The Electrification of the Norwegian Transport Sector. The Example of the Electric Vehicle Initiative.

Knut André Vold

Master thesis in Development, Environment & Cultural Change

Centre for Development and Environment

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Abstract

This thesis investigates the development of the Norwegian EV initiative.
As the transport sector accounts for more than one-quarter of the total greenhouse gas emissions globally, a transition to more environmental-friendly solutions in this sector is necessary for the world to limit global warming to 1.5 degrees. Electric vehicles are free of tailpipe emissions and are more energy-efficient than fossil-fueled vehicles. UNEP estimates that 1.2 billion new vehicles will be deployed around the world within the following decades. With this in mind, a transition to electric vehicles is considered a central measure to reduce climate emissions from the transport sector.

Norway is at the forefront globally in the transition from fossil-fueled to electric vehicles. The Norwegian EV initiative has developed over 30 years. Many actors have been involved in shaping the initiative. Actor-Network Theory (ANT) is both the theoretical and methodological framework for this thesis. Through the research, a complex web of actors has revealed itself, involving actors from the categories of technology, industry, politics, environmental organizations, interest organizations, economy, social society, and the international landscape. In line with the ANT approach, this thesis “follows the actors.” The data has been collected through interviews with various actors involved in the development. Secondary data has been utilized to provide further context.
This thesis aims to contribute knowledge about how the Norwegian EV initiative has come about, what actors have been involved, and how they have influenced each other.

Keywords: Electric vehicles, Actor-Network Theory, ANT, Norwegian EV development, EV Incentives, System of automobility

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1 Introduction

It is code red for humanity.

This is the warning by the UN Secretary-General António Guterres (UN 2021) after the release of the latest climate report by the Intergovernmental Panel on Climate Change (IPCC). The reactions have been strong since the UN released this report in September 2021. The report provides policymakers with assessments of the scientific basis of climate change, its impact, future risks, and adaptation and mitigation options. More than 700 authors from 90 countries have contributed to the writing of this report. The report concludes that there is no longer any scientific doubt that humans are the leading cause of climate change, that the impacts will be really bad (in some cases also catastrophic), and for every small piece of a degree warming we can prevent by curbing the emissions will reduce this damage substantially. "The alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk," says the UN Secretary-General (UN 2021a).

The message from the UN Secretary-General is frightening. Through the Paris Agreement in 2015 and the recent COP26-conference in Glasgow, world leaders around the globe are solidifying the goal to limit global warming to 1.5 degrees. However, the current trajectory shows that the world is on track towards 2.7 degrees warming (UN 2021b). To change the current trajectory, structural changes in large parts of society are needed. The transport sector is one of them. "Transport, which accounts for more than one quarter of global greenhouse gases, is key to getting on track. We must decarbonize all means of transport, in order to get to net-zero emissions by 2050 globally," says the UN Secretary-General (UN 2021c). [1] Also, calculations estimate that 1.2 billion new vehicles will be hitting the roads within the following decades and that emissions from the transport sector will rise by 30 %, given the current emission trajectory the world is on (UNEP 2021). The transport sector is also heavily reliant on fossil fuels as an energy

[1] The transport sector entails more than just road transportation. It also includes aviation and the maritime sector.

source. Numbers from IPCC show that the transport sector was the least diversified in energy end-use (IPCC 2018). 65 % of total global oil consumption was in transport, and 92 % of the fuel mix in transport is oil. These numbers suggest that the transport sector has significant challenges breaking with the fossil paradigm and applying renewable energy sources.

As a result, sustainable innovations and large-scale implementation of environmental-friendly solutions in this sector are required to be able to limit the emissions from the transportation system. Electrifying the transport sector in combination with decarbonizing electricity and energy can deliver deep cuts in CO2 emission and is a requirement if the world is to achieve its emission targets (Williams et al. 2012).

Electric vehicles, the focus area of this thesis, are at the heart of this electrification of the transport sector. Electric vehicles represent an essential option to fossil vehicles since they have no tailpipe emissions and are expected to be 2-4 times more energy-efficient than their fossil counterparts (IEA 2021, 9). Electric vehicles will also reduce the dependency on oil. In Norway, about one-third of the greenhouse gas emissions come from the transport sector (Miljødirektoratet 2021b). In these calculations, the transport sector covers road transport, domestic aviation, coast maritime and fishing, and heavy equipment vehicles (such as tractors, construction machines, leisure boats). The report estimates that about half of the Norwegian transport emissions derive from road transport and that 17 % of Norway's total climate emissions derive from road transport, with passenger vehicles being the most significant emitter. Consequently, changing from fossil-fueled vehicles to electric vehicles can substantially reduce Norway's climate emissions in the transport sector.

Norway is at the forefront globally in the transition from fossil-fueled to electric vehicles. Of the country’s entire passenger vehicle fleet, 14,8 % are electric vehicles (Elbilforeningen 2021). These numbers are far more significant in Norway than in any other country. The next countries on this list are Iceland (4,4 %), Netherlands (2,7 %), Sweden (2,0), and China (1,6 %), according to the International Energy Agency (2020, 44).

From the Paris agreement, Norway has committed itself to reduce its emissions by at least 50 %, up towards 55 %, by the year 2030 (Miljødirektoratet 2021a), compared to emission levels in 1990. In 2018, the country had a total emission number of 52 million tonnes of CO_2. The emissions from the Norwegian road traffic have increased by 26 % since 1990, and the transport sector as a whole is responsible for a total of 32 % of the emissions in Norway (Miljødirektoratet 2021b).

As mentioned, Norway is at the forefront of EV adoption in the world. Numbers from the last year's International Energy Report (IEA 2020) show that the EV trend is growing worldwide but that no country is close to the successful implementation that Norway has seen so far. Of all new passenger vehicles sold in Norway in 2021 so far, 62,5 % have been electric cars, according to the Norwegian Information Council for Road Traffic (OFV 2021a). According to the same source, electric vehicles represented 77,5 % of the country's new passenger vehicles sales in September 2021. Norway is receiving international attention because of its impressive adoption of electric vehicles.

The Norwegian Parliament has, through their national transport plan 2022-2033, for some better known as NTP, set some of the world's most ambitious climate targets for the transport sector. The national goal is that all new passenger vehicles sold should be zero-emission by 2025 and that emissions from the transport sector as a whole should be reduced by 50 % by 2030 (Det Kongelige Samferdselsdepartement 2021).

This thesis will investigate the development of the Norwegian EV initiative through the Actor-Network Theory (ANT) approach. It will explore how the initiative has come about, who the central actors have been, and how the different actors have shaped and reshaped the initiative. The investigation has "followed the actors" from the Norwegian EV initiative, taking all they have said and done into account.

1.1 The Importance of the Automobile

Today, personal mobility is seen as a central element of modern society. Much of this is thanks to the implementation and improvement of the automobile. The car often also plays a central role in literature, commercials, and films, far from 'just being' a transport mean. It can even be said to be a symbol of social status and offer an opportunity to 'climb the social ladder.' Some even portrait the car as an extension of themselves. "A car isn't just a car – it's an extension and an enabler of the person we most like to be. Independent ownership of our mobility is ownership of ourselves" (Klochikhin 2018). Marshall McLulan, a Canadian philosopher who studied media theory, explained that technology could be perceived as an extension of the human being. He compared the effects of the automobile to the impact that home television and horses have had on us humans: "the simple and obvious fact about the car is that, more than any horse, it is an extension of man that turns the rider into a superman. It is a hot, explosive medium of social communication" (McLulan 1964, 241).

Having said that, it was not obvious that the fossil car would be the dominant type of vehicle. In the early birth of the automobile, around the year 1900, it was not a given that fossil cars would be the preferred choice. There existed both electric cars, fossil cars, and steam-driven cars. Both in 1899 and 1900, the electric vehicle actually outsold the other types of cars in the US. 28 % of the vehicles produced in the US in 1900 were electric vehicles. That year, the electric vehicle sold more than both gasoline and steam-powered cars combined (EnergyGov 2021). However, the competition between the three vehicles was decided in 1912. As Asphjell et al. (2013) explain, there were at least two reasons why the gasoline-powered car won the race and stayed the dominant force for the next 100 years. The first reason was that the American man Charles Kettering who invented the electric starter for gasoline cars in 1912. This simplified the process of starting the gasoline car. The second, and perhaps the most well-known reason, was that Henry Ford, in 1908, released the Ford Model T. This car was trendy, widely available, and affordable. In the period 1908-1927, Ford mass-produced the car and sold 15 million entities of this model T (Asphjell et al. 2013, 9). The Ford T put the "world on wheels" (Brooks 2008). In 1914 the US in total produced 568 000 vehicles, and 99 % of these cars had an internal combustion engine. The electric vehicle fell short, and even though some efforts were made to make electric and steam cars competitive until the 1930s, the fossil car would keep the "driving seat" for the next 100 years. Asphjell et al. also point out that the big oil companies also impacted the development. The fossil cars and big oil companies created a strong common dependency. The fossil cars needed fossil fuels, and the oil companies now had a massive market inside the automobile industry thanks to fossil cars.

British scientist John Urry places the role of the car within what he describes as the "system of automobility" (2004). He explains that the car has become the dominant force in mobility, organizing people's perception of opportunities and constraints regarding movement. It is a central “item of individual consumption” and is a powerful actor in the mobility system, organizing road planning, city planning, urban and suburban housing, and petrol infrastructure. Urry’s system of automobility will be further discussed in chapter 3.1.

The car has become a deeply embedded symbol of modern society. As Arve Hansen and Kenneth Bo Nielsen (2017, 3) explains: "The private car is one of the most powerful commodities to emerge from the technological progress of the last decade. The private car is, perhaps, the closest we get to a truly global 'blueprint of modernity'". Outside being a technical-mechanical phenomenon, the car also gives social and cultural value. It has become a symbol of liberty and the opportunity to move around freely, independent of no one else. The car has also become a symbol of comfort and convenience, and the increase in car ownership ratios seems to be closely linked with economic growth and growing wealth (Hansen and Nielsen 2017, 3).

Like all things, cars demand context around them. When we participate in automobility, we also engage in larger forces that link us to various systems, choices, and interactions. The vehicle requires a significant infrastructure to function. There is a need for "roads, but also bridges, car-carrying ferries, mechanics, roadside-hotels and restaurants, petrol stations, parking space, traffic police, insurance companies, engineering colleges, and a large oil and iron industry, to name a few" (Hansen and Nielsen 2017, 3).
Automobility arguably shapes the way people see the world and conceptualize being a human, conceptualize time and space, and value things in their lives. "We can implicate automobiles, drivers, pedestrians, roads, parking lots, houses, suburbs, petroleum supplies, food availability, energy infrastructures, and many other unique objects, systems, habits, and symbols as part of what makes up automobility" (Pflugfelder 2017, p.5). Because cars interfere in all these areas of society, it inherently makes the vehicle a political issue. Politicians need to balance restrictions and incentives to manage the growing transport sector, especially the increasing number of cars on the road. "Automobility is thus our era's dominant form of mobility, coercing and enabling many different kinds of movement and reliant upon a vast array of technologies forces for its continued availability" (Pflugfelder 2017, 5).

The car is both a technical phenomenon and a cultural and social value phenomenon. The vehicle remains a challenge for achieving sustainable development and representing an object symbolizing consumer aspiration worldwide. The accommodation of traditional cars on the road with internal combustion engines (ICEs) has reached a 'tipping point.' Estimations say that the global population will increase considerably in the years that come. This population increase, coupled with the aspirations people have for attaining a car for the symbolic value and more comfortable life, creates a situation where it is expected that there will be considerable growth in the total number of vehicles globally, especially in the developing world. If most of these vehicles are made with ICEs, this will significantly increase greenhouse gas emissions and intensify air pollution. As it seems highly unlikely that people will stop driving passenger vehicles anytime soon, a transition to electric cars instead of ICE vehicles is considered an important step to reduce emissions from the sector.

Electric vehicles do not emit in the end-use, and transitioning to EVs will promote a more robust shift from fossil fuels to renewable energy sources. The obstacles are that electric vehicles have a higher vehicle price than fossil cars, which have dominated the market for a hundred years. There are also concerns about the driving range and charging infrastructure of EVs. However, these concerns are being increasingly addressed, and governments worldwide are implementing different policies and incentives to create a better market for EVs. Norway is at the forefront.

1.2 Aims, Objectives and Research Questions

Norway has been described as the “poster child of the EV revolution” by the business magazine Forbes (Nikel 2019). However, the reasons behind the relatively successful EV initiative in Norway are often oversimplified. In the Forbes article, the author explains that “the answer is simple, favorable environmental math, and financial incentives” (Nikel 2019).

There is a tendency that the reasons behind the Norwegian EV initiative often are oversimplified. That can potentially create a knowledge gap, as the network of other actors involved in the development of the initiative might be hidden from sight.

This thesis aims to investigate the Norwegian EV initiative, looking more closely at all the actors involved in the initiative. As a researcher, I wanted to understand better who the actors that allowed and constrained the development were and how these actors affect each other in the network.

Actor-Network Theory (ANT) is applied to investigate this Norwegian EV initiative. ANT is a network-oriented approach to exploring different phenomena. It can be a valuable tool to look at the development of the EV initiative in Norway, as it focuses more on the interplay between the EV technology and the organization of the initiative. ANT is a theory but can be better understood as a valuable methodological toolbox because of its ontological perspective and concepts.

The development of the Electric vehicle initiative in Norway certainly consists of many different actors that have shaped the development and implementation of the initiative to increase EVs in the Norwegian market. This thesis will look closely at all these different actors and linkages that have shaped the EV initiative in Norway, both human and non-human actors.

ANT can be described as a systematic method for bringing out the infrastructure behind scientific and technological development. Even if the technology is a success or failure, we are often only given a simplified picture of the implementation of the technology, and some heroic accounts receive the attention. The Actor-Network Theory is concerned with the people, things, devices, and entities that make up technological development's actor-network. It focuses on addressing the complex interplay between the different organizations, processes, and technology to better understand Norway's successful EV initiative development by looking at what has shaped, enabled, and constrained changes. ANT can be described as an excellent toolbox for exploring the connections between actors, how they shape and reshape a technology's development, and how practices and devices work together (Latour 2005, Law 2009). ANT will support me in dealing with how the different actors are *drawn together* and organized through the processes of assemblage. Both human and nonhuman actors will be investigated without any pre-assumption of the power relations. All entities that may be said to act upon the network of actors will be investigated, and I will seek to understand how they have constrained or allowed specific actions to take part in the network. I will study these connections and look at how global currents are also present in Norway's development of the EV initiative. ANT researcher Wiebe E. Bijker (1992, 3) explains how ANT can be used:

> Our technologies mirror our societies. They reproduce and embody the complex interplay of professional, technical, economic, and political factors. In saying this, we are not trying to lodge a complaint. We are not proposing some kind of technological witch hunt. We are not trying to say, "If only technologies were purely technological, then all would be well." Rather, we are saying that *all* technologies are shaped by and mirror the complex trade-offs that make up our societies; technologies that work well are no different in this respect from those that fail. The idea of a "pure" technology is nonsense. Technologies always embody compromise. Politics, economics, theories of the strength of materials, notions about what is beautiful or worthwhile, professional preferences, prejudice and skills, design tools, available raw materials, theories about the behaviour of the natural environment – all of these are thrown into the melting pot whenever an artifact is designed or built. Sometimes the product fails in a tragic and spectacular manner. More often it works.

This thesis will investigate why and how EVs entered the Norwegian market and how different historical events, actions, politics, actors, and international developments have shaped and been shaped to create the environment where the EVs initiative in Norway has become such an unprecedented development. I will look into the different interactions between users, actors, and events and see how these have affected the diffusion of EVs in the country. I will provide the framework for answering the research questions for this thesis:

What are the reasons for Norway's successful development of the EV initiative? Who are the actors behind this development?

1.2.1 Outlining the Chapters

This first chapter has worked as an introduction for the thesis by setting the context for what will follow.

Chapter 2 presents the theoretical and methodological framework, which is Actor-Network Theory. The theory enables the researcher to investigate the EV initiative in Norway through a network-based approach by looking at all the different actors that have enabled or constrained the EV initiative's development. Chapter 2 will explain the theory in greater detail and outline some of the writings and understanding that have informed the research. The methodological approach of this thesis is also described in further detail.

Chapter 3 begins with explaining the “system of automobility.” After that, some of the technical concepts of the electric vehicle are explored to provide some background understanding of the technical actors in the EV initiative. As well, some of the particular Norwegian characteristics are also presented to give some further background knowledge. Both things and people have shaped the EV initiative in Norway, and therefore it is central for the research to explore both.

In chapter 4, the story of the development of the Norwegian EV initiative is investigated in further detail. The story's beginning is marked at the start of the 1990s, and the development is divided into five different time periods. In line with ANT research, the investigation “follows the actors” (Law and Callon 1988, 284) wherever they lead the researcher. The aim is to understand better the network of actors involved in the development of the initiative. In order to follow the actors, the interviewees are allowed much space in the chapter. Quotes from the interview objects are included. They are allowed to make their own theorizing about the story, and influential actors, in line with ANT. Both technical and social actors are taken into account. Additional information from quantitative data and secondary resources are added to balance the story of the development of the EV initiative.

In chapter 5, the actor-network that has been explored in the development of the Norwegian EV initiative is presented. I discuss the different findings and look at how the Actor-Network Theory-concepts are visible in the Norwegian EV initiative. The chapter outline the network of actors involved and how they have shaped and reshaped the development, based on the research in chapter 3 and 4. Also, I investigate and discuss the more comprehensive development internationally and the potential influence by and from the Norwegian development. I also discuss the possibility of a new “system of automobility” and how the transport sector in the future might look.

Chapter 6 concludes the thesis.

2 Theory and Methodology: Developing an ANT Framework

This chapter will present the theoretical and methodological framework, called Actor-Network Theory, that enables me to investigate the EV initiative in Norway. At the beginning of the chapter, I will introduce the chosen theoretical framework before showing some of the resources that informed my writing and understanding of the theory. The final part of this chapter will attempt to show how the insights from the theoretical framework translate into the methodological approach chosen.

The Actor-Network Theory will provide me with the tools to study assemblage processes or the drawing-together of actors in what resembles a network. In this case, through the network of the Norwegian EV initiative.

2.1 Theoretical Framework: A Background in Science Studies

Actor-Network Theory (ANT) is the theoretical framework chosen for this thesis. ANT is applied here in an effort to better reveal the complexities of our socio-technical world through the case study of the Norwegian EV initiative. ANT is described as a good tool for describing networks – how they come in and out of existence, identifying their components, and determining the relationship between different actors. It helps us better understand how certain claimed "truths" are constructed and how various technical objects enable and mediate organized action. The EV initiative in Norway is investigated as such a web of networks. It consists of a wide range of inseparable parts, such as material, processual, organizational, economic, environmental, social, and many other parts. These different parts are linked in multiple ways, each adding to the complex whole, which is the development of the Norwegian EV initiative.

For a long time, the debate surrounding science and technology was dominated by technological determinism. Technological determinists believe science is all-powerful and will eventually reveal anything there is to know about nature and the environment. They think that science can be used for the almost limitless advancement of humankind.

For example, during World War II, the horrible images from the bombing of the two Japanese cities Hiroshima and Nagasaki, showed the world the power that science could contain. The perception was that we, as humans, in turn, could explore and benefit from it. Academic Raymond Williams (1990, 1) described this view in society: "people often speak of a new world, a new society, a new phase of history, being created – brought about – by this or that new technology: the steam engine, the automobile, the atomic bomb."

Technological determinists believe that technology and innovations are the key movers in history and social change. "Technological determinism is the claim that technology causes or determines the structure of the rest of society and culture" (Dusek 2006, 84). Technological determinists also see technology as the driving force of developing cultural values and social structures, not the other way around. Media analyst Marshall McLulan describes the way technology influences society:

> "the medium, or process, of our time – electric technology is reshaping and restructuring patterns of social interdependence and every aspect of our personal life. It's forcing us to reconsider and re-evaluate practically every thought, every action, and every institution formerly taken for granted" (McLulan et al. 1967, 8).

Bearing in mind that this was before the internet's impact, he makes an interesting point.

On the opposite side, you have social sciences. Social sciences have traditionally dealt less with science and technology questions than hard science (Jasanoff 2004). These hard sciences entail natural sciences, economics, and history. To give an example, a car's manufacturing has historically been more of the domain of a mechanic or an engineer. In contrast, social phenomena like culture, beliefs, and values have more often tended to be the territory of social sciences.

During the 1960s, Thomas Kuhn challenged the technological deterministic-view on science and technology questions. He argued that there was a sociological backbone to science that affected how science and technology were created (Kuhn 1962). Kuhn believed that cultural factors, hierarchies, negotiations, and learning processes all played a part in knowledge production. New discoveries or tools could prove previous ‘truths’ wrong, and a paradigm shift would occur. The social factors aided in discovering these new ‘truths.’ He turned the focus over to what the scientists were doing and the way they were creating knowledge. Thomas Kuhn's work inspired other social scientists. Knowledge and research that also focused on the social aspects of technology developed further. It paved the way for new theories on scientific knowledge and its sociology. One of these theories was Science and Technology Studies (STS).

Actor-Network Theory, the theory in focus for this thesis, is a branch within STS. It offers a more holistic view of technology. ANT argues for a socio-technical approach, where neither position is privileged. The actors within a network are placed within a flat ontology to favor neither of the parts. What a flat ontology means will be better explained later in the chapter.

"Our technologies mirror our societies," ANT researcher Wiebe E. Bijker (1992, 3). explains in his book. "They reproduce and embody the complex interplay of professional, technical, economic, and political factors." Bijker believes that pure technology is "nonsense" and that all technology is formed or shaped by our society and the many complex trade-offs within.

> Technologies always embody compromise. Politics, economics, theories of the strength of materials, notions about what is beautiful or worthwhile, professional preferences, prejudice and skills, design tools, available raw materials, theories about the behaviour of the natural environment – all of these are thrown into the melting pot whenever an artifact is designed or built. (Bijker 1992, 3)

Actor-Network Theory provides relevant tools and concepts for understanding the EV initiative in Norway as a dynamic process and product of a complex power play between different actors and interests. Academic Benjamin K. Sovacool (2006, 10-11) explains in one of his articles that the use of ANT in energy technology “can be noteworthy, then for de-centering the technological artefact as the object for inquiry and expanding scholiastic focus on 'technology' to include the vast social and cultural networks that surround it."

This thesis is concerned with the development of the Norwegian EV initiative and how the development has been shaped. The Actor-Network Theory will serve primarily as a tool in this research to explore the socio-technical processes and analyze both the human and non-human actors that have played a part in this complex network, often referred to as assemblage. The investigation will focus on the relational aspects amongst the politicians, historical context, pioneers, economics, environmental organizations, artifacts, manufacturing techniques, strategies, and social and cultural factors surrounding the development of the EV initiative in Norway.

As will become evident in the following subchapter, this application of ANT will be in line with the tradition of approaching research as an inductive process where the collection of data is gathered empirically through interviews, without pre-established assumptions or notions about expected outcomes.

The following part of this chapter provides an overview of some of the valuable literature, resources, and insights that have helped shape this study. A brief introduction to some relevant literature to understanding technological development in society and the importance of energy for the development of modern society in Norway is provided. Then Actor-Network Theory is thoroughly reviewed, and I provide some key concepts for understanding ANT. I will also explain how I will use these concepts from the theory in my methodological approach. The Actor-Network Theory approach will allow me to attempt to uncover the people, organizations, facts, documents, and policies that have been shaped and reshaped to create the technological development and acceptance for EVs in Norway. These actors combine, shape, and reshape to provide the overall environment that sets the conditions for a technology to succeed or fail.

2.1.1 Technological Sublimes – Shaping Society

When studying the process of the EV initiative in Norway, it can be helpful to also look at the connection between technologies and society. Some technologies can awake and change feelings, thoughts, and opinions amongst people. Professor David Nye has spent a lot of his academic career studying the importance of technology in society and how the two have evolved together through history, each affecting the other. In his book, *American Technological Sublime,* he adds extra attention to the social aspect of technological extremes, such as the development of the Golden Gate Bridge (opened in the US in 1937) or the Moon Landing (in 1969). About technology, he explains:

> [It can create] experiences of awe and wonder, often tinged with an element of terror, which people have had when confronted with particular natural sites, architectural forms, and technological achievements. This book is about the social construction of certain powerful experiences in industrial society, which is to say it is about the politics of perception" (Nye 1994, xvi).

Immanuel Kant, the famous philosopher, also reflected on the concept of the sublime. Nye aligns with Immanuel Kant, the well-known philosopher, who also contemplated about the idea of the sublime object. In Kant's work *Critique of Judgement*, published in 1790, Kant explains that:

> The sublime can also be found in a formless object, insofar as we present *unboundedness*, either [as] in the object or because the object prompts us to present it, while yet we add to this unboundedness the thought of its totality…So it seems that we regard … the sublime as the exhibition of an indeterminate concept of reason… But the other liking (the feeling of the sublime) is a pleasure that arises only indirectly: it is produced by the feeling of a momentary inhibition of the vital forces followed immediately by an outpouring of them that is all the stronger. Hence, it is an emotion, and so it seems to be seriousness, rather than play, in the imagination's activity (Kant 1987, 98).

Immanuel Kant believed that the sublime should be understood as a moral experience. It creates an environment for reflections and emotions in our minds that makes us conscious of ourselves. David Nye explains that sublime objects give us "courage to measure ourselves against the apparent omnipotence of nature" (Nye 1994, 7) and that technological objects "fuse practical goals with political and spiritual regeneration" (Nye 1994, xx). He also expresses the importance of grasping the sublime around new technologies. The idea about technological sublimes, also emphasizing social aspects and values, is an opposing force to the already mentioned technological determinism. These technologies are more than just something that has been created or built; they also express a belief in what will happen next. These new sublime technologies can represent promises about a wished development (Nye 1994).

