(5), 572–579.

Amit, M., Chebath, J., Margulets, V., Laevsky, I., Miropolsky, Y., Shariki, Ko., . . . Itskovitz-Eldor, J. (2010). Suspension Culture of Undifferentiated Human Embryonic and Induced Pluripotent Stem Cells. *Stem Cell Reviews*, 6(2), 248-259.

Anon. (2003). *Research priorities for a sustainable livestock sector in Europe* (White Paper). Horizon 2020. Animal Task Force. [2014-12-30].

BBC. (2014). *What is climate change mitigation?* Retrieved from: <https://www.bbc.com/news/science-environment-26980837>

Bhat, Z. F., Kumar, S., & Fayaz, H. (2015). In vitro meat production: Challenges and benefits over conventional meat production. *Journal of Integrative Agriculture*, 14, 241–248.

Birch, K., Levidow, L., & Papaioannou, T. (2010). Sustainable Capital? The neoliberalisation of nature and knowledge in the European "Knowledge-based bio-economy". *Sustainability (Basel, Switzerland)*, 2(9), 2898-2918.

Blaikie, N. (2010). *Designing social research: The logic of anticipation* (2nd ed.). Cambridge: Polity Press.

Bohmann, A., Pörtner, R., Schmieding, J., Kasche, V., & Märkl, H. (1992). The membrane dialysis bioreactor with integrated radial- flow fixed bed—a new approach for continuous cultivation of animal cells. *Cytotechnology*, 9(1-3), 51–57.

Bonny, S. P. F., Gardner, G. E., Pethick, D. W., & Hocquette, J. F. (2017). Artificial meat and the future of the meat industry. *Animal Production Science*, 57, 2216-2223.

Bonny, S. P. F., Gardner, G. E., Pethick, D. W., & Hocquette, J. F. (2015). What is artificial meat and what does it mean for the future of the meat industry. *Journal of Integrative Agriculture*, 14(2), 255–263.

Boudreault, P., Tremblay, J. P., Pépin, M. F., & Garnier, A. (2001). Scale- up of a myoblast culture process. *Journal of Biotechnology*, 91, 63–74.

Bredahl, L., Grunert, K. G., & Fertin, C. (1998). Relating consumer perceptions of pork quality to physical product characteristics. *Food Quality and Preference*, 9(4), 273-281. https://doi.org/10.1016/S0950-3293(98)00007-X.

Brinkmann, S., & Tanggaard, L. (2012). *Kvalitative metoder: empiri og teoriutvikling*. Oslo: Gyldendal akademisk.

Brown, Y. B. (2012). Limits to climate change mitigation and the adaptation imperative. *Brookings*. Retrieved from: <https://www.brookings.edu/opinions/limits-to-climate-change- mitigation-and-the-adaptation-imperative/>

Bruce, A., Castle, D., Gibbs, C., Tait, J., & Whitelaw, C. B. (2013). Novel GM animal technologies and their governance. *Transgenic Research*, 22(4), 681–695.

Bustamante, M., Robledo-Abad, C., Harper, R., Mbow, C., Ravindranath, N. H., Sperling, F., Haberl, H., de Siqueira Pinto, A., & Smith, P. (2014). Co-benefits, trade-offs, barriers and policies for greenhouse gas mitigation in the agriculture, forestry and other land use (AFOLU) sector. *Global Change Biology*, 20(10), 3270-3290.

Camillus, J. C. (2008). Strategy as a wicked problem. *Harvard Business Review*, 86(5), 98-130.

Carlarne, C. (2007). From the USA with love: sharing home-grown hormones, GMOs, and clones with a reluctant Europe. *Environmental Law*, 37, 301.

CDC. (2012). *CDC estimates of foodborne illness in the United States*. Retrieved from: http://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html Accessed: April 20th, 2020

Chen, V. C., Couture, S. M., Ye, J., Lin, Z., Hua, G., Huang, H. I. P., Wu, J., Hsu, D., Carpenter, M. K., & Couture, L. A. (2012). Scalable GMP compliant suspension culture system for human ES cells. *Stem Cell Research*, 8(3), 388–402.

Chiles, R. M. (2013). If they come, we will build it: In vitro meat and the discursive struggle over future agrofood expectations. *Agriculture and Human Values*, 30(4), 511–523.

Chiou, T. W., Murakami, S., & Wang, D. I. C. (1991). A fiber bed bioreactor for anchorage-dependent animal cell cultures: Part I. Bioreactor design and operations. *Biotechnology and Bioengineering*, 37, 755–761.

Collins, C. A., Olsen, I., Zammit, P. S., Heslop, L., Petrie, A., Partridge, T. A., & Morgan, J. E. (2005). Stem cell function, self-renewal, and behavioral heterogeneity of cells from the adult muscle satellite cell niche. *Cell (Cambridge)*, 122(2), 289–301.

