Natural Gas Ferries in Norway

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Innovation systems, social and ecological change
2006

20 353 words

Synopsis

This paper studies the emergence of natural gas powered ferries in Norway and their diffusion as a means to reaching the goals of reducing NO_x emissions. Though experiences with natural gas powered ferries have been good, there is little sign that there will be any further prioritizing of these over diesel ferries.

I will analyze natural gas powered ferries in a sustainable development perspective, as an environmentally friendly alternative. Further, the values, policies and institutions affecting the ferries are analyzed.

Natural gas powered ferries could prove useful in the long term for reducing national emissions of NO_x. Diffusion is going slow, and there is no official strategy to prioritize gas ferries when replacing the many old ones. Industry is interested in this new technology to build competencies but unwilling to make large investments alone. To reach international agreement for NO_x reduction taxes on emissions will be introduced. Natural gas ferries as a technological system might need support for infrastructure and a more overarching strategy to be significant.

Keywords: environmental technology, sustainable development, environmental policy

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1 Introduction

Technology surrounds us; in nearly everything we do, we use or rely on technology in some form. Technology has in the last few centuries been an integral part of what has improved our lives: our comfort, our longevity, our knowledge. We are proud of the technological capability of our nations, and our civilization: from huge bridges, and satellites orbiting our globe; to modern medicine and the Internet. We have tended to measure how developed a country is, by how many cars, television sets and telephones they possess – and we have striven to be at the frontier of technological advance.

The past century, however, did not only bring about a technological heyday, but also a deeply felt anxiety for what is in store for our future: Do we live in a world that is rapidly decaying because of our habits, our lifestyles, our values? While we have sought to make our lives easier, and to be less dependent on the capricious natural world around us, we have created new problems that may be out of our control – we cannot easily apply a technological fix to rising sea levels, rising temperatures, and poisonous air and soil that is killing our fish, crops and forests. We need to act to prevent an irreversible global environmental crisis before it is too late. And for this effort, technology will play a crucial role. If we are to move towards s*ustainable development*, technological development will be necessary to move away from the often highly energy consuming and waste producing technologies we are using today. Nevertheless, a *social* change is also due to make such technological shift possible. We need to change the direction and quality of our development and growth to curb our energy consumption and waste generation to reduce the ecological *footprint* that we are leaving.

As an engineer, I am inclined and conditioned to concentrate on technical aspects of technology. While it is interesting, and important to know how technology *works*, I was increasingly more interested in technology in a bigger perspective – in a social and

environmental context. Globally, energy supply and demand issues are gaining prominence in light of the ongoing oil-war in the Middle East, and the world's *addiction* to oil is by its interrelatedness and by association increasingly putting issues of global warming on the agenda.

On a more personal level a shift in interest started when I left the hands-on technical college I studied at, to work at CERN, a bastion of pure science, created to advance the frontiers of human knowledge. This search of pure science is inspiring in the sense that it lifts the scope from the purely economical *means-to-an-end* that is otherwise driving technology. It gives new perspective to the technophile as well as the technophobic.

Combined, these issues stimulated an interest in technologies for alternative energy, which led me to the ESST program – which further got me in contact with the *Norwegian Pollution Control Authority* and *The Federation of Norwegian Coastal Shipping* who were interested in an issue with *natural gas* powered ferries and why there was an apparent standstill in the diffusion of these. Natural gas powered ferries emit less NO_x than diesel ferries – that is better for the environment, and Norway has committed to emitting less NO_x. The question is really simple: why don't we use the better technology, and use it now? My point of departure is that this cannot be answered simply by looking at the technology in isolation. Since the motivation, at least overtly, is to mitigate pollution, it is interesting to study this situation in light of sustainable development and environmental protection.

However, this particular case is not drawing too much attention in the media; there are no big headlines, no fiery activists are chained to anything. It is all somewhat quiet – and unless you have a particular interest you will not inadvertently stumble across too many discussions in popular media on this topic. What you will find is a few notes on technical issues in relation to speed, costs, safety and so on. More technical assessments involve marginal costs

per amount of released nitrogen oxides, and the actual technological feasibility, but very little is written about the social framework into which they are introduced. It is as if there is little consciousness about the possibility that the successful diffusion of technology could be determined by other factors than the actual technological features. Several writers have shown and emphasized how social factors such as values, institutions, laws, policies and religion have affected technological development (e.g. Landes (2003), Rosenberg (1982), Mokyr (1992), Hughes (1989) and Bijker (1989)). This is no less true for the introduction of *environmental* technology – where active policy setting, social groups, laws and "green" values have been and are very important.

I have been interested in finding out more about what lies behind the decisions that are made, and perhaps those who are *not* made – in light of the environmental melioration that this technology is intended for. I have interviewed several interesting actors in this respect: the political administration of the *Ministry of the Environment*, and the *Ministry Transport and Communication*; a senior advisor of *Confederation of Norwegian Enterprise*; and representatives from the Norwegian environmentalist groups *Friends of the Earth*, and *Nature and Youth*. I have also had some contact with an engineer in the field, from *SINTEF*, a center for industrial and technological research.

This paper will have a purpose that is depending on the reader. Engineers should find this paper interesting, whether they are working with natural gas ferries or any other technology with an environmental profile.

I also hope that students of the STS field will find it interesting to see the links between technology and society contextualized within environmental politics, values and institutions. The relations between society and technology, and how they influence and shape each other have been studied in depth by historians. I think, however, that it is interesting to use this kind

of perspective on current events in technological development.

There is a growing consent across political and social lines, that we are at a crossroads, where our current choices in technology and energy use can significantly shape our future. The environmental challenges are many, and there is no single technology that can be replaced to fundamentally change our path towards ecological destruction – no single technological switch. The efforts we have to make will be diverse, costly and numerous. Changing the fuel in ferries in Norway may not seem as the most important and significant environmental effort – and it may even be arguable if it is a move towards sustainable development at all – but we have to evaluate what we can do to reduce power consumption and waste emissions for a wide array of technology.

This paper will be a simple case study of one of these instances. Besides the purely informational aspect, I will show that it is important that the considerations for alternative technology is taken beyond the intrinsic technical properties of the new technology. Also, while dealing with current events in technological development, we should be aware that societal forces shape the technological evolution.

What is surprising is that there is very little disagreement between politicians, industrial lobbyists, and environmental groups about the environmental benefits of natural gas in ferries. Even producers and users seem to be interested. Still there is no strong momentum in this development – like there is a stalemate – where everyone is waiting for another's initiative. Landes showed that Europe during the Industrial Revolution experienced a pattern of conducive political, and institutional development that spurred the investments, research and development that characterized that period. Can we see any such pattern regarding natural gas ferries, as technology for the environment today? I will argue that we do not – not yet. Despite a change in values and an awareness of the challenges ahead, changing the orientation of

technological momentum is not done overnight. I believe we will see a further diffusion of natural gas ferries, but to an extent below the potential. There are a number of factors that could explain this sluggishness, and possible reasons it may change:

While there is not much disagreement on natural gas as a good alternative to diesel, there are other concerns as to whether natural gas ferries are a good technological choice, and a wise use of money instead of other options to meet environmental goals. A central question is if natural gas ferries really are part of sustainable development.

Norway acknowledges its responsibility to reduce the emission of NO_x and other toxic waste, both morally and through international agreements. I will show where natural gas ferries belong in this context – and why there are no definite plans for their promotion.

There are however changes in Norwegian policy to control NO_x emission. While these may make natural gas ferries more profitable, they are not popular, even among supporters of the new ferries. How will these changes affect the future of ferries?

This thesis will answer these questions based on an eclectic theoretical background: the *social construction of technology* to point out that we are not doomed to the whimsical path of technology; I will discuss the background for how we approach sustainable development and environmental politics; and how we can look at these in the sense of institutions.

2 Ferries in Norway

In this section I will look into ferry transport in Norway. This is to show what kind of environment natural gas ferries can be introduced into. There are changes, not only in technology, but also in the administration of ferrying, and the challenges in traffic, industry, pollution and so on.

Traditionally, Norway has been a sea faring nation, using the waterways to transport goods and people. The fjords that cut deep into the country, and the difficult conditions for road making in western Norway, made the fjords important transport paths. For instance, in the 19th century, mail between Oslo and Bergen was trafficked by land to Lærdal, and then out the fjord and by sea to Bergen (Foss, 2003, p. 12). As cars became more common in the beginning of the 20th century, there was an increasing need for better roads. Oftentimes going across the water is the easiest way to concatenate roads for short travel time. The first Norwegian car ferry was put to use in 1918, and was fairly modern for its time. Since traffic was limited, the first ferries had the capacity of only a few cars. In 1938 there were 110 ferry routes in Norway, trafficked by 135 ferries (ibid., p. 17). Only 5 of these routes had a capacity of more than 16 cars. Since then, the scales have changed – there has been an enormous increase in road traffic, and ferries have become bigger and faster. We can get an impression of the change if we compare some statistical figures. While in 1938 there were 135 ferries transporting approximately 4 million passengers (ibid.), in 1999 190 ferries transported 37 million (SSB, 2000).

2.1 The current situation

There has not, however, been a continuous increase in the ferry traffic. There has been a trend towards building bridges and tunnels where that is possible, to reduce travel time. During the 1990s the total number of ferries in domestic traffic was reduced from 221 to 190 (ibid.).

However, since few ferry stretches can easily by replaced with a bridge, ferries will remain a necessary and important means of transportation, and an important part of the road network.

Historically the companies running ferries in Norway have been granted licenses for certain areas. These were very often renewed to the same ferry company several times. These licenses have also often been accompanied by subsidies to keep ticket prices for the customers at a reasonable level. This created companies with a high degree of stability, and local belonging, such as *Fosen Trafikklag*, and *Fylkesbåtane i Sogn og Fjordane*. Norway has been rather open to international coastal traffic, and the use of ports by international ships. Thus Norwegian shipping has been in tough international competition for freight and transport. The national car ferrying has, however, been rather protected (Thomassen, 2003). Parliament decided that from 1996 to 1998 bids should be solicited for six ferry routes. This means that, in theory, whoever in the market can enter a bidding round for the right to run a certain route (Hervik and Bråthen, 2003, p. 8). The reason for doing this, of course, was to try to spur a more efficient management of the ferry traffic, and get the service as cheap as possible. If successful, this should have positive effects on the amount of subsidies, lower prices, more frequent or faster ferries. In 2003, it was decided that all ferry routes should be put out for bids within a period of 7 to 10 years. This development has lead to a consolidation of small and local transport companies into larger and more regional companies. In other cases we can see that companies have taken up activity far from its original area. As Hervik and Bråthen (2003) point out, the socioeconomic benefits that we should draw from this, depends among other things on whether we can get a real competition with fair rules, and if requirement specification can help renew and improve the ferries. In 2004, the Minister of Transport and Communication at the time, Torhild Skogsholm, deemed the new arrangement a success, in the sense of an improved service for the passengers, and it was decided to put another two

routes out for bids (Vestre, 2004).