It is valuable for this thesis to also apply the concept of technological sublimes to a Norwegian context. Norwegian scholar Knut Sørensen mentions the massive expansion of hydroelectric power for industrial purposes in Norway during the 20th century as an example. Norway utilized its rivers, lakes, and waterfalls to produce electricity for the growing industry. Sørensen described it as a symbolically important project for Norway, developing a modern society and creating the narrative of "building the country" (Sørensen 2010, 74). Another example is the building of the Årdal aluminum plant. It has been called "a symbol for the modern Norway" (Asdal 2008, 109).

What type of process is the electric vehicle initiative in Norway? The answers will probably vary a lot, depending on who you pose the question to. The question opens for different interpretations, and will probably awake different feelings, thoughts, relations, and opinions that people attach to the initiative. It can be presented in social constructions. Some might attach terms like "environmental-friendly" or "green" to it, while others might claim the complete opposite. They might argue that it is "unsustainable," "counterproductive," or simply a "symbolic political policy" rather than a policy that actually gives substantial emission cuts. These answers are not rigid technical definitions but show the different interests and values the people asked might have. As Norway is receiving international attention for its leading adoption of electric vehicles, the electric vehicle can perhaps be viewed as such a technological sublime. This is further discussed in chapter 5.

2.1.2 The Current Fossil Paradigm and the Need for Innovations

A transition to a carbon-neutral society will demand massive cuts in emissions in every sector, in every corner of the world. One of the tremendous challenges is that fossil fuels are still the dominating source of our energy consumption. Estimations point out that more than 80 % of our total energy consumption comes from fossil fuels (Ritchie and Roser n.d.). For the future, the target is to replace this fossil regime with a regime where renewable energy dominates the energy mix.

Researcher Keith Smith (2011) describes the current status in the world as a situation of a fossil fuel lock-in. He describes it as a “fossil energy regime” (Smith 2011, 23). All the resources, technology, organizations, businesses, and how we apply energy have been locked in on the extraction and usage of fossil energy. He argues that the transition to a renewable energy regime will require a historical shift on a scale we have not seen since the industrial revolution. The industrial revolution changed how people conducted their work. With the use of fossil energy, like coal, we were enabled to run machines in a way we had never been able to before. Now we must move beyond this dependency on fossil energy to a new paradigm based on renewable energy sources.

To analyze this required transition from fossil to renewable energy sources, Smith separates what he describes as different necessary innovations. The first type of innovation is what he describes as *incremental innovations* (Smith 2011). These innovations are less significant changes to the already established products and processes. For example, in the automobile industry, incremental innovations could be innovations that reduce the car's total weight or increase the engine's fuel efficiency. These innovations would reduce the usage of fossil energy. The car manufacturers will still work within a known environment. These incremental changes are helpful to cut emissions but will not be sufficient for the world to limit the worst consequences of climate change. As Smith argues: "This form of innovations is first and foremost about further developing existing technologies either by improving the performance levels on some areas or by reducing costs by more efficient application of resources and materials" (Smith 2011, 27).

Smith explains that it is far more complicated to apply what he calls *disruptive and radical innovations*. Successfully using these disruptive and radical technologies will require a lot of resources and time and might be considered risky by many. There is not only a lack of resources and knowledge that stops these disruptive technologies from being used. These innovations might challenge the existing market relations and the established companies in the businesses. They are new technologies or ways to produce that have the potential to outcompete the traditionally dominating businesses. When these technologies are being introduced, prominent market actors might be reluctant to the proposed changes. They will perhaps try to stop the transition and are might be supported by certain political parties in situations where the companies have a connection to political decision systems. Therefore, politics also have a prominent role in the transition to take place. Smith explains that the challenge we are faced with when it comes to reducing climate emissions "is a challenge that requires more than just *incremental innovations* tied up with existing technologies. Not even disruptive technologies are sufficient. The transition requires a complete regime change" (Smith 2011, 31).

Scholar Staffan Jacobsson (2011) discusses how these changes can come about. He introduces the need for *technological innovation systems* to be built (Jacobsson 2011). These systems are "a network of actors," including businesses, actors, resources, financial institutions, and knowledge organizations that work together to develop, produce and use new sustainable technology.

So how are we to move beyond this fossil paradigm? Developing new technology is "forty percent development and sixty percent missionary work," Sørensen explains (2010, 82). The current political, material and social systems require a reorganization. We must see the creation of new networks and actors that break the current fossil paradigms. These new networks and actors must focus on innovations that deeply reduce global emissions for the different sectors. For disruptive or radical technology to succeed, you need great technology, impressive political work, and convincing the public as well as the businesses.

2.2 Actor-Network Theory

As mentioned above, Actor-Network Theory is a branch within Science and Technology Studies (STS). STS brings together insights from several academic disciplines to explore the role of science and technology in society. STS literature is a diverse field that includes applying disciplines like social theory, cultural studies, law and politics, anthropology, philosophy, and economics (Jasanoff 1995).
A key group of sociologists and philosophers, including Bruno Latour, Michel Callon, and John Law, developed ANT to respond to what they felt were certain shortcomings within the field of STS (Latour 1987, Muller 2015).

Latour (1987, 4) explains that ANT moves beyond STS and focuses on "science in the making." In his book, *Reassembling the Social: an introduction to actor-network-theory*, Bruno Latour (2005) discusses the reasoning and circumstances that led to the creation of ANT. His work in this book is described as one of the more significant works within the field (Sovacool 2017). Latour explains that ANT writers wanted to go back to the roots of sociology, namely the scientific study of social life. The subject of sociology consists of the two elements science and society. These two elements are complexly intertwined with one another.

An important perspective within ANT is what some writers and researchers refer to as a 'flat ontology.' A flat ontology can be understood as a model where all objects have the same degree of being-ness. Initially, all things have the same value. The critical factor is their ability to affect other objects. This perspective moves humans away from the center of agency, in contrast to what conventional social views have done. Latour's 'flat ontology' builds on two essential premises. The first is that human and non-human actors are equal actors. The social entities are not favored over the technological but treated at an equal footing. The second premise is that these actors do not have any agency or qualities on their own but are shaped by their relations with other actors/entities. Latour explains that sociology has taken society as a given context, while ANT researchers will investigate closer how various elements and influences shape society by "tracing associations" (Latour 2015, 5).

A fundamental insight in ANT is the belief that any entity –people, animals, or things, is the result of a drawing together of other entities, represented by its relation to these other entities. John Law (2009, 141) explains that ANT "describes the enactment of materially and discursively heterogeneous relations that produce and reshuffle all kinds of actors including objects, subjects, human beings, machines, animals, 'nature,' ideas organizations, inequalities, scale and sizes, and geographical arrangement."

ANT seeks to explain how scientific or technical objects become integrated into our everyday lives (Sovacool 2017, 81). These objects are not things in the usual sense but rather "nodes in a network that contains both people and devices in interlocking roles" (Feenberg 1999, 114). ANT attempts to uncover all these "nodes" that are drawn together in this heterogeneous network. These nodes can, for example, be facts, machines, people, or politics that are aligned and shaped together into a network to create an overall environment that provides the conditions for a technology to succeed or fail.

The term "actor" is also worthy of extra attention when understanding ANT. The ontological perspective of ANT gives both human and non-human actors equal footing. Bruno Latour prefers using the word 'actants' instead of 'actors,' as it comes across as a more neutral term. It gives extra attention to the idea that actors might as well be non-human entities. The concept of mutual dependency explains the reason for the decentralization of the human actor. For this thesis, I will stick to the term actor. However, as outlined here, actors can be both humans and non-human entities, and they are both placed on equal footing ahead of the research.

ANT researcher Callon (1986) explains that both human actors and technological objects are equally dependent. In his text, he describes the development of electric vehicles in France during the 1970s. At the time, many believed this would become an important technological innovation in France. The French project, initiated in 1973, asked two French electric companies to develop a new electric car. The project included many different actors, like consumers, government departments, battery technology, and other social and non-social entities. "An entity in an actor-world only exists in context," Callon explains (1986, 30). He investigated how the electrons, the customers, the public regulators, and Renault, who accepted a change in manufacturing, were all on an equal footing in the network. "None of these ingredients can be placed in a hierarchy or be distinguished according to its nature" (Callon 1986, 23).

In his book, Pandora's Hope, Bruno Latour (1999) provides an example of how entities do not have inherent qualities on their own but take form due to their relations compared to other entities. His example is the gunman. A man and a gun can form a new entity when connected. This new entity is the gunman. A man cannot shoot someone all by himself, despite what some pro-gun lobbyists might say. On the other side, the argument might be that the gun itself causes the problem. A weapon that fires all by itself is relatively rare. ANT desires to focus on the connection that brings together the man and the gun, creating a gunman. The gunman can shoot someone, whereas the man and the weapon by themselves do not do this. ANT research can provide unexpected conclusions. Here, the argument is that the actual connection between the two entities, the man and the gun, is to blame for all the shootings worldwide, not the man or the gun by themselves.

There is also a debate whether the Actor-Network Theory is a theory at all. Some call it a theory; others call it a method. John Law (2009, 141) argues that "the actor-network approach is not a theory. Theories usually try to explain why something happens, but actor-network theory is descriptive rather than foundational in explanatory terms." Bruno Latour has remarkably argued both that it isn't a theory (1998) and that it is a theory (2005). He first and foremost argues that ANT is a "negative argument" against the established social sciences, rejecting that theoretical frameworks can be "applied" to explain any given case (Latour 2005).

As mentioned, one of the central points in ANT research is that the aim is to follow the actors. ANT researcher John Law (1992, 380) explains that "if we want to understand the mechanics of power and organization, it is important not to start out assuming whatever we wish to explain." Therefore, the foundation for an ANT study should focus more on the actors' own "theorizing" of what they do. ANT leaves more space for the actors themselves to shape the structure of the study, opposite to more structuralist ideas where pre-established structures and ideas are the foundation for the study. "There is an old rule of sociological method, unfortunately more honoured in the breach than the observance, that if we want to understand social life then we need to follow the actors wherever they may lead us," Law and Callon (1988, 284) explain to us.

Instead of mapping underlying or pre-established systems that form the world around them, ANT expresses that stable formations are only the exception to the rule. These stable formations do not have a shape or from outside the cases in which they are represented (Law 2009, 141). When a stable pattern occurs, these are the exceptions to the rule because the world we live in is described better by change and non-order. An ANT investigation wants to explore the case in front, without giving attention to pre-established "social" constructs like 'power,' 'identities,' or 'interests' as a starting point for the research. These constructs do not exist independently outside the specific case under investigation. Instead, these actors are worthy of being explained through the case they play a part in, rather than by pre-established language. John Law discusses this way of ANT research:

> For instance, it is a good idea not to take it for granted that there is a macrosocial system on the one hand, and bits and pieces of derivative microsocial detail on the other. If we do this we close off most of the interesting questions about the origins of power and organisation. Instead we should start with a clean slate. For instance, we might start with interaction and assume that interaction is all that there is. Then we might ask how some kinds of interactions more or less succeed in stabilising and reproducing themselves: how it is that they overcome resistance and seem to become "macrosocial"; how it is that they seem to generate the effects such power, fame, size, scope or organisation with which we are all familiar. This, then, is one of the core assumptions of actor-network theory: that Napoleons are no different in kind to small-time hustlers, and IBMs to whelk-stalls. And if they are larger, then we should be studying how this comes about -- how, in other words, size, power or organisation are generated. (Law 1992, 2)

ANT emphasizes that it is better to study group formation instead of just groups. Another way to say it: the goal is to describe what is being glued instead of the glue itself (Latour 2005, 5). The task is to deconstruct the group and investigate what is going on inside. An example of this is to examine the group called a "home." A "home" contains many different entities, like building materials, paperwork, and the efforts of builders, architects, and others. Another example, the car, can be deconstructed into many different entities.

During these pages, I have tried to explain Actor-Network Theory in more abstract terms. However, this misses the point slightly. As mentioned above, ANT does not seek to create generalizable knowledge. Every case study is unique and should be treated as such. John Law elaborates that ANT seeks a more descriptive approach to knowledge production instead of a foundational approach. It does not seek to create a prominent theory of generalizable knowledge but instead tries to show a description or account of the case at hand. ANT can better be understood as a "toolkit for telling interesting stories about, and interfering in, those relations" (Law 2009, 141-142).

The main point in ANT research is that it explores how actor-networks are composed and how they emerge. It looks at how the networks are shaped and maintained and how they compete with other networks and are made more durable over time. It allows the researcher to investigate a case without any pre-established structures or ideas as a foundation, following the actors wherever they might lead the investigator.

In the following part, I will describe the concepts: assemblage, translation, and punctualization. These are important to understand when conducting ANT research as well as for interpreting the investigation.

2.2.1 Central concepts for doing ANT research

For this research, I have chosen three Actor-Network Theory concepts I believe are essential for the reader to have an understanding of. These three concepts are assemblage, translation, and punctualization. First, it is necessary to mention that during ANT's historical development, these processes and concepts have been applied in slightly different ways and with varying relations among each other.

The first concept central to the understanding of ANT is the processes of ***assemblage*** in actor-networks. The assemblage of an actor-network refers to the drawing together of different heterogeneous entities in a network (Muller 2015, 28). The assemblage is relational, as these multiple actors/entities are linked together to form the actor-network. For the actor-network of the EV initiative, these heterogeneous entities are all the things that may act upon other entities in the network. They are part of the assemblage. For example, the batteries, humans, documents, targets, sites, and policies that play a role in the network. Assemblage is regarded as one of the central components and focus areas when conducting ANT research. It "refers to the ordering of dissimilar entities so that they work together toward a common goal for a particular period of time" (Sovacool 2017, 82). Deleuze and Parnet (1987, 69) elaborate on this and explain that an assemblage contains "a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them across ages, sexes, and reigns-different natures. Thus, the assemblage's only unity is that of co-functioning: it is a symbiosis, a 'sympathy.'" In these networks, assemblages are relational. It arranges human and non-human actors together to form a collective whole.

> In our societies, there are thousands of lieutenants to which we have delegated competences, it means that what defines our social relations is, for the most part, prescribed back to us by non-humans. Knowledge, morality, craft, force, sociability are not properties of humans but of humans accompanied by their retinue of delegated characters. Since each of these delegates ties together part our social world, it means that studying social relations without the non-humans are impossible (Johnson 1998, 310).

These assemblages work in a dynamic way because they constantly couple up with other entities in the network that have little value independently. In the absence of one of the critical components in the network, the whole assemblage might fall apart. In the research of EVs and automobility, ANT decenters the focus on solely technological objects and expands the focus of "technology" to involve the related cultural and social networks. The belief in a flat ontology as a starting point for ANT research enables the researcher to investigate closer all the networks around the development, without any pre-existing explanations.

As John Urry, a researcher who has looked a great deal at mobility, explains: "The adoption of automobiles is the product of a complex power play between divergent actors and their interests" (in Sovacool 2017, 82).

Necessarily, ANT research also needs to set some boundaries for the inquiry – meaning which actors should and should not be included. However, following the ontological nature of ANT, it is undesirable and difficult to limit this world before the investigation, as some actors will first become visible during the research. Still, a prior conception of the elements comprising the actor-world to be investigated is necessary. But, as Callon (1986) argues, the researcher should keep in mind that every single actor within the network is essential to its existence. If one of the actors is removed, the whole development can potentially fall apart. In ANT, all these actors can be understood as performative, as they have the ability to push, limit, allow or constrain specific actions or performances within the network. Professor Kristin Asdal explains that ANT is not concerned about finding an assumed structure that can be applied to all cases but rather "about examining that which enables and constrain action" (Asdal 2011, 222). However, this does not say that all the actors within a network are just as equally important or should be managed in the same way. When using ANT, the researcher should focus on all the surroundings that may enable or constrain actions in the network. This concept was central to Latour in his book called *Aramis or the Love of Technology* (Latour 1996). In this book, he writes about the failed railway system in France and how technology must fascinate and interest humans and things simultaneously. Therefore, the innovator behind the development has to trust the assemblage of things that have particular uncertainties, like the uncertain nature that groups of people have.

> The same sort of involvement that has to be solicited from DATR, RATP2, etc. now has to be solicited from motors, actuators, doors, cabins, etc…they too have their conditions, they allow or forbid other alliances. They require, they constrain, they provide (Latour 1996, 56).

The second concept in this thesis is **translation**. It can be viewed as a contended phase, as it is vulnerable to resistance (Callon 1986). It can be understood as the process where actors within the network assign roles and characteristics to other enrolled actors to pursue their own vision or aims. One actor might influence another actor and attribute it with identity, interests, a role to play, a course of action to follow, and projects to carry out. Acceptance for these translations are not given, and therefore, conflicts might arise. The success of translation can never be taken for granted. As Callon (1986) explains, the actor-networks stability, or durability, depends on the abilities of the so-called translator-spokesperson. This translator-spokesperson's successful ability to enroll and translate other actors within the network decides the success or stability of the actor-network. "The translator is thus the spokesman of the entities he constitutes" (Callon 1986, 25). Callon also explains that translation is at first an endeavor (an attempt to achieve a goal) and that later it may be reached:

> Translation build an actor-world from entities. It attaches characteristics to them and establishes more or less stable relationships between them. Translation is a definition of roles, a distribution of roles and the delineation of a scenario. It speaks for others but in its own language….Translation cannot always be taken for granted, and the strategies used depend upon the particular circumstances in which they develop…. Successful translation depends upon the capacity of the actor-world to define and enrol entities which might challenge these definitions and enrolments. (Callon 1986, 25-26)

The concept of translation is concerned with how actors within the network mobilize, compare, and hold together bits and pieces. It is the process that refers to the negotiations and definitions that occur when an actor's identity, relations, and opportunities of actions attached to the network are decided. This thesis will look at these translation processes and how actors have translated and changed other entities as they are enrolled into the network.

The third phase concept is **punctualization**. This process is often also called 'black boxing.' A black box is something people can call a system or process where they know the result it produces, but they do not understand how it works. They can realize its function without knowing much about how the internal parts work. Famous ANT scientist Bruno Latour (1999, 304) explains black boxing as this:

> The way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need to focus only on inputs and outputs and not on its internal complexity. Thus,

> paradoxically, the more science and technology succeed, the more opaque and obscure they become.

ANT is concerned with opening up these ' black boxes' and revealing their inner workings. Actor-Network Theory research can also investigate how certain actor-networks become black-boxed.

A very relevant example is the car. It can be investigated to show how black boxing works. The car has been a significant technological development that has enormously affected modern society and personal mobility. It is now recognized by most as an indispensable element of modern-day society. When the cars run smoothly, people tend to focus very little on the internal complexity or workings of the car. An argument is that when the vehicles have improved, the user's knowledge about the car's inner workings decreases. For example, the knowledge might be weaker about the inner workings of the engine and what exactly happens when the gear changes. This lack of knowledge does not necessarily apply only to the technical factors, but can also apply to the poltical efforts behind. When the vehicle is fully integrated into everyday life, people might forget the car’s development policies. This black boxing of the car is relevant to this thesis. As Latour said: the more successful the technology, the more "obscure they become" (Latour 1999, 304).

Actor-Network Theory focuses on opening up the black boxes of technologies, as some of the entities might become invisible as the scientific or technical work has succeeded. Even entire actor-networks may be punctualized within larger networks. As Callon states, "the process of punctualization thus converts an entire network into a single point or node in another network" (in Cressman 2009, 7).

As the network stabilizes, some entities might be given greater importance than others. An example is Louis Pasteur, the French microbiologist who is considered "a hero of French science" as well as a "great man" who revolutionized French agriculture. Bruno Latour, however, argues that it is more suitable to consider Pasteur as a product of everything that happened around him at that time. Instead of the notion of Pasteur as a great man, he instead argues that "all actions, including those of great men, are relational effects" (Law 2009, 145). Latour then illustrates how a network of domesticated farms, technicians, laboratories, veterinarians, statistics, etc., was generated in France at that time. "Farms were turned into laboratories, vaccines made from attenuated bacteria, cattle stopped dying of anthrax, and Pasteur became a great man" (Law 2009, 145). Another way to phrase it is that Pasteur was a great network.

In ANT, a network is not any more robust than its weakest link. Thomas Hughes (1983) exemplifies this with the car. The car is a stable network when all the different parts work together at the same time. Many parts effectively become invisible and produce the stable network – the car – with the inner working remaining "black-boxed" (Latour 1999), presuming that the internal works run smoothly. However, if one of the parts stops working correctly, it can affect the rest of the network, and the result might be a breakdown of the system. The example illustrates the fragility of the network. A fossil car can contain hundreds of working parts. If, say, for example, the spark plugs stop working, the whole network of the car might break down, and the vehicle will not work. Actor-Networks tends to highlight certain actors, while others will be given less attention. Especially stable networks will produce fewer traces that can easily be identified and researched. Therefore, a good ANT account will try to include as many parts and traces from the network as possible and treat each entity as a "full-blown actor" (Latour 2005, 120).

As mentioned before, in ANT, there is no distinction between human and non-human actors. Because of this, both technical and social actors in the network should be taken into account when investigated. If one actor within any of the two fails, it can result in a failure of the whole system. Michel Callon (1986, 22) exemplifies this through his research on the development of the electric vehicle in France during the early 1970s: "For, if the electrons do not play their part or the catalyst become contaminated, the result would be no less disastrous than if the users rejected the new vehicle, the new regulations were not enforced, or Renault stubbornly decided to develop the R5."

In *Reassembling the Social* (2005), Latour also introduces *intermediaries* and *mediators* and explains their relationship. He describes *intermediaries* as objects that can be viewed as inputs and outputs without knowing their internal workings. Intermediaries move force or meaning throughout the network without changing the content or quality of it. Mediators "transform, translate, distort, and modify the meaning of the elements they are supposed to carry" (Latour 2005, 39). In summary, mediators transform meaning or force, while intermediaries do not transform meaning or force. Mediators are unpredictable and can not be taken for granted. Therefore, good ANT research should include a description of as many mediators as attainable and describe how they contribute to creating connections with other mediators within the network.

This research will give extra attention to the concepts discussed above, which are assemblage, translation and punctualization. Both Cressman (2009) and Latour (2005) explain that the way people interpret ANT may be very different. Therefore, providing this detailed overview of ANT and its central concepts has been a challenging task. However, the above discussion is an effort to provide a general overview of some of these central concepts, which might be essential when understanding the work in this thesis. The relevance of these concepts should become further evident during the presentation of the case below, especially in the chapter 5 discussion.

2.3 Methodological Framework

As already suggested, ANT is maybe not so much a theory. It can instead be interpreted as a methodological toolbox for doing research. With its ontological perspective and concepts, ANT can be applied in various ways in many different cases. It is applicable within many subjects, from medicine and geology to technology studies. However, what unifies all ANT studies is the unifying call to "follow the actors" (Latour 1987, 2005).

Therefore, to follow the above-stated unifying call, this study applies ANT to a "national" case (limited to Norway), allowing access to some relevant actors. A global case would have further complicated the picture of relevant entities and actors and possibly further limited access to relevant actors.

Still, the development of the Norwegian EV initiative does not exist in a vacuum, unaffected by global events. At the same time, events in the Norwegian EV development might have implications and connections to the more extensive EV development internationally. This local-global connection illustrates the potential significance a case like this can have in the context of the more comprehensive sustainable energy transition, both in Norway and around the world.

Following the concept of a flat ontology in ANT, the thesis does not make any recommendations or prior assumptions about the most important or appropriate inquiries. Even further expanding the research to a regionwide or perhaps worldwide sphere could have been a valuable addition to this work. However, that would move beyond the scope of this particular research and beyond the resources and time available for the researcher. Following the actors in Norway's development of the EV initiative has been an enlightening endeavor and hopefully has provided some valuable knowledge for the reader.

In summary, this thesis will use ANT as a tool to attempt to highlight the actor-network involved in the Norwegian EV initiative. The complexity of such a development will be illustrated, and an overview of many of the different actors that have played a part in the development of the EV initiative in Norway. As ANT does not believe in creating general knowledge applicable to all cases, this thesis will not try to make a general rule or framework relevant to any given topic. The effort will be to describe the formation of actors within this specific case study. The actors will be allowed to make their own theorizing about the development of the initiative, instead of me as a researcher theorizing for them. Also, the three central concepts, the assemblage of actor-networks, translation, and punctualization, will be discussed in relation to the study of the Norwegian EV initiative.

Still, a further elaboration on the methodological foundation for this research is necessary to set the foundations for the following research presentation, investigation, and discussion of findings.

By following the actors within this EV initiative and taking all that they have said or done into account, the research shows how different forces around a technological development can shape, reshape and define its very own existence. To let the actors be 'spokespeople' for their interests is key to Actor-Network theory. Tracing the actors will lead the research to a proper understanding of the technology and initiative under investigation.

With this in mind, the first step of the methodology for this research was to identify specific actors relevant to the Norwegian EV initiative. To work out a list of various actors and their potential importance, it was necessary to build up a certain knowledge base about electric vehicles and their importance.

The early parts of the research were dominated by conducting a sizeable literature review to build a reasonable basis for knowledge about the topic. Through these reviews, I was also able to make expectations and identify potential problems that I could further investigate through the empirical study. However, I needed to think critically about how I created this base level of knowledge on the topic. As for most literature reviews, the reader must remember to think about the potential motivations, positions, or biases that those that write the article might have. If I had been uncritical, this could have led me to take some of the literature's perspectives for granted, therefore building up preconceptions.