Cong, C., Chang, Y., Deng, J., Xiao, C., & Su, Z. (2001). A novel scale-up method for mammalian cell culture in packed-bed bioreactor. *Biotechnology Letters*, 23(11), 881–885.

Corbin, J. & Strauss, A. (1990). Grounded Theory Research: Procedures, Canons, and Evaluative Criteria. *Qualitative Sociology*, 13(1), 3-21.

Dagevos, H., & Voordouw, J. (2013). Sustainability and meat consumption: Is reduction realistic? *Sustainability: Science, Practice and Policy*, 9(2), 60–69.

Danermark, B., Ekström, M., Jakobsen, L. & Karlsson, J. C. (2002). *Explaining society: An introduction to critical realism in the social sciences*. London: Routledge.

Danermark, B., Ekström, M., Jakobsen, L., & Karlsson, J. C. (1997). Generalization, scientific inference and models for an explanatory social science in Danermark, Berth (Eds.) *Explaining Society: Critical realism in the social sciences*. Ablingdon, Oxon: Routledge.

Deloitte. (n.d). *"Using behavioural design to overcome decision-making paralysis"*. Retrieved from: https://www2.deloitte.com/us/en/insights/focus/behavioral-economics/overcoming- decision-making-paralysis.html#

Dey, I. (2004). *Grounded Theory*. In C. Seale (Ed.), Qualitative Research Practice. London: Sage Publications.

Dilworth, T., & McGregor, A. (2015). Moral steaks? Ethical discourses of in vitro meat in academia and Australia. *Journal of Agricultural and Environmental Ethics*, 28(1), 85–107.

Dreyfus, H. L., & Rabinow, P. (2014). *Michel Foucault: Beyond structuralism and hermeneutics*. Chicago: Routledge.

Dryzek, J. S (2013). *The politics of the earth: Environmental discourses* (3rd ed.). Oxford: Oxford University Press.

Dryzek, J. S. (1997). *The Politics of the Earth*. Oxford University press, New York.

Dürrschmid, M., Landauer, K., Simic, G., Blüml, G., & Doblhoff-Dier O. (2003). Scalable inoculation strategies for microcarrier-based animal cell bioprocesses. *Biotechnology and Bioengineering*, 83(6), 681–686.

Egbert, R. & Borders, C. (2006). Achieving success with meat analogs. *Food Technol-Chicago*, 60, 28–34.

Elzerman, J. (2006). Substitution of meat by NPFs: Sensory properties and contextual factors. In H. Aiking, J. de Boer, & J. Vereijken (Eds.), *Sustainable protein production and consumption: Pigs or peas?*. 116–122. Dordrecht: Springer

Eriksen, S., & Selboe, E. (2012). The social organisation of adaptation to climate variability and global change: The case of a mountain farming community in Norway. *Applied Geography*, 33, 159-167. 10.1016/j.apgeog.2011.10.003.

European commission. (no date). *Climate change consequences*. Retrieved from: <https://ec.europa.eu/clima/change/consequences_en.>

European commission. (no date). *Adaptation to climate change*. Retrieved from: <https://ec.europa.eu/clima/policies/adaptation_en>

FAO. (2009). *The State of Food and Agriculture*. Electronic Publishing Policy and Support Branch, Communication Division, FAO, Rome, Italy.

FAO. (2001). *The State of Food Insecurity in the World 2001*, Rome. FAO (2004a), Rome, Italy.

Fisher. (2007). *Researching and writing a dissertation –a guidebook for business students*, Prentice Hall, London.

Foucault, M. (1980). *Power/knowledge: Selected interviews and other writings*, 1972-1977: Pantheon. New York.

Foucault, M. (2012). *Discipline and punish: The birth of the prison*: Vintage. New York.

Fraser, N. (1981). Foucault on modern power: Empirical insights and normative confusions. *Praxis international*, 1(3), 272-287.

Gangtø et. al. (2018). *Tørkesommeren 2018*. Oslo. Meteorologisk institutt. Retrieved from: <https://fido.nrk.no/cccfcb66f38035154dd25ba51c2573ae231d397583bee2a4e545ae 0b6e3fc2 dd/T%C3%B8rkesommeren%202018__.pdf>

Geels, F. W., Kern, F., Fuchs, G., Hinderer, N., Kungl, G., Mylan, J., …& Wasserman, S. (2016). The enactment of socio-technical transition pathways: Are formulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy*, 45(4), 896-913.

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental innovation and societal transitions*, 1(1), 24-40.

Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, 39(4), 495-510.

Geels, F. W. (2005). *Technological Transitions and System Innovations: A Co-Evolutionary and Socio-Technical Analysis.* Edward Elgar Publishing Ltd, Cheltenham, UK.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6-7), 897-920. https://doi.org/10.1016/j.respol.2004.01.015.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration process: A multi-level perspective and a case-study. *Research Policy*, 31(8-9), 1257-1274.