Since all the ferry routes are supposed to be subject to a bid round (NPRA, 2003) there is likely going to be more changes in the structure of ferry business in the years to come, and it is hard to predict the course of changes. We are already seeing some, in the form of larger companies, but also geographical sprawl, and international competition. Hope is that these changes will help ensure a better service for the allocated money. In the national budget for 2006 there is some NOK 1.3 billion (€160 million) put on the table for buying ferry services on the national roads (FIN, 2005, p. 148).

2.1.1 A brief introduction of relevant actors

Actors then come in three strata: the political; the technological and industrial; and lobbyists trying to speak on behalf of industry, the environment, or both.

The Ministry of the Environment is obviously is important in this issue. They are responsible for environmental goals, and are the reminders of the signed protocol for the reduction of NO_x through the *United Nations Economic Commission for Europe*'s (UNECE) *Convention on Long Range Transboundary Air Pollution* (CLRTAP) which Norway signed in 1999 and which was ratified in 2002.

The Ministry of Petroleum and Energy are the ones setting the agenda for the increased use of natural gas domestically in Norway, through the so-called "White paper on gas".[1] They are responsible for rationally using natural gas, not least through the official bureau Enova.

The Ministry of Transport and Communication administers the Norwegian roads and is responsible for the quality of the ferry services on national roads. They have the power to set clauses and requirements for ferry traffic, including, if they want, choice of fuel.

1 "Gassmeldingen" White paper 9, 2002. Produced by the Ministry of Petroleum and Energy (OED).

Ferry companies buy ferries from shipyards, and sell services to the state, as the ferry stretches are part of the roads. They are left with the bill if a tax on NO_x is introduced, though this would of course have impact on the buyer: the state and users.

There are also several interest groups: The NHO speaks broadly for the enterprises, shipyards, shipping companies, etc. and is the largest employers' organization in Norway. Another group is for instance the HOG[2] which is an interest group for petroleum industry in western Norway. Finally, there are environmental organizations, like Friends of the Earth, Nature and Youth, and Bellona, who speak for the environment on a broad platform.

2.2 Ownership and funding

The car ferries this paper will focus on, are part of the national road system in Norway. The responsibility for these roads is with the Norwegian Public Road Administration[3]. These include European routes and national roads, but also roads that are owned by the counties, but administered by the NPRA. The NPRA is a subordinate agency under the Ministry of Transport and Communication in Norway.

Even though the ferry routes are considered *part of* the road system, the ferries are owned by ferry companies. As mentioned before, the ferries have been run by local companies who have been granted a license from the public administration within a certain area. As this system is being abandoned, new requirement specifications can be set in the bidding rounds. Recently, one such requirement was, in fact, the use of natural gas on the route between *Molde* and *Vestnes* on the north-western coast of Norway (SD, 2006). Let us look at how a new ferry will be funded.

Normally, the NPRA would set the requirement specifications for a route. If there are

2 Hordaland Olje og Gass
3 Statens Vegvesen

special circumstances, as for the case for natural gas as, a requirement has come from a higher political authority. Different actors in the market can then offer different packages, that would fulfill the requirements when it comes to frequency, speed, capacity, noise, pollution, ticket price, and costs. The winner of the bid needs to get a contract with a shipyard to make a vessel according to the desired price and specification, and such a contract is made in a similar way, where yards enter a bidding round for the contract. In the European Economic Community (EEC), these bidding rounds need to be open for the whole *economic area*. This opens for tough international competition. The Norwegian shipyards have gone through hard times the later years, with a decreasing number of contracts due to this competition, and an increasing share of the construction in Norway is dedicated to specialized ships, within petroleum industry, and natural gas vessels, like the ferry "Glutra". This development they hope will help them compete on knowledge and competence instead of labor prices. Many advocates of natural gas ferries find that an important side effect of introducing them is the jobs they will create in the yards, and that these should be kept in Norway (NRK, 2004). In the EEC it is not legal to favor national industry directly. However, a way for Norwegian yards to improve their position in the competition for contracts is to make parts of the production an R&D project. Then they can apply for national for national R&D funds, from for instance *Innovasjon Norge*[4]. In fact, this procedure is much the same, whether the new ferry in question is powered by natural gas, or diesel. The difference is that the gas ferries for the time being are more expensive, due to the technological difference and novelty – and are thus the more relevant for R&D funds.

Another way of funding natural gas powered ferries, is by means of third party solutions. This is made possible through an emission law from 2001. There has been an example of this,

4 Innovation Norway, a bureau which distributes R&D funds.

where an industrial actor, *Gassco*, facing the demand to reduce emissions of NO_x has offered to subsidize the conversion to natural gas on a nearby ferry route. In this case, they will rather help reduce emission from the ferries than from their own activity, because it would be cheaper. Thus, by market forces, the emission reductions are done where they are most cost efficient. The third party solutions are for special cases, that must undergo individual assessment and evaluation (SFT, 2003). The idea of emission quota trading strongly resembles the third party solution principle, although in a much more fluent system, where the trading of the right to pollute will make the cuts in emissions where they at any given time is the cheapest to achieve. Although desired by many, this has proved to be a rather elusive environmental tool, that I shall look at closer in chapter 3.4 Policies.

2.3 Pollution

The crude and small ferries in the automobile's infancy polluted little in absolute measures compared to today's ferries that can hold hundreds of cars. In fact, the pollution caused by coastal traffic has been given little attention compared to that inflicted by cars. This is probably because cars emit NO_x, SO_2, CO_2, and particles, and create noise close to where people live. CO_2 is a green house gas, which is not directly harmful, but can cause global warming if the concentration in the atmosphere becomes too high. Nitrogen oxides, or NO_x, is a common term for various compounds of nitrogen and oxygen. These cause acid rain if released into the atmosphere, and can cause respiratory problems if they occur in large concentrations. The latter is largely a problem local to where the gases are emitted, as in cities with much traffic and industry.

Ferries, and other coastal traffic, however, is largely decentralized. This can explain why less has been done to reduce the emission of NO_x in ships and ferries than in cars. Car manufacturers have for instance had to make catalytic inverters standard to reduce NO_x

emissions. At the same time, cars have also become a lot more fuel efficient. If we compare some statistical data since 1990, we can see how coastal traffic is lagging behind automobiles when it comes to environmental friendliness. It can also be seen as an argument as to why one should perhaps turn to this sector to find the most cost efficient measures to reduce emissions.

		1990	**2004**
		Emission to air	
Cars	CO_2 (in 1000 tonnes)	4,619	4,288
	NO_x (in tonnes)	44,289	12,424
	NO_x/CO_2	0,0096	0,0029
Sea traffic	CO_2 (in 1000 tonnes)	1,841	2,451
(domestic)	NO_x (in tonnes)	39,124	54,279
	NO_x/CO_2	0,0213	0,0221

Table 1: Emission comparison, cars and domestic cabotage (SSB, 2006a)

If we compare data from cars and mobile sources at sea (i.e. boats and ships) we first of all see that the emission of CO_2 from cars has decreased from 1990 to 2004. This is despite the fact that there is an increasing number of cars in Norway in the same period. As there is little to do with the amount of carbon released from the combustion of one unit of fuel, we attribute this to fuel efficiency. It is released as CO or CO_2, but by and large there is a linear correlation between fuel consumption and CO_2 emission. A new car makes little NO_x while burning the fuel, however. From 1990 to 2004 the total emission of NO_x from cars fell from 44,289 tonnes to 12,424 tonnes, or roughly one fourth. For domestic traffic at sea the corresponding numbers are 39,124 tonnes and 54,279 tonnes. Although this can be related to an increase in traffic, we can compare the emissions of CO_2 to those of NO_x, and we find that relative to CO_2 the emissions of NO_x are stable. That means there has not even been a relative amelioration in NO_x emissions in coastal traffic.

2.4 Why natural gas?

Natural gas, as it is for the consumer, consists largely of hydrocarbons in the form of methane – compounds of hydrogen and carbon, which when combusted transform into CO_2 and H_2O. Thus, when burnt, the emission of nitrogen and sulfur compounds (NO_x and SO_2) and soot particles is severely reduced. This is the environmental rationale for replacing diesel ferries with natural gas ferries.

Norway is committed to reduce both SO_2 and NO_x emission through the Gothenburg protocol. While the former is more under control, the latter is challenging for Norway. But how significant are really the ferries in the total emission of NO_x? Norway's total emissions are about 225 000 tonnes yearly. Traffic at sea contributes to 40 % of the total, and ferries are 7 % of that. The NO_x emission from ferries is thus $225000 \cdot 0.4 \cdot 0.07 = 6300$ tonnes (Ottesen, 2005; SFT, 2006). That may not sound like a lot of the total emissions in Norway, but it constitutes a considerable 13 % of the amount that needs to be eliminated to comply with the Gothenburg protocol.

However, clearly, even if all ferries in Norway were replaced with natural gas ferries overnight, this would not solve Norway's NO_x problems. It is only one alternative to a part of the solution. There are however some reasons why attention has been directed towards the ferries. One reason is that the ferries are getting quite old. The average age is 21 years (SFT, 2006, p. 36). If replacement of diesel ferries takes place as the old are phased out anyway, it will be more cost efficient. Another point is that ferries are a good place to start; it is easy to create the necessary structure, as they operate in a limited area according to schedules. The third point is to create an infrastructure for natural gas. One or several ferries somewhere is a rather large customer of natural gas. Other potential users might not be able to carry the costs of infrastructure without major users. This is in fact part of a strategy stipulated by the

Ministry of Oil and Energy in 2002 (OED, 2002) to stimulate the use of natural gas for national production.