In the start, I searched for academic articles and books. Its been written much about electric vehicles around the world, especially during the last decade. If you type in 'Electric Vehicles' in the google search tool, an extensive number of different articles will show up on the screen. Norway is widely mentioned, and this provided me with an excellent opportunity to build up knowledge valuable for my later research. Especially within the development of the EV initiative, a critical review of the articles was necessary.

Articles from, for example, *Elbilforeningen* (The Norwegian EV Association) might have political motivations to push further development of the EV initiative behind their claims. While, for example, the study released by the German Research Institute (IFO) that claimed that electric vehicles in Germany emit more carbon than diesel cars proved to have other motivations, influenced by, for example, traditional car manufacturer lobbies (Brussels Times 2019). This German report was later slaughtered in international media and proved to have many errors and inaccuracies in the information. To make the focus smaller, I later started to investigate articles focusing more solely on the development of the EV initiative within Norway. For example, 'Elbil på Norsk' (Asphjell et al. 2013), a Norwegian book about the EVs history in Norway, proved to be a great asset in building up my knowledge about the surrounding settings in the Norwegian development of the EV initiative. When on the path of investigation, I accessed an increased number of relevant available material. A challenge hence became to narrow down the literature list, a task easier said than done. Reports from TØI

(Figenbaum and Kolbenstvedt 2013; Assum et al. 2014; Figenbaum 2017; Figenbaum 2019) did, for example, prove valuable to gaining knowledge to statistical data and quantitative research on the development of the Norwegian EV initiative. I have also evaluated primary documents relevant to the thesis. One of them is the government document called NTP (the National Transport Plan). This document provides an overview of the transport sector and explains the official political plans for the sector moving forward. The latest NTP was released in 2021 and presents the Norwegian Government's politics in the transport sector for the next 12 years (Det Kongelige Samferdselsdepartement 2021). After going through all these different sources, I developed a clearer idea about the development of the initiative and who the relevant actors might be.

As with an ANT approach, the emphasis is on listening to the actors within the network. "This rule of method, then, asks us to take seriously the beliefs, projects, and resources of those whom we wish to understand" (Law and Callon 1988, 284).

Despite the rather theoretical discussion in this chapter, the research can be said to be driven more by methodology than by theory. As stated previously, ANT can be perpetrated as more of a methodological toolbox than a theory, with its ontological perspective and principles. The main target in this thesis will be to follow the actors (Latour 1987, 2005). The data was collected through in-depth semi-structured interviews, considering the benefits and disadvantages of this approach to data collection. The thesis contains interviews with four actors that either have extensive knowledge about the development of the Norwegian EV initiative or have been involved as one of the actors themselves. The people I interviewed were:

- **Øystein Asphjell**, engineer. Is one of the three authors behind the book *Elbil på Norsk* (Asphjell et al. 2013). Øystein has an above-average interest in cars and worked in the construction department at Think from 1999.

- **Odd Einar Dørum**, Former Norwegian politician and former Member of Parliament, representing Venstre (the Liberal Party in Norway). Odd Einar was an active politician who promoted the EV initiatives during the 1990s and the beginning of 2000. He was Norway’s Minister of Transport from 1997-1999.

- **Ole Gudbrann Hempel**, by the time of the interview he worked as Business Manager of Public Charging at Fortum. Here he had responsibility for the development of the charging infrastructure at Fortum. He now works at Tesla. The interview represents his thoughts and ideas at the time he worked at Fortum.

- **Marius Valle**, technology journalist at Teknisk Ukeblad (TU) in Norway. He has written a substantial amount of articles about the development of electric vehicles in Norway. He runs a podcast about EVs – called Elbil – Teknisk sett – where he discusses EV technology with a colleague at TU.

There were many reasons why these actors were chosen. The hope is that their various backgrounds will help provide a comprehensive picture of the development of the EV initiative in Norway. Deciding who I was going to interview was based on a few different factors. First, the knowledge gained from the literature reviews formed both the framing of the questions and the actual people I wanted to interview. Canadian anthropologist and author Grant McCracken elaborates on the importance of the literature reviews before interviews:

> "It begins to establish the domain the interview will explore. It specifies categories and relationships that may organize the data. It helps to indicate the larger factors that direct respondent testimony. It helps to determine what the respondent should ask about and what he or she should listen for." (McCracken 1988, 31)

As the research will show, some actors who had a central role in the development were not interviewed in this thesis. I did initially try to contact them both by mail and phone. However, either a lack of response or lack of time on the actors' behalf were most often the reason the actors were unable to be involved in an interview for this thesis. However, as they were important actors, they are still presented in detail during the investigation. Still, I believe that the actors in this thesis provide exciting perspectives and reflections and the development of the EV initiative in Norway.

The interviews follow Kvale's 'traveler metaphor,' where the interviews look more like conversations, structured at the beginning around some central topics, but with plenty of space for additional questions that emerge as the conversation goes on (Kvale 2008).

In line with the Actor-Network Theory approach, the interviewees were allowed to dictate the direction of the conversation to a great degree. During their interviews, I wanted to hear their perspectives, worries, thoughts, feelings, and expectations, in line with the ANT approach to “follow the actors.” The questions were kept as open and general as possible to lead to more relevant and detailed responses from the interviewees. The main target was to encourage the interviewees to speak as much as possible, with me as the interviewer interrupting as little as possible. For example, a question like “Can you tell me more about the main challenges in the EV initiative in the beginning?” led to a better response from the interviewee than if I had asked: “Was the price of the electric vehicles a primary challenge at the beginning of the EV initiative? The second question's response would probably be of less value as the question could be answered relatively short.

The interviews were both recorded and transcribed. I believe this reduced the risks of misunderstandings. The transcriptions were later translated into English. I have done my utmost to make sure the content of the conversations has not changed. Most of the interviews were conducted during the covid-pandemic. All the interviews were therefore done over the phone (on speaker). Of course, this had some implications for how the conversations, as the interviewer and interviewee could not see each other.

The thesis also uses secondary data from sources such as news articles, government- and corporate articles, and journal articles. These complement the primary data, provide further context, and extend the insights into the relationships and roles of different actors. These sources are valuable for the discussion of the results from the primary research.

During 30 years of development, it is clear that the number of actors that have played a part has become quite extensive. One significant challenge has been the number of actors involved in various degrees in the network of the development of the Norwegian EV initiative. During the research, the potential size of the actor-network was very extensive. Therefore, this thesis has made some priorities over which actors to include. Latour introduced the concept of *intermediaries* and *mediators* in his book *Reassembling the Social* (2005). As mentioned in chapter 2.2.1, mediators are actors that transform and translate meaning or force through the network. Therefore, this thesis has tried to describe as many mediators as possible, which means actors who have changed and translated meaning or force in the development of the Norwegian EV initiative. I have done this by allowing the interviewees lots of space to theorize about the development of the initiative and which actors they believed played a significant role. Also, extensive use of secondary resources has supported the choices of mediators in the network.

Another challenge has been the issue of subjectivity within ANT. One of the concepts in Actor-Network Theory research is that the actors themselves are allowed to shape the structure of the study, opposite to more structuralist ideas where pre-established ideas and structures lay the foundation for the theory. The interviewees tended to speak mainly about the importance of the network they have the strongest connection to. I would argue that the people I have interviewed have substantial implications for the structure of this thesis. Thus, to counter some of this subjectivity, the thesis also uses secondary research to provide perhaps more balanced views on the development and the importance of the different actors.

In hindsight, this research is perhaps grasping over a too extensive actor network. Thirty years of development has created a considerable amount of different actors involved. Therefore, bearing in mind the scope and size available, I could perhaps have benefitted from narrowing down the focus of the development. This could be interesting for a later research project. Still, I believe this research provides an exciting account of the development of the Norwegian EV initiative.

3 The Electric Vehicle: Organisation and History

As both people and things are of equal importance in ANT research, the following part will investigate some of the central technical concepts within the electric vehicle. Both things and people have shaped the EV initiative in Norway, and without one or the other, the network might have collapsed. Therefore, this chapter will investigate some of the essential workings inside an electric vehicle, in line with the ANT approach to treat both human and non-human actors equally at the start of exploring. It will introduce the idea of a «system of automobility" and explain what this system entails. Especially the battery within the electric car will be further analyzed, looking at how certain advancements have contributed to the increased attention to electric vehicles. Also, some Norwegian characteristics will be presented to provide some background understanding.

3.1 EVs as part of the wider 'System' of Automobility

> Today, we experience an ease of motion unknown to any prior urban civilization… we take unrestricted motion of the individual to be an absolute right. The private motorcar is the logical instrument for exercising that right, and the effect on public space, especially the space of the urban street, is that the space becomes meaningless or even maddening unless it can be subordinated to free movement (Sennett 1977, 14).

When analyzing the electric car, it is also valuable to look at the EV within a broader automobile context. The electric vehicle is also part of the more extended history of the car. The car plays a central role in today's society and economy. It is first and foremost about moving people – safely and efficiently. Over the past century, the number of vehicles on the road has grown tremendously. It is viewed as an indispensable element of modern-day society and cannot be understood solely by its practicality. The vehicle's construction and features carry certain cultural and symbolic meanings. These meanings can influence people subconsciously. The car connects places and countries, expanding people's access to welfare and activities. It's a symbol of freedom and independence. It also extends access to goods and services. At the same time, it causes considerable challenges to the environment and climate.

John Urry was a British scientist known for his work within the sociology of mobility and tourism. He placed the car within what he called the ‘system’ of automobility (2004). He explained that the current automobility system that we are all part of is a complex system. It involves “cars, car-drivers, roads, petroleum supplies and many novel objects, technologies and signs” (Urry 2004, 27).

Urry (2004, 25-26) described automobility in detail. He saw it as a manufactured product of 20th-century capitalism, with leading industrial manufacturing companies playing a central role. As he believed, it is a “powerful complex” that has connections to other industries as well. It defines and redefines car manufacturing, petrol infrastructure, road building, city planning, urban and suburban housing, and services alongside roads. The car reorganizes how people view their opportunities and constraints of movement. Other mobilities like walking, biking or public transport might become less significant. As well as these attributes, the automobile is also regarded as a central “item of individual consumption.” The car can provide status and value to its users/owners. It can be understood as a symbol of a successful career, freedom, family, masculinity, etc. A perception that has been dominating for an extensive time is that the car is a central factor in the discourse of what constitutes a good life. However, the vehicle also represents significant “environmental resource-use.” Both locally and globally. The manufacture of cars and roads requires a massive scale of materials, space, and energy (Urry 2004).

The use of passenger cars has become deeply embedded in cultures around the world. This path has been stabilized by heavy financial investments and by powerful interests like, for example, car companies, organizations, and oil actors with similar interests. Urry argued that this system of automobility has created a lock-in situation shaped since the end of the 19th century. Economies and societies have been ‘locked-in’ on what can be described as the ‘century of the car’ (Urry 2004, 27). As he explained, much of our landscapes are built to facilitate automobility. Around one-quarter of London and almost half of LA’s land area is dedicated to car-only environments (Urry 2004, 30).

It is important to remember that the extent of desire and use of the car can be very different within different social groups. Still, cars have high visibility in the social landscape today.

This system of automobility has proven challenging to 'unlock.' It has been a relatively stable network for quite a long time. "The car-system seems to sail on regardless, now over a century old and increasingly able to 'drive' out competitors, such as feet, bikes, buses and trains" (Urry 2004, 32). Urry also explained that the development of such a system had been affected strongly by institutions:

> Social institutions such as suburban housing, oil companies, out-of-town shopping centres, can have the effect of producing a long-term irreversibility that is 'both more predictable and more difficult to reverse' according to North (1990: 104). The effects of the petroleum car over a century after its relatively chance establishment show how difficult it is to reverse locked-in institutional processes as billions of agents co-evolve and adapt to that remaking of the system of automobility across the globe (32).

Interestingly, Urry argued that the days of the car were numbered and that a new system of transport would eventually arrive. In this "post-car system," the car does not hold the same central position (Kingsley and Urry 2009). John Urry argued that we could see automobility tipping into this so-called new system, namely the "post-car system" (2004). He believed that the current thoughts about automobility have been more focused on technical adjustments to the car to decrease the consumption of fuels or on making minor improvements to the public transport service. But, as Urry said, the "real challenge" is how to break with the current automobility system. He emphasized that the current system is complex and difficult to unlock but offers "six technical-economic, policy and social transformations that in their dynamic interdependence might tip mobility into a new system" (33). One of these transformations he mentioned is the transition from fossil to electric vehicles. Urry argued that there might be a "tipping point" when a large portion of drivers change over to driving electric or hybrid/hydrogen (33). Another change is the innovations in materials used when constructing cars, such as aluminum or carbon fibers, which might make us less dependent on steel in manufacturing the vehicle. These materials will also reduce the weight of the cars significantly, making the need for powerful car engines less significant. In turn, this again might improve the driving range of, for example, electric vehicles. Urry also argued that we might experience an increased demand for smaller "micro-cars" for crowded urban areas. The development of 'smart-card' technology, car-sharing, increased political focus on more holistic mobility integrating other types of mobility, and the advancements in internet and communication technology are other transformations that could help tip automobility into the "post-car" system, according to Urry (34-35).

The system of automobility is complex, but changing. The question is whether these changes are just adjustments to the current system or if these adjustments might help tip automobility into a new system, in what Urry called the 'post-car system". This debate will be further investigated in chapter 5.2.3.

3.2 What is an Electric Vehicle?

Schwedes and Keichel emphasize that the electric car, including its associated infrastructure, is complex (2020, 3). Many different actors play a part in politics, economics, car manufacturers, energy suppliers, users, and charging infrastructure. In order to investigate the electric vehicle initiative in Norway, it is helpful to understand what differentiates an electric vehicle from the traditional fossil car, often referred to as an internal combustion engine (ICE) car. Some scholars, when they write about electric vehicles, include both battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), as well fuel cell electric vehicles (FCEL). To narrow down the focus of this thesis, the onus in this theory will be on battery electric vehicles – here referred to as electric vehicles. The reason behind this is to keep it as simple as possible.

One of the main strengths of the electric vehicle is that it is at least 2-4 times more energy-efficient than a regular internal combustion engine (IEA 2021, 9). The EV creates no local exhaust emissions and makes very little noise compared to a fossil car. EVs can be used to reduce carbon emissions. They will reduce the dependency on oil, provided that the power is generated from other sources. This is central to understanding why the electric vehicle is viewed as an essential technology to reduce emissions from the transport sector.

In the current transport sector, the total number of electric vehicles is growing. The idea of the electric motor in a car is not a recent innovation. 28 % of the total vehicles were electric from 1897 to 1900 (Un-Noor et al. 2017, 1). However, the ICE vehicles gained momentum in the period after that, and together with low oil prices, they dominated the market during the 20th century.

In the following part, I will try to explain some of the basic concepts of the inside of an electric car. This is part of “following the actors,” a central aspect of ANT research. The rest of this chapter will investigate technical actors that are important for the Norwegian EV initiative and helpful to understand when exploring the development of the initiative.

Different vehicle models from other car manufacturers will have distinct differences. There is a range of different EVs on the market today, and the technological choices chosen in the cars are not the same. However, these basic concepts presented here will provide some understanding of some of the workings of the electric vehicle.

The basic concept of the electric vehicle is not very complicated, as can be seen in figure 1. An electric vehicle consists of a rechargeable battery that can store energy, an electric motor, often regenerative brakes, and a power connector.

I must make that point very clear; I am here presenting the internal working of the electric car in very simple terms. There are many more parts, connections, and workings that this thesis will not cover. The way the inside of different EV models looks might also vary significantly between the models.

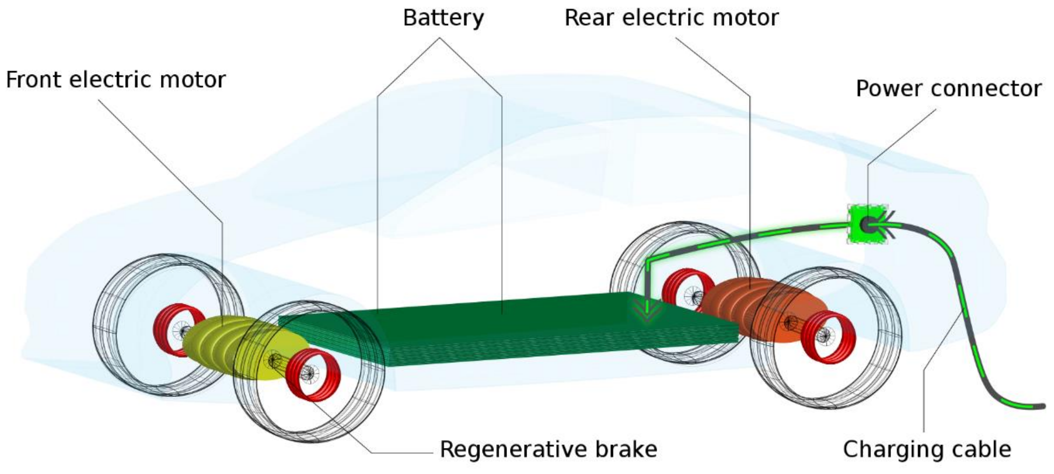

Figure 1 - Electric car diagram. (Source: Furst 2019). CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0)

The crucial point with the electric vehicle is that the internal combustion engine is replaced with a rechargeable battery and an electric motor. The EV is driven by an electric motor powered by a battery pack, which in turn, is recharged with electricity from the power grid through a charging cable. The charging point can be at home, work, roadside, or a charging station. The electric engine can have up to 90 % fewer moving parts than a traditional internal combustion engine (Krosofsky 2021). Regenerative braking is a desired attribute as it regenerates energy back to the battery (Lowry and Larminie 2012, 19).

One of the main challenges is storing energy in the battery in the electric vehicle. Energy is stored chemically in the battery and later turned into electric power that moves the car forward. One of the main challenges is that it takes more time to recharge an electric vehicle compared to an ICE vehicle because only a limited amount of energy can be charged at the time. Exactly how long it takes to recharge your battery comes down to several factors, such as the battery size and the overall health of the battery in the vehicle, the temperature of the battery, the amount of electrical current (Amps) that the car can handle, and how fast the charger is.

3.2.1 Battery Technology

There are a significant number of different EVs on the market today. They come in many different shapes and forms. They all have in common that the battery is a crucial component within the car. As Lowry and Larminie explain, the battery is usually the component within the vehicle with the highest cost, weight, and volume (2012, 29). Battery technology is rapidly changing, and significant investments are being made in improving the technology. As the world gets more and more electrified, the need for effective battery technology is increasingly important. Producers are looking at how they can change the combination of materials in the batteries to limit the environmental impact of producing batteries and reduce the cost price. To better understand the electric vehicle, this part will provide a generalizable overview of some of the most critical technical aspects of the battery, which is the perhaps most crucial component within the electric vehicle.

A battery pack most often consists of battery cells or battery modules that are connected electrically. This package also contains sensors and other components that make it possible to manage and control it, giving helpful information about the current level in the cells to the battery system (Maiser 2014).

The battery system usually also contains a Battery Management System (BMS). The BMS monitors and controls the whole battery system. The battery management system works as a security measure and improves the length of the battery's life. The BMS system regulates and controls the battery, including charging, discharging, cell equalizations, and monitoring and controlling the overall temperature of the battery (Miao et al. 2019, 10).

3.2.2 The Lithium-Ion battery

Researchers and developers in the battery industry constantly work to improve the battery system, looking for better materials or combinations to enhance the performance of the batteries. For over 200 years, the technical limits of the batteries have been pushed. The ‘lead acid’ battery was the traditional battery type in electric vehicles for a long time. However, most of the battery packs in electric vehicles are today built with

Lithium-Ion batteries. The batteries might look simple on the outside. The packed battery cell is a system that delivers electrical energy when demanded. However, on the inside, there exists a highly complex electrochemical system, organizing multiple components and reactions. Sometimes the outcomes of the combination between different components and reactions are even mysterious. (Petrovic 2021).

The Li-Ion batteries can be found in many modern electric technologies, like cameras, computers, smartphones, and most importantly, in electric vehicles. This battery type has some significant advantages (Gunvaldsen et al. 2019). It offers high energy efficiency and lower weight than its competitors. Li-Ion batteries also perform well in high temperatures.

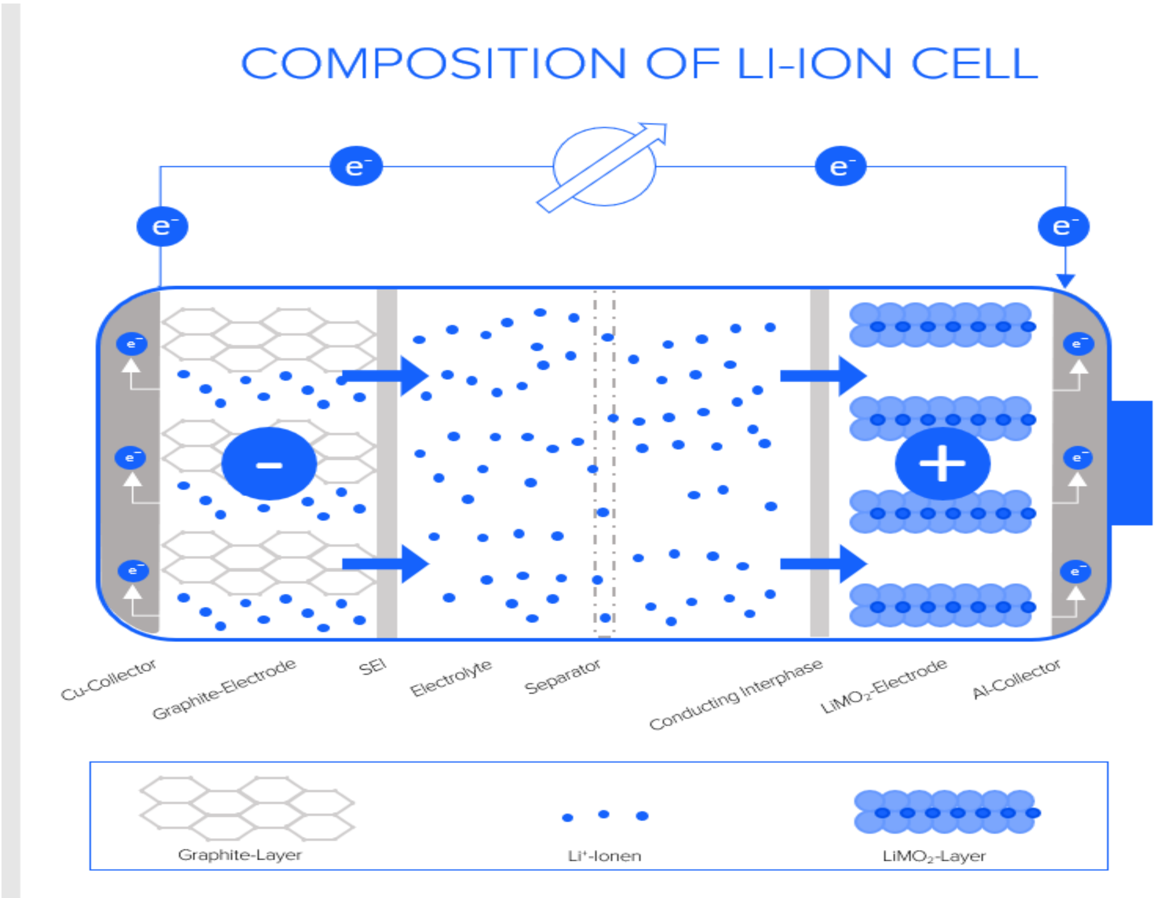

Figure 2- The different layers and setups within a conventional Lithium-Ion battery. (source: Twaice 2019)

Figure 2 shows one of the possible setups within a conventional Lithium-Ion battery. This process is a highly advanced electrochemical process; therefore, I will try to explain the process in a simplified way below. It is important to remember that the battery's inside and the materials used will vary depending on the producers. This is only an example.

The batteries most often comprise an anode, a cathode, two current collectors, a separator, and an electrolyte. In this example, Copper (Cu) on the left side is the negative current collector for the anode, while the Alumiuim (Al) on the right is the positive current collector for the cathode.

During discharge (when driving), lithium atoms are ionized and therefore separated from their electrons. Then the lithium ions (the name of the lithium after the separation) travels from the anode through the electrolyte and separator until they reach the cathode on the other side. The separated electrons also travel to the cathode. The separator blocks electrons from flowing inside the battery. Therefore, the electrons flow through the car instead (providing the vehicle with power) to reach the cathode on the other side. When charging, the opposite occurs. The lithium ions are small enough to move through the separator between the anode and cathode. In part because of lithium's small size, Li-Ion batteries can have a very high charge storage per unit mass and volume. (Office of Energy Efficiency and Renewable Energy 2017). The battery cells vary in shape and size. The chemistry on the inside also varies, depending on what form and shape the battery has. Different chemistry has to do with attributes like price, charge, weight, production, safety, and more.

The prices for Lithium-Ion batteries have declined steadily over the last decade, as evident in figure 3 below. The price has fallen from almost 1200 dollars per kWh to only 137 dollars per kWh in 2020, representing a nearly 90 % price reduction (Frith 2021). When considering these numbers for a vehicle with, for example, a 50 kWh battery pack, that equals more than 53 000 dollars worth of savings just in the battery.