Geels, F. W, & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, 36(3), 399-417. doi:10.1016/j.respol.2007.01.003

Genus, A., & Coles, A. M. (2008). Rethinking the multi-level perspective of technological transitions. *Research Policy*, 37(9), 1436-1445.

Gerber, P. J., Mottet, A., Opio, C. I., Falcucci, A., & Teillard, F. (2015). Environmental impacts of beef production: Review of challenges and perspectives for durability. *Meat Science*, 109, 2–12. https://doi.org/10.1016/j.meatsci.2015.05.013.

Golafshani. N. (2003). Understanding reliability and validity in qualitative research. *Qualitative Report*, 8(4), 597.

Goodwin, J. N., & Shoulders, C. W. (2013). The future of meat: A qualitative analysis of cultured meat media coverage. *Meat Science*, 95(3), 445–450.

Greger, M. (2007). The human/animal interface: Emergence and resurgence of zoonot- ic infectious diseases. *Critical Reviews in Microbiology*, 33(4), 243–299.
Greene, E., & Allen, R. (1991). Growth factor regulation of bovine satellite cell growth in vitro. *Journal of Animal Science*, 69(1), 146–152. doi:10.2527/1991.691146x
Grin, J., Rotmans, J., Schot, J. W., Geels, F. W., & Loorbach, D. (2011). *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. New York, Routledge LtD.
Grin, J., Schot, J., Rotmans, J., Geels, F. W., & Loorbach, D. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*. (Vol. 1, Routledge studies in sustainability transitions). London: Routledge.
Grunert, K. G & Bredahl Jensen, L,. & Brunsø, K. (2004). Consumer perception of meat quality and implications for product development in the meat sector - A review. *Meat Science*. 66(2). 259-272. https://doi.org/10.1016/S0309-1740(03)00130-X.
Haas, P. M. (1992). Introduction: epistemic communities and international policy coordination. *International organization*, 46(1), 1-35.
Hajer, M., & Versteeg, W. (2005). A decade of discourse analysis of environmental politics: Achievements, challenges, perspectives. *Journal of Environmental Policy & Planning*, 7(3), 175-184.
Hajer, M. A. (1995). *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford University Press: UK.
Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., & Rufino, M.C., . . . Notenbaert, A. (2014). Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences* 111(10), 3709–3714.
Head, L., Adams, M., McGregor, H. V., Toole, S. (2014). Climate change and Australia. *Wiley Interdisciplinary Reviews*: *Climate Change*, 5(2), 175–197.
Hocquette, J. F. (2015). Is it possible to save the environment and satisfy consumers with artificial meat? *Journal of Integrative Agriculture*, 14(2), 206–207.
Hocquette, A., Lambert, C., Sinquin, C., Peterolff, L., Wagner, Z., Bonny, S. P. F., ... & Hocquette, J. F. (2015). Educated consumers don't believe artificial meat is the solution to the problems with the meat industry. *Journal of Integrative Agriculture*, 14(2), 273–284.
Hocquette, J. F. (2016). Is in vitro meat the solution for the future? *Meat Science*, 120, 167–176. https://doi.org/10.1016/j.meatsci.2016.04.036.
Hoek, A. C., Luning, P. A., Stafleu, A., Graaf, C. (2004). Food-related lifestyle and health attitudes of Dutch vegetarians, non- vegetarian consumers of meat substitutes, and meat consumers. *Appetite*, 42(3), 267–272.
Holliday. (2002). *Qualitative research*. Sage, London
Hopkins, P.D., & Dacey, A. (2008). Vegetarian Meat: Could Technology Save Animals and Satisfy Meat Eaters?. *Journal of Agricultural and Environmental Ethics*, *21*(6), 579-596. https://doi.org/10.1007/s10806-008-9110-0
Hou, F. J., Nan, Z. B., Xie, Y. Z., Li, X. L., Lin, H. L., & Ren, J. Z. (2008). Integrated crop-livestock production systems in China. *The Rangeland Journal*, 30, 221–231. https://doi.org/10.1071/RJ08018
Humpenöder, F., Popp, A., Dietrich, J.P., Klein, D., Lotze-Campen, H., Bonsch, M., Bodirsky, B., Weindl, I., Stevanovic, M., & Müller, C. (2014). Investigating afforestation and bioenergy CCS as climate change mitigation strategies. *Environmental Research Letters*, 9(6), 064029. http://dx.doi.org/10.1088/1748-9326/9/6/064029.
Jacobsen, D. I. (2005). *Hvordan gjennomføre undersøkelser?: innføring i samfunnsvitenskapelig metode*. Høyskoleforlaget, Kristiansand.