2.5 Natural gas technology and natural gas ferries

Norway has vast amounts of fossil fuel in off shore repositories. A large portion of this is natural gas, of which 94.6 billion standard cubic meters were produced ($9.46 \cdot 10^{10}$ Sm^3, in 2001). More than half was exported (50.5 billion Sm^3) to continental Europe and Great Britain, about one third of the gas produced is re-injected to create pressure to extract more oil. Less than 0.8 % was used domestically, of which 90 % in for industrial purposes, and only 1 % is used for transportation. Traditionally, natural gas has been used to a very little extent in Norway for heating, cooking and transportation (OED, 2002).

White Paper 9:2002 is a plan for increasing the domestic use of Norwegian gas. If there can be made a network for distribution of natural gas in Norway, that could be an incentive for new industry. This would in turn be relatively environmentally friendly, compared to importing electrical power from abroad – especially if that were to be made for instance from coal. Norway is a country with a geographically spread population, and the physical surroundings are not very welcoming to infrastructure, such as roads and pipelines. In conjunction to that Norway has been relatively self-sufficient with cheap hydro power, and these together have made it far easier and profitable to export natural gas than to use it.

When exporting in large quantities, it is common to lay pipelines, with gas flowing through at low pressure. These pipelines are big investments, and cannot be justified for small or few users. In Norway there are very few places where pipelines can be made profitable, and gas needs to be transported in some other way. By reducing the volume of gas, it can be transported by road or sea to relatively small users. This is done in two ways: either

compressing the gas at high pressure (CNG – *compressed natural gas*); or cooling it down, so that it becomes liquid (LNG – *liquefied natural gas*) (OED, 2002). The processes of compressing or cooling are energy consuming, hence LNG and CNG have a net energy loss compared to gas at atmospheric pressure.

The White Paper acknowledges the environmental benefits of using gas in ferries, but suggests that any conversion to natural gas ferries should first be done on the routes which are closest to gas sources. In 1996 already, the Parliament decided to fund a research project to get experience with the possibilities of running ferries on gas. Two ferries were to be made, one with LNG and another with CNG. The company MRF was given the task of administering this. The building started in 1999 by the shipyard Aker Langsten, which completed the LNG ferry, the "Glutra" in 2000. The CNG project was abandoned (Grøvdal, 2006). All later planned and projected ferries are LNG ferries, and from now on I will use the term LNG ferry instead of natural gas ferry.

The "Glutra" is the world's first and so far the only ferry running on gas[5], though some other LNG powered vessels have been made. It was between 30 and 40 percent more expensive than an equivalent diesel ferry. Some estimates show that this can drop to about 10 % (ibid.). We have to bear in mind that the "Glutra" was a prototype. It was also rather small, and the extra cost is percentage-wise lower on larger ferries (Einang & Rise, 2006)

2.5.1 Benefits and difficulties

LNG ferries have numerous benefits. Not only do they significantly emit less NO_x, they also eliminate SO_2 emissions, and reduce CO_2 emissions. They can also be made to run quieter. For the routes between Bergen and Stavanger, there has been significant under-capacity. The five new LNG ferries currently under production are going to be trafficking the two main

5 That is according with national rules and regulations, and not just as tests.

routes, and cut down on travel time, and the amount of cars left behind. Speed, is however, linked to the emission of CO_2. An important incentive for making new ferries is not only to replace old ones, but to increase capacity on the route. As a step in "modernization", an increased frequency is not enough, shorter travel time is also desired (Vegen og Vi, 2004). However, as speed increases, so does the emission of CO_2. Thus, the new ferries can contribute to a higher CO_2 emission than the old. Natural gas is considered a clean power source, and a good alternative to diesel, but it is still a fossil fuel, and contributes to further the carbon imbalance in the atmosphere, and thus global warming. On the other hand, though, the demand for faster traffic would have remained independently of LNG ferries. Thus, it can be argued that LNG ferries remain a better option.

Another side effect of having LNG ferries is that there will be a distribution network for LNG that other smaller users can draw benefit from. This can make it easier for new or existing industry to use this relatively sound energy.

A third, and very important aspect, is that the evolution of LNG ferries can help the struggling shipyards in Norway create jobs, specialize and get new knowledge to become more competitive on the international market.

3 Ferries as a technological system

Technology shapes society. From simple stone tools, to nuclear technology – from newspapers and television to automobiles and airplanes, technology has changed how, and where we live, what we eat, how we dress, how we communicate with each other, what we do for a living and what we're afraid of. It has changed us, down to the way we behave and think.

Looking back in brief on technological history, it may seem like technological inventions have appeared after bursts of individual creative thinking. Inventions such as the telephone and light bulb are boldly and simplistically associated with great names like Alexander Graham Bell and Thomas Alva Edison. Their technology has since then diffused and evolved into what we know now. In hindsight, this development may seem streamlined and almost autonomous, with society, people and culture as bystanders to this development. This idea, that technology is exogenous to society, and that a society and its culture is determined by its technological capacity is called *technological determinism.* In its extreme version, such a doctrine would ultimately mean that the cultural differences between native tribes in the "undiscovered" New World, and 15th century Europeans were attributable to the differences in technological progress – since technology shapes society, it is the one of the main factors in our society and culture. In a "soft" version of technological determinism, one holds that technological change drives social change, but at the same time that technology responds to pressure in society (Smith, 1994).

Several social scientists have shown convincing examples of this interaction between technology and society. Wiebe Bijker has explored the development of the bicycle: Early bicycles had large front wheels that would ensure high speeds without any speed exchange. These were dangerous, leading to the a wish for lower bicycles, but at the same time, the high bicycles were seen as macho, leading to even higher versions (Bijker, 1989, p. 43). He also

shows that the introduction of the pneumatic tire did not succeed in convincing the public in what it was originally designed for, to reduce vibrations. It was only accepted, as it turned out that it would allow riders to go faster. (ibid. p. 45). Thus *society* shaped the evolution of the bicycle technology.

Another perspective, presented by Thomas P. Hughes, is to view technology in a larger context. Some technological achievements become significant within several broad reaching branches of human activity. Electrical power, the internal combustion engine, and ICT are examples of such *large technological systems* (Hughes, 1989). Looking at whole systems of technologies, or branches of technology, has some advantages over examining single instances – giving us a *bird's perspective* on technology. In his article *The Evolution of Large Technological Systems,* Hughes studies the introduction of the electrical power system in the late 19th century as a large technological system. The reason he uses the word *system* is that there are a lot of complementary technologies and actors involved in the process of diffusing electrical power throughout society. Without generators there is no use for electrical motors, with electrified industry comes electrical engineers, and education, books, professors, and organizations. They are all interrelated, and part of the large technological system.

To begin with, these interrelations and dependencies were loose, technologies were new and experimental and standards we nonexistent. As the number of users of electricity increased, and bigger and more expensive machinery was invested, the production of power had to be increased, more power lines had to be built, more people were to be educated, more books written, more people dependent on it. The system is growing, and as it grows it is harder to go back, and harder to change technological specifications. Hughes says the technological system is acquiring momentum – a reference to physics, where momentum is the product of speed and mass. A moving object with a large mass is hard to divert from its

path, and the same is true for technological systems. When investments have been made in knowledge and capital goods, these will be sunk costs, and lost if the system was to change radically overnight. Electrical power is in our days ubiquitous, and as a technological system, it may seem autonomous. Or to put in Hughes' words: “Old systems, like old people tend to become less adaptable, but systems do not simply grow frail and fade away. Large systems with high momentum tend to exert a soft determinism on other systems, groups and individuals in society” (ibid. p. 55). But we should not treat even the largest system as a technological juggernaut. Electrical systems differ from Europe to the US; in Great Britain they drive on the left side of the road. Through this concept of style in technological systems, Hughes tries to show that the systems are shaped by society, and that, to a greater or lesser extent, society is playing its part in determining the direction a technological system takes. Though difficult to change, *style* helps show that even the largest technological systems are shaped and constructed by society. Then, if technological systems become a burden, or an environmental threat to our society, we could, and should, try to change the *trajectory* to create a new style. For instance, we can see the abolition of leaded fuel and the introduction of catalytic converters as conscious and logical societal shaping of the automobile as a large technological system – where technological improvements and political decisions together changed the style.

This brings us back to ferries. Ferries can be seen as a technological system, or as part of a bigger system, including all automotive transport, or we could look at the internal combustion engine with all its dependencies as a system. The delimitation of systems is hard, but in relation to ferries the system will surely include the actual ferries, the shipping companies, ship builders, politicians, policies, fuel prices, security requirements, customers, and so on. In this special case, the objective is to look into what is needed for this particular system to

change its style from diesel fuel to natural gas. Clearly, it is not enough to simply look into the technical challenges regarding this shift in style. It is more complicated than simply – *can ferries run on natural gas?* If we want to understand and change the system we need to engage in a more holistic assessment.

Historians and economists have long tried to explain technical change and technological progress. David Landes, in his important historical account of the Industrial Revolution acknowledges that "the Industrial Revolution [...] opened a new age if promise. It also [...] revolutionized the social order; and as much changed man's way of thinking as his way of doing" (Landes, 2003, p. 41). However, he also points to the values, political, legal and institutional properties of society as ultimately the determining factors of technological development (Rosenberg, 1982, p. 11). The assessment of these key issues is still necessary to understand the technical change in our present.

3.1 Diffusion

Some times technology can make a difference just by the sheer power of its existence. This is true where the technology poses a threat to existing power balances, whether the technology is the Spinning Jenny in 18th century England, or nuclear arms in today's Iran. However, for most practical purposes, *diffusion* is crucial for the technology to have any impact. To describe technological change, it is common to use the terms: *invention*, as the generation of ideas; *innovation*, as the development of the ideas into use, or a commercial product; and *diffusion*, as the spread of that technology across its potential market (Stoneman and Diederen, 1994). These processes are not linear – as new ferries are made and put to use, the technology spreads, but for every new ferry that is built there will be new inventions, new competencies, new markets and so on. The innovation aspect, or its profitability and feasibility in a market is in part determined by the technological change, or improvement in

costs, security and such. We see that these processes are interlinked and have feedback loops on each other. Also, these processes are dependent on external factors: political ambitions, fuel prices, costs of labor et cetera. If there is to be any more innovation, invention and diffusion related to LNG ferries, the costs and benefits must be clearer. As they are not necessarily a better product in doing what a ferry should do, they will only be profitable and diffuse if externalities are changed in their favor. For instance, this could be changing the price of fuel in the favor of natural gas (over diesel), or putting a price on pollution. By changing the surroundings in favor of LNG ferries, it is possible to further, or encourage diffusion – making them a better choice economically.