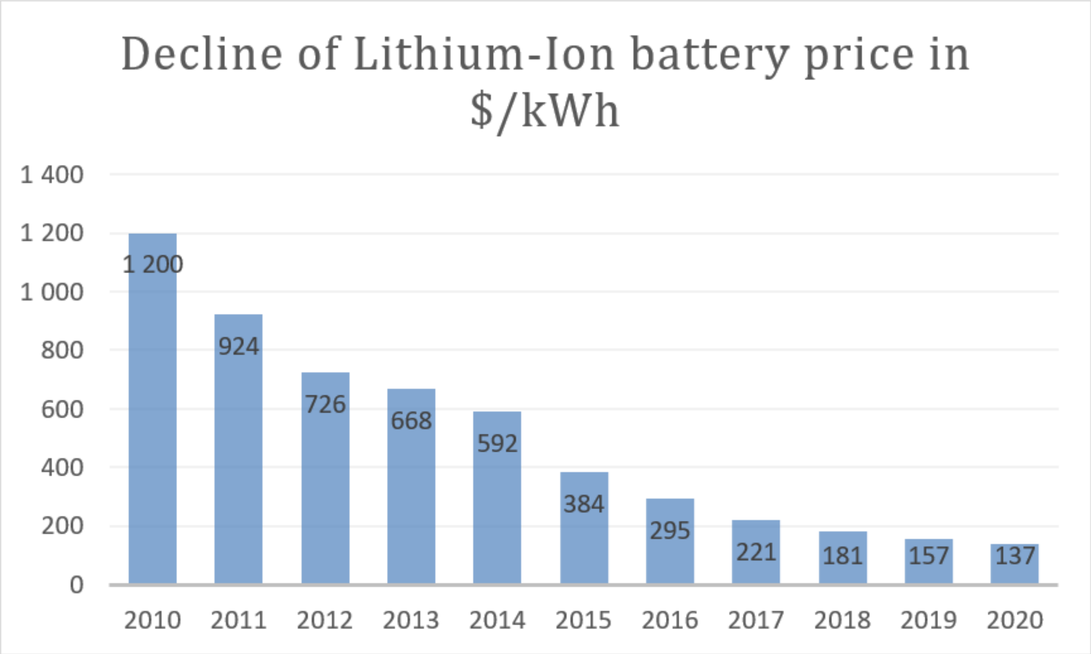

Figure 3- Illustration of how the Lithium-Ion battery price has declined between 2010 and 2020. (source: Frith 2021)

The assemblage of the battery pack into the car is critical. There are many different ways in which automakers do this. Here, I will provide an example of a possible assemblage of the battery pack in a Tesla Model S, described as the vehicle "that revolutionized the EV market when it came to Norway in 2013" (Norwegian Automobile Federation, n.d.). It was built differently than previous EV models, with a large battery pack, providing a long driving range. According to Energsoft (2019), the battery cells in this battery pack is cylinder-shaped and named 18-650. This name tells you something about the size of the cell. The 18-650 battery is 18 mm broad and 650 mm long, only slightly larger than regular AA batteries purchasable at grocery stores (Energsoft 2019). The battery pack in this first Tesla model S consists of 16 battery modules, and each battery module comprises 444 battery cells each. One of the perks of building the battery pack in such a way is that if there are issues with one of the cells or battery modules, it is easier to locate the error by separating the modules than to look into every cell in the battery pack. It is also faster and cheaper to replace one module instead of the whole battery pack.

3.3 Norwegian conditions for EVs - Cold winters, but also some favorable conditions

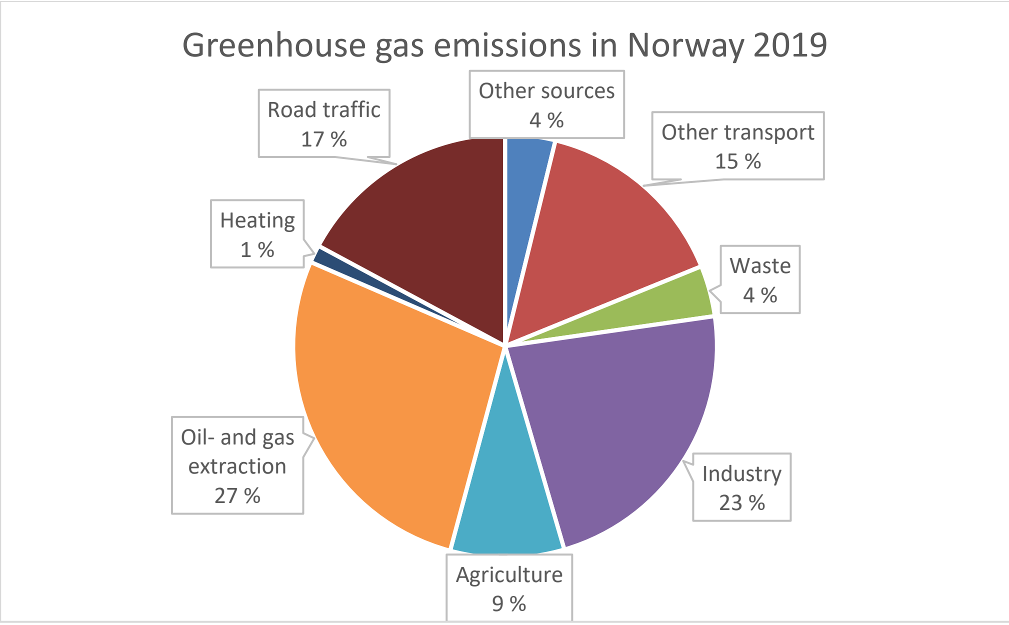

Figure 4- Diagram showing the distribution of emissions amongst the different sectors. (Source: Miljødirektoratet 2021a)

Figure 4 above illustrates that a large portion of Norway's climate emissions derives from the transport sector, with road traffic representing 17 % of the total emissions, according to the Norwegian Environment Agency (Miljødirektoratet 2021b). Passenger vehicles are the most significant emitter within that category.

When looking at the development of the EV initiative in Norway, a background look at the country’s characteristics can be helpful.

Compared to many other places in the world, the winters in Norway can be pretty rough. In some places, temperatures can be below -20 °C. However, the winter temperature in the most inhabited areas will typically be somewhere between 0 to – 15 degrees (Figenbaum 2020, 94). An issue with cold winters and electric vehicles is that the low temperature will substantially reduce the cars' energy efficiency. Multiple factors cause this efficiency loss, one of them being the extra energy required to heat the cabin in the vehicle (Laurikko et al. 2012). The cars are often also required to use winter tires, increasing the rolling resistance and energy consumption. The same goes for air drag, which also increases during winter and low temperatures (Figenbaum 2020, 9). In addition to all these factors, the performance of the lithium-ion batteries, the dominant battery technology today, decreases significantly in cold temperatures due to reduced reaction rate in the electrochemical process (Hu et al. 2019, 1). In sum, the winter conditions in Norway are not favorable for a long driving range for electric vehicles.

Despite the unfavorable winter conditions, Norway, as a country, also has many characteristics that favor Norweigan EV market uptake.

One of these favorable characteristics is that electric cars in Norway have an emission advantage since Norwegian energy production is ‘cleaner’ than in many other countries in the world. In terms of Norway's power supply, nearly all the electricity derives from hydropower. Therefore, emissions linked to electric vehicles are substantially less when the car is powered by renewables instead of fossil energy sources, like oil and coal. 96 % of the Norwegian power comes from hydropower, mainly from hydroelectric power plants built before 1980 (Figenbaum 2020, 92).

Norwegian households also have a strong electricity grid connection, robust for high power periods. According to Norwegian EV expert Erik Figenbaum, one of the reasons for why we have built this strong grid, is because most Norwegian houses are entirely or partly heated with electricity during the often cold winters (2020, 92). In addition to this, Norway has also built out power cables to other countries in Europe, securing power access and stabilizing the primary grid. Thanks to hydroelectric power, Norwegian electricity prices have also been regularly low. The costs for gasoline and diesel fuels are also high due to high taxes on fossil fuels. Electric vehicle drivers in Norway are the EV drivers in Europe that save the most on the cost of electricity compared to petrol or diesel (Figenbaum and Kolbenstvedt 2015).

When it comes to the issue of cold winter, preheating technology for the battery in cold conditions and other key heating strategies are significantly helping electric vehicles to maintain some of their range despite the cold weather (Hu et al. 2019, 1).

Norway has the second-lowest population density in Europe, only beaten by Iceland. Still, 80 % of the population lives in urban areas (Norwegian Ministry of Transport and Communications 2017). The country is narrow-shaped and long with various terrain.

Large fjords, lakes, and mountains make the Norwegian landscape spectacular and propose challenges to the transport sector. The geographical features of the country have implications for the need for passenger transport. The Norwegian passenger transport sector is highly reliable on cars because of relatively low population density and limited rail and public transport networks. The car makes up around 90 % of all motorized passenger kilometers traveled in Norway (Tietge et al. 2016, 47).

Norway also stands out as a country with a high GDP per capita level. It has an economic safety net with its sovereign wealth fund, based on Norway's revenues from its petrol export income. The market value of the Norwegian wealth fund, known as "Oljefondet" in Norway, is per October 2021, worth over 11 400 billion NOK (Norwegian Bank Investment Management 2021). Electric vehicles can be essential in the development of a more sustainable transport system in Norway, binding together cities, villages, and people. The need to move around and transport goods and products over short and long distances have always been there. Therefore, a practical, environmentally friendly, and safe transport system can be considered a critical foundation in modern society and essential for creating wealth and welfare. The electric vehicle is one of these options.

This chapter has described some of the technical actors in the Norwegian EV development. We have investigated the battery and some of the other inside components in the electric vehicle. Also, some Norwegian background knowledge has also been provided. This is valuable knowledge for the chapter that follows.

4 Following the Actors

So how has the electric vehicle initiative in Norway, since its beginning in the early 1990s, transitioned into the impactful electric vehicle initiative that it represents today? How have the different actors involved interacted to shape and reshape the actor-network of the Norwegian electric vehicle initiative? The following chapter will investigate these questions. This account of how the electric vehicle initiative in Norway has developed draws mainly from the interviews conducted and additional information from quantitative data and secondary resources.

As Wiebe E. Bijker explained in his book, pure technology does not exist (1992). They are formed and shaped by the many complex trade-offs within our society. Technology development embodies a compromise between social, technical, material, economic, environmental, and political factors. They are the result of a complex interplay between these different factors. This chapter will explore the development of the EV initiative in Norway and the various actors involved through a 30 years period.

As mentioned previously, I have interviewed Øystein Asphjell (engineer and expert about the EV development in Norway), Odd Einar Dørum (politician), Ole Gudbrann Hempel (works with charging infrastructure), and Marius Valle (technology expert on EVs). They represent different sides of the development of the EV initiative in Norway and either have been directly involved in the development or sit on substantial knowledge about parts of the story. In this chapter, I have dedicated much space to what the interviewees reflect on and say. This is in line with ANT's emphasis on letting the actors make their own theorizing about a development.

4.1 1989 – 1998: The First Political Incentives and Niche Activities

Before 1989, there were only modest efforts to promote the development of EVs in Norway. During the 1970s, various prototypes of electric vehicles were developed. Inventor Lars Ringdal started making a small electric car with plastic bodywork (Figenbaum and Kolbenstvedt 2013, 12). Inspired by the oil crisis in 1973, where access to oil was limited, Ringdal decided to develop a car that did not rely on access to oil

(Asphjell et al. 2013, 115). Later, his son, Jan Otto Ringdal, would continue these ideas with what could have become a Norwegian industry adventure.

The 1990s is perhaps the appropriate starting point for the electric vehicle initiative in Norway. Environmental organizations pressured the politicians, political EV incentives were gradually implemented, and Norwegian electric vehicle producers Think (then called Pivco) and Buddy (then named Kewet, a danish company) looked to establish commercialized production in the country.

Figenbaum and Kolbenstvedt (2013) refer to this period as a *test phase*. They argue that one of the most central aspects during this period was to remove the 'disincentives' that worked as barriers for people trying to purchase an electric vehicle. The dominating view amongst people at the time was that an electric car was far too expensive and challenging to buy. Norway had high taxes for the registration of imported vehicles. The first EV incentive implemented in Norway was to remove the high tax price for registering an electric car. Here, some pioneers played a central role.

4.1.1 Bellona Importing the first EV – a Red Panda

In 1989, environmental organization Bellona with leader Frederic Hauge got together with technology expert Harald N. Røstvik and the famous pop-group a-ha. Together, they wanted to prove that the electric vehicle was a viable option to the fossil cars. They imported the first electric vehicle to Norway, a rebuilt red Fiat Panda, from Switzerland in 1989 (Asphjell et al. 2013, 68). Frederic Hauge recalls: "The bureaucrats were scratching their heads. How were they going to put import tax on that car? Into what category would they place the car? After a year of speculation, they decided to categorize the electric vehicle as a “*diesel-driven camping van*” (Asphjell et al. 2013, 103). When the Fiat Panda arrived in Norway, the owners applied for an exemption from the value-based registration tax. In 1990, the first temporary tax advantage for electric vehicles became a reality. It later became a permanent value-based tax exemption in 1996. This tax exemption was the first of many EV incentives to come. The first political EV win in Norway. Odd Einar Dørum, who was an active politician around this time, recalls the role of Bellona at the time:

> **Odd Einar Dørum**: "Bellona, with Frederic Hauge as the spearhead, clearly played an important part in the development of the first EV incentives."

However, Bellona and their companions were not finished pushing the government. The electric car was still not an attractive option, neither economically nor practically. As Aphjell et al. explain (2013, 70), Bellona had, at the time, a considerable appeal to the youth in Norway, and together with the international pop stars a-ha, they managed to get quite substantial media focus and attention around their case. During the 90s, Bellona also pushed the government to exempt EVs from paying toll road charges.

> **Ole Gudbrann Hempel**: For example, Frederic Hauge and Bellona forced the politicians to allow free passage in the toll roads for electric vehicles. He drove past the toll road with Norway's first electric car [the red fiat panda] every day, refusing to pay. His vehicle then got towed by Oslo municipality and auctioned out. However, people did not want to buy the electric vehicle at the auction, and Hauge could then buy back the EV time and time again from the auction. He kept driving past the toll road, refusing to pay. In the end, the municipality gave in and EVs were allowed free passage."

4.1.2 The Political Actors – Many opportunities: New Industry, Climate policies, and Pressure

The number of political incentives to promote the development of EVs in the Norwegian market increased during this period. At the beginning of 1997, electric vehicles were exempted from paying tolls in roads projects in which the state was a partner. The parties did, in the end, all agree to the proposal, as Dørum recalls:

> **Odd Einar Dørum**: "We came up with the proposal in 1995 in the Oslo city council, about allowing the EV free passing in the toll roads. All parties agreed to this in the end, but it took time and demanded strong will from us politicians. The reason why all the parties agreed to the proposal was that people saw the electric car as something exotic. We also saw the potential for what it could contribute with when it came to cutting greenhouse gas emissions from the transport sector… That is why the electric car became an option for us. The EVs had little impact on the environment and climate. In the party I represent, the Liberal Party, we decided that we wanted to go for this."

The proposal introduced in the Oslo city council in 1995 became a permanent incentive from 1997. The free toll roads incentive has been assessed as a significant measure to promote EVs (Figenbaum sand Kolbenstvedt 2013, v). Toll roads are expensive for drivers in many places in Norway, and therefore this measure potentially has a significant impact on the advantage of buying an EV. For a commuter in the area around Oslo, the cost in 2013 could be between 6 000- 10 000 NOK[2] a year, only on toll roads (Figenbaum and Kolbenstvedt 2013, v). Therefore, the EV exemption was a significant incentive to promote increased EV usage, as the potential savings for the owners were considerable.

During this period in the 1990s, electric vehicles also received a reduced annual license fee. This meant that EV owners only had to pay a portion in yearly license fees compared to those owning fossil cars. All these exemptions were only introduced after years of work from interested actors that collected media attention and pushed the municipality of Oslo and the Government.

However, the incentives were not only implemented due to the pressure from interested actors and the potential for greenhouse gas emission cuts in the transport sector. Øystein Asphjell explains that the politics were also inspired by the potential for a new Norwegian industry.

> **Øystein Asphjell**: "..Part of the motivation behind the incentives was the vision that it was right – a vision about a green transformation in society. However, I believe that a significant factor behind all the political EV incentives and politics was that the politicians wanted to contribute to the creation of a new Norwegian industry. A successful Norwegian EV industry would contribute to the creation of many jobs."

This period also saw the birth of the Norwegian company Pivco (Personal Independent Vehicle Company) and the Danish company Kewet (later known as the Norwegian company Buddy) in Norway. Both started developing small electric vehicles, making two-seaters. In this period, Kewet and Pivco mainly sold their cars to municipalities and companies that wanted to test and experience the technology (Figenbaum 2017, 20). Dørum Gudbrann Hempel also recalls the influence by the establishment of Buddy, and especially Picvo (later named Think):

> **Odd Einar Dørum**: "Think and Buddy were important actors. The government looked at the possibility of starting a new industry here. Think was a great tool

[2] these numbers are converted to NOK based on 2021 rate between euros and NOK. Therefore the price might be a bit off.

> for us to start asking for zero-emission cars. We rooted for technology development that led to the development of zero-emission vehicles."

> **Ole Gudbrann Hempel**: "…A lot of the political incentives, like the exemption from registration tax, were introduced in relation to the development of Think [previously known as Pivco]. The government wanted to support Norwegian industry, and especially the development of the Norwegian automotive industry. So that's why you got the incentives. Through the 90s, we saw a lot of these incentives introduced in relation to this."

The 1994 Winter Olympics in Lillehammer in Norway proved an important arena for Pivco to showcase their car. They demonstrated that their prototype electric cars worked successfully at the games, performing at temperatures below -20 degrees in front of an international crowd. This success was a boost for the company when it came to possible future investors that could help them finance the industrialization of their vehicles (Figenbaum 2017, 20).

Pivco's dream was to produce EVs on a proper scale from their factory at Aurskog. In October 1998, they traveled to Brussels for the Electric Vehicle Symposium and Exhibition (EVS). The EVS was an international arena where companies could attract international attention. Pivco had produced functional electric vehicles until now, but only on a small scale (Asphjell et al. 2013, 137-138). They were running out of goodwill amongst their investors, and therefore expectations were high around the release of Pivco's latest car development at this exhibition. Pivco scratched together all of their remaining capital for this event. At the EVS they launched their new name, Think, and showcased their latest car. It was well-received at the event. Think had spent all their money and were announced bankrupt the following Monday. However, they had conversations with Ford Motor Company at the exhibition, and Ford seemed to show particular interest in Think's electric vehicles.

4.1.3 The International landscape

The Norwegian EV actors also drew inspiration from the US. In 1990, the California Zero-Emission Vehicle (ZEV) mandate was initiated in the American state to deal with the rising local emissions in California. As the state looked to improve the local air in the area, they created the mandate to demand car manufacturers operating in the state to start selling at least 2 % electric vehicles from 1998, 5 % in 2001, and 10 % in 2003

(Figenbaum 2017, 20). As you will see later, this Californian mandate would play a role in the development of EVs in Norway.

> **Odd Einar Dørum**: "I remember well the law proposal in California in the 90s. This had a big impact. California started demanding zero-emission vehicles. We were actually a forerunner at this in the world here in Norway."

4.1.4 The creation of the Norwegian EV Association

In 1995 the municipality of Oslo and the city's electric utility company, with support from industry actors, got together to create the Norwegian EV Association to promote electric vehicle interests. Initiated as a stakeholder organization, their first name was NORSTART (Figenbaum 2017). They would become an actor that had an important role in promoting EV interests in Norway.

> **Øystein Asphjell**: ".. I remember well the beginning of NORSTART (now the Norwegian EV Association). We gathered the branch, with Elbil Norge AS, Buddy, us at Think, Bellona and some of the supply industry and car suppliers. We created a strong organization that could speak to the press and pressure the politicians."

However, In 1998, the price of electric cars was still twice that of gasoline cars, according to Figenbaum (2017, 20). The traditional ICE car industry did not really bother to fight against the EV incentives that were introduced during this period, and there was little criticism to trace in the newspapers at the time (ibid, 20). Compared to the fossil car, the quality of the electric vehicle was still not on the same level, and the selling numbers of EVs were low in Norway, mainly restricted to a few enthusiasts and companies that wanted to test the battery technology and the new car segment.

4.2 1999 – 2002: A New Norwegian Industry Adventure on the Horizon?

As mentioned earlier, The EV company Think went bankrupt after announcing their new car at the international EV event in Brussels in 1998. However, their efforts seemed to have paid off. Towards the end of 1998, talks were initiated between Think and the massive international car company Ford Motor Company. For Ford, with the ZEV mandate in mind, the price of establishing their own production of electric vehicles was far higher than purchasing Think (Apshjell et al. 2013, 139). The manager at Ford, Mr. Jacques Nasser, wanted to test the Think car himself and took the car for a drive with his family the Christmas in 1998 in the US. As cited in Asphjell et al (2013), he retold the story to the employees at Think at Aurskog:

> My wife and I decided to take this little, weird car to church one day, and as we were heading down the highway we felt very small and tiny in comparison to the enormous American trucks and SUVs… but I knew that the car I was driving had been engineered by Vikings in the cold north, so it was tough and strong – despite its size (Asphjell et al. 2013, 139-140).

In October 1999, the country saw the official opening of the electric vehicle factory at Aurskog, with guests like Ford's manager Mr. Jacques Nasser, Norwegian Prime Minister Kjell Magne Bondevik, and the Norwegian King Harald present.

> **Øystein Asphjell**: "...Ford came in at Think, buying 51 % of the stocks in Think in 1999, with an obligation to purchase the remaining 49 % within the following year. They had an incredible amount of money and planned to employ a lot of skilled engineers…I started working in the construction department at Think. It was a dream come true for a car enthusiast like me. We did a lot of development work in the UK, and I was allowed to draw cars and test prototypes. I even participated in full-scale crash testing with Think in Germany..."

Figenbaum explains that the main reason behind Ford's purchase of Think was their goal of delivering electric vehicles to the market in California at the lowest possible cost to meet the requirements of the ZEV mandate in California, mentioned previously (2017, 20). Instead of making their own EVs, they viewed Think as a better economical option. Ford put extra investment into technology development, and in late 1999, they opened the Think factory at Aurskog. "When Ford starts production in a new country, we are serious about what we do. We are here to stay, and we are here to maintain employment," said Mr. Jacques Nasser, CEO at Ford Motor Companies at the time (Asphjell et al. 2013, 142). With Ford in place at Think, a small EV niche market emerged (Figenbaum 2017).

> **Øystein Asphjell**: "At Think, we had a strong belief that we were on the right way – that EVs would be successful. The main idea at Think was to develop a small and light car – for the city and urban areas. We never doubted that we had many good ideas."

Expectations increased as Think was picked up by the massive global car manufacturer, Ford. Investments were made to develop the new car model PIV4, or Think City, as its name now was. This next-generation electric vehicle also had to pass American car demands. Mr. Nasser explained that: “We want to put leverage on the political incentives here in Norway, and utilize the technology and factory to create an “EV Greenhouse” in Norway. Somewhere we can point to as an example of how politics and new technology create a strong market for the good of the environment” (Asphjell et al. 2013, 143). Until now, Think had only produced a small number of cars. Now, the goal for the Think City model was to build five vehicles a day. Between the autumn of 2000 and 2002, Think produced around 1200 cars, where about half were sold to the Norwegian market. The rest were divided between the US and some European markets (149-151).

4.2.1 Further EV Incentives – EV Plates and VAT-exemption

To help improve the Norwegian EV market, the governments implemented further EV incentives. In 1999, specific EV number plates (for example, EL000001) were presented. In 2000, an incentive that reduced company car taxation for EVs came (Figenbaum and Kolbenstvedt 2013, v).

Despite having created a niche market, electric vehicles still proved to be too expensive for most of the market. Therefore, in 2001, to increase EV competitiveness, an exemption from VAT (then at 24 %) was introduced to all-electric vehicles. The VAT (Value Added Tax) is a tax added to all the goods and services sold.

4.2.2 Trouble in California

As mentioned previously, a central motivation behind Ford's purchase of Think in 1999 was the demands that the Californian state had put on the car manufacturers that operated in their state in 1990. These demands were called the Zero-Emission Vehicle (ZEV) mandate. They contained specific targets of how many zero-emission vehicles the car manufacturers had to sell in the Californian state to continue operation there. In contrast to Ford, other car manufacturers in the country, like GM and Chrysler, went to court and sued the Californian state for what they meant were environmentally harmful demands from the Californian state (Asphjell et al. 2013, 143). The claim was that the price for buying new fossil cars became higher because of the extra development costs required to create zero-emission vehicles for the manufacturers. This would, in turn, lead people to keep their old, more polluting cars, leading to a higher total local pollution as a sum. On the 21st of July 2002, the big car manufacturers won the court case. The Californian state was forced to rethink its plans about the ZEV mandate, and only days later, Ford announced that they wanted to sell Think. Three years after buying their first stocks in the company.

4.3 2003 – 2009: Successful niches keeping EVs alive

In 2003, Ford sold Think, and EVs suffered several setbacks. Internationally, car manufacturers stopped producing EVs because of poor sales numbers and other priorities. A planned ban on Cadmium in batteries in the EU also proved challenging for the EV market. As is explained by Asphjell et al. (2013), Think was sold from Ford to a company named Kamkorp (Asphjell et al. 2013, 154). The deal was signed in 2003, and Ford left Think with a strictly regulated bank account to ensure that Think would have enough capital to exist for at least 18 more months. The cooperation between the Swiss-company Kamkorp and the people at Think was not the best. There were disagreements, and during Kamkorp's ownership, Think could not produce any significant number of EVs. In 2005, the first employees at Think were temporarily laid off, and in 2006 Think was again announced bankrupt (Asphjell et al. 158).