Jönsson, E. (2016). Benevolent technotopias and hitherto unimaginable meats: Tracing the promises of in vitro meat. *Social Studies of Science*, 46(5), 725–748.
Kadim, I. T., Mahgoub, O., Baqir, S., Faye, B., & Purchas, R. (2015). Cultured meat from muscle stem cells: a review of challenges and prospects. *Journal of Integrative Agriculture*, 14(2), 222–233.
Kern, F., & Rogge, K. S. (2018). Harnessing theories of the policy process for analysing the politics of sustainability transitions: A critical survey. *Environmental innovation and societal transitions*, 27, 102-117. https://doi.org/10.1016/j.eist.2017.11.001.
Kern, F., & Rogge, K. S. (2016). The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? *Energy Research & Social Science*, 22, 13-17. https://doi.org/10.1016/j.erss.2016.08.016.
Key, T. J., Davey, G. K., & Appleby, P. N. (1999). Health benefits of a vegetarian diet. *Proceedings of the Nutrition Society*, 58(2), 271–275.
Kjøtt- og fjørfebransjens Landsforbund (KLF). (No date). *About KLF*. Retrieved from: http://kjottbransjen.no/Om-KLF
Knittel, N. (2016). Climate Change Adaptation: Needs, Barriers and Limits. *Climate Policy Info Hub*. Retrieved from: <http://climatepolicyinfohub.eu/climate-change-adaptation-needs- barriers-and-limits>
Kuzemko, C., Lockwood, M., Mitchell, C., & Hoggett, R. (2016). Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research & Social Science*, 12, 96-105. doi:https://doi.org/10.1016/j.erss.2015.12.022
Laestadius, L. I. (2015). Public perception of the ethics of in vitro meat: determining an appropriate course of action. *Journal of Agricultural and Environmental Ethics*, 28(5), 991–1009.
Laestadius, L. I., & Caldwell, M. A. (2015). Is the future of meat palatable? Perceptions of in vitro meat as evidenced by online news comments. *Public Health Nutrition*, 18(13), 2457–2467.
Larsson, S. C., & Wolk, A. (2006). Meat consumption and risk of colorectal cancer: A meta-analysis of prospective studies. *International Journal of Cancer*. Journal International du Cancer, 119(11), 2657–2664.
Lerner, H., Henrik. L., Bo, A., Stefan, G., & Anders, N. (2013). Stakeholders on meat production, meat consumption and mitigation of climate change: Sweden as a case. *Journal of Agricultural and Environmental Ethics*, 26, 663–678.
Le Mouël, C., Marajo-Petitzon, E., Dumas, P., Manceron, S., Féménia, F., Levert, F., ... & Guyomard, H. (2015). How to feed the World: Is reducing meat consumption part of the solution? *ICoMST*, August 23–28. Clermont-Ferrand (France).
Lobell, D., & Burke, M. (2010). *Climate change and food security adapting agriculture to a warmer world*. Vol. V. 37, Advances in global change research. Dordrecht: Springer.
Lynch, J., & Pierrehumbert, R. (2019). Climate impacts of cultured meat and beef cattle. *Frontiers in Sustainable Food Systems*, , 3, 5. https://doi.org/10.3389/fsufs.2019.00005 (2019).
MCE. (2016-2017). St. Mld. 41: *Klimastrategi for 2030 – norsk omstilling i europeisk samarbeid*. Retrieved from: https://www.regjeringen.no/no/dokumenter/meld.-st.-41-20162017/id2557401/sec2?q=parisavtalen#KAP2-2: Regjeringen.
Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6), 955-967. doi:10.1016/j.respol.2012.02.013

Marcu, A., Gaspar, R., Rutsaert, P., Seibt, B., Fletcher, D., Verbeke, W., & Barnett, J. (2014). Analogies, metaphors, and wondering about the future: Lay sense-making around synthetic meat. *Public Understanding of Science*, 24, 547–562.

Mathews, K. H. J., & McConnell, M. (2011). *U.S. beef and cattle industry: Background statistics and information.* [2012- 03-27]. Retrieved from : http://www.ers.usda.gov/news/BSECoverage.htm

Mathison, S. (1988). Why triangulate? *Educational Researcher*, 17(2), 13-17. 10.3102/0013189X017002013.

Mattick, C. S., Landis, A. E., & Allenby, B. R. (2015). A case for systemic environmental analysis of cultured meat. *Journal of Integrative Agriculture,* 14(2), 249–254. https://doi.org/10.1016/S2095-3119(14)60885-6.

Mattick, C. S, & Allenby, B. R. (2013). The future of meat. *Issues in Science and Technology*, 30(1), 64–70.

Meadowcroft, J. (2011). Engaging with the politics of sustainability transitions. *Environmental innovation and societal transitions*, 1(1), 70-75. doi:https://doi.org/10.1016/j.eist.2011.02.003

Meadowcroft, J. (2009). What about the politics? Sustainable development, transition management, and long term energy transitions. *Integrating Knowledge and Practice to Advance Human Dignity*, 42(4), 323-340. doi:10.1007/s11077-009-9097-z

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: a guide to design and implementation.* Fourth edition. San Francisco, CA: Jossey-Bass, a Wiley brand.