This chapter's aim is to account for the elements that go into explaining the potential diffusion of LNG ferries. LNG ferries are not intrinsically *good*, or *right* (nor *bad* or *wrong*).

Whether LNG ferries are considered *green*, *good* or *sustainable* comes largely down to opinion. If we are willing to pay for its diffusion is dependent on this perception. This is why we should see beyond the technical specifications of LNG ferries in explaining the potential. The different opinions and conceptions of users, owners, politicians, environmental organizations, and petroleum industry can shape the future evolution of LNG ferries. This influence by social actors is why we can see the technical evolution as the a social construction. With technology like LNG ferries that is pursued because of its environmental benefits, the social shaping forces are just as prominent as with other technology.

3.1.1 Diffusion and Sustainable Development

Sustainable development is commonly defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). While natural gas is a fossil fuel, the proponents of its use still tend to use the

term “sustainable development” and “environmentally friendly energy supply” when speaking for its environmental benefits (OED, 2002). While most people recognize that natural gas burns cleaner than most other fossil fuels, there can be disagreement as to whether it is sensible, or visionary enough to replace one fossil fuel with another. Nevertheless, if you can grade sustainability into *more* or *less* sustainable, it seems to be clear that sustainability is not only connected with technology itself, but also its extent of use, or diffusion. For instance, what is unsustainable with international air travel is not only that it pollutes a lot, but that we tend to travel more and more. Sustainability is thus connected with the extent, but also the way it is heading. In that sense, converting to LNG ferries would be turning the development towards something more sustainable. If one sees LNG ferries as sustainable, it would reveal a certain pragmatism in the view. Something that pollutes less is *more* sustainable than what it replaces. However, as long as it runs on a fossil fuel, it is dependent on a depleting energy source, and it is contributing to climate change, it is not sustainable in a strong sense.

Traditionally, when speaking of diffusion, one thinks of a commodity embodying new technology, that penetrates a market (Stoneman and Diederen, 1994). The product has some properties that put the company that acquires it in an advantageous position to those who don't have it, or fills the need of an individual (a need created by marketing, or not). The environmentally friendly product does not necessarily have such property – that it is better than what it replaces, at what it is supposed to do. The benefits are external to its function. This is true for for instance the CFC free refrigerator, or lead free gasoline. The same applies to LNG ferries. They are not better at being a ferry than one running on diesel. It's hard to make producers, companies and the general public opt for the more environmentally friendly product if there is no incentive in price or quality. These products have to be *made* favorable to the other. The external benefits must somehow be internalized. One way is to put taxes on

the harmful product,or make it illegal, as with CFC containing products. The measures usually reflect the severity of the situation. When the effects on the ozone layer of CFCs were discovered, it called for drastic measures, while the Danes have settled for a less dramatic tax when trying to limit the use of plastic grocery bags.

3.2 Technology

Technology has had a tremendous impact on our physical environment. We use and depend on technologies and systems everyday, some of which we are not even conscious or aware about. You can use your mobile phone without knowing anything about wireless transfer protocols – and charge it without understanding how last winter's rain could make that possible. As such, technology is black-boxed to most of us – we do not know how it works. The artifacts are in that way an embodiment of the knowledge that we as a society have. That is the way it needs to be: if we needed to understand how everything worked, technology would hardly make our lives easier. But if we believe technology is supposed to make our lives easier, or make new things possible, we need to ask ourselves some questions when technologies turn out to cause problems. For instance, the automobile is a great thing, it can quickly and flexibly transport people and goods – but with it comes problems, like urban congestion, local and global climate problems, and a global political tug of war over resources – and we need to ask ourselves how we ended up in this situation. Did technology, or the technological system get out of hand or was it based on the wrong premises? As James Flink notes in his 1972 article, the automobile around the end of the 19th century was seen as a clean replacement for the horse and carriage in the cities. The horses left dung in the streets that caused heavy dust when it dried, and the carriages were bulky and clogged the streets, while the automobile was smooth and only released a little smoke that would go with the wind. This scenario is ironic in light of the blame that the automobile has been alloted since the 1950s. Had the images of the

Great London Smog from 1952 been known in 1900, would legislation on automobile use and construction have been different? Would it as a large technological system have acquired a different momentum, or style? This is of course impossible, but trying to picture the long term effects of technology that is being introduced is important. That way we can set the premises for as system as it develops, and avoid serious side effects. This is known in environmental policy as the *precautionary principle*.

Many technologies enter a state of *closure* as they mature. *Closure* or *rhetorical closure* is a term used by Wiebe Bijker to describe a state where the technology is perceived as mature, in the sense of disappearance of problems: "*the key point is that relevant social groups* see *the problem as being solved"* (Bijker, 1989, p. 44). This does not mean that a "closed" technology cannot be re-opened. This is what happened for automobiles and noxious gas emitting industry after the Great London Smog in the 50s, what happened to the ozone-containing fridge, and leaded fuel in the 70s and 80s – the technologies were re-opened as their ulterior effects were discovered. In this sense, environmental technology was born as existing technology was re-opened.

Ann Boyce, in her book called *Environmental Technology,* says the term "refers to the knowledge and skills necessary to manage, work with and control hazardous materials and pollutants" (Boyce, 1996, p. 4). While this is true for many technologies seeking to mitigate the environmental problems posed by a technology, I would argue that *environmental technology* also includes efforts to eliminate the use, or production of hazardous materials and pollutants.

Natural gas powered ferries, as compared to diesel ferries, can be seen as both trying to manage polluting materials, but also as trying to eliminate them. While other alternatives to conventional diesel ferries seek to stop pollutants like NO_x and SO_2 in the fuel from going into

the atmosphere with various cleaning systems, the natural gas ferries replace the diesel fuel with a fuel that does not create them, and thus taking the problem at its root. For some this technological simplicity in simply avoiding a problem instead of adding new technology on top can seem appealing. However, assuming that technology will automatically diffuse because of some inherently better properties than its predecessor is to simplify history. As Bijker has shown with the example of the development of the bicycle, and as with the famous example of the QWERTY keyboard, which remains the same today despite its original goal to make typing slower (Rogers, 1995, p. 8), technological development does not follow a logic which is solely determined by the technical intrinsic properties of the artifact – it is shaped by its surrounding society. As mentioned earlier, looking back in history may lead to the conception that the diffusion of inventions was inevitable due to the persuasion offered by the technological superiority. This is often supported by stories of adventurous inventor-heroes, that have shaped our society as we know it now. A concept that goes hand in hand with technological determinism to describe this view is Whig History: the notion that development in the past has been a line of progress leading to our society today. If we study the introduction of technology in our time, it is easier to see that technological development does not happen in a vacuum. There are values, laws, existing policies, habits, tradition, social and political interest groups, economic incentives and so on, that shape our technological future. As I will try to show in this paper, this is no less true for environmental technology. To be sure, technology is shaping our society. Technology and its byproducts have pervaded our society and our environment to the extent that our extended use if it is threatening to destroy vital parts of what sustains our daily life. This has again given prominence to environmental values, new policies and “green” social groups that seek to shape and change technology and society. What seems to be the case when studying why, or why not technology is spreading in

society, is that it is not enough to simply study the physical properties of technology, one needs rather lift the scope to include strong social factors.

3.3 Values

Our natural environment has always been been crucial to life. Throughout the centuries we have exploited it for our own well being. While it is not new that we have tended to overuse natural resources, the notion of an environmental consciousness as a fear for the collapse of the planet's ecosystem as a whole is a rather new one. With the industrial revolution and increasing populations came also an inflated resource use, and unprecedented waste production. Although perhaps a strong simplification or an example of Whig history, the very beginning of the industrial revolution is linked to Thomas Newcomen's invention in 1712 of the steam engine to pump water out of coal mines (Bakan, 2004). Though a tremendous relief to miners, this opened for an increased use of coal, both by providing coal more easily, but at the same time providing a machine with widespread application value, that was powered by coal. While coal was never a clean source of power, and neither conceived as one, the idea that our emissions from power use can affect the ecosystems at long range and globally was not present until much later. However, problems related to the increased efficiency and subsistence capacity of the earth was questioned already in 1798, by Thomas Robert Malthus. In his “Essay on the Principles of Population” he questioned the future of society, as populations grew due to a higher subsistence of the land. However, he claimed, populations grow geometrical ratio, while subsistence only arithmetical (Malthus, 1798, p. I.18). While Malthus might have been wrong in some of his assumptions, he made a valid and long lasting point about the problems of unchecked population growth, and how it can ultimately endanger our own existence, if we exceed the earth's ability to support us.

From Newcomen's steam powered pump, some technology has become more efficient.

Efficiency means using less fuel to get the needed output energy, and this efficiency is good, even in an environmental perspective. Less fuel gives less waste. Still, as technology is put to use for the improvement-hungry and increasing population, the problem is increasingly in the *scale* of our production, and for most of the 20th century, all kinds of industry and transport was allowed to release waste into the air and sea without much control. In the 60s, after decades of dumping waste in air, sea and soil, the *common sink resources,* (Carter, 2001, p. 164) the ecosystems started to show signs of degradation, such as deforestation, the acidification of lakes and erosion. Rachel Carson, in her important 1962 book, *Silent Spring*, raised public awareness around chemicals, especially DDT. Pesticides and other artificial chemicals were found in the food chain, and one started to realize the extent of pollution; its long range, and long term, and possibly irreversible effects. The common sink resources had reached their maximum capacity, and began degrading – a true tragedy of the commons.

The change in social awareness to the environment since has been crucial. This environmental consciousness was a product of the 60s, a time full of change (Jamison, 2001, p. 16). *Ecology*, the branch of biology that deals with the *interaction* between organisms in an environment became crucial to new understanding of our environment and the word *ecology* became a term used by activists trying to spread environmental consciousness. Around the world, universities established environmental departments, and environmental protection agencies were set up, and social movements were formed (ibid.). The focus was on environmental protection – the protection of ecosystems, and reduced waste production. We can see this new consciousness reflected in Norway, as the first national parks were founded in 1962, with a national park plan in 1964, a ban on buildings close to the beaches in 1971, and the foundation of the Ministry of the Environment in 1972 (MD, 2002).

After this environmental *enlightenment* in the 1960s, the 70s brought further attention to

the limits of natural resources. Especially remarkable was the Club of Rome's *Limits to Growth* which emphasized that the so-called *ecological footprint* that the increasing population leaves: in our search for economic growth we use natural resources faster than they are replenished, this must be reduced before we destroy the earth to the extent where the *quality of life* will drop, regardless of economic growth. This echoes Malthus' ideas of the world population living on the edge of what the world can sustain. The following oil crisis of 1973 and 1974, although not as such related to an oil shortage, added extra attention to the consumption and dependencies of non-renewable energy sources.