4.3.1 Bus/taxi lanes opened for EVs

According to Figenbaum (2017), the period before had shown the potential for EVs in Norway. Therefore, the incentives stayed in place, despite Ford pulling out of Think. The EV lobbyists in Norway continued to push for further political incentives for EV owners, and in 2003 it was decided that the bus/taxi lanes in the Oslo region would be accessible to EV owners (Figenbaum 2017). The Norwegian EV association had grown in strength and kept promoting electric vehicles and EV incentives. Think was reestablished in 2006 by some Norwegian investors. The EV incentives stayed intact, and Think eyed an opportunity to launch a new electric vehicle on the market.

At the end of this period, the Norwegian government introduced reduced rates for EVs on national main road ferries. In 2005, electric vehicles gained access to drive in bus/taxi lanes in the whole country, which significantly affected the sales of EVs in city areas especially (Figenbaum and Kolbenstvedt 2013, 27). The government also launched Transnova (now Enova) at the end of this period. It would prove to be another important tool, as will be discussed in the following subchapter.

4.3.2 Tesla visiting Think

Øystein Asphjell, who worked many years at Think, recalls a fascinating story from 2006. Think was visited by a relatively unknown and unconventional electric vehicle company from California:

> **Øystein Asphjell**: "… There are many episodes that come to mind.. you know, I picked up Eberhardt, the previous owner of Tesla, at Gardemoen [Oslo airport]. He visited Norway to propose cooperation between Tesla and Think. Eberhardt had established Tesla in California, and they wanted to make electric cars in a new way. The company Lotus would make their chassis, and Tesla wanted to make their batteries themselves in Thailand. They had this grand idea about a Tesla Roadster. The idea was to make an electric sports car that had no compromises. It would be an expensive car. At Think, we made an environmentally friendly, small, and simple electric vehicle. We did a lot of compromises to make it as simple as possible. It meant, for example, that the windows on our Thinks were opened and closed with a manual crank. Our thought was that if you want to drive green and electric, you will accept compromises like that. Eberhardt thought differently. For him, if you were going to sell an electric car, it had to outcompete the fossil car in all aspects. No compromise anywhere. That was his main idea. When he came to visit us, he spoke about how Think and Tesla were not competing for the same customers. He explained that we were different companies and should cooperate about sales channels and stores, car dealers, service networks, and perhaps battery production. He expressed a wish for our two companies to work together. However, at Think, we shook our heads, as we did not believe an expensive electric sports car was the right way to go. We had more belief in the direction we were heading…"

In hindsight, Apshjell admits that Tesla was perhaps more right than they were at Think. As he explained, Tesla looked for cooperation between the two companies as Eberhardt believed they did not compete for the same customers. Asphjell also recalls that

Eberhardt had some remarkable ideas about people’s perception of charging electric cars:

> **Øystein Asphjell**: “Eberhardt had this crazy (at the time) idea about the recharging of the battery. ”No one asks about how long time the car takes to recharge. They only ask how far can the car go?” At the time, Eberhardt planned for a battery size inside the Roadster that meant that it could take two full days to fully recharge the car battery at home with standard electric output. For us, that was the wrong plan. We thought there was no point in selling an electric vehicle that would need two days to recharge. Instead, the reality for us was an electric vehicle with a battery that you could recharge during the night. He told us that people tend not to care too much about that. They only ask, “how far can it go?” And then he could reply: “Well, it goes 500km”. Eberhardt had many exciting thoughts, but at the time, we didn’t think he was right. But yes, in the end, he was.”

Think evaluated the proposal from Eberhardt but did not believe in the technical solutions and the market segment that Eberhardt wanted to enter. Therefore, they decided to turn down the offer from Tesla.

By 2009, Think was again running out of funds, following the 2008-2009 financial crisis (Asphjell et al. 2013). This time Think was purchased by a Finish company called Valmet, and production got transferred to Finland. Although the production numbers in Finland were a bit unclear, Valmet announced in 2010 that they had produced the Think car number 2500 (Asphjell et al. 2013, 165).

4.4 2010 – 2012: The EV Market expanding

During the period between 2010 and 2013, the Norwegian EV market changed quite substantially. At the same time as Norway improved its charging infrastructure through the establishment of Transnova (later called Enova), the traditional international vehicle industry started producing EVs again. The technology of the Li-Ion batteries had improved, and the prices for the batteries were reduced significantly (Nykvist and Nilsson 2015). At the same time, the global focus on climate policies to decrease greenhouse gas emissions became stronger. The EU had also signaled a proposal to set a stricter limit to the average amount of CO_2 emissions/km allowed for new vehicles sold from 2020 (Figenbaum 2017, 23). In sum, this was a warning to the car manufacturers that they needed a larger share of EVs in the car mix to meet those future requirements.

4.4.1 International Car Manufacturers entering the Norwegian EV Market – i-MiEV and Leaf

In 2010, Mitsubishi entered the Norwegian car market and started selling its electric I-i-MiEV through car dealers. The first cars were delivered early in 2011, and over 1000 cars were sold in less than a year (Figenbaum 2017, 23). Later that year, other traditional car manufacturers joined the EV market, like Nissan, with their model Leaf. Sales kept increasing rapidly.

> **Marius Valle:** "It was during the time when MiEV and Leaf arrived in Norway that we saw the EV sales increase drastically. These electric cars were actual cars, instead of… and now I have to be careful about what I say…instead of four-wheeled motorcycles, like, for example, the Buddy. The MiEV and Leaf felt like proper cars that you could take on long drives with your whole family. You could drive longer distances because the charging network was also being built out at the time."

Figenbaum (2017, 23) argues that these manufacturers took advantage of the situation of opportunity made by the incentives already in place in the Norwegian market, resulting from EV niche actors' efforts for over two decades.

> **Øystein Asphjell**: "It was inevitable that the large car manufacturers would eventually knock on the door in Norway with electric car options. Globally, we saw an increased focus on climate policies and new emission demands towards the car industry. Many people claim that "if Think only had been able to hold on a bit longer, it would have been a massive success." But I am not so sure about that. Because the competition against the big manufacturers is extremely tough, perhaps you can say that Think "died in time."

4.4.2 The Importance of Transnova for Charging Infrastructure

As mentioned previously, Transnova (now Enova) was established at the end of the former phase. Transnova's mandate was to work as a government instrument to support and help climate-efficient technologies and concepts to develop (Kristensen 2018, 12). One of their responsibilities was establishing a program that encouraged companies to build out charging stations around the country. The development of charging infrastructure accelerated from 2010. By 2011, Transnova had contributed about 70 million NOK in investments into a charging infrastructure program that saw 1.900 charging points in Norway by the end of 2011 (Kristensen 2018, 12).

Dørum explains that politics played a role in supporting the establishment of charging infrastructure.

> **Odd Einar Dørum**: "Politically, we have set ourselves emission targets that we must reach. There has been a political will to push this forward. And we have pushed to get a good charging infrastructure in place...It boils down infrastructure, and after a while, the charging infrastructure has expanded dramatically, to all regions in the country."

Asphjell also points out that Norway had a considerable advantage compared to other countries, as the government already established a charging infrastructure in many parts.

> **Øystein Asphjell**: "When the big international car manufacturers entered the Norwegian EV stage, Norway had an advantage since we had already built out quite a lot of charging infrastructure. The idea about the electric car had matured for quite a long time in Norway, compared to many other countries. Norwegians knew more about the EV and that it worked."

In 2012 the Norwegian Parliament also followed up the EV initiatives with a broad climate policy settlement, called "Elbilforliket" (Det Kongelige Miljøverndepartement 2012). The settlement, agreed to by all the political parties, stated that Norway would continue to utilize its tax system to cut emissions in the transport sector. The government would also maintain the support for establishing a charging infrastructure and continue to allow electric vehicles access to bus/taxi lanes. These incentives were intended to stay in place until at least 2017 or when Norway reached 50 000 EVs on the road (Det Kongelige Miljøverndepartement 2012).

4.4.3 The End of what could have become a Norweigan Industry Adventure

Think was declared bankrupt, for the fourth and last time, in 2011. Ford actually reached out to Think again in 2010, wanting to buy stocks in the Norwegian company. However, Ford struggled financially themselves and could not go forward with its plans (Asphjell et al. 2013, 169). Estimations say that Think managed to produce about 2,500 electric vehicles in total (Asphjell et al. 2013). 2011 marked the end of a central chapter in the history of the Norwegian industry and the global electric vehicle history. Asphjell reflects on what the main challenges for Think was:

> **Øystein Asphjell**: "The main challenge for Think was not a lack of interest in EVs or lack of political will. The main challenge for Think was that we tried to do everything ourselves. Our strategy was to sell cars in a new way – without a more traditional car dealer network. We wanted to sell our EVs online and with small stores at shopping malls. We were also in a dialog with IKEA about selling our cars there. We wanted to offer our own service network and looked to cooperate with, for example, Elkjøp on that. So our idea was to build our own sales network, car dealer network, and service network. Even our sales brochures were different from the traditional ones. We wanted the Think car to be like a lifestyle product, like a mobile phone. So at Think, we were very confident that we would create a new car concept – a short-distance city car that was still robust. As mentioned, we wanted to do everything ourselves, meaning that we burned a lot of money on all sides since everything was going to be built up from scratch by us. I would argue that this was the wrong strategy. Perhaps, this, more than anything, was the reason why we were not able to make it. In hindsight, we could have made it easier by attaching ourselves to some already established suppliers. It ended up being too much to carry for a small company, like Think. We spent up all our money before we were able to succeed on all fronts."

Despite Think not making it in the automobile world, Apshjell does not believe that Think was a failure. They did pioneer work in the industry and were an important actor that pushed the government to implement incentives to promote EV adoption in Norway.

> **Øystein Asphjell**: "It's important for me to remove the myth that the Think story was a fiasco. We did significant pioneer work. Jan Otto Ringdal, the inventor behind Think, his main idea was not to create the typical electric car but rather the small city car. He wanted to create a new segment within the value chain of transport. That was his main idea. A small car that uses very little space and that was easy to park. Place for a man and his lunch, those ideas. Ringdal was flying around to cities in the world in 1992/1993 with a color-coded map of the cities he visited. The map showed how buildings and cars took up much space in the city. It was the portion taken up by cars he wanted to show. The roads were so big and the parking spots so many. The roads squeezed out people and space. You know this is advanced city planning today. This idea he had in the middle of the 90s."

4.5 2013 – Present: The EV Revolution in Norway

Norway has experienced remarkable growth in the EV market share numbers in the last decade, far ahead of any other country in the world. The numbers so far for 2021 shows that electric vehicles make up 62,5 % of the total number of new passenger vehicles sold in Norway (OFV 2021a). In 2012, the number was 3 %, while in 2015, the number was 23 %. Jan Fagerberg, one of Norway's front professors within innovation studies, describes the EV initiative in Norway as an electric vehicle revolution. "The electric vehicle revolution is the most important innovation that has been done in Norway during the last years. It shows that when politicians facilitate it, both the public and private can change habits" (in Toft 2018). Figure 5 and 6 below shows the remarkable growth in electric vehicles in Norway since 1990.

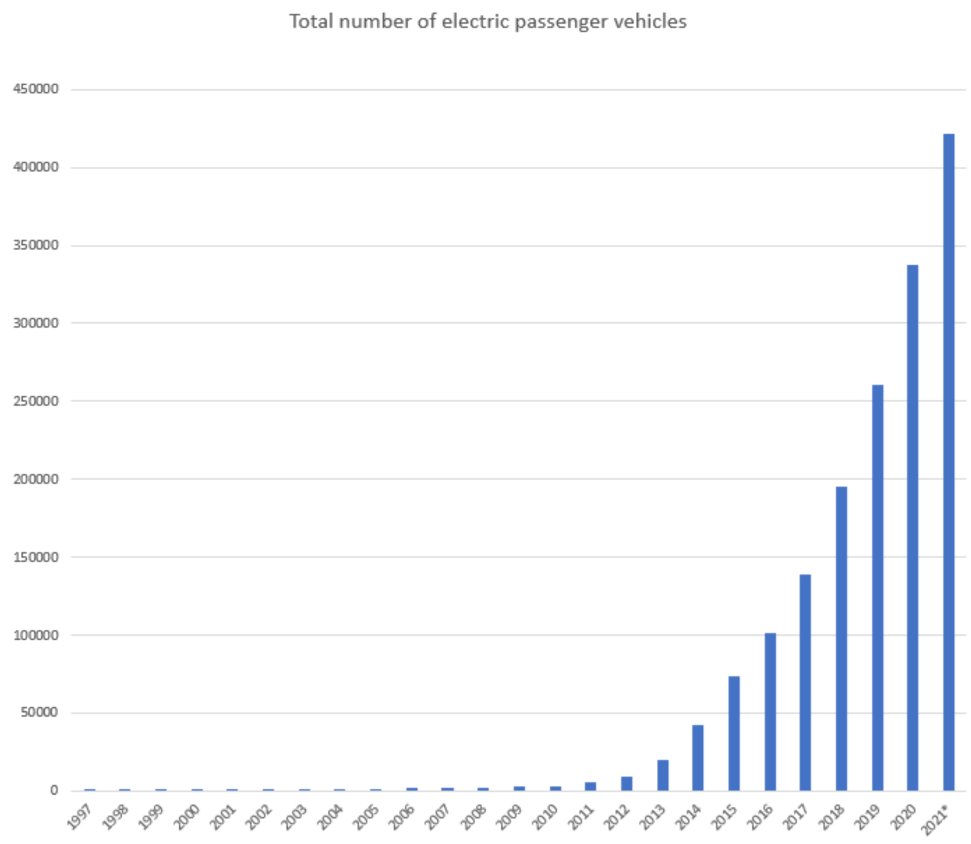

Figure 5- Chart showing the growth of the total number of electric vehicles on the roads in Norway. (Source: Asphjell et al. 2013, 39; Norsk Elbilforening 2021)

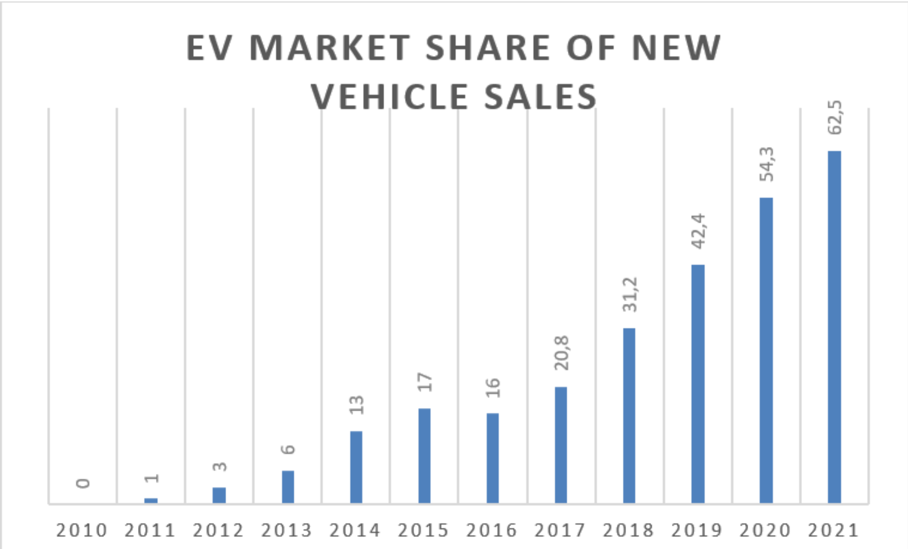

Figure 6- showing the EV market share of the total sales of passenger vehicles in Norway each year. (source: Norsk Elbilforening 2021)

4.5.1 Tesla changing the Automobility Industry

A central aspect to this incredible growth over the last period has been the increased selection of models from car suppliers and dealers, ranging from Volkswagen E-golf to brand new sports cars like the new Porsche Taycan. The EV market is now offering something to a broader customer group with various wishes and demands.

By 2013, Norway saw an increasing selection of electric vehicles available on the market (Figenbaum 2017, 24). Increased competition led to falling prices on cars. Figenbaum (2020, 101) explains that people who bought the EVs wanted to save time driving in the bus/taxi lane and save money on the toll road exemption. Especially after 2013, when the price of an EV came below the cost of buying an ICE vehicle, multi-vehicle households started buying EVs. He also emphasizes that Tesla Model S entering the Norwegian market in 2013 had a significant impact. Tesla demonstrated that long-range was possible in practice and built out a reliable Supercharger network in Norway. Tesla is compatible with 98 % of Norwegians average travels (Figenbaum and Kolbenstvedt 2015). Both Dørum and Valle believe that Tesla entering the market significantly impacted the Norwegian EV adoption:

> **Odd Einar Dørum**: ".. It's clear that Tesla, with their own battery factory, they pushed the speed on the development in the market."

> **Ole Gudbrann Hempel**: "When Tesla model S came to the market in 2013, and Leaf the year before, Norway had already established these political EV incentives. And this was the reason for people waking up to the idea about electric vehicles. There was no specific commercial about "buy this EV then you can do this or that.." People saw it themselves and started to utilize the advantages and ordered electric vehicles. Nissan knew about this, and they had already mapped out the Norwegian market when they released the Leaf in the country. Tesla had also mapped out the Norwegian market to know that the Norwegian market had a lot of potentials. So both Tesla and Nissan Leaf were central and active in Norway to increase their volume of electric vehicles. Both of these actors should have a lot of honor for the EV sales in Norway because the prices for their cars were more at a competitive level."

When the Tesla Model S arrived in Norway, it pushed the limits for the electric vehicle. With a large battery pack, the car redefined the maximum driving ranges of EVs, still within a decent price range.

> **Marius Valle:** "They built a large passenger vehicle. With a big enough range to substitute it with a normal ICE car. However, it took some time to get everything in place, with the charging network, for example. If you look at Leaf or the MiEV – they were proper cars – but they still looked a bit weird. But Tesla came with cars that could drive long, had sporting performance, and was not that expensive. I do not remember the price exactly, but I think you could get it from 400k and up. So I believe this changed a lot of people's perception about what an EV is. It is clear that without Tesla, it might not have gone as fast as it has."

The other car manufacturers are not resistant to innovation and change, but change has developed slowly. However, Tesla came in with disruptive and radical innovation and technology in the automobile industry.

> **Marius Valle**: "We have seen a lot of development. But the most important has been the battery technology. There have not been any big leaps, but the energy density has steadily improved while the prices have gone down regularly. You also have actors that have had a big influence on how this technology has been developing. I am speaking about Tesla. The battery technology they used was an advantage, and they developed their car from the bottom and up as an electric vehicle. That means a lot. Because many of the other cars on the market and that still arrive is kind of a rebuilt fossil car. Maybe except the Leaf. However, they probably have used some car parts from the traditional cars too. I know that the Renault Zoe has a lot of Renault Megan components."

Marius Valle recalls a conversation he had with some American engineers from Tesla once. He was not allowed to cite them in the interview, but he remembers the conversation:

> **Marius Valle:** "I talked to multiple engineers in Tesla once in France, at a Tesla event. They were Americans. I went all the way to France to speak with them, but I was still not allowed to quote them. I tried discussing with them how they develop an EV compared to the traditional manufacturers (like Audi). I said something like: "You create an EV from the bottom. You do not have any legacy you need to be cautious about, so you can build it all from scratch. For example, Audi, when they make an EV, they must use some of what they already have." One of the engineers replied: "But do they really need to do that?" This is one of the many assumptions - that car manufacturers must build cars with what they have. When Audi made Audi E-Tron, a rebuilt fossil car in many ways, the engineer at Tesla argued that when Audi made cars in this way, they were not properly interested in making EVs. It was rather something they had to do. They find the simplest way to build it together, not fully invested into it."

4.5.2 Strong EV Policies

What is striking when looking at the political efforts to create the EV initiative in Norway is the willingness to keep supporting the incentives with investments and measures over such a long period.

> **Odd Einar Dørum: "**It was small wins. One new incentive after the other. Then we followed up with tax measures and subsidies, and exemption of VAT. Together, it made up this incentive package that has led the electric car from being exotic to now making up over half of the new passenger vehicle sales in the country."

Some have argued that the governments should have done more financially to save the company Think from bankruptcy, but Asphjell believes that is not the case:

> **Øystein Asphjell**: "…I believe that is unfair. All the Norwegian governments did a fantastic job implementing political incentives for the increased implementation of EVs. For example, the EV access to the bus/taxi lane and the EV exemption from VAT were both important. They implemented these incentives effectively, with a long-term vision that Norway could become a lead example for other countries to follow. It shows that cooperation between public and private businesses can be fruitful – to create a paradigm shift in the transport sector."

Since the beginning of the initiatives in 1990, the actors promoting EVs had grown. Niche actors, interested businesses, the Norwegian EV Association, and environmental organizations had a more substantial influence.

> **Ole Gudbrann Hempel**: "An advantage was that we also had an electric vehicle lobby that had been growing since the Think-times. They were able to keep the pressure on the government to maintain the incentives, even when the sales numbers were pretty low. The fact that these incentives were held in place was fundamental."

There also seems to be a link between increased environmental attention and a focus on policies that could cut emissions in Norway. Despite changing governments over the past 25-30 years, the political consensus around support for the EV initiative has maintained strong.

> **Odd Einar Dørum**: "At the Liberal Party, we wanted to use the market to improve the environment and climate. We looked at what we could do. That's where the electric vehicle came in as a measurement. The EV initiative has sustained in both good and bad days!"

The EV initiatives have stayed in place. The initial goal in 2012 was to keep all the incentives going until Norway had reached 50,000 EVs. We now see 400 000 electric vehicles on the roads (Elbilforeningen 2021).

> **Ole Gudbrann Hempel**: "First and foremost, the progress we have seen is thanks to the political incentives implemented."

4.5.3 NTP – Ambitious Target to only sell Zero-Emission Passenger Vehicles by 2025

The Norwegian Parliament has, through their national transport plan 2022-2033, for some better known as NTP, set some of the world's most ambitious climate targets for the transport sector. The national goal is that all new passenger vehicles sold should be zero-emission by 2025 and that emissions from the transport sector as a whole should be reduced by 50 % by 2030 (Det Kongelige Samferdselsdepartement 2021). This target has become a unifying target amongst politicians in Norway. Dørum explains that there is still a lot of work remaining to achieve the target:

> **Odd Einar Dørum**: "It's clear that the political incentives have had much to say for the development. We created a political alliance around electric vehicles that have helped make them cheaper. There has been cooperation across the political specter on this particular development. But there is still work left to reach the targets for 2025. Reaching that target is both necessary and possible."

4.5.4 Are fast Chargers being built fast enough?

With the establishment of Transnova (now Enova), the Norwegian EV initiative has also focused on expanding the charging infrastructure in the country.

> **Ole Gudbrann Hempel**: "…in 2015, with Enova, the parliament decided that a national fast-charging network was going to be built out in Norway. It would be developed through Enova and a public tender contract. Suddenly Norway had a good fast charging coverage on all national transport corridors except Finmark and Lofoten in the north."

Ole Gudbrann Hempel also recalls back to 2013, when there were not many fast chargers in Norway. He points out that the car manufacturers also looked to promote charging infrastructure as well as their cars:

> **Ole Gudbrann Hempel**: "Cooperation with the car manufacturers was also important. One of the things that Nissan did was to sponsor 50 fast chargers to be built around different Kiwi stores spread across Norway when they arrived in the Norwegian market. We at Fortum were chosen as the operators of these chargers. I think this was back in 2013 to stimulate fast chargers to be built around the country so that drivers could move where they wanted. Nissan was part of making the first effort at a national network of fast chargers."

Many factors are influencing how fast an electric car recharges. It depends both on the charger and the car:

> **Marius Valle**: There are many things that affect how well your car will recharge the battery. You have what happens on the charger and what happens in the car. The first is how many kW (effect) the charger can deliver. So if you charge at a charger that has 50 kW, then this is what you maximum can get. Or 150kW or 300 kW, at the new superchargers, that is what you max can get. The next is the car. The car decides how much effect (kW) it wants to receive. Even though a charger can deliver 300 kW, it does not mean that you can receive it. How much you will receive depends on what voltage (V) the car battery has and how the battery control system in the car is programmed. Because the car's system decides, it can say, "now I want 400 V and 50 A". [This gives 20kW]. When you connect to a charger, the car is the boss. The car controls the charging. Ant this

> is a security mechanism, so if the battery is very cold, the vehicle will limit the amount of effect it wants to receive. Or if the battery is quite full or gets a lot of power, it also might cut down the effect (kW). These measures are about protecting the battery against damage. If you had charged with max effect up to 100 %, it would probably be fine a couple of times. But then the battery will be damaged over time, reducing the lifetime and health of the battery."

However, some argue that the charging infrastructure needs to be expanded faster (Kristensen et al. 2017, 10). The first group of EV owners were generally people with short commutes and did not necessarily use public charging infrastructure to any particular extent. They had the possibility to charge at home. However, there is a more significant challenge for owners today, that might not be able to establish a home charger. However, most EV owners still do not use public charging to any particular extent. In 2017, only 3 % said they needed to fast charge on a daily basis, while only 15 % required to fast charge once a week (Kristensen et al. 2017, 10). However, the EU recommends that there should be an available charging station for every 10th electric car by 2020. In 2015, Norway should have had 25 000 public charging stations available. The fact is that Norway had 1350 stations.

Some barriers must be overcome in order to succeed.