Mitalipova, M. M., Rao, R. R., Hoyer, D. M., Johnson, J. A., Meisner, L. F., Jones, K. L., Dalton, S., Stice, S. L. (2005). Preserving the genetic integrity of human embryonic stem cells. *Nature Biotechnology*, 23(1), 19–20.

Molnar, G., Schroedl, N. A., Gonda, S. R., & Hartzell, C. R. (1997). Skeletal muscle satellite cells cultured in simulated microgravity. *In Vitro Cellular & Developmental Biology. Animal*, 33(5), 386–391.

Moritz, M. S. M., Verbruggen, S. E. L,, & Post, M. J. (2015). Alternatives for large-scale production of cultured beef: A review. *Journal of Integrative Agriculture, 14*(2), 208-216. https://doi.org/10.1016/S2095-3119(14)60889-3.

Neuman, W. L. (2014). *Social Research Methods: Qualitative and Quantitative Approaches* (7th ed.). Pearson, Essex, UK.

Neuman, W. L. (2011) *Social Research Methods: Qualitative and Quantitative Approaches*. 7th Edition, Pearson, Boston.

Neumann, T., Hauschka, S. D., & Sanders, J. E. (2003). Tissue engineering of skeletal muscle using polymer fiber arrays. *Tissue Engineering*, 9(5), 995–1003.

NIAA (Nevada Interscholastic Activities Association). (2012). *Living in a world of decreasing resources and increasing regulation: How to advance animal agriculture*. In: Annual Conference of the National Institute for Animal Agriculture. Colorado Springs, National Institute for Animal Agriculture, USA.

Nofima AS. (No date). *GrowPro*. Retrieved from: https://nofima.no/prosjekt/growpro/

Norilia AS. (No date). *About Norilia*. Retrieved from: https://www.norilia.no/hovedartikler/about-norilia

Nortura AS. (No date). *About Nortura.* Retrieved from: https://www.nortura.no/om

Novoselova, T., Meuwissen, M., & Huirne, R. (2007). Adoption of GM technology in livestock production chains: an integrating framework. *Trends in Food Science & Technology*, 18(4), 175-188. https://doi.org/10.1016/j.tifs.2006.12.005.

NTB. (2019). *Tørkesommer ga importrekord i 2018*. Retrieved from: <https://www.abcnyheter.no/nyheter/norge/2019/02/12/195551082/torkesommer-ga-importrekord-i-2018>

OECD. (2011). *Towards Green Growth*. Retrieved from Paris: https://www.oecd.org/greengrowth/48012345.pdf

Official Journal of the European Union. (2015). Regulation (EU) 2015/2283 of the European parliament and of the council of 25. November 2015 on novel foods, amending regulation (EU) No 1169/2011 of the European parliament and of the council and repealing regulation (EC) No 258/97 of the European parliament and of the council and commission regulation (EC) No 1852/2001. *Official Journal of the European Union* 11.12.2015 EN L 327/1.

Official Journal of the European Union. (2003). Regulation (EC) No 1829/2003 of the European parliament and of the council of 22 september 2003 on genetically modified food and feed. *Official Journal of the European Union* 18.10.2003 EN L 268/1.

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., . . . & Kok, K. (2017). The roads ahead: narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*, 42, 169-180. https://doi.org/10.1016/j.gloenvcha.2015.01.004.

Olssen, M. (2003). Structuralism, post-structuralism, neo-liberalism: Assessing Foucault's legacy. *Journal of Education Policy*, *18*(2), 189-202.

Orzechowski A. (2015). Artificial meat? Feasible approach based on the experience from cell culture studies. *Journal of Integrative Agriculture*, 14(2), 217–221. https://doi.org/10.1016/S2095-3119(14)60882-0.

Osunmuyiwa, O., Biermann, F., & Kalfagianni, A. (2018). Applying the multi-level perspective on socio-technical transitions to rentier states: the case of renewable energy transitions in Nigeria. *Journal of Environmental Policy & Planning, 20*(2), 143-156.

Otto, F., James, R. & Allen, M. (2014). *The science of attributing extreme weather events and its potential contribution to assessing loss and damage associated with climate change impacts*. Oxford. Environmental Change Institute. Retrieved from : <https://unfccc.int/files/adaptation/workstreams/loss_and_damage/application/pdf/attributinge xtremeevents.pdf >

Park, Y., Chen, Y., Ordovas, L., & Verfaillie, C. M. (2014). Hepatic differentiation of human embryonic stem cells on microcarriers. *Journal of Biotechnology*, 174, 39-48.

Park, S., & Stephanopoulos, G. (1993). Packed bed bioreactor with porous ceramic beads for animal cell culture. *Biotechnology and Bioengineering*, 41, 25–34.

Patton, M. Q. (2001). *Qualitative Research & Evaluation Methods. (3rd ed.).* California: Sage Publications, Inc.

Petetin, L. (2014). Frankenburgers, risks and approval European. *Journal of Risk Regulation*, 5(2), 168–186.