Following this, the 70s environmental discourse was based around the concern for natural resources. The 80s added the degradation of nature by waste and pollution as a theme in the environmental debate (Radermacher, 1999). The most prominent of issues of this kind in the 1980s, not least in Norway, was the acidification and eutrophication[6] of lakes, the awareness around leaded fuels, ozone layer depletion, and the Chernobyl nuclear power plant accident.

A new paradigm emerged with the introduction of s*ustainable development* as a guiding principle in environmental issues. The UN World Commission on Environment and Development, led by Norwegian PM Gro Harlem Brundtland, released a report called *Our Common Future.* This report defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 19). This sums up the logical ethics in providing for present generation, without corrupting the earth's ecosystems and resources. Our economic growth should not be based on credit from future generations. This is commonly referred to as *intergenerational justice.*

6 Eutrophication is the enrichment of nutrients in water due to waste in the form of phosphorus and nitric substances from industry, transport, and domestic use. This leads to algal bloom, which can disrupt the ecosystems.

Sustainable development, however is not limited to the developed world, but stresses the importance of justice with developing countries. This justice also has a quite rational element. We cannot afford, in an ecological sense, that the developing countries develop like Europe and North America have.[7]

The concept of sustainable development is an effort to create a more encompassing and holistic approach to the main problems we will face in the 21st century. It builds on previous ideas but differs from the *Limits to Growth* theories in that it assumes that technological development and economic growth are necessary, and possible without breaching the boundaries of the environment. It presupposes that growth can an must continue, to ensure the *needs of the present* (i.e. especially the needs of the poor), but economic growth and production need to become more energy efficient, with less throughput of material, and more distributive and fair. We must change the *quality of growth* (WCED, 1987, p. 52), where growth no longer is equal to large consumption and large emissions.

3.3.1 The rationale of Sustainable development

The World Commission Report is not only trying to convince people that sustainable development is an ethical issue. Unlike *Silents Spring* that raised attention to environmental problems by means of a prosaic text, *Our Common Future* tries to make clear the inevitable logic that should prevent us from inflicting more damage to our environment. The *rationale* of sustainable development can be summed up with the two theses that poverty is a cause of environmental degradation, and that the industrial world needs to consume less and consume smarter. The most profiled, and potentially most devastating problem is *global warming*. But

7 Poor and desperate people will resort to destroying their immediate environment to sustain life. Low income will also increase the chances that people exploit natural resources in a damaging way. Poverty is thus a direct cause to environmental degradation (WCED, 1987:28). The global justice aspect has many more facets regarding international security and peace, which, while interesting, is of little relevance to the present purpose.

another serious issue that is perhaps fading in the consciousness of public debate is acid precipitation. This problem is recognized in *Our Common Future*:

> "In Europe, acid precipitation kills forests and lakes and damages the artistic and architectural heritage of nations; it may have acidified vast tracts of soil beyond reasonable hope of repair. The burning of fossil fuels puts into the atmosphere carbon dioxide, which is causing gradual global warming" (WCED, 1987, p. 2).

Today the threat of global warming absorbs a lot of attention, both as an area of action, and as a topic of debate. However, while acidification does not presently seem to pose as an immediate threat to our livelihood as it did some decades ago, it is important to acknowledge the problem and the need for further action.

3.3.2 Shades of green

This acidification is caused by NO_x, SO_2 and other exhausts from the combustion of fossil fuels. But also the emission of CO_2 into the atmosphere can have similar effects: the absorption of CO_2 into the oceans can cause the water to acidify, and this can have effects on coral reefs and and the ability of shellfish to produce shells. Environmental problems are interlinked and can have serious feedback mechanisms enforcing the our problems. Sustainable development is no longer just a special field of interest, or what one of Carson's critics pejoratively called “the cult of the balance of nature” (Lee, 1962); our problems are real, and the obligation to do something is clear. The rationale is that if we fail to create growth for the poor, and a more equitable distribution of wealth, and if we cannot reduce the footprint of our growth, then Malthus and the Club of Rome are going to be right in that there are limits. If we continue to deteriorate the earth, then it will no longer be able to sustain us, and the earth's limits are going to be lower. As William Lafferty points out – since sustainable development is rational, one should assume that a rational government would be willing to

make adjustments to further sustainable development (2004). However, almost 20 years have passed since *Our Common Future* put this on the agenda, and though a lot of good and creative efforts have been made with regards to sustainable development, the ecology and climate crisis seems more imminent now than twenty years ago.

Have we been sedated into thinking that it will work out without our intervention, or are we simply not following our logic because we are stuck in a spiral of economical and *physical* growth? *Our Common Future* states that "the challenge is to ensure that these new values are more adequately reflected in the principles and operations of political and economic structures" (WCED, 1987, p. 28). If they are not, we will continue to see growth based on unsustainable premises, for the sake of growth itself. Sustainable development is ultimately a means to maintain and increase *quality of life.* John Kenneth Galbraith wrote an article called *Economics and the Quality of Life,* in 1964, and thus predating much of the environmental discourse. Consistent with its succinct title, this article cuts through the clutter of economic arguments, and asks what economics should do to adjust to the new challenges we are facing. For poor societies, Galbraith argues, nothing is as important as their poverty and nothing is as pressing as its mitigation. The main problem, the *economic problem,* is to provide goods enough for all with the scarce resources available. If economic life fails, it will give immediate physical repercussions on the population. In an *affluent society*, Galbraith's favorite term for the wealthy 1960s United States, the link between physical problems and economy is much weaker. We have become able to produce the goods we need, in terms of *grain and steel* and economy is mostly focused on luxury items. The economic problem has lost it grip, but not its prestige – and the economic measuring stick is still being applied to everything, everything is measured in terms of its economic yield. Galbraith goes on – a private individual will try to get free from economic dictation as he or she gets more wealthy,

to prioritize differently, while a nation, or a corporation still seems to be under the economic *spell.* We should gradually try to shift away from the *economic problem* to the challenge of improving the *quality of life.* Breaking free from these limits of economy could enable us to prioritize differently – and to consider a range of other possible goals, "from the beautification of our cities, the cleaning of roadside commerce and advertisement, the enlargement of cultural opportunity, the redemption of mass communication, to the suppression of the influence of weapons makers on foreign policy" (Galbraith, 1964, p. 122). The obvious extension of this is that we could, and should focus on environmental issues and sustainable development; it could prove crucial to *quality of life* without being profitable on the short run.

Most people and politicians now agree that we need to take measures to improve the environment around us, or at the very least stop further damage. There are different value-based approaches to how changes in economic life should incorporate the environment, however. While there are countless labels to describe groups of people with a distinct set of attitudes or values, I shall mention two main branches; we can see these as ideal opposites, or opposing cultural formations (Jamison, 2001, p. 128). After decades of environmental activism that has evolved into organizations and groupings of more or less structured, formalized and ideal structure, we can divide today's environmentalists into those who believe in *ecological resistance* or *green business*.

Green Business

As environmental issues and sustainable development increasingly have been integrated into laws and policies, business has had to live with some new rules, regulations and conditions for their practice. Some changes in business have been driven by a genuine concern for the environment, but by and large, any change in favor of the environment has been seen as a restriction on business. However, increasingly businesses have found ways to make

environmental concern coexist with their shareholders' concerns for profitability: cutting energy use, or investing in technology to save energy is often a cost efficient as well as environmentally friendly; this *demand* for various technology for environmental purposes may also be conducive to economical growth; and an environmentally friendly company profile may help increase market shares.

The people and businesses that believe that environmental issues can coexist with profit and economical growth – or that *pollution prevention pays* (to use catchy phrases) are part of a *green business* approach to sustainable development. Proponents of green business, believe that so-called *ecological modernization* of business and technology can provide us with growth and material abundance, while providing the necessary reduction of our ecological footprint. As we shall see in the next chapter, this idea is what drives the effort to build environmental concerns into policy on terms that business can understand.

Critical ecology

At the other end of the continuum of environmentalists, we find what we can call critical ecology. They would argue that ecological modernization is just a slowing down of degradation of our environment, and efforts to for instance make the automobile *cleaner* is just a way for business to get attention away from the fact that what they do is ultimately environmentally hostile – or to slightly change the meaning of a quote: the automobile is "unsafe at any speed" (Ralph Nader quoted in Jamison, 2001, p. 125). When oil companies try to profile themselves as environmentally benign, by using new technology or funding environmental projects, they are improving, but are still part of the problem.

This category includes people from the quiet individual, who is doing his or her share for the environment; and lobbying mainstream organizations; to militant protesters who chain themselves to trees and prevent construction work; and to *deep ecologists* who reject the *man-*

in-environment image in favor of a *total-field* image (Jamison, 2001, pp. 147ff; Næss, 1989, p. 28). What they have in common is an acknowledgment that sustainability can only be achieved with a general change in lifestyle, consumption and values, and not by simply adding *technological fixes* to existing problems.

These are idealized opposites, and in the space between there are countless varieties. Also, there can be made no simple dichotomy that *green business* people are to be found in corporations, while critical ecologists are only among environmental organizations.

3.3.3 Critique of *Sustainable Development*

Those of us born in the 80s have generally little insight in the environmental movements, and the process of building an environmental consciousness in previous decades that are the roots of the concept of sustainable development. There is a general popular conception that sustainable development is the solution to our environmental problems, and that if the principles behind it would only be followed, we would ensure a healthy planet.

Growth

However, there are critical voices to the sustainable development concept. The *Our Common Future* (OCF) report "has been seen as both ambiguous and contradictory and incapable of specifying the mechanisms and changes necessary to realize sustainable development" (Langhelle, 1999, p. 129). One of these contradictory elements is the bias towards growth. The report states on page one, that sustainable development opens the possibility of a new era of growth. Possibly, it is this embracing of growth that has made it possible for businesses to proclaim growth in the name of sustainability and ecological modernization. Some, however, stress that growth is not what we need – rather a reduction is in place. The report does, however, stress that it does not endorse growth for the sake of growth alone to improve GNP.