One of these is the uneven geographical distribution of EV sales. In half of the country, the EV sales are not increasing in any particular measure, and nine municipalities make out half of the EV sales (Pedersen 2021). Especially in the northern parts of Norway, the EV market has for a long time been moving slow. According to Pedersen (2021), 67 Norwegian municipalities have a passenger vehicle stock where EVs make out as little as under 2 %. It's important to mention that these places are small municipalities with low population density. Still, many of the northern parts of Norway have so far been lagging behind in EV adoption.

However, tendencies are indicating that things might be about to change in the north of Norway. Interestingly, the highest percentage increase in EV market share sales of new passenger vehicles occurred in Finmark (northernmost county in Norway) in the first half of 2021 (Skogstad 2021). Christina Bu, who works as general secretary at the Norwegian EV Association, describes it as "remarkable" (ibid). As she points out, people in Finmark do not have the same pleasure of all the political incentives as people in the southern parts (where the EV market share sales are higher) might have. There are very few toll roads and ferries in Finmark, so the EV exemption of these charges has a more negligible effect. EV access to the bus/taxi lanes is also of very little importance in Finmark. She points out that economic incentives, like the VAT exemption, and the improved charging infrastructure in the region, are decisive factors that have helped improve the sales numbers (Skogstad 2021). Also, the increased selection of EV models with an improved driving range is also a factor. Enova has supported the construction of fast-charging stations in the region, resulting in that Finmark now having 21 fast-charging stations, compared to only 1 in 2019 (Skogstad 2021). I would argue that including all the areas in Norway in the transition over to electric passenger vehicles is of great importance, especially as the concept of 'fair climate policies' is becoming an increasingly important subject in current climate discussions in Norway. "A green transition that is understood as fair is a prerequisite to succeed with the green transition" (NOU 2021, 135).

The mentioned charging infrastructure is another one of the barriers to even higher adoption of electric vehicles in Norway. For more extended distance travels, a well-organized charging infrastructure must be in place. The Norwegian charging infrastructure has been criticized for not being user-friendly. As the Norwegian EV market has grown, so has the number of charging companies that operate the charging stations. According to an article by the Norwegian EV Association in 2020, ten different charging companies exist in the country (Haugneland 2020). Many of these come with their own apps and different price models, potentially confusing for the users. The Norwegian EV Association did a questionnaire where they asked over 15 000 EV owners if they thought the various payment models at fast charging were easy to understand? As seen in figure 7, 47 % replied no.

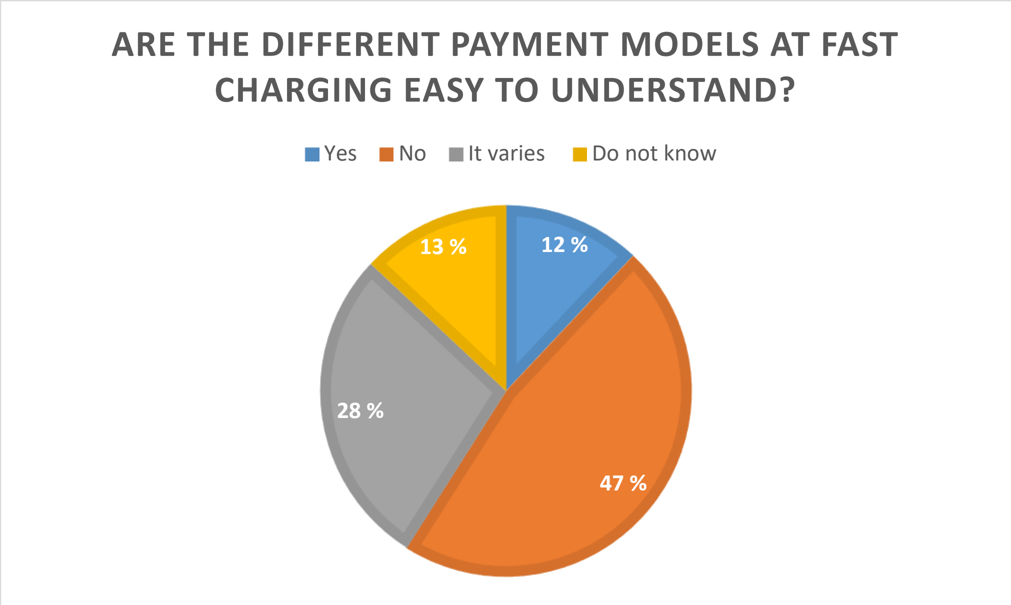

Figure 7- Questionaire by the Norwegian EV Association (source: Thronsen 2021)

Also, access to charging points, especially at peak times, has received criticism for being insufficient (Skogstad 2020). If the charging infrastructure is inadequate, the transition over to fully electric passenger vehicles transport is in danger of being delayed. It can also cause a higher degree of "range anxiety" in the Norwegian public. Range anxiety is a term that has been used increasingly as the Norwegian EV market has grown. It's a form of fear or anxiety of running out of power on an EV drive before finding a charging point. Another issue is the lack of access to charging at home for Norwegians living in housing associations. According to research done by the Norwegian EV Association and Nordic Energy Research in 2020, 59 % of Norwegians living in housing associations cannot charge an electric vehicle where they live (Viseth 2020).

During peak times at popular charging stations, people can also experience long queues at the stations (Skogstad 2020). The Norwegian Automobile Federation explains that if the Norwegian state does not take a more active role in establishing more charging infrastructure, the 2025-target of only selling zero-emissions passenger vehicles might be in danger (Valle 2021a).

4.5.5 Economy

The EV initiative has encountered some challenged through its development also. Many have argued it is too expensive. Odd Einar Dørum admits that the price of the EVs and the EV promoting policies have been barriers to the development. Still, the incentives have been significant in making the EV's price compete with the cost of ICEs.

> **Odd Einar Dørum**: "It has certainly been demanding work at times to defend these incentives. People have come up to us and told us: "are you aware of how this much this costs the Norwegian state?" But my response to that has been that it does cost money to create change! Yes, there was a hole in the national budget. However, we in the Liberal Party have always believed that this was the right decision. We fought for keeping these advantages in 2013 and 2017, and we demanded the incentives upheld if we were to join the governments those years."

Norway has one of the highest VATs in the world, at 25 % (PWC n.d.). The VAT exemption for EVs has later been described as one of the most essential political measures that were implemented to promote EVs in the country. When talking about why consumers today decide to buy an EV instead of a gasoline car, Marius Valle explains the importance of the VAT exemption as an economic incentive:

> **Marius Valle:** "Economy, I would say, is the most important reason people have changed over to EVs. And when they first have tried an EV, they rarely go back. Because it is more comfortable to drive, less maintenance, etc.…not having to pay VAT, it is very nice for Norwegian people. The feeling of not having to pay VAT seems to have been an important factor for people to buy an EV. People get the feeling that they have already received a discount on the vehicle. A 25 % discount. It also makes some people argue that: "this proves that people that buy an EV are not thinking about the climate or environment when they purchase the electric car." To some extent, that is correct, but it is also exactly why we have implemented these economic incentives."

A questionnaire performed by the Norwegian EV Association supports Marius Valle's reflections on the importance of the VAT exemption and economic incentives. The Norwegian EV Association did a questionnaire amongst its members during the summer of 2021. They asked their members about the most important reasons the EV owners decided to buy an electric vehicle instead of other options. The results from the questionnaire, illustrated in figure 8 below, show that economy/low cost is still a fundamental reason for Norwegians to buy EVs.

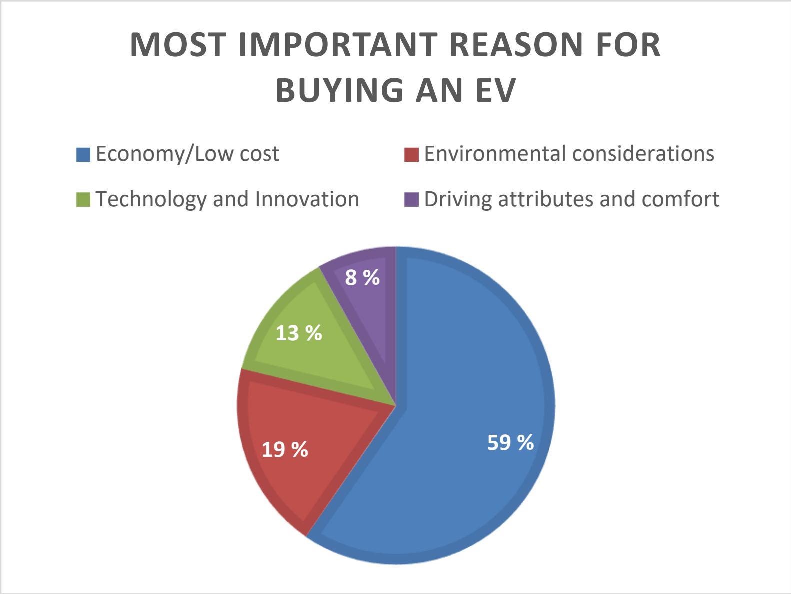

Figure 8 - Questionaire to EV owners by the Norwegian EV Association in 2021. (Source: Nesheim 2021)

However, the VAT exemption for certain EV cars is now under pressure. In 2022, Norway might see VAT being introduced to electric vehicles in the more expensive segment (Stensrud 2021).

> **Ole Gudbrann Hempel**: "There has been some debate about the people buying Tesla, for example. Some people say that the people who buy Teslas are wealthy and should pay more tax for their cars."

The proposal is that electric cars that cost up to 600 000 NOK should still receive VAT exemption. However, more expensive vehicles than 600 000 NOK should receive a VAT tax for the additional price. It means that an EV that costs 700 000 NOK will receive an extra VAT tax of 25 000 NOK (25 % of 100 000).

> **Odd Einar Dørum**: "There have been people questioning our politics. Different politicians have questioned if all EVs should receive the incentives, and the latest now is the debate about whether EVs that cost over 600.000 NOK should be exempted from the VAT tax or not. So the EV incentives are up to debate all the time."

Ole Gudbrann Hempel explains that Norway needs to be cautious about removing the EV incentives too early:

> **Ole Gudbrann Hempel**: "Most political parties agree that we can't just remove all the incentives at once. They must analyze which incentives can be

> removed/decreased and to what degree, and how this will affect the EV sales in the market. It has become quite a critical national climate policy. We have committed ourselves through the Paris agreement. So, removing or decreasing the EV incentives can have strong consequences. Denmark did quite well in the EV market until 2016. But then they made some changes to their tax system and EV incentives. Then the electric vehicle sales fell by 80 %. It was a disaster. Denmark has become an example of what not to do when removing incentives and subsidies for electric cars. It was too early. This is something Norway is aware of and wishes to avoid."

The Norwegian government estimates that the EV incentives cost the state almost 19,2 billion NOK each year (Figenbaum 2017, 31). As Erik Figenbaum explains, the EV incentives seem to be gradually changing now because of the government costs and the high market share of EVs. Local authorities are now allowed to implement toll roads and payment for EVs at ferries. However, these fees are restricted to only half the price of ICE vehicles. As the target is that 100 % of all new passenger vehicles sold should be zero-emission, the EVs incentives remain relatively strong in Norway.

5 Discussion

In this chapter, I discuss the network's assemblage in the Norwegian EV initiative and the different translations that have occurred. Also, the different punctualizations that have been revealed are discussed. I explore the implications for the future of the Norwegian transport sector, investigate the international EV developments, and consider whether these changes in transport are indeed a transition to a new "system of automobility," as John Urry has presented.

5.1 The Assemblage of the Actor-Network and the Process of Translation

The ANT approach is concerned with how actor-networks emerge, how they hold together, how they both shape and reshape, and how they might fall apart. This research has followed the Norwegian EV initiative from a story about a relatively small niche market of electric vehicles into one of the leading EV markets in the world.

In Actor-network Theory, the research does not only focus on the technological object. Focus is expanded and also involves all the cultural and social networks surrounding it. These networks interact dynamically and constantly with one another. Therefore, the electric vehicle does not hold much value alone. "Our technologies mirror our societies," ANT researcher Wiebe Bijker once said (1992, 3). The electric vehicle serves no purpose unless people drive it. As seen in the previous chapters, many cultural, political, economic, and technological factors needed to be in place before Norwegians started purchasing EVs in any noticeable number. Michel Callon, ANT researcher, explains what he investigates in his ANT analysis of the case of the electric vehicle in France during the 1970s:

> "How is it that ideas and writings that issue from these institutions are able to revolutionise, if only gradually, conditions of work in industry, the universe of consumer goods and lifestyles? How are the discoveries made…diffused such that they become universally known and recognised? How are certain technical devices, shaped in research departments … able to conquer markets throughout the world?" (Callon 1987, 19)

The investigation in this thesis has explored many of the questions that Callon mentions above. One of the central ANT concepts that this thesis is concerned with is the assemblage of the network. As explained in chapter 2, these assemblages are often complex and involve both human and non-human actors. In the case of the Norwegian EV initiative, the complexity of the development is apparent. During 30 years of development, the initiative has involved many networks and actors. This research has looked into the Norwegian EV initiative's assemblage to understand better the complex web of actors that has made up the Norwegian EV initiative. The second important ANT concept in this research is the process of translation. In short, translation is a contended phase where actors within the network shape and reshape other actors enrolled into the network. This translation might change the identity, interests, roles, and actions of other actors. Conflicts may arise, and the success of translation can not be taken for granted.

As discussed in this thesis, the electric vehicle is not a new technology. At the beginning of the 20^{th} century, the competition between the electric, damp-driven, and fossil car was not decided. However, the EV technology proved inadequate to the fossil car around 1912, and the fossil car has since dominated the passenger vehicle fleet in most areas of the world. There were some attempts to develop EVs in Norway during the 1970s. However, the real assemblage of the actor-network in the Norwegian EV development did not form until 1990. As seen in this research, the appropriate starting point for the EV initiative in Norway was when environmental organization Bellona, together with Harald Røstvik and the pop-group a-ha, pushed the Norwegian politicians into implementing the first political incentives to promote the development of electric vehicles in Norway. In 1989, “the idealists took the opportunity,” as Asphjell et al. explain (2013, 67). They imported the red fiat panda and wanted to show a practical solution to the climate issues they were talking about. The assemblage of the network, the EV initiative in Norway, began as the heterogeneous actors Bellona, the fiat panda, politicians, the first political incentives were drawn together in a network and started to interact with each other.

What exactly were the visions at the beginning? Frederic Hauge, the leader at Bellona, explains: “To point at the problem is easy. To work with the problem to find examples that can create precedence is harder. Our method has been actions that can give momentum" (Asphjell et al. 2013, 103). The team started pushing the government through different actions—one of these where when they demonstrated that electric vehicles should not pay toll roads. Harald Røstvik explains: "Together we made the plan to travel to Switzerland, buy the electric vehicle and then performing the EV stunts. Behind this was a team attractive to the media: popstars, a researcher, an environmental organization…." (Asphjell et al. 2013, 106). These efforts saw the first political incentives introduced to promote the usage of electric vehicles in Norway. Bellona looked at how they could push the politicians to create incentives to encourage electric vehicles sales in Norway. At the same time, politicians themselves were looking at ways to reduce greenhouse gas emissions. For them, the electric vehicle seemed a reasonable option. Odd Einar Dørum, involved in the processes as a politician, explained that the politicians viewed the electric vehicle as something "exotic." The politicians were looking at cutting emissions in the transport sector, and electric vehicles became an option that looked promising.

At the same time, Norwegian entrepreneurs wanted to create an automobile industry in Norway. The company Pivco (later Think) had a vision about mass-producing electric vehicles from their factory at Aurskog. From the research, it seems likely that the political incentives were also highly motivated by the possibility of a new Norwegian industry adventure with Think. The politicians saw the potential of an industry contributing to higher employment. This period also saw the creation of NORSTART (later known as the Norwegian EV Association). This interest organization has also played a significant part in pushing for further incentives and worked as a place for knowledge sharing between the EV interested actors as well as providing information to the Norwegian society about the possibilities of electric vehicles.

The opportunity for Think to become an impactful Norwegian industry seems to have played a role in the persistence of the political will to keep and develop further economic incentives to create a larger market for electric vehicles in the country.

From the research on the development of the Norwegian EV initiative over a 30 year period, it is clear that many actors have been involved in the shaping and reshaping of the initiative. Therefore, I have tried to make an overview of some of the actors central to the development of the Norwegian industry in figure 9. The actors/entities involved are placed within the categories: technology, industry, politics, pioneers, economy, society, and international landscape. However, this overview only scratches the surface, and this thesis has looked deeper into each of these categories. When investigating these categories, a new set of networks of actors unfold within each category. This set of networks and how they interact with each other is what this ANT research has explored in more detail.

A very simplified actor-network map

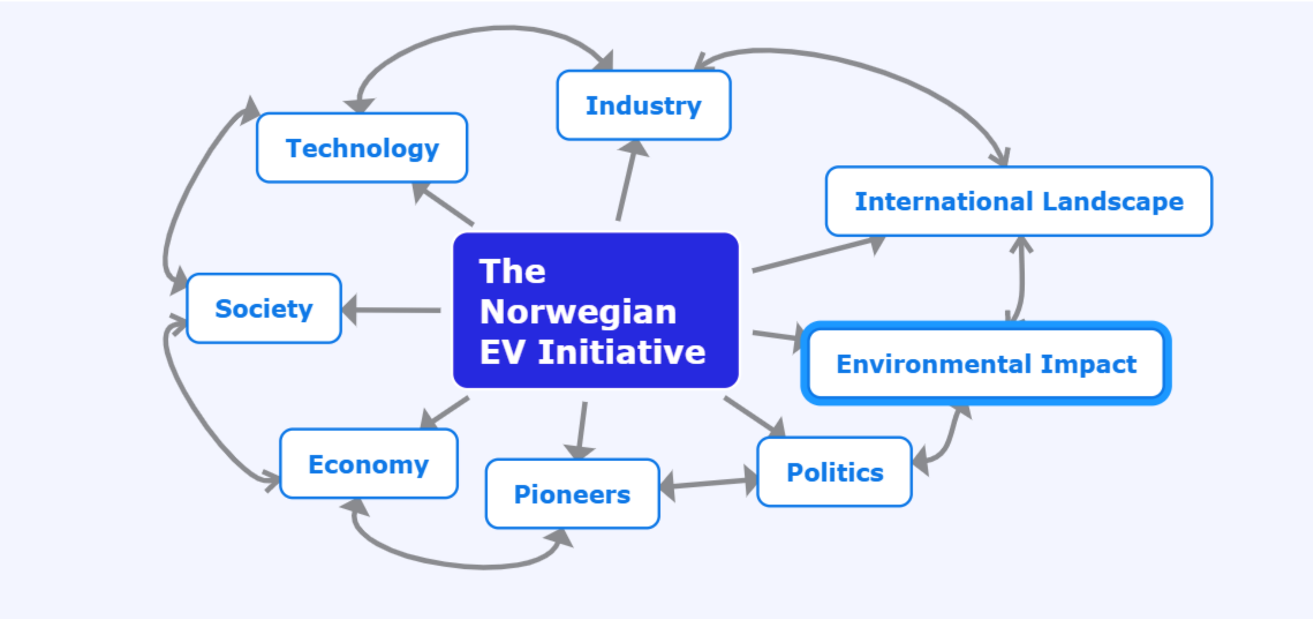

Figure 9 - Note: created by the author.

In the Norwegian EV initiative-network assemblage, many different actors have been involved, both human and non-human. Below, in figure 10, I have created a more extended actor-network map. The example below serves as a helpful tool to categorize some of the central actors in the network.

A map of the actors involved in the Norwegian EV initiative

Figure 10 - Note: created by author. This more extensive map is also a simplification of the entire initiative, but is a helpful tool to categorise some of the central actors in the network. Inspired by the multi-level perspective framework on the Norwegian EV development presented by Erik Figenbaum (2017, 28).

Over 30 years, the actor-network of the Norwegian EV development has become extensive. Therefore, it became apparent during the investigation that involving all the entities and actors that have been part of the network was going to move beyond this thesis's available time and space. The decision was made to identify some key moments that seem to have been crucial in creating and forming the actor-network according to the actors. The ANT approach was then used to describe these moments. It might seem arbitrary that the researcher has chosen some moments to focus on and leave others behind. The researcher has made every effort to allow the actors themselves to decide these critical moments and key actors by letting them tell their own stories using their vocabularies. This investigation reveals some of the negotiations and compromises made in the actor-networks in developing the Norwegian EV initiative.

Pioneers have played a significant role in developing the Norwegian EV initiative, as this thesis has shown. In the beginning, niche pioneers strongly affected the assemblage of a more durable network of actors surrounding the EV initiative, pushing the politicians to enroll political incentives into the network. The Norwegian EV Association has also had a strong influence.

Technology has a central role in the Norwegian EV initiative. The electric vehicle is essential for the network to be alive. Technological advancements in battery efficiency and price have strongly shaped the other actors in the network. Also, the role and development of charging infrastructure seem to play a pivotal role in people's perception of the usefulness of electric vehicles in Norway.

The industry is another actor-network within the EV initiative that plays an important role. As seen in the research, the efforts to create a new Norwegian industry with the EV producer Think played a significant role in the steadiness and improvements of Norwegian EV policies. Also, when the international car manufacturers entered the Norwegian EV market in 2010, with models like the Mitsubishi MiEV and Nissan Leaf, the EV sales numbers increased strongly. Especially the entrance of the Tesla Model S in 2013 contributed to a drastic increase in the EV sale numbers.

Think, when investigated, is an actor, but also a network of actors itself. The development of Think was for a long time looking promising. The company had ambitious visions, but the period of translation where other actors were enrolled into the network was unstable. Ford played a significant role in the translation of the network. However, when Ford was forced to sell Think, many things changed at Think, and the development was never able to become successfully stable, and in the end, went bankrupt.

Politics has been central. Norway has had strong EV incentives in place for a long time. The politicians looked at ways in which to reduce emissions, and the EVs proved attractive means to reduce emissions from the transport sector. The network of Norwegian EV policies has been impressively durable, influenced by pressure from environmental organizations and interest organizations like the Norwegian EV Association and Think, who looked to establish EV manufacturing in the country. ENOVA has proven a valuable tool to promote the establishment of Norwegian charging infrastructure. Also, the broad climate settlement policy in the parliament has played a role in solidifying the development. The National Transport Plan works as a central government paper, where the parliament stated the goal that all new passenger vehicles sold by 2025 should be zero-emission vehicles. These are all actors that solidify the network.

The economic factors have been central to why an increasingly large number of Norwegians decide to purchase an EV instead of a fossil car. As Marius Valle explained: “Economy, I would say, is the most important reason people have changed over to EVs.” The purchase price has been strongly shaped by the economic incentives implemented by different Norwegian governments. VAT exemption, no registration fee, no/reduced toll road fee, and ferry charges have been strong incentives. As well, the low maintenance cost of an EV has also encouraged buyers. The EVs have also decreased in price, as the car's technology and the battery have improved over time. However, the EV initiative has also come at a substantial cost for the Norwegian state.

The **international landscape** has also influenced the development. At the beginning of the EV initiative, the Californian ZEV mandate created a belief that Think’s cars could also sell in the Californian state. Also, this ZEV mandate influenced the international car producer Ford. The mandate forced Ford to think about how to produce more zero-emission vehicles, and they decided to buy Think. Ford's entrance at the factory at Aurskog reinforced the belief that Think might succeed and that EVs would be the future. In the same way, as the international landscape made the network of the Norwegian EV initiative more impactful and durable, the decline of the ZEV mandate and the withdrawal of Ford from Think also made the network more unstable again.

The perception in **Norwegian society** has changed over time and stabilized. In the beginning, the small electric cars did not dominate the traffic picture in any way in

Norway. It was a niche product, and those driving the vehicles were perceived as a bit 'strange.' However, this perception slowly changed in the Norweigan society as economic advantages, technology developments, and environmental impacts have shown that the EV is a reasonable option to the fossil car. Now, there seems to be a strong belief amongst many Norwegians that EVs are the future in the passenger vehicle segment.

Environmental impact is an essential factor for development. The politicians were looking at ways in which to reduce greenhouse gas emissions in transport, and the EV was an interesting possibility. Because of the massive emissions from fossil cars, the transition over to zero-emission vehicles is essential if Norway and the world limit global warming and climate change.

I introduced the concept of a **translator-spokesperson** in chapter 2. It explains the process when a single entity or actor (the translator spokesperson) represents a network of actors. In the Norwegian EV initiative, the political incentives can be interpreted as one of these translator spokespeople. The incentives are often highlighted as the reason for the successful adoption of EVs in Norway. As seen in this investigation, many actors have shaped these political incentives. Still, the incentives are highlighted as the actor. Another example is the car company Tesla. Tesla seems to have become a translator-spokesperson for the vast developments in EV technology and EV adoption over the last decade.

5.1.1 Punctualization

As mentioned previously in chapter 2.2.1, the process of black-boxing is also called punctualization. When two or more actors are connected together, they form what is understood as an actor-network. In ANT research, these networks always consist of actors. At the same time, these actors can themselves consist of a whole new network of actors when the researcher opens them up for investigation. Sometimes, these connections can be challenging to understand fully, and an actor (that again consists of a network of actors) can be taken for granted or black-boxed. This black box arises when people no longer question how a particular technology or knowledge is constructed. During the investigation of the development of the EV initiative, the thesis attempt to open up some of these technologies or pieces of knowledge arguably have become black-boxed to a certain degree. As EVs have become increasingly integrated into everyday lives for Norwegians, these technologies or bits of knowledge have become black-boxed.