Peters, G. P. (2016). The 'best available science' to inform 1.5 °C policy choices. *Nature Climate Change*, 6(7), 646-649. doi:10.1038/nclimate3000

Petrovic, Z., Djordjevic, V., Milicevic, D., Nastasijevic, I., & Parunovic, N. (2015). Meat Production and Consumption: Environmental Consequences. *Procedia Food Science, 5*, 235-238. https://doi.org/10.1016/j.profoo.2015.09.041

Phillips, B. W., Horne, R., Lay, T. S., Rust, W. L., Teck, T. T., & Crook. J. M. (2008). Attachment and growth of human embryonic stem cells on microcarriers. *Journal of Biotechnology*, 138(1-2), 24–32. https://doi.org/10.1016/j.jbiotec.2008.07.1997.

Pluhar, E. B. (2010). Meat and morality: Alternatives to factory farming. *Journal of Agricultural and Environmental Ethics*, 23(5), 455–468.

Polkinghorne, R., Philpott, A, J., Gee, B, A., Doljanin, C, A. & Innes, C, J. (2008). Development of a commercial system to apply the Meat Standards Australia (MSA) grading model to a beef supply chain to optimise eating quality to the consumer. *Australian Journal of Experimental Agriculture*, 48. 10.1071/EA05181.

Post, M. J., Levenberg, S., Kaplan, D. L., Genovese, N., Fu, J., Bryant, C.,…Moutsatsou, P. (2020). Scientific, sustainability and regulatory challenges of cultured meat. *Nature Food*, 1, 403–415. https://doi.org/10.1038/s43016-020-0112-z

Post, M. J. (2012). Cultured meat from stem cells: Challenges and prospects. *Meat Science*, 92(3), 297–301. https://doi.org/10.1016/j.meatsci.2012.04.008.

Rapley, T. (2004). *Interviews*. In C. Seale (Ed.), Qualitative Research Practice. Sage Publications, London.

Regulation (EU) 2015/2283 of the European Parliament and of the Council (European Commission, 2015).

Reuveny, S. (1990). Microcarrier culture systems. *Bioprocess Technology*, 10, 271–341.

Ringdal, K. (2013). *Enhet og mangfold*. Bergen: Fagbokforlaget.

Rosenbloom, D., Berton, H., & Meadowcroft, J. (2016). Framing the sun: A discursive approach to understanding multi-dimensional interactions within socio-technical transitions through the case of solar electricity in Ontario, Canada. *Research Policy*, 45(6), 1275-1290.

Rosenzweig C, & Hillel D. (1998). *Climate change and the global harvest*. Oxford University Press, New York

Ruralis.no. (No date). *Protein 2.0*. Retrieved from: https://ruralis.no/prosjekter/protein2-0-overgangen-til-biosyntetisk-protein-evaluering-av-effekter-utfall-og-muligheter-for-norges-post-animalske-biookonomi/

Salvage, B. (2012). *Are meat analogs in industry's future?* Retrieved from: http://www.meatpoultry.com.

Sart, S., Agathos, S. N., & Li, Y. (2013). Engineering stem cell fate with biochemical and biomechanical properties of microcarriers. *Biotechnology Progress*, 29(6), 1354–1366.

Schneider, Z. (2013). In vitro meat: Space travel, cannibalism, and federal regulation. *Houston Law Review*, 5(3), 991.

Schill, W. P., & Kemfert, C. (2011). Modeling strategic electricity storage: the case of pumped hydro storage in Germany. *The Energy Journal (Cambridge, Mass.)*, *32*(3), 59-87.

Seehusen, T., Waalen, W. Hoel, B. Uhlen, A.K. Persson, T. & Strand, E. (2016). *Endret klima-effekter av endret klima og behov for tilpasninger- norsk kornproduksjon.* In Strand, E. (red.) (2016) Jord og plantekultur 2016. NIBIO, 2(1), 14-17.

Seale, C. (1999). Quality in qualitative research. *Qualitative Inquiry*, 5(4), 465-478.

Sexton, A. (2016). Alternative proteins and the (non)stuff of "meat". *Gastronomica*, 16(3), 66–78.

Sharma, S., Thind, S., & Kaur, A. (2015). In vitro meat production system: why and how? *Journal of Food Science and Technology*, 52(12), 7599-7607.

Shenton, A. K. (2004). Strategies for Ensuring Trustworthiness in Qualitative Research Projects. *Education for Information*, 22(2), 63-75. doi:10.3233/EFI-2004-22201

Slingenbergh, J., Gilbert, M., de Balogh, K., & Wint, W. (2004). Ecological sources of zoonotic diseases. *Revue Scientifique et Technique (International Office of Epizootics)*, 23(2), 17.

Smetana, S., Mathys, A., Knoch, A., & Heinz, V. (2015). Meat Alternatives: Life cycle assessment of most known meat substitutes. *International Journal of Life Cycle Assessment*, 20(9), 1254–1267.