As Robert F. Kennedy said in a speech in 1968 (in Segger & Reynal, 2005, p. xxxi):

> Our gross national product [...] counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for those who break them. It counts the destruction of our redwoods and the loss of our natural wonder in chaotic sprawl. It counts napalm and the cost of a nuclear warhead, and armored cars for police who fight riots in our streets. It counts Whitman's rifle and Speck's knife, and the television programs which glorify violence in order to sell toys to our children.

Rather, growth in a sustainable development perspective "must quickly design strategies that will allow nations to move from their present, often destructive process of growth and development onto sustainable development paths" (OCF in Langhelle, 1999, p. 130). Thus, growth is not generally prescribed as a solution in itself, but development is. Development is necessary to move away from destructive behavior – and this development must be accompanied by economic growth, but growth must be decoupled from *resource use*. A *zero-growth* approach would not be sustainable because it could not readily tackle problems, such as moving away from CFC gases, or for that matter old polluting diesel ferries, some economists argue (Boyle, 2003, p. 175).

The content of "sustainable development" has perhaps been diluted, but the OCF report quite clearly sets the boundaries for the kind of growth we should pursue – so that although sustainable development requires growth, it does not entail that growth is necessarily sustainable.

The conservation of the environment

Sustainable development is also commonly understood as on par with environmental protection. But sustainable development is about the conservation of development, not the conservation of nature (Wolfgang Sachs in Langhelle, 1999, p. 134). As Gro H. Brundtland

notes: people argue that an activity is not sustainable because it leads to environmental problems; but nearly all human activities have adverse effects on the environment; sustainability is relative, and we have to see it in a greater context – and that is why there are a lot of mixed feelings about the term sustainable development in environmental movements (ibid.). The main concern is to provide for *humans* – and "a policy that procures development by dint of damages to the environment, violates the proviso [of sustainable development] only insofar as these damages are detrimental to future development" (R. Malnes in Langhelle, 1999). To provide for themselves, humans have to interfere with ecosystems. And while cutting down forest for agriculture interferes and disturbs ecosystems, one cannot say that it is inherently wrong. If it were so, we could not live on this planet in anything near the number we now populate it with. But the problem occurs as forest is cut down for agricultural use without a sound and critical evaluation of the value it had as a forest compared to what it will have as cultivated land. Deforestation is a serious global problem, and the consequent loss of ecosystems will reduce the future sustainability of the population (Langhelle, 1999, p. 135; WCED, 1987, p. 127). The OCF report also acknowledges precaution as extremely important, as we cannot easily foresee the effects of our intrusion. It also points out that states have a *strict liability* to other states to "take all reasonable precautionary measures to limit the risk when carrying out or permitting certain dangerous but beneficial activities (WCED, 1987, p. 349). This means, that while sustainable development largely is focused on the well-being of humans, it also conveys a strong respect and concern for nature. However, as I have tried to show, it does also mean, that using non-renewable resources (such as a ferry or a car running on diesel) or causing physical impact on our environment (such as clearing a forest, or dumping an oil rig in the North sea) is not necessarily unsustainable (Langhelle, 1999). Our goal is, after all, not to eliminate toxic waste, rather to curb the emissions so that we do not

cause irreversible damage.

3.4 Policies

This section will explain the options and difficulties of policies pertaining to the environment and sustainable development. There are many types of policy instruments that intend to protect the environment or provide sustainable development. Which instruments are chosen, and how rigid and far reaching they are, varies according to the priority or sense of urgency that is perceived in relation to specific environmental problems. The *types* of political instruments are also, of course, determined by the level of accuracy that the causes of environmental problems can be measured, and the willingness to set up an adequate bureaucracy to manage the fiscal implication of policies.

It is common to speak of four different types of policy instruments available. First, *Regulation*, that is, controlling environmental problems by simply setting strict limits to some activities. That could be banning the use of certain substances (like CFC), or demanding certain technologies to be used. If a substance needs to be controlled, not necessarily banned, one could set emission rules. These could be *ambient*, for instance that the number of particles in the air in a street cannot go above a certain level. Another option is to demand *emission* standards from the source, and a third is to set criteria for *design* in technology, like using LNG-engines in ferries. Regulation policies are considered to have a number of strengths – they are reliable (if they are enforced), easy to articulate, predictable, and *can* stimulate innovative activity. They can also have a number of less attractive attributes – such as legalizing pollution to a certain limit, having high costs of control, and being too focused on mending the symptoms rather than eliminating the problem (Smink, 2002, pp. 50ff).

Second, we have *voluntary action.* This simply means that businesses, groups of

businesses, or an industrial branch on a voluntary basis engage in environmentally friendly activities due to their *corporate social responsibility*, or as a way to improve public relations. This is generally seen as *efficient,* in that it has a low cost (that is, a high ratio environmental output to public spending input), but largely not *effective,* in that ambitions are low, and rarely met.

Third we have *government expenditure*, where public money is being spent directly to improve environmental quality. This is often done cooperatively with voluntary action, for instance partly subsidizing friendly technology, or investing in infrastructure for recycling materials.

Fourth is so-called *market based instruments* (MBIs). This is a large group of policy instruments, but what they have in common is the idea that the *invisible hand,* or that self interest, given the right conditions, will ensure that environmental efforts will be taken where they can be done more cheaply. Taxes on emissions, and tradeable permits are examples of these instruments. The idea is that if your expenses are proportionate with your emissions, or your ecological footprint, then, *self interest* will drive businesses to reduce these emissions by investing in friendly technology, or introduce resource and power saving regimes (Carter, 2001, ch. 7).

As indicated, these forms of policies are not isolated or mutually exclusive, and often policies will be implemented as a combination of different types. I will focus on the regulation and MBIs because it is interesting to see how MBIs are becoming more popular than regulation, at least rhetorically (though MBIs are not new). If we go back to the 60s when environmental issues developed, governments treated the problems simply as an unfortunate side effects of economic growth, while there was little question about the underlying rationale of growth (Carter, 2001, p. 162) (though Galbraith's questioning of the

intrinsic purpose of growth is a good example to the opposite). Environmental policies were simply patches to mend the wounds of a booming post war economy. Neil Carter calls this way of thinking from the 60s and 70s *the traditional policy paradigm* where "government policies were reactive, piecemeal and tactical" and few countries had any comprehensive plan for how to address environmental problems. Instead branches of government with little power were founded to deal with the problem without recognizing the interdependencies between the environment, and political, economical and social systems (Carter, 2001, p. 169). Environmental policy thus became little more than a top-layer of restrictions to economic life, where *regulations* most often was prescribed for environmental problems. These focused on so-called *end-of-pipe* solution – that simply manage the problems, or the symptoms instead of addressing the underlying causes. In the 80s, however, the environment was further degraded, despite the regulations. Businesses and right wing politicians felt that *regulations* were not successfully addressing the problem, while the economy was put under unnecessary strain. Thus, *regulatory policies* got a serious backlash in the 80s – while politics were dominated by the right, with political heads of state such as Ronald Reagan in the US, Margaret Thatcher in the UK and Norway's Kåre Willoch. The right managed to win a rhetorical game, where regulatory instruments were regarded as a *burden* and were re-labeled *command and control* (Carter, 2001, p. 287).

But the 80s also brought a series of new events that brought the environment to our attention and on the political agenda, with radioactive fallout, hunger in Africa, and dead fish in the lakes. What was new for this reawakening, compared to the one in the 60s, was the acknowledgment of the deep interdependencies in the environment, and the transnational and global effects it can lead to. This decade brought about the notion of sustainable development, and with that an understanding that there is a *differentness* in the policies needed for

sustainable development than those of conventional politics, and even those of environmental protection (Lafferty, 2000, p. 12; Bomberg, 2000, p. 61). The new conception that our common future was not only dependent on environmental protection – but also growth and development – opened for a new way of thinking, where governance for sustainable development would to a larger extent be incorporated into economic life. *Market based instruments* seek to provide such a solution, in bringing environmental problems into the economic rationale of businesses and individuals. Hans Bressers and David Huitema calls this idea a *magic carpet*, a shortcut to sustainable development, where there is no need for continuous interference, or a Leviathan to control everything, since sustainable development will be brought forward by businesses' own rational economic self interest, by the *invisible hand* (Bressers and Huitema, 1999).

However, the magic carpet is not flying; according to Bressers and Huitema these types of instruments have shown to be significantly less cost-efficient than their theoretical potential. They claim economic text books underestimate the problems associated with MBIs and focus on the underlying assumptions to why it should work, and disregard the empirical material that goes against it. While the authors are not opposed to the idea of MBIs, they point out some issues that policy makers should take into consideration for new policies, besides the apparent cost-efficiency argument:

- the competitiveness for business at home and abroad
- the redistribution effect the policy will entail
- the implementability
- the flexibility
- the relation to existing policies

Policy makers tend to prefer instruments that involve little visible cost to businesses, but at the same time they are apprehensive about MBIs because they are not tested, and their implications are not known (Bressers and Huitema, 1999, p. 186; Carter, 2001, p. 300). Policy makers are afraid that new polices are going to cause undue changes in the economical environment. However, environmental policy is redistributive in its nature (Bressers and Huitema, 1999, p. 185). It is there to incorporate natural resources into the value chain. It is hard to picture a scenario where the biggest environmental perpetrators are punished without causing redistribution of wealth and power. So, while MBIs are intended to fulfill environmental goals as cheaply as possible, they contain side effects that can be as unfair as those of regulatory policies. For instance, consider a very simple MBI: an increased gasoline tax. This is applied uniformly, and is supposed to reduce CO_2 and NO_x emissions, and possibly improve urban air quality. However, it will have different ramifications for different businesses. For a pizza place that delivers it could be a minor rise in expenses while for a transport company it could be much more significant. Also it has a bigger implication on low profit-margin companies and poor people, than on those better off, and as such has a *regressive* impact.

Another example of MBIs is a *tradeable permit* system, where polluters are given a quota for pollution. However, the question as to how to distribute these quotas initially is difficult. Theoretically they could be assigned based on previous emissions, but that would favor the worst polluters, and punish the ones that had already made an effort to reduce emissions. Otherwise everyone could be given the same quota, but that could also create some redistributive effects, such as favoring certain industries over others, or making a particular industry vulnerable to international competition. This *unfairness* and lack of experience is why policy makers are uneasy about rushing into this type of policies. As Carter notes:

"Bureaucracies tend to be conservative institutions which prefer tried and trusted mechanisms such as regulations" and could be influenced by businesses in a privileged position, who are also interested in a certain stability, and *business as usual* (Carter 2001, pp. 170, 300). However, a political and technological change is necessary for sustainable development. Technological change relies on a conducive social environment to provide the necessary political change – and technological change has traditionally been likely to involve losers and a shift in power (e.g. Mokyr, 1992). Thus, the question is to what extent we want technological change for sustainable growth.