First, I would argue that some of the potential motivations behind the development of the first EV incentives have to some degree become back-boxed as the development has stabilized. To use an example, the Norwegian EV Association summarises the Norwegian EV policy with these words on their website:

> The Norwegian success story is first and foremost due to a substantial package of incentives developed to promote zero-emission vehicles into the market. The incentives have been gradually introduced by different governments and broad coalitions of parties since the early 1990s to speed up the transition (Norsk Elbilforening n.d.).

The text above is correct. However, in this summary, some of the important actors behind the EV incentives are hidden. Here, the process of punctualization has made an entire network of actors into a single actor in another network, in this case, the package of incentives. The actors that shaped and reshaped the EV incentives network have been black-boxed. As the investigation in chapter 4 shows, many actors were involved in shaping the first EV incentives during the 1990s. Together with Harald Røstvik and the pop-group a-ha, environmental organization Bellona pressured the government to implement the first incentives through actionism. Also, the hopes of a Norwegian industry adventure through the establishment of Think certainly impacted the formation and durability of the EV incentives. To revisit a statement by Odd-Einar Dørum, he explained that Think also was an important actor. “The government looked at the possibility of starting new industry here. Think was a great tool for us to start asking for zero-emission cars. We rooted for technology development that led to the development of zero-emission vehicles.” The international influence, especially the ZEV mandate, has also been investigated in this thesis. This global influence on the Norwegian EV initiative was discovered when actors and their motivations were investigated more thoroughly.

Secondly, as the electric vehicle has become increasingly common in the Norwegian market, the knowledge about the electric vehicle's inner workings has also become increasingly black-boxed. Arguably, those who bought electric cars in the early period were perhaps more interested in the car's inner workings than those who purchase EVs in the mass market today. The niche market during the 1990s perhaps contained more technology nerds interested in the technological aspects of the car than what many of the buyers today are. This EV network is increasingly stabilized, and people have an increasingly strong trust in the technology's quality. However, as the popularity of EVs is still relatively recent, many customers are investing time and effort in understanding the technical sides of the car and the variables that may influence the range and performance of the vehicle. As well, the charging network demands user knowledge. As technological development becomes more and more successful, fewer people focus on its internal complexity. Interestingly, the digitalization and technological advancements on the inside of the car arguably make the car's inner workings increasingly black-boxed. The car’s inside network of actors is becoming increasingly complicated and digitalized, therefore also increasingly black-boxed for its users.

5.2 What Next? The Way Forward

Norway has committed itself to reducing greenhouse gas emissions by 50% -55 % by 2030, compared to 1990-levels. To achieve these reductions, deep cuts in the transport sector are required, as the sector stands for about one–third of the total emissions in the country. Norway has set ambitious targets for significant cuts in CO2 emissions in the sector. By the end of 2025, all new passenger vehicles and light vans shall be zero-emission vehicles. Also, all new buses should be zero-emission vehicles or use biogas by 2025. In addition, by 2030, the target is that all heavy-duty vehicles, 75 % of new long-distance coaches, and 50 % of trucks should be zero-emission (Regjeringen 2021a).

Electric vehicles represent over 60 % of the new passenger vehicle sales so far in 2021. Therefore, the trajectory to reach 100 % seems possible within 2025. As director of OFV in Norway, Øyvind Solberg Thorsen, explains: “The pace of registrations for new passenger vehicles is clear. People want electric cars, preferably SUVs or others, that meet space, equipment, range, and price demands. Many new electric vehicles fulfill these demands, and they are coming in an increasing number” (OFV 2021b).

The transport sector entails more than just passenger vehicles. Not only passenger vehicles are being electrified. By 2030, most of the transport segments should be zero-emission vehicles. There is currently a lot of developments happening in the transport sector. By the end of 2021, Norway should have 57 ferries running on batteries (Energiogklima n.d.). Hydrogen solutions for freight transport and heavier vehicle segments are also being developed, and actors like Posten, Coop, and Schenker have set a target to have at least 100 freight vehicles running on hydrogen within 2025 (Hovland 2021). The Norwegian Hydrogen Plan by the Norwegian Ministry of Petroleum and Energy and the Norwegian Ministry of Climate and Environment (2020, 34) states that:

> Heavy goods transport by road is an area in which hydrogen could potentially play a role in reducing emissions. This is thanks to its lower weight-to-range ratio compared to batteries, and to the fact that there could be limited access to sustainable bio-based fuel. A hydrogen tank can also be refilled as quickly as a tank of diesel, which is significantly faster than the time needed to charge an equivalent battery vehicle.

The hydrogen plan was launched in 2020 and emphasizes that hydrogen can have an important role in transitioning to a cleaner transportation sector, particularly in the maritime industry, aviation, and freight transport. To decarbonize the transport sector, a holistic approach to the challenges and solutions is required.

5.2.1 Life-Cycle Analysis

As mentioned, the EV is at least twice, and perhaps even four times, as energy-efficient as a vehicle with an internal combustion engine (IEA 2021, 9). According to Figenbaum and Kolbenstvedt (2013), this means that the total emissions of the EV from energy source to the wheels will be lower than the fossil cars, even with electricity produced with an average European energy mix. Especially for Norway, the emission cuts could be more than 95 % as Norway is very much supplied with electricity from their hydroelectric power system (Figenbaum and Kolbenstvedt 2013). All energy production, however, will have an environmental impact.

As mentioned, electric vehicles have no tailpipe emissions. However, it is essential to remember that the electric car still represents an environmental burden. Life cycle assessments (LCAs) are necessary to understand the electric cars' total environmental impact. The life cycle assessments are used as a holistic approach to assessing the environmental effects of the electric vehicle through its life cycle. That includes production, use, and the end-of-life phase (Chordia et al. 2021). The minerals used in the batteries, and the dismantling of the batteries when they have deteriorated, both involve substantial carbon emissions. The same also applies to the manufacturing and transport of vehicles to customers worldwide. The EVs are promoted as “zero-emission” vehicles, but in reality, they also represent an environmental burden. Marius Valle explained his view when asked about how environmentally friendly the electric car is:

> **Marius Valle:** “My answer is I don’t know. Yes, it is environmentally friendly because you create no local pollution and particles when you drive around the city. But I spoke with an expert on LCA analyses, and after I spoke with her, I understood that there is a difference between climate and environment. The more you read about something, the more you understand that you don’t understand, you know. But my perception is that: yes, in sum, it is positive both for climate and the environment to drive an EV, especially in Norway. And most likely most places.”

One of the biggest arguments against EVs is that the battery production for an electric vehicle is much more detrimental to the environment than the internal combustion engine. The initial environmental footprint from current EV production is larger than the production of ICE vehicles. The mining processes produce a large extent of climate emissions. Lithium is especially central here—cobalt causes ethical dilemmas. Recycling is also an issue. The numbers used in the LCAs on EVs differ considerably. As Ellingsen et al. (2017) explains, the LCA studies find emission levels from production ranging from 38 – 356 kg CO2-eq/kWh (Elligensen et al. 2017, 1). The main reason for this massive variation in results is the different assumptions regarding energy need both in the manufacture of the battery cells and battery pack. In 2019, a report by a leading German economy institute claimed that electric vehicles emit more than diesel vehicles. Their study investigated life-cycle emissions from EVs and concluded that electric cars emit between 11 and 28 % more than their diesel counterparts (Brussels Times 2019). This report received a lot of criticism.

Another LCA analysis, made by the International Council on Clean Transportation (Bieker 2021), explains that the life cycle-emission of EVs are already much lower than that of gasoline cars. This report demonstrates that the life-cycle emissions in Europe are already 66-69 % lower. Also, the emissions are 60-68% lower in the US, 37-45 % lower in China, and 19-34 % lower in India. As the electricity mix is expected to continue to decarbonize in the future, the emission gaps between EVs and gasoline vehicles are only likely to increase. Also, modern EV production is in its relative infancy compared to the manufacture of ICE vehicles. So as time goes on and new processes come into play, the environmental impacts are expected to be reduced.

As seen, the LCA analyses have different results. What is certain is that the production of electric vehicles comes at an environmental cost also.

5.2.2 International Impact

The Norwegian EV development does not exist in a vacuum, unaffected by global events. Internationally, electric vehicles are now obtaining an increasing momentum in market sales. In 2020, electric vehicle sales globally exceeded 10 million cars(Cui et al. 2021). EV sales represented a 4,6 % market share of total passenger vehicle sales. There was a 46 % increase in the number of high-volume EV passenger vehicle models and a 12 % reduction in battery pack costs from the previous year. Also, the number of EV public chargers increased by 48 %. Europe has overtaken China as the largest market for electric vehicles (Cui et al. 2021). It is important to notive that these numbers represent both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), where BEVs represent around 70 %.

China holds a dominating position in the total number of EV sales. In 2020, the Chinese people bought 1,3 million EVs, representing 41 % of the total EV sales globally. Six of the top ten countries registered an incredible annual growth rate in 2020. According to Cui et al. (2021, 7) these countries were Germany (270%), Italy (247%), France (200%), Belgium 171%, the UK (135%), and Sweden (134%).

The Norwegian market is not so substantial globally regarding the total number of EVs sold. However the market share of EVs in Norway's total passenger vehicle sales is still far ahead of any other country. The country seems to have paved a path that other countries around the globe seem to adopt on a growing scale. Therefore, there is a noticeable tendency that the Norwegian market increase might also transmit over to other countries in the world. Other countries are now setting targets only to sell zero-emissions vehicles within specific dates.

It's easy to be carried away when looking at the sharp incline in sales numbers of EVs around the world. Therefore, it is essential to mention that there is still a long way to go before the transition to zero-emission passenger vehicles is fully implemented.

To measure whether the Norwegian EV initiative has had any international effect is not the easiest.

One argument is that the Norwegian EV initiative has helped push the development of better EVs and battery technology globally. DNV GL's report by Alvik and Bakken (2020) support this claim. In the conclusion of their report, they explain that the Norwegian EV initiative has helped pressure global battery prices down. According to the report, the effect may seem marginal at first, but it has produced significant CO2 emission reductions in global developments. They explain that a higher volume of electric vehicles in Norway will slightly reduce the price of EVs elsewhere as the price of batteries and technology decrease. This creates a self-reinforcing effect – as the price of technology and batteries decrease, more people will purchase EVs, which again pushes the development and price of the technology. It is complicated to measure how much the Norwegian EV initiative has contributed to emission cuts globally. Still, the prediction in the DNV GL report is that the emissions globally would be close to 400 million tonnes higher over the period 2010-2050 without the Norwegian EV initiative (Alvik and Bakken 2020, 6). These calculations are highly debatable, but they serve as an example to show the potential global effect of the Norwegian EV initiative.

Elon Musk, CEO at Tesla, expressed his view on the Norwegian EV initiative in an interview (Frydenlund 2016) with the Norwegian EV Association in 2016: "Norway is a world leader when it comes to electric mobility. Your political incentives represent a great catalyst for the fantastic EV adaptation, and you have fought for sustainable transport for more than 20 years."

The number of electric car models is increasing rapidly. In 2020, 370 different EV models were available globally on the market (IEA 2021, 23). That was a 40 % increase from 2019. Most of the traditional international car manufacturers are now announcing increasingly ambitious electrification plans for their vehicle fleets. According to the latest IEA report, 18 out of the world's top 20 vehicle manufacturers have now stated goals to rapidly scale up their production of electric vehicles and their portfolio of different EV models (IEA 2021). Volvo has announced that they will only sell electric cars from 2030. Already by 2025, their aim is that 50 % of their sales are electric vehicles. In a statement, Volvo's chief executive Håkan Samuelsson explains: "To remain successful, we need profitable growth. So instead of investing in a shrinking business, we choose to invest in the future – electric and online. We are fully focused on becoming a leader in the fast-growing premium electric segment" (Volvo Cars 2021). Audi has announced that they will only develop electric vehicles by the end of 2026 (Automotive News Europe 2021), and Volkswagen will only sell electric cars in Europe by 2035 (Reuters 2021). Although these developments are in the early stages in many places, the transition in transport from producing EVs instead of ICE passenger vehicles seems more and more likely as the traditional car manufacturers are in growing fashion turning their production strategies over to making an increasing number of electric cars.

However, the transition is moving slower than wished. Transportation habits and preferences for the users are seemingly hard to change.

5.2.3 A New System of Automobility?

As mentioned in chapter 3.1, electric vehicles are part of a broader complex system of automobility. As Urry argued, the car is part of a system that involves many different elements. Through the investigation of the EV initiative in Norway, it is evident that electric vehicles are part of a system that involves more than just the vehicle. It also involves car drivers, roads, charging stations, energy supply, signs, politics, industry, environmental concerns, parking spots, habits, preferences, and other factors. The electric vehicle seems to provoke different feelings amongst people, as some see it as a solution and others only see it as a counterproductive, expensive political symbol. Therefore, I would argue that the EV can be interpreted as a technological sublime representing something outside of only its technology. It represents a part of the transportation system's future transition, which can provoke different feelings amongst people.

Urry argued that we might see automobility tipping into a new system, which he called the "post-car system" (Urry 2004). It is interesting to consider whether the Norwegian transport sector is indeed in such a transition over to a new system of automobility. The fossil car has been the dominating transport option in Norway for a long time, and the “fossil lock-in” has seemed very challenging to break. However, there are signs that the Norwegian transport system is indeed changing. The transition to electric vehicles is one of these. Urry mentioned electric cars as a potential tipping point. As this thesis has shown, Norway seems to have moved beyond a tipping point regarding integrating electric vehicles. The tendency is clear. More and more people are substituting their fossil vehicles with electric cars. The automobile vehicle industry is also increasingly transforming its businesses to make electric vehicles, thereby also increasing the model options for Norwegian buyers. Therefore, Norway seems to have passed a tipping point when it comes to adopting EVs, especially as the government has stated that 100 % of new passenger vehicle sales should be electric by 2025.

Other transformations that Urry argued could help tip automobility into a new system were innovations in materials used in the manufacture of vehicles, increased demand for smaller “micro-cars” for urban areas, the development of ‘smart-card’ technology, car-sharing, increased political focus on a more holistic mobility service integrating other types of mobility, and the advancements in internet and communication technology (2004, 34-35). Norway and other countries around the world are indeed experiencing many of these transformations today. Digitalization, software, and automatization are at the forefront of mobility changes of both people and goods. The network of connected services in GPS systems, sensors, and online communication technology creates an increased seamless web of services. It has resulted in more intelligent transportation systems (ITS) where car-sharing, car-renting, e-scooters, e-bikes, and so on are becoming increasingly popular. All of these services are also increasingly easy to access through different apps and integration within other systems.

A report by the Institute of Transport Economics in Norway (Cyriac and Julsrud 2018) investigates car sharing in Norway. They explain that car sharing is a service in rapid development. It has long been perceived as a niche service, but there is an increase in the number of users of the services and the number of platforms available, especially in urban areas. Car sharing is challenging the current mobility system, dominated by privately owned cars. It can reduce the number of vehicles on the road and the total amount of driving per user.

The future might also see autonomous vehicles. Oslo, Norway's capital, is currently testing out a pilot project with autonomous shuttle buses in the city (Pokorny et al.

2021). Hyperloop trains, which can travel at a speed of about 1000 km/h (Solberg 2017), are another mobility option under testing. All the developments mentioned might spur the transition process, both at the behavioral level for people and policy-making. The EV initiative also illustrates the importance of financial incentives for accelerating disruptive innovations in the transport sector.

A central issue is that the entire passenger car park is continuing to grow in Norway. In 1950, 81 000 passenger vehicles were registered in Norway. By the end of 2003, the number had increased to 2,3 million cars, while by the end of 2019, Norway had about 2,9 million vehicles registered (Holtsmark 2020). The Norwegian government has set a target about zero-growth of the total amount of passenger vehicles in and around cities – focusing on increased access to walking, biking, and use of public transport (Regjeringen 2021b).

It remains to see whether the innovations and transformations currently taking place in the Norwegian transportation system today are enough to push the system into a new era, a "post-car system," as Urry argued. In chapter 2.1.2, researcher Keith Smith introduced two types of innovations and their potential influence on the current fossil paradigm that countries are struggling to move beyond. Incremental innovations are less significant modifications to already established products and processes, while disruptive and radical innovations can significantly upset the current structure, transforming the market.

Although the electric vehicle itself is by no means a recent phenomenon, my argument is that it is not until recently that it has become a disruptive innovation. Many actors have had played a part, contributing to the improvement of EV technology. The company Tesla has undoubtedly been a disruptive factor in the EV market, challenging the very perceptions of a car. Herbert Diess, the chairman of the board of management of Volkswagen Group, recently stated Tesla is setting the new standard in the car industry. He explains that Tesla has changed the market. Not only by mass-manufacturing electric vehicles but also by developing software in their vehicles that are far superior to their competitors (Valle 2021b). Having no ties to the old car manufacturing industry, Tesla came in with disruptive and radical innovations that changed the passenger vehicle market.

It is essential that the transition the electric cars do not become the only transition in the Norwegian transport sector. Electric vehicles alone are by no means a sufficient transition in the transport sector. The transition requires structural changes in all the transportation segments, and the issue with growing ownership of passenger vehicles must be addressed as the population increases. A holistic approach to the transition required in the Norwegian transportation system is essential, looking at ways to reduce emissions and resource use. As Smith explains, reducing greenhouse gas emissions "is a challenge that requires more than just *incremental innovations* tied up with existing technologies. Not even disruptive technologies are sufficient. The transition requires a complete regime change" (Smith 2011, 31). The transportation system consists of a network of actors, including businesses, actors, resources, finances, politics, and society. The transportation system is changing, but it remains to see whether these changes will be sufficient for transport to move into a sustainable path.

6 Conclusion

Electric vehicles are recognized as a crucial measure to reduce emissions from the transport sector around the world.

Structural changes in most parts of society are required if the world is to have a chance at avoiding the worst scenarios of climate change. The transport sector is directly responsible for about 24 % of the carbon emissions globally (IEA 2020). Transportation is a central driver of social and economic development, connecting people to work, education, trade, health care, leisure, and each other. Privately owned passenger vehicles are a central part of this. According to United Nations Environment Programme calculations, 1.2 billion new vehicles are expected to be deployed within the following decades (UNEP 2021). With the current trajectory, where fossil fuels dominate the sector, the emissions from the transport sector will rise by 30 %. That raises worrying concerns both for the climate, local air, and energy security as there will be an increased need for both gasoline and diesel for fuel. Therefore, a drastic transition to a more sustainable transportation system is needed, with rapid reductions in climate emissions from the sector. Electrifying the transport system is considered a crucial step in this process, hence why the electric vehicle (EV) plays an important role.

Norway, the country investigated in this thesis, is at the forefront of the adoption of electric vehicles in the world. 14,8 % of the Norwegian passenger vehicle fleet is now represented by electric vehicles (Elbilforeningen 2021), far ahead of any other country, with the other European countries Iceland (4,4 %), Netherlands (2,7 %), and Sweden (2,0 %) following (IEA 2020, 44).

This thesis has investigated the development of the Norwegian EV initiative through the Actor-Network Theory (ANT) approach, which has been the theoretical and methodological framework for this investigation. In line with ANT, the research has "followed the actors" from the EV initiative (Law and Callon 1988, 284), taking all they have said and done into account. The data has been collected through in-depth semi-structured interviews with Odd Einar Dørum (a former politician involved in the forming of EV politics), Øystein Asphjell (EV expert and former employee at Think), Ole Gudbrann Hempel (works with Norwegian charging infrastructure), and Marius

Valle (runs a Norwegian EV podcast and knows a lot about the different EV models in Norway). Secondary data from news articles, books, government articles, corporate articles, and journal articles have also been utilized to provide further context and extend the insights of the different roles and connections between the various actors in the Norwegian EV development.

Through the research, a complex web of actors has revealed itself, involving actors from the categories of technology, industry, politics, environmental organizations, interest organizations, economy, social society, and the international landscape. How the actors from the mentioned categories have been shaped and reshaped in the development, have been investigated. Through 30 years of development, it is evident that the Norwegian EV initiative's actor-network has become extensive. Therefore, this investigation has not included every possible entity playing a part in the network of actors. That would have moved beyond the available space of this research. However, this thesis has investigated key moments and actors that have been central to the formation and durability of the actor-network of the Norwegian EV initiative. It might appear arbitrary in ANT research for the researcher to choose critical moments, but by "following the actors" as the ANT approach suggests, the actors themselves have decided the critical moments and central actors. Through interviews and extensive research, the actors have been allowed to tell their own stories. This is a rather complex network of actors all influencing each other, allowing or denying specific actions. Gro Harlem Brundtland, previous Norwegian Prime Minister and Director-General of the World Health Organisation, once said that "everything is connected to everything" (Johnsen 2015). This statement fits in well with this investigation. All the different actors in the network have connections, and without one, the story might have been different.

Having investigated the development through an ANT lens, this research has used three ANT concepts— assemblage, translation, and punctualization. Assemblage has looked at the process of how multiple actors have linked together to form the actor-network of the Norwegian EV initiative. The concept of translation has been concerned with how actors within the network have influenced and shaped other enrolled actors. Punctualization is the third ANT concept this thesis uses. Often, when the Norwegian EV initiative is described, the explanations for the success are oversimplified. As stated in a Forbes article: "The answer is simple, favorable environmental math, and financial incentives” (Nikel 2019). However, the financial incentives are a sum of actors assembled to form the actor financial incentives. These actors behind might be hidden from view. In ANT, this process is called punctualization or black-boxing. When closed, the box is seen as simply a box (one actor). However, when the box is opened, all the elements inside become visible. As this research has explored the initiative in greater detail and opened up these black boxes, several other central actors have revealed themselves.

The starting point of this research is the beginning of the 1990s, when environmental organization Bellona, famous pop group a-ha, and EV pioneer Harald Røstvik, pressured the Norwegian government to implement the first political EV incentives like the free EV passing in toll roads and exemption from registration tax. They accomplished this through dedication, hard work, and a few stunts that caught the media's eyes. Another important actor that has revealed itself through this research is the Norwegian car company Think, which tried to make it in the automobile industry by manufacturing small electric vehicles. It is not certain that all the political EV incentives that came at the end of the 1990s and the beginning of the 2000s would have been implemented if it had not been for the Norwegian car company. Odd Einar Dørum, who was active in politics in this period, explains that Think was a central actor and that “Think was a great tool for us [politicians] to start asking for zero-emission cars” (see chapter 4.1.2). When international car manufacturers started producing more EV models in 2010, Norway had already established a favorable electric vehicle “foundation,” with financial incentives, charging infrastructure, and other advantages that helped spur the interest amongst Norwegian buyers. The electric vehicle became an option that made sense, both in terms of the environment, economy, and car quality. Especially Tesla entering the center stage in the car manufacturing world has shown that electric vehicles offer both quality and comfort. Combined with the favorable economic EV incentives from the Norwegian politicians, a strong Norwegian EV Association, and a rapid improvement in battery technology and charging infrastructure, the network of the Norwegian EV initiative seems to have solidified and strengthened. The goal that all new passenger vehicles sold by 2025 should be zero-emission appears to be a unifying vision as well (Det Kongelige Samferdselsdepartement 2021).

Electric vehicles are far superior to internal combustion engine (ICE) vehicles in terms of energy efficiency. The EVs are also free of tailpipe emissions, contributing to minimal air pollution and noise compared to the ICE vehicles. They provide reduced emissions during their use, depending on the energy mix and over their lifecycle. Increased use of electric vehicles will also lead to less dependency on fossil fuels in gasoline and diesel. However, EVs also comes with an environmental burden. Life cycle assessments (LCAs) are necessary to see the holistic picture of the environmental impact of the electric vehicle. One of the key challenges for electric vehicles lies in production. Especially the material resources in the EV batteries, like cobalt, nickel, and lithium, must be extracted, which requires significant energy use. The extraction represents carbon emissions, pollution of soil and water, as well stress on water supplies.

However, as the rapid increase in EV development is relatively recent, it is expected that the battery technology, materials used, and manufacture of electric vehicles will only improve as the development continues. It is crucial to remove fossil fuels both in the transport sector and from electricity production.

The number of passenger vehicles in the world is projected to increase in the following decades. Therefore, it is doubtful that the passenger vehicles will be gone any time soon. Because of this, EVs are an essential innovation to reduce emissions from the transport sector. However, electric vehicles alone will not provide the shift needed in the transport sector. It is only part of the solution. A holistic approach to the transport sector and sustainable solutions are required to accomplish the transition needed. The future might see a change in the “system of automobility,” as Urry (2004) argued. Expansion and improvement of public transportation systems, walking opportunities in the cities, bike lanes, small electromobility solutions, like privately owned and shared e-bikes/bikes and e-scooters, can all contribute to fewer vehicles on the road. Digital transportation systems and e-mobility is growing. Also, services like car-sharing and carpooling are becoming increasingly popular. Renewable energy sources must power the transport system in the future. The electric vehicle is a crucial step towards a more sustainable transportation system. Norway is at the forefront of EV adoption, and there is a complex network of actors to thank for this successful Norwegian EV initiative.

Bibliography

Alvik, Sverre and Bent E. Bakken. 2020. Global emission reductions resulting from Norway's EV policy. Report no: 2020 – G–DT-TE-1, rev 01. DNV GL. https://eto.dnv.com/2019/norway-ev-policy

Asdal, Kristin. 2008. "Saken." In *Tekst og historie. Å lese tekster historisk*, edited by Asdal, Kristin, Trygve Riiser Gundersen, Helge Jordheim, Kjell Lars Berge, Karen Gammelgaard, Tore Rem, and Johan L. Tønnesson, 107 -135. Oslo: Scandinavian University Press.

Asdal, Kristin. 2011. *Politikkens natur - naturens politikk*. Oslo: Universitetsforlaget.