Smil, V. (2016). Examining energy transitions: A dozen insights based on performance. *Energy Research & Social Science*, 22, 194-197. https://doi.org/10.1016/j.erss.2016.08.017.

Smil, V. (2005). *Creating the Twentieth Century: Technical Innovations of 1867-1914 and Their Lasting Impact*. Oxford University Press, Incorporated, New York.

Smith, P., & Gregory, P. J. (2013). Climate change and sustainable food production. *Proceedings of the Nutrition Society*, 72(1), 21-28.
Smith, A., & Kern, F. (2009). The transitions storyline in Dutch environmental policy. *Environmental Politics*, 18(1), 78-98.
Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change*, 7(1), 85-114.
Song, Y., Manson, J. E., Buring, J. E., & Liu, S. (2004). A prospective study of red meat consumption and type 2 diabetes in middle-aged and elderly women: The women's health study. *Diabetes Care*, 27(9), 2108–2115.
Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design. *Energy Research & Social Science*, 45, 12-42.
Sovacool, B. K. (2016). How long will it take? Conceptualizing the temporal dynamics of energy transitions. *Energy Research & Social Science*, 13, 202-215.
Sovacool, B. K., & Geels, F. W. (2016). Further reflections on the temporality of energy transitions: A response to critics. *Energy Research & Social Science*, 22, 232-237. https://doi.org/10.1016/j.erss.2016.08.013.
SSB. (2019). *Halverte kornavling etter tørkesommer*. Retrieved from: < https://www.ssb.no/jord- skog-jakt-og-fiskeri/artikler-og-publikasjoner/halverte-kornavlinger-etter-torkesommer>
Steiner, D., Khaner, H., Cohen, M., Even-Ram, S., Gil, Y., Itsykson, P.,…Reubinoff, B. (2010). Derivation, propagation and controlled differentiation of human embryonic stem cells in suspension. *Nature Biotechnology*, 28(4), 361–364.
Stephens, N., Di Silvio, L., Dunsford, I., Ellis, M., Glencross, A., & Sexton, A. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. *Trends in Food Science & Technology*, 78, 155-166. https://doi.org/10.1016/j.tifs.2018.04.010.
Stephens, N., King, E., & Lyall, C. (2018). Blood, meat, and upscaling tissue engineering: Promises, anticipated markets, and performativity in the biomedical and agri-food sectors. *Biosocieties*, 13(2), 368-388.
Stephens, N., & Ruivenkamp, M. (2016). Promise and ontological ambiguity in the in vitro meat imagescape: From laboratory myotubes to the cultured burger. *Science as Culture*, 25(3), 327–355.
Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Sage Publications, Inc, Newbury Park, CA.
Suemori, H., Yasuchika, K., Hasegawa, K., Fujioka, T., Tsuneyoshi, N., & Nakatsuji, N. (2006). Efficient establishment of human embryonic stem cell lines and long-term maintenance with stable karyotype by enzymatic bulk passage. *Biochemical and Biophysical Research Communications*, 345(3), 926–932.
SUN Zhi-chang, YU Qun-li, & HAN Lin. (2015). The environmental prospects of cultured meat in China. *Journal of Integrative Agriculture*, 14(2), 234-240.
Tatsumi, R., Anderson, J. E., Nevoret, C. J., Halevy, O., & Allen, R. E. (1998.) HGF/SF is present in normal adult skeletal muscle and is capable of activating satellite cells. *Developmental Biology*, 194(1), 114–128.
Thagaard, T. (2013). *Systematikk og innlevelse - En innføring i kvalitativ metode*. Bergen: Fagbokforlaget Vigmostad & Bjørke AS.
Troy, A., Cadwallader, A. B., Fedorov, Y., Tyner, K., Tanaka, K. K., & Olwin, B. B. (2012). Coordination of satellite cell activation and self-renewal by Par-complex-dependent asymmetric activation of p38α/β MAPK. *Cell Stem Cell*, 11(4), 541–553.