3.5 Institutions

Change can also be limited by what we can call *institutions.* While the content of the term varies from context to context, a commonly used definition is Douglass C. North's that "Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North, 1991, p. 97). Thus they are the social constructs that shape the way we behave, and even the values we hold and the way we think. Institutions are the reason why you pass someone at the right side in the corridor; why men drink beer and do not sip wine at football games; to some extent why corporations are bound to make money; and why you buy their products.

According to Richard Nelson, institutions evolve rather than being planned (Nelson, 2006, p. 22). That is, institutions are a resultant of our society, and they change slowly and reluctantly. Radical changes in institutions do not often happen overnight. As mentioned, the environmental awakening that has happened since the 1960s have altered our values and conceptions, and even politics – but *institutions* die hard: while most have come to the conclusion that priorities in economic life have got to change in favor of sustainable

development, the actual changes are slow. Still, as Neil Carter points out, economic growth takes privilege over environmental protection, and producer groups over environmental groups. The traditional policy paradigm is institutionalized and supported by existing power structures (Carter, 2001, p. 191). So can this help to explain why change towards sustainable development is slow? As Björn Johnson have argued, actual change in institution does not occur as a simple effect of change in ideas and values. In the 1930s, the economic crisis of the Great Depression called for a new policy paradigm – a new way of thinking for public spending. From 1936 when John Maynard Keynes released his "General Theory of Employment, Interest and Money" it took a considerable amount of years before there was an effective counter-cyclical policy in place to manage employment, production and demand, to ensure a more stable economic life. Johnson calls this *policy learning* where

> "over a long period of time, experiences and practices, bureaucratic competence, statistical data [...], policy preparation organizations in the government administration, organizations and institutions for economic counseling and advice, macroeconomic theory and visions and ideas of what is politically and economically possible and valuable co-evolved in a self-reinforcing way. Considerable development of values, institutions and organizations were required before macro-economic stabilization policy was established on the policy scene" (Johnson, 2002, p. 3).

Johnson draws a line between these events and the development of innovation policies. I think it is interesting to look at in light of environmental politics. Similarly, there has been a crisis, or an environmental "depression" in the past decades. While the need to do something is evident, and the will is somewhat also present, even in countries where environmental issues count, economics will go first (Jansen in Carter, 2001, p. 309).

Could one reason for this be that we simply have not adjusted to a policy paradigm where the environment has value, and where generational and geographical justice counts? We can

see the process we are in as a learning process, where the necessary statistical data and the political experience is still lacking. As we have looked into, policy makers try to shift away from regulatory styles to market based instruments. If we see this as a trial and error type of experimenting with policies, we can expect the move to the often more complex world of MBIs to take time to master. Sustainability problems are very complex – they consist of external effects of economic activity, public goods, and slow processes in a global context with high uncertainty. Sustainable development demands relevant and accurate information and statistics; but to untie us from the economic spell, the mechanisms tailored for market goods, national economies, and short term processes will not do (Radermacher, 1999, p. 340).

There seems to be a need for a deeper change than simply adding new features to the current economic policy. Elizabeth Bomberg lists some features that need to accompany a governance towards sustainable development: The awareness of sustainability problems; implementing strategies for reaching the sustainability goals; institutionalizing norms and principles to underpin sustainable development; and steering mechanisms to reach the goals. Norms, practices and mechanisms that support sustainable development need to be *institutionalized* so that a community theoretically would be governed for sustainability without an omnipotent Leviathan (Bomberg, 2004).

4 Thesis composition

A lot has been written about the actual technical properties of natural gas ferries and I am not trying to further elaborate on this. I would like to write a paper that is valuable to those involved in LNG technology without any connection to ESST or the STS community. In such I want to *use* ESST as a bridge between different fields, hopefully for a mutually better understanding, rather than simply submitting another case study to the pool of ESST literature. As a result this paper uses an eclectic collection of theories to help explain why, or why not a technology is evolving and diffusing, despite its technological properties. I hope it will be interesting for those who develop the technology as well as for those in position to make political decisions.

The aim of this paper is to try to point to reasons why technological change in the name of the environment and sustainable development is going slowly, as in the case of LNG ferries in Norway. To do this I have gone through factors that historically have been important in determining the development of technology through history – values and ideas, policies and governments, and institutions – and seeing them in light of LNG ferries as a technological system. To gather information I have performed a literature search in the theoretical background and in government and other documents regarding sustainable development, natural gas use and LNG ferries. I have also selected some key informants that I have found relevant to this particular case.

4.1 Interviews and involved actors

Obviously there are many organizations, politicians, government bodies, producers, users and others that are in varying degree involved in the development of LNG ferries, be it in a conducive or obstructive way. I have chosen to study what happens on a political level, and my choice of informants and naturally the whole focus of the paper is influenced by this. Due

to limitations in time, not only in the actual interviewing process, I have chosen to keep the number of interviews low. The interviews were performed in an informal way, though surroundings and the varying preparations on the side of the interviewee greatly affected the general tone of the interview. Not surprisingly, interviews in the government hive in Oslo with a well-prepared and to-the-point deputy secretary of the Ministry of Transport and Communication has a more formal flavor than the interviews with the leaned back representatives of environmental organizations on a loft at the old docks in Bergen. I did perhaps not take sufficient heed to this difference in advance, but I hope any inadequacies on my behalf will not affect the final outcome.

I have attempted to choose a small but significant selection of interviewees: the most significant government ministries, the main organization for Norwegian employers, and environmental organizations.

4.1.1 Interviewees

A very important actor in putting political pressure behind the development of environmental technology and sustainable development is obviously the Ministry of the Environment. This ministry "owns" the problem of NO_x, and other wastes, and greenhouse gases. I interviewed two members of the staff, a senior advisor and a head of department. These prefer to remain anonymous, because their statements reflect the view of the ministry, not their own.

Another very important political entity is the Ministry of Transport and Communication. They are in charge of ensuring that ferries are provided as a service in the road network. I interviewed Pål-Tore Berg who is deputy secretary of the Transport department.

NHO, or the Confederation of Norwegian Enterprise is important in that it is an interest organization for employers in Norway. That includes lobbying for the interests of industry.

They have shown a strong interest in the shaping of regulatory regimes for NO_x and how it will affect the competitiveness of Norwegian enterprise. I interviewed Geir Høibye who is a senior advisor of energy and environment in the innovation department. He is strongly involved in the current discourse on NO_x tax.

NHO is also the umbrella organization who covers the RLF, the The Federation of Norwegian Coastal Shipping, who introduced me to this case in the first place, through former assistant director, Espen Søilen.

The LNG ferries hold most relevance in the western part of Norway. I interviewed the leader of Friends of the Earth in Hordaland (the region in which Bergen is situated) and a representative of Nature and Youth, Norway.

It would of course also be interesting to interview a representative from the Ministry of Trade and Industry, as they are involved in the aspects regarding innovation in the ship industry and natural gas industry. Additionally, of interest would be the Ministry of Petroleum and Energy, as it is one of the main driving force behind the expanding use of natural gas. The same goes for representatives from the actual producers of ferries and the shipping companies who own them. My limited time window restricted the number of interviews possible, but given the confines of this paper, it is also necessary to control the span of the data.

In any case, doing the interviews have been an interesting part of the work with the thesis, both for getting crucial information for this paper, but also as interesting fields trips and skills training.

4.2 Bias

Everything we write is biased – what we are interested in, what we believe in and what we want to say influence the way a paper is written. What is important is getting this bias out in

the open for the reader to be able to critically examine the contents. For me, the fact that I have a background as an engineer and that I am Norwegian will influence not only the conclusions I make, but also the questions I ask.

However, a more concerning potential source of bias is that I am writing this paper by request from and funded by the mentioned Federation of Norwegian Coastal Shipping (RLF). However, I see myself as unbound from any preconceived conclusions, though the RLF has to some extent been involved in setting the scope and focus for this paper, in wanting to understand why diffusion is slow, and in suggesting potential interviewees.

4.3 Structure

Acknowledging that most people, including myself, have little prior knowledge to ferries in Norway, I found it imperative to add a section in the beginning with general information about this subject, though focused around the introduction of LNG ferries and the problems thereof.

Next I have been laying out in relatively high detail the conceptual framework in which I want to discuss the development of and problems regarding LNG ferries. This section does not discuss LNG ferries as such, but rather creates the theoretical backdrop for my consequent analysis of the ferries and natural gas.

5 The politics of LNG ferries

5.1 Views on technology

There are generally few that question the point that natural gas used in ferries has an environmental benefit over the use of diesel. What is important is considering what such a change would entail, and imply. While the environmental organizations I have interviewed are surprisingly in accordance with government and business when it comes to the basic support for LNG ferries, they are rather more skeptical to the general presentation of natural gas as environmentally friendly. In isolation they acknowledge that it has benefits in ferries, but they have at least a few objections.

First of all – simply saying that natural gas is cleaner than diesel does entail that a change from one to the other is the most adequate thing to do. I interviewed environmental organizations in Bergen (*Friends of the Earth* and *Nature and Youth*), home to a relatively large park of natural gas buses. Natural gas buses have a similar rationale as ferries, but they are perhaps more pertinent to NO_x issues, as they operate within city limits – thus the local benefits of them are higher. Surprisingly though, my interviewees are not particularly enthusiastic about natural gas buses. The main of these objections is a question of efficiency. Sure – buses on gas have environmental benefits, but the claim is that the money could be spent wiser. The infrastructure and buses are a rather big investments. This money could have been used to provide a better service for mass transport, higher frequency, cheaper tickets etc. This could lead more people in urban Bergen to relieve the strain on the road system by taking the bus instead of their private car. My interviewees think that this would yield more environmental benefit than investing in gas buses. At the same time, gas buses could give the impression that technology will fix the environmental problems without our effort, while cutting prices and improving service could lead to a higher level of public involvement. The

same could be valid for LNG ferries. For the extra costs, one could for instance improve public transport; more buses on the ferries could alleviate the current problems of capacity on certain stretches.