Assum, Terje, Marika Kolbenstvedt, and Erik Figenbaum. 2014. *The future of electromobility in Norway—some stakeholder perspectives*. TØI report 1385/2014. Institute of Transport Economics. https://www.toi.no/getfile.php/1339916-1426236637/Publikasjoner/T%C3%98I%20rapporter/2014/1385-2014/1385-2014-elektronisk.pdf

Asphjell, Arne, Øystein Asphjell, and Håvard Kvisle. 2013. *Elbil på Norsk*. Trondheim: Transnova.

Bieker, Georg. 2021. *A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars*. ICCT. https://theicct.org/sites/default/files/publications/Global-LCA-passenger-cars-jul2021_0.pdf

Bijker, Wiebe E. 1992. *Shaping technology/building society: studies in sociotechnical change*. Cambridge, Mass: MIT Press.

Brooks, Lindsay. 2008. "Ford Model T: The Car That Put the World on Wheels." The *New York Times*, June 01, 2008. https://www.nytimes.com/2008/06/01/books/chapters/chapter-autos-model-t.html

Brussels Times. 2019. "Electric vehicles emit more CO2 than diesel ones, German study says." April 17, 2019. https://www.brusselstimes.com/news/business/technology/55602/electric-vehicles-emit-more-co2-than-diesel-ones-german-study-shows/

Callon, Michel. 1986. "The Sociology of an Actor-Network: The Case of the Electric Vehicle." In *Mapping the Dynamics of Science and Technology*, edited by Michel Callon, John Law and Arie Rip, 19 – 35. London: MacMillan Press.

Chordia, Mudit, Anders Nordeöf and Linda A. Ellingsen. 2021. "Environmental life cycle implications of upscaling lithium-ion battery production." *The International Journal of Life Cycle Assessment* 26: 2024-2039. https://doi.org/10.1007/s11367-021-01976-0

Cressman, Darryl. 2009. *A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering & Translation*, Simon Fraser University, Vancouver. https://studylib.net/doc/10685098/1-a-brief-overview-of-actor-network-theory--punctualizati

Cui, Hogyang, Dale Hall, Jin Li and Nic Lutsey. 2021. *Update on the global transition to electric vehicles through 2020*. ICCT. https://theicct.org/sites/default/files/publications/global-update-evs-transition-oct21.pdf

Cyriac, George and Tom E. Julsrud. 2018. *The development of organised car sharing in Norway: 1995-2018*. TØI report 1663/2018. Institute of Transport Economics. https://www.toi.no/getfile.php?mmfileid=49603

Det Kongelige Miljøverndepartement. "Norsk klimapolitikk.", St. meld. Nr. 21 (2011-2012), Oslo: Det Kongelige Miljøverndepartement. 2012. Accessed August 21, 2021. https://www.regjeringen.no/contentassets/aa70cfe177d2433192570893d72b117a/no/pdfs/stm201120120021000dddpdfs.pdf

Det Kongelige Samferdselsdepartement. "Nasjonal Transportplan 2022-2033.", St. meld. Nr. 20 (2020-2021), Oslo: Det kongelige Samferdselsdepartement. 2021. Accessed April 30, 2021. https://www.regjeringen.no/no/dokumenter/meld.-st.-20-20202021/id2839503/?ch=1

Deleuze, Gilles and Claire Parnet. 1987. *Dialogues*. New York: Columbia University Press.

Dusek, Val. 2006. *Philosophy of technology: An introduction*. Malden: MA: Blackwell.

Eddy, Nathan. 2021. "Audi CEO reveals timetable for brand to become electric-only." *Automotive News Europe*, June 21, 2021. https://europe.autonews.com/automakers/audi-ceo-reveals-timetable-brand-become-electric-only

Elbilforeningen. 2021. "Elbilbestand." Last updated September 30, 2021. https://elbil.no/om-elbil/elbilstatistikk/elbilbestand/

Ellingsen, Linda A-W., Christine R. Hung and Anders H. Strømman. 2017. "Identifying key assumptions and differences in life cycle assessment studies of lithium-ion traction batteries with focus on greenhouse gas emissions." *Transportation Research. Part D, Transport and Environment* 55(2017): 82-90. https://doi.org/10.1016/j.trd.2017.06.028

Energi og klima. n.d. "Elektriske bilferger i Norge." Accessed: 01.11.2021 https://energiogklima.no/elektriske-bilferger-i-norge/#:~:text=Med%20MF%20Eidsfjord%20og%20MF,drift%20i%20l%C3%B8pet%20av%20%C3%A5ret.

Energsoft. 2019. "Battery Prices Dropped Again." Last updated December 30, 2019. https://energsoft.com/blog/f/battery-prices-dropped-again

EnergyGov. 2021. "History of the Electric Car, US Department of Energy 2021." Accessed April 04, 2021 https://www.energy.gov/timeline/timeline-history-electric-car

Feenberg, Andrew. 1999. *Questioning Technology*. New York: Routledge.

Figenbaum, Erik. 2017. "Perspectives on Norway's supercharged electric vehicle policy." *Environmental Innovation and Societal Transitions* 25(2017): 14-34.

Figenbaum, Erik. 2019. *Charging into the future – Analysis of fast charger usage*. TØI Report 1682/2019. Institute of Transport Economics. https://www.toi.no/publications/charging-into-the-future-analysis-of-fast-charger-usage-article35355-29.html

Figenbaum Erik. 2020. "Norway—The World Leader in BEV Adoption." In *Who's Driving Electric Cars*. Edited by Marcello Contestabile, Gil Tal, Thomas Turrentine, 89 – 120. Cham: Springer International Publishing. https://doi-org.ezproxy.uio.no/10.1007/978-3-030-38382-4_6

Figenbaum, Erik and Marika Kolbenstvedt. 2013. *Electromobility in Norway – experiences and opportunities with Electric vehicles*. TØI Report 1281/2013. Institute of Transport Economics. https://www.toi.no/getfile.php?mmfileid=33828

Figenbaum, Erik and Marika Kolbenstvedt. 2015. *Competitive electric town transport. Main results from COMPETT-an Electromobility+project*. TØI Report 1422/2015. Institute of Transport Economics. https://www.toi.no/publications/competitive-electric-town-transportmain-results-from-compett-and-electromobility-project-article33368-29.html

Furst, Ian. 2019. "Svg diagram with labels for an electric car." CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0) Accessed at: https://commons.wikimedia.org/wiki/File:Electric_car_diagram.svg

FN. 2019. "Klimaendringer." Last updated 24.09.2019. https://www.fn.no/tema/klima-og-miljoe/klimaendringer

Frith, James. 2021. "EV Battery Prices Risk Reversing Downward Trend as Metals Surge." Bloomberg. September 14, 2021. https://www.bloomberg.com/news/newsletters/2021-09-14/ev-battery-prices-risk-reversing-downward-trend-as-metals-surge

Frydenlund, Ståle. 2016. "Elon Musk: – Thank you, Norway!" Norsk Elbilforening, April 29, 2016. https://elbil.no/elon-musk-thank-you-norway/

Geels, Frank W. 2012. "A Socio-technical Analysis of Low-carbon Transitions: Introducing the Multi-level Perspective into Transport Studies." *Journal of Transport Geography* 24 (2012): 471-82.

Gunvaldsen, Ivar, Steinar Mathiesen and Knut A Rosvold. 2019. "Batteri." Store norske leksikon. July 24, 2019. https://snl.no/batteri

Hansen, Arve, and Kenneth Bo Nielsen. 2017. *Cars, Automobility and Development in Asia : Wheels of Change*. Routledge Studies in Transport, Environment and Development. London: Routledge.

Haugneland, Petter. 2020. "Her finner du hurtigladestasjonene i Norge", Norsk Elbilforening, July 01, 2020. https://elbil.no/her-finner-du-hurtigladestasjonene-i-norge/

Holtsmark, Bjart. 2020. "Elektrifisering av veitransport – hva er miljøeffektene og kostnadene?" *Samfunnsøkonomen* 134 (4), 50-65. https://www.ssb.no/forskning/ansatte/_attachment/432567?_ts=174bf61f898

Hovland, Kjell M. 2021. "Transportaktører satser stort: Vil ha minst 100 hydrogenlastebiler i 2025.", E24, Last updated: August 31, 2021. https://e24.no/det-groenne-skiftet/i/2dj97x/transportaktoerer-satser-stort-vil-ha-minst-100-hydrogenlastebiler-i-2025

Hu, Xiasong, Yusheng Zheng, David A. Howey, Hector Perez, Aoife Foley and Michael Pecht. 2019. "Battery warm-up methodologies at subzero temperatures for automotive applications: Recent advances and perspectives." *Progress in Energy and Combustion Science* 77 (2020). https://doi.org/10.1016/j.pecs.2019.100806

International Energy Agency [IEA]. 2020. "Tracking Transport 2020." IEA. Accessed November 05, 2021 https://www.iea.org/reports/tracking-transport-2020

International Energy Agency [IEA]. 2020. *Global EV Outlook 2020*. IEA, Paris. Accessed September 24, 2021. https://iea.blob.core.windows.net/assets/af46e012-18c2-44d6-becd-bad21fa844fd/Global_EV_Outlook_2020.pdf

International Energy Agency [IEA]. 2021. *Global EV Outlook 2021*. IEA, Paris. Accessed October 29, 2021 https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf

IPCC. 2018. *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, edited by Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, et al. In Press. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

IPCC. 2021. "Summary for Policymakers." In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, et al. Cambridge University Press. In Press. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

Jacobsson, Staffan. 2011. "Systembygging for ny energi." In *Det norske samfunn*, edited by Jens Hanson, Sjur Kasa and Olav Wicken, 45-57. Oslo: Gyldendal Akademisk.

Jasanoff, Sheila. 1995. *Handbook of science and technology studies*. Thousand Oaks: Sage Publications.

Jasanoff, Sheila. 2004. *States of Knowledge*. London and New York: Routledge.

Johnsen, Alf B. 2015. "Derfor er Gro blitt klima-optimist." VG, January 29, 2015. https://www.vg.no/nyheter/innenriks/i/rwLPR/derfor-er-gro-blitt-klima-optimist

Johnson, Jim. 1988. "Mixing Humans with Non-Humans: Sociology of a Door-Opener." *Social Problems* 35(3): 298 – 310. https://ezproxy.uio.no/login?url=https://www.jstor.org/stable/800624

Kant, Immanuel. 1987. *Critique of Judgement*. Translated by Werner S. Pluhar. Indianapolis/Cambridge: Hackett Publishing Company.

Kingsley, Dennis and John Urry. 2009. *After the Car*. Cambridge: Polity Press.

Klochikhin, Evgeny. 2018. "A car is Not (just) A Car: How We Define Ourselves Through Car Ownership." Medium, September 15, 2018. https://medium.com/@eklochikhin/a-car-is-not-just-a-car-how-we-define-ourselves-through-car-ownership-b7d1bac751ae

Kristensen, Frank S., Morten L. Thomassen and Leif H. Jakobsen. 2018. *Case Study Report: The Norwegian EV initiative*. Catalogue number: KI-04-18-239-EN-N. Danish Technological Institute, Directorate-General for Research and Innovation (European Commission) , JIIP Joint Institute for Innovation Policy. https://op.europa.eu/en/publication-detail/-/publication/9aef7f7f-2cc0-11e8-b5fe-01aa75ed71a1/language-en

Krosofsky, Andrew. 2021. "Do Teslas Have Transmissions?" Green Matters. January 01, 2021. https://www.greenmatters.com/p/do-teslas-have-transmissions

Kuhn, Thomas. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Kvale, Steinar. 2008. *Doing Interviews*. London: SAGE Publications.

Latour, Bruno. 1987. *Science in action: how to follow scientists and engineers through society*. Milton Keynes: Open University Press.

Latour, Bruno. 1998. "On Recalling ANT." In *Actor Network and After*. Edited by John Law and John Hassard. Oxford: Blackwell Publishers.

Latour B. 1999. “On Recalling ANT." *The Sociological Review* 47(1_suppl): 15-25. doi:10.1111/j.1467-954X.1999.tb03480.x

Latour, Bruno. 1999. *Pandoras Hope: Essays on the Reality of Science Studies.* Cambridge, Massachusetts: Harvard University Press.

Latour, Bruno. 2005. *Reassembling the Social.* Oxford: Oxford University Press.

Laurikko, Juhani, Arto Haakana and Robert Granstrõm. 2012. "Assessing range and performance of electric vehicles in Nordic driving conditions – Project "RekkEvidde." *World Electric Vehicle Journal* 5(1): 45 -50. DOI: 10.3390/wevj5010045

Law, John, and Michel Callon. 1988. "Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change." *Social Problems (Berkeley, Calif.)* 35(3): 284-297.

Law, John. 2009. "Actor network theory and material semiotics." In *New Blackwell companion to social theory*, edited by Bryan Stanley Turner. Malden: John Wiley & Sons.

Lowry, John, and James Larminie. 2012. *Electric Vehicle Technology Explained*. 2nd ed. Hoboken, N.J.: Wiley.

McCracken, Grant. 1988. *The Long Interview*. Los Angeles: SAGE Publications Inc.

Maiser, Eric. 2015. “Battery packaging –Technology review.” In AIP Conference Proceedings 1597, 204 (2014): 204-218. https://doi.org/10.1063/1.4878489

McLulan, Marshall. 1994. *Understanding Media: The Extensions of Man*. Cambridge, Mass: MIT Press.

McLulan, Marshall, Quentin Fiore and Jerome Angel. 1996. *The medium is the massage*. Berkeley, California: Gingko Press.

Miao, Yu, Patrick Hynan, Annette von Jouanne and Alexandre Yokochi. 2019. "Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for Advancements." *Energies* 12 (6): 1074. https://doi.org/10.3390/en12061074

Miljødirektoratet. 2021a. "Miljømål 5.2." Last updated August 20, 2021. https://miljostatus.miljodirektoratet.no/miljomal/klima/miljomal-5.2/

Miljødirektoratet. 2021b. "Klimagassutslipp fra transport." Last updated August 11, 2021. https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-transport/ >

Muller, Martin. 2015. "Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space." *Geography Compass* 9 (1): 27-41.

NAF. 2021. "Elbilsalget til himmels i september: - Flere hurtigladere må på ny regjering sitt arbeidsbord fra dag én." NTB, September 23, 2021 https://kommunikasjon.ntb.no/pressemelding/elbilsalget-til-himmels-i-september---flere-hurtigladere-ma-pa-ny-regjering-sitt-arbeidsbord-fra-dag-en?publisherId=2126680&releaseId=17916299

Nesheim, Rune. 2021. "Elbilisten 2021: De fleste av oss velger elbil av økonomiske årsaker." Norsk Elbilforening, August 24, 2021. https://elbil.no/elbilisten-2021-de-fleste-av-oss-velger-elbil-av-okonomiske-arsaker/

Nikel, David. 2019. "Electric Cars: Why Little Norway Leads The World In EV Usage." Forbes, June 18, 2019. https://www.forbes.com/sites/davidnikel/2019/06/18/electric-cars-why-little-norway-leads-the-world-in-ev-usage/?sh=24cc5dc513e3

Norsk Elbilforening. n.d. "Norwegian EV policy." Accessed: November 02, 2021. https://elbil.no/english/norwegian-ev-policy/

Norsk Elbilforening. 2021. "Statistikk Elbil." Last updated: September 30, 2021. https://elbil.no/om-elbil/elbilstatistikk/

Norwegian Bank Investment Management. 2021. "The fund's market value." Accessed October 13, 2021. https://www.nbim.no/en/

Norwegian Ministry of Petroleum and Energy and Norwegian Ministry of Climate and Environment. 2020. *The Norwegian Government's hydrogen strategy*. June 03, 2021. https://www.regjeringen.no/contentassets/8ffd54808d7e42e8bce81340b13b6b7d/hydrogenstrategien-engelsk.pdf

Norwegian Ministry of Transport and Communications. "National Transport Plan 2018–2029." St. meld. Nr. 33 (2016-2017), Oslo: Norwegian Ministry of Transport and Communications. 2017. Accessed April 04, 2021.

NOU. "Norge mot 2025 — Om grunnlaget for verdiskaping, produksjon, sysselsetting og velferd etter pandemien." Oslo: Finansdepartementet, 2021:4. https://www.regjeringen.no/contentassets/612755ca262842329ae0a7968e66351f/no/pdfs/nou202120210004000dddpdfs.pdf

Nye, David. 1994. *American technological sublime.* Cambridge, MA: The MIT Press.

Nykvist, Björn, and Måns Nilsson. 2015. "Rapidly Falling Costs of Battery Packs for Electric Vehicles." *Nature Climate Change* 5(4): 329-332.

Office of Energy Efficiency and Renewable Energy. 2017. "How Does a Lithium-ion Battery Work?" September 14, 2017. https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work

OFV. 2021a. "Nybil-boom og elbilrekord i september." October 01, 2021. https://ofv.no/aktuelt/2021/nybil-boom-og-elbilrekord-i-september

OFV. 2021b. "Snart er tre av fire nye personbiler elektriske." September 01, 2021. https://ofv.no/aktuelt/2021/snart-er-tre-av-fire-nye-personbiler-elektriske

Pedersen, Ole P. 2021. "Er Elbil-Norge en illusjon? I halve landet øker andelen knapt. Sjekk din kommune her." *Teknisk Ukeblad*, March 14, 2021. https://www.tu.no/artikler/er-elbil-norge-en-illusjon-i-halve-landet-oker-andelen-knapt-sjekk-din-kommune-her/507917

Petrovic, Slobodan. 2021. *Battery Technology Crash Course : A Concise Introduction*. 1st Ed. Cham, Switzerland: Springer.

Pflugfelder, Ehren Helmut. 2017. *Communicating Mobility and Technology: A Material Rhetoric for Persuasive Transportation*. London/New York: Routledge.

Pokorny, Petr, Belma Skender, Torkel Bjørnskau and Espen Johnsson. 2021. *Performance of automated shuttles at signalized intersections*. TØI Report 1822/2021. Institute of Transport Economics. https://www.toi.no/getfile.php?mmfileid=55332

PWC. n.d. "Quick Charts. Value-added tax (VAT) rates." Accessed October 13, 2021. https://taxsummaries.pwc.com/quick-charts/value-added-tax-vat-rates#anchor-N

Regjeringen. 2021a. "Norway is electric." Last updated June 22, 2021. https://www.regjeringen.no/en/topics/transport-and-communications/veg/faktaartikler-vei-og-ts/norway-is-electric/id2677481/

Regjeringen. 2021b. "Byvekstavtaler og belønningsavtaler." Last updated September 21, 2021. https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/kollektivtransport/belonningsordningen-bymiljoavtaler-og-byvekstavtaler/id2571977/

Reuters. 2021. "VW to end sales of combustion engines in Euope by 2035." Last updated June 26, 2021. https://www.reuters.com/business/sustainable-business/vw-end-sales-combustion-engines-europe-by-2035-2021-06-26/

Ritchie, Hannah. and Max Roser. n.d. "Energy Mix". OurWorldInData. Accessed September 14, 2021 https://ourworldindata.org/energy-mix

Schwedes, Oliver and Marcus Keichel. 2020. *The Electric Car*. Wiesbaden: Springer Fachmedien Wiesbaden GmbH.

Sennett, Richard. 1977. *The Fall of Public Man*. New York: Vintage Books.

Simonnes, Helge, Martin Thronsen and Norsk Elbilforening. 2020. *Et Norsk Eventyr: Norsk Elbilforening I 25 år*. Lysaker: Dinamo Forlag.

Skogstad, Knut. 2020. "Topp 10: Her var det mange utålmodige elbil-eiere i sommer. " TV2, September 03, 2020. https://www.tv2.no/a/11606240/

Skogstad, Knut. 2021. "Hang etter – nå er det her elbilsalget øker mest." TV2, August 28, 2021. https://www.tv2.no/a/14168735/

Solberg, Mari G. 2017. "Slik kan vi få Hyperloop i Norge – med noen tilpasninger av konseptet." *Teknisk Ukeblad*, May 28, 2017. https://www.tu.no/artikler/slik-kan-vi-fa-hyperloop-i-norge-med-noen-tilpasninger-av-konseptet/387888

Sovacool, Benjamin K. 2006. "Reactors, Weapons, X-Rays, and Solar Panels: Using SCOT, Technological Frame, Epistemic Culture, and Actor Network Theory to Investigate Technology." *The Journal of Technology Studies* 32(1/2): 4-14.

Sovacool, Benjamin K. 2017. "Experts, theories, and electric mobility transitions: Toward an integrated conceptual framework for the adoption of electric vehicles." *Energy Research & Social Science* 27(2017): 78 – 95.

Stensrud, Espen. 2021. "Stortingsvalget: Hva skjer med momsfritaket?." Norsk Elbilforening, September 16, 2021. https://elbil.no/stortingsvalget-hva-skjer-med-momsfritaket/

Sørensen, Knut. 2010. "Det norske samfunn - et innovasjonssystem?" In *Det norske samfunn*, edited by Ivar Frønes and Lise Kjølsrød, 67-90. Oslo: Gyldendal Akademisk.

Thronsen, Martin. 2021. "Ny undersøkelse: Nær halvparten forstår ikke prismodellene for hurtiglading." Norsk Elbilforening, June 16, 2021. https://elbil.no/ny-undersokelse-naer-halvparten-forstar-ikke-prismodellene-for-hurtiglading/?utm_source=newsletter&utm_medium=email&utm_campaign=nyhetsbrev-1-0621#msdynttrid=0DmiV2L100gzM3cuD6DXxjPnNWp5FyTm-ygpnIKDfWA

Tietge, Uwe, Peter Mock, Nic Lutsey and Alex Campestrini. 2016. *Comparison of Leading Electric Vehicle Policy and Deployment in Europe*. International Council on Clean Transportation [ICCT]. https://theicct.org/sites/default/files/publications/ICCT_EVpolicies-Europe-201605.pdf

Toft, Martin. 2018. "Elbilrevolusjonen er den viktigaste innovasjonen i Noreg dei seinare åra." Uniforum, October 08, 2018. https://www.uniforum.uio.no/nyheter/2018/10/elbilrevolusjonen-er-den-viktigaste-innovasjonen-i.html

Twaice. 2019. "Batteries explained – from cell formats to chemistries." Last updated August 26, 2019. https://twaice.com/articles-battery-technology/

[Permission to use the picture granted through email dialogue. Contact the author if further evidence is wanted.]

United Nations [UN]. 2021a. "Gutteres: The IPCC Report is a code red for humanity." August 09, 2021. https://unric.org/en/guterres-the-ipcc-report-is-a-code-red-for-humanity/

United Nations [UN]. 2021b. "COP26 opens in Glasgow with calls for ambitious solutions to tackle climate emergency." November 01, 2021. https://news.un.org/en/story/2021/11/1104522

United Nations [UN]. 2021c. "Sustainable transport key to green energy shift: UN Secretary-General." October 14, 2021. https://news.un.org/en/story/2021/10/1103062

United Nations Environment Programme [UNEP]. 2021. "End of leaded fuel use a 'milestone for multilateralism." August 30, 2021. https://news.un.org/en/story/2021/08/1098792

Un-Noor, Fuad, Sanjeevikumar Padmanaban, Lucian Mihet-Popa, Mohammad Nurunnabi Mollah, and Eklas Hossain. 2017. "A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development." *Energies* 10(8): 1217. https://mdpi-res.com/energies/energies-10-01217/article_deploy/energies-10-01217-v2.pdf

Urry, John. 2004. "The 'System' of Automobility." *Theory, Culture & Society* 21(4-5): 25-39. https://journals.sagepub.com/doi/pdf/10.1177/0263276404046059

Valle, Marius. 2021a. "NAF: – Ladestasjoner er avgjørende for å nå målet om kun nullutslippsbiler i 2025." *Teknisk Ukeblad*, November 02, 2021. https://www.tu.no/artikler/naf-ladestasjoner-er-avgjorende-for-a-na-malet-om-kun-nullutslippsbiler-i-2025/514733?utm_source=newsletter-tudaily&utm_medium=email&utm_campaign=newsletter-2021-11-03

Valle, Marius. 2021b. "Volkswagen-sjefens advarsel: – I dag er det Tesla som setter standarden." *Teknisk Ukeblad*, November 08, 2021. https://www.tu.no/artikler/volkswagen-sjefens-advarsel-i-dag-er-det-tesla-som-setter-standarden/514863?utm_source=newsletter-tudaily&utm_medium=email&utm_campaign=newsletter-2021-11-09

Viseth, Ellen S. 2020. "Ber Stortinget om å presse gjennom ladestøtte for borettslag" *Teknisk Ukeblad*, May 13, 2020. https://www.tu.no/artikler/ber-stortinget-om-a-presse-gjennom-ladestotte-for-borettslag/492028

Volvo Cars. 2021. "Volvo Cars to be fully electric by 2030." March 02, 2021. https://www.media.volvocars.com/global/en-gb/media/pressreleases/277409/volvo-cars-to-be-fully-electric-by-2030

Williams, James H., Andrew DeBenedicitis, Rebecca Ghanadan, Amber Mahone, Jack Moore, William R. Morrow III, Snuller Price and Margaret S. Torn. 2012. "The technology path to deep greenhouse gas emissions cuts by 2050: the pivotal role of electricity." *Science (American Association for the Advancement of Science)* 335 (6064): 53-59.

Williams, Raymond. 1990. *Television: technology and cultural form*. London: Routledge.

Wong, Catherine M.L. 2016. "Assembling Interdisciplinary Energy Research through an Actor Network Theory (ANT) Frame." *Energy Research & Social Science*, 12(2016): 106 – 110.