UNEP. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication*. Nairobi, Kenya: UNEP.
Unruh, G. C. (2000). Understanding carbon lock-in. *Energy policy*, 28(12), 817-830.
Verbeke, W., Marcub, A., Rutsaert, P., Gaspar, R., Seibt, B., & Fletcher, D. (2015). 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science*, 102, 49–58. https://doi.org/10.1016/j.meatsci.2014.11.013.
Verbeke, W., Sans, P., & van Loo, E. J. (2015a). Challenges and prospects for consumer acceptance of cultured meat. *Journal of Integrative Agriculture*, 14 (2), 285–294.
Verbeke, W., Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., & Barnett, J. (2015b). 'Would you eat cultured meat?': consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science*, 102, 49–58.
Verbeke, W., Van Wezemael, L., de Barcellos, M. D., Kugler, J. O., Hocquette, J. F., Ueland, O., & Grunert, K. G. (2010). European beef consumers' interest in a beef eating-quality guarantee insights from a qualitative study in four EU countries. *Appetite*, 54(2), 289–296.
Verbeke, W., Pérez-Cueto, F. J. A., de Barcellos, M. D., & Krystallis, A. (2010). European citizen and consumer attitudes and preferences regarding beef and pork. *Meat Science*, 84, 284–292.
Verbong, G., Geels, F. W., & Raven, R. (2008). Multi-niche analysis of dynamics and policies in Dutch renewable energy innovation journeys (1970–2006): hype-cycles, closed networks and technology-focused learning. *Technology Analysis & Strategic Management*, 20(5), 555-573.
Wacket, M. (2019). *Germany to phase out coal by 2038 in move away from fossil fuels.* Reuters. Retrieved from: <https://www.reuters.com/article/us-germany-energy-coal/germany-to- phase-out-coal-by-2038-in-move-away-from-fossil-fuels-idUSKCN1PK04L >
Wadel, C. (2014). *Feltarbeid i egen kultur*. Oslo: Cappelen Damm.
Wanner, T. (2015). The New 'Passive Revolution' of the Green Economy and Growth Discourse: Maintaining the 'Sustainable Development' of Neoliberal Capitalism. *New Political Economy*, 20(1), 21-41. doi:10.1080/13563467.2013.866081
Wang, Y., & Ouyang, F. (1999). Bead-to-bead transfer of Vero cells in microcarrier culture. *Cytotechnology*, 31(3), 221–224.
Wang, Y., & Ouyang, F. (1999). Recycle of Cytodex-3 in Vero cell culture. *Bioprocess Engineering*, 21(3), 207–210.
Westskog, H., Selvig, E., Aall, C., Amundsen, H., & Jensen, E. S. (2018). *Potensial og barrierer for kommunale klimatiltak.* Retrieved from: https://pub.cicero.oslo.no/cicero-xmlui/handle/11250/2495875
World Bank. (2012). *Inclusive green growth: The pathway to sustainable development*: World Bank Publications.
Yan, M., Cheng, K., Luo, T., & Pan, G. X. (2014). Carbon footprint of crop production and the significance for greenhouse gas reduction in the agriculture sector of China. *Assessment of Carbon Footprint in Different Industrial Sectors*, 1, 247–264.
Yin, R. K. (2014). *Case study research: Design and Methods* (5th ed. ed.). Thousand Oaks, Los Angeles, CA: Sage.
Yin, R. K. (2009). *Case study research: Design and methods* (4th Ed.). Thousand Oaks, CA: Sage.
Yin, R. K. (1994). *Case study research: Design and methods* (2nd ed.). Thousand Oaks, CA: Sage. Retrieved from http://www.madeira-edu.pt/LinkClick.aspx?fileticket=Fgm4GJWVTRs%3D&tabid=3004

Zembylas, M. (2005). Three Perspectives on Linking the Cognitive and the Emotional in Science Learning: Conceptual Change, Socio-Constructivism and Poststructuralism. *Studies in Science Education*, 41(1), 91-115.

Zhao, F., Pathi, P., Grayson, W., Xing, Q., Locke, B. R., & Ma, T. (2005). Effects of oxygen transport on 3-D human mesenchymal stem cell metabolic activity in perfusion and static cultures: Experiments and mathematical model. *Biotechnology Progress*, 21(4), 1269–1280.

Zweigerdt, R., Olmer, R., Singh, H., Haverich, A., & Martin, U. (2011). Scalable expansion of human pluripotent stem cells in suspension culture. *Nature Protocols*, 6(5), 689–700.

8. Appendix

Consent form

Consent can be given in writing (including electronically) or orally. NB! You must be able to document/demonstrate that you have given information and gained consent from project participants i.e. from the people whose personal data you will be processing (data subjects). As a rule, we recommend written information and written consent.

- *For written consent on paper you can use this template*
- *For written consent which is collected electronically, you must chose a procedure that will allow you to demonstrate that you have gained explicit consent (read more on our website)*
- *If the context dictates that you should give oral information and gain oral consent (e.g. for research in oral cultures or with people who are illiterate) we recommend that you make a sound recording of the information and consent.*

If a parent/guardian will give consent on behalf of their child or someone without the capacity to consent, you must adjust this information accordingly. Remember that the name of the participant must be included.

Adjust the checkboxes in accordance with participation in your project. It is possible to use bullet points instead of checkboxes. However, if you intend to process special categories of personal data (sensitive personal data) and/or one of the last four points in the list below is applicable to your project, we recommend that you use checkboxes. This because of the requirement of explicit consent.

I have received and understood information about the project *[insert project title]* and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in *(insert method, e.g. an interview)*
- ☐ *for information about me/myself to be published in a way that I can be recognised (describe in more detail)– if applicable*

I give consent for my personal data to be processed until the end date of the project, approx. *[insert date]*

(Signed by participant, date)