Secondly, and more importantly are the side effects of building an infrastructure for natural gas. The idea behind changing to a new fuel in ferries or buses is to introduce it to a fleet of similar vehicles in set routes in limited areas. That provides a more cost efficient introduction and use at an early stage. This will make the infrastructure, the natural gas, available to a new range of customers, and this is what worries the environmentalists. As we have touched upon, *sustainability* is not determined for a certain activity without reference to a bigger picture. An activity which is harmful to the environment may still be sustainable, or a move towards sustainability. While natural gas used as a replacement for diesel in ferries might be a sustainable use of energy, it does not mean that the use of natural gas is environmentally friendly, or sustainable. If the infrastructure of gas leads to the further use of natural gas for other uses, such as heating in private households, the condition for sustainable use of natural gas is gone. Even if natural gas replaces fuel oil to for heating and produces less pollution, it is still not sustainable development, because it displaces other, potentially more benign technology, such as various forms of bio-fuel.

Lastly – and rather connected to the previous is a critique of the use of the word “natural gas”. Environmentalists are critical to the way natural gas is presented as an environmentally friendly source of energy by the Norwegian government and petroleum industry. As with oil, gasoline and diesel, natural gas is a fossil fuel, and the correct term should be fossil gas. This is more than pedantic nitpick – it is important to keep in mind that natural gas is a fossil fuel. Presently, especially buses are presented as if natural gas is an option equally desirable as renewable energy. This development is not necessarily healthy in the long run in providing for

a gradual shift to sustainable and renewable energy sources.

With today's high oil prices, natural gas also becomes relatively more profitable, and large enterprises are involved and want to increase markets. With higher prices liquefied gas (LNG) also becomes more favorable to atmospheric gas in pipes. Earlier, it was only profitable to use gas where the consumption was large enough to support the investment of pipes (n24, 2006). With higher prices smaller markets are interesting, and the gas can be delivered by ships, instead of through pipes. Even exports are now feasible in the the form of LNG, and that makes it easier to combine exports with domestic use. This move away from laying pipes pleases environmentalists: it takes the pressure away from making long term commitments to the use of gas to repay the investments.

There are strong forces pushing for the increased use of natural gas in Norway. Government has funded research programs in association with research institutes and business, and proclaimed the need for natural gas power in industry to spur new growth and to alleviate for electrical power shortages. We could picture LNG used in ferries without using it for industry and as a power source for anything else, but the feasibility of LNG ferries is strongly linked with the efforts to generally use more gas. This is a precondition for LNG ferries. It is not likely that we will see a significant use of LNG ferries without a widespread increase in natural gas use. Thus it is not only the question of NO_x that has *re-opened* the diesel technology in ferries, it is also the systemic push natural gas in a larger context. Nevertheless, we are responsible for the sustainable development in this case, and for using natural gas only where it is beneficial.

5.2 What are the values showing us?

> "This government will build its environmental politics on the principle of sustainable development, the precautionary principle, and solidarity with our descendants. Our goal of a

> just distributions is valid both between those who are alive today and between present and coming generations. Norway shall be a leading nation in environmental policy. We will lead a policy which manages resources in a better way, conserves the biological diversity and reduce emissions to prevent human made climate change. To solve these environmental challenges we need committing international cooperation" (Norway's governmental platform, Soria Moria, 2005).

Norway has long liked to present itself as environmentally conscious. Though, as many have noted, it is our duty, as a rich European country, with the power to do both research and environmental efforts that are not directly economically profitable. At the same time Norway's wealth has come from the petroleum industry – where searching, producing and using has huge environmental side effects. This should keep sustainability high on the agenda in Norway (Teknologirådet[8], 2005). This is the context in which LNG ferries are discussed.

While LNG ferries are not an oft-visited topic in the Norwegian public, other aspects of natural gas uses are. The most prominent of these is the debate over natural gas power plants. This has been, and is *highly* debated in Norway, even leading to the first government of Bondevik to step down. Now there is a growing consensus that this kind of plant should not be made if it is not CO_2 neutral, that is without a safe deposit for CO_2. This could provide very clean energy, and while not renewable, a potential clean source of energy for decades. Comparably LNG ferries seem less idealized, and more pragmatic. Used in transport natural gas *will* emit CO_2 but it is reducing NO_x. This underlines the idea that sustainability must be considered in each case, and that what is environmentally damaging may not necessarily be unsustainable. With everyone I have talked with I have met this pragmatism – yes LNG ferries emit CO_2 and no, it is not a step towards renewable energy, but it is the right thing to do in that we are doing what we can now, with the technology available. We are not sitting around waiting for "future technology".

8 Norwegian Board of Technology

However, in trying to view this in a more idealized context – even if LNG ferries are a good use of energy, are the preconditions for it within the proviso for sustainable development? First of all, besides the need for replacement of old ferries, one of the main reasons for the current drive towards is the desire for taking the edge off the increasing traffic on certain stretches in western Norway. With this accommodation comes the desire for faster and more frequent ferry traffic. Although the LNG ferries have a lower CO_2 emission than diesel, with all other factors the same, the increase in capacity *and* speed will lead to an increased net CO_2 emission. The Transport administration seem to justify this by saying that it is a necessary development, and that the improved *service* makes the increased emissions acceptable.

But can we accept that this is providing for "the needs of the present without compromising the ability of future generations to meet their own needs"? Is making sure an increase in traffic is progressing smoothly taking care of the *needs* of the present? Is going faster now, literally, something we can justify for future generations? A credible argument for this comes unexpectedly from the environmental organizations: in a larger picture, the faster and more frequent ferries can have a positive environmental impact. There are fast boats (not for cars) trafficking the distance between Stavanger and Bergen. These pollute a lot, comparable to air traffic, and improving the service on the ferries may take some popularity away from these, and even air traffic between these cities. Another, and related aspect is that ferries are perceived as making traffic slow. A faster ferry service could take attention away from the forces who want to make roads around and over the fjords in the area. Though a totally different type of environmental problems, the organizations I have talked with think such an impact in the landscape would be highly unfortunate. Again, this shows a pragmatic view on environmental issues. It is not necessarily shared by other Norwegian environmental

groups.

We see that there is agreement that natural gas in ferries is a fairly intelligent use of resources and of the technology presently available. But on other fields there is disagreement. As mentioned, the context in which LNG ferries are discussed is one where natural gas is used as an energy carrier to a much larger extent. This is where agreements end: Industrial actors, and many politicians see the use of natural gas as clean and intelligent also for industrial use, and more importantly, even to spur growth and new jobs in industry. While, to be sure, there is great concern about keeping industrial growth within the bounds of sustainable development in current political discourse, the environmental organizations more categorically see industrial development based on an increased use of fossil fuels as unsustainable.

5.3 Where are policies heading?

Up until now there has been little regulation of emissions at sea. NO_x emissions in land based industries have largely been controlled with regulation policies, where factories have been allowed a certain yearly emission quota. However, as the deadline for reducing NO_x emissions through the Gothenburg protocol is rapidly approaching, there is a need to start doing something more drastic. For a long time there were plans for a common certificate system for "green" power between Sweden and Norway. These plans were thwarted by disagreements and difficulties in implementation. Perhaps this is part of the reason why ambitions were low when the policy solution for reducing NO_x was presented this year. The new government (since fall 2005) has envisaged a tax per kilogram of emitted NO_x from 2007 to accommodate for the goals towards reducing emissions. While action is commendable, the proposal has widely been received as highly damaging to industry, shipping and fishing – especially in rural areas. Several industrial lobbyist organizations have raised their voices against this new

tax, which, as they see it, has a regressive impact on industrial actors.

The idea, is of course, that such a tax will allow market forces to make sure investments in environmental technology are made to reduce emissions where they are the cheapest. This is the basic idea of market based instruments, and normally business would prefer this over regulations. The NHO is opposing this new tax, and has presented a counter-proposal. They have several complaints about this tax: They think it is rushed – not that it comes early, but that it is not properly thought through. The claim is that it will cost too much and put small enterprises out of business. By imposing this tax in a "one size fits all" manner you will not get an efficient emission reduction in relation to the total expenses. Small businesses, and businesses with low margins will immediately run into problems. Though these may use equipment where the investments are small in order to reduce emissions, they might not have the liquid capital to make such choices. This can lead to a consolidation of for instance small and independent fishermen into larger units, which is against government policy. A tax of only NOK 10 per kg (€ 1.30) will lead to extra costs of NOK 380 million (€ 48 mill.) for coastal traffic, the NHO has calculated in a letter to the Norwegian PM. However, government calculations indicate that a tax in the range of 50 – 60 NOK per kg is necessary to achieve the wanted effect (Revised National Budget, FIN, 2006, p. 75). Several industry unions are reacting.

Naturally, when industrial actors are suggesting alternatives to a tax, it is in their own self interest. We have to remember though, that even though a tax means income to the state, it does not necessarily entail that it is a cost efficient incentive. As Bressers and Huitema claim – if policy makers overlook effects on competitiveness and redistribution the magic carpet will not fly. Though a redistribution of power might be necessary in the long term for sustainable development; it will not be popular, and if it will not lead to an environmental

benefit, there is no point playing havoc with people's jobs and communities. Environmental policies should seek not to redistribute power, nor favor some industrial actors over others, nor put some industrial branches in a disadvantage to international competition, if that is not a goal in itself. If estimates are right, it seems likely that many small fishing boats will not handle increased costs of up to several hundred thousands. Increased shipping costs at sea can lead to a further shift to transport on land. A reduction of NO_x through a reduction of employment and productivity is not what we want – rather we need an efficient way to implement better technology where it is the cheapest. There is clearly room for improvement on the proposed new tax.

Currently, the NHO is asking the government to put off this tax for another half year and consider the NO_x taxing regime that the NHO is proposing. They suggest a whole new model for tax and paying for the implementation of environmental technology through a private fund. Businesses would pay the tax to a fund, which then redistributes the money to pay for investments where they are most cost efficient. For instance, in such a model big companies with high-cost investments could help pay for more cost efficient investments in businesses that cannot afford it. Additionally, it could also shape the development in such a way that more reduction is done in high-intensive areas, as NO_x to a degree is a local problem. Further, a private fund could more freely than the state remunerate businesses that do invest in technology themselves, without infringing international competition rules, for instance in the EEC. To many this sounds like a more efficient system that will have less economic impact on business in Norway. This support is obviously mainly from industrial actors themselves. However, my interviewee in the environmentalist camp is not at odds with the general idea of this type of policy, as long as the polluter ultimately pays for the pollution.

I think it is likely that we will see some modification of the tax announced from 2007 in

the direction of something like the fund. If policy makers tend to go for instruments that do not seem to have too direct and profound implications for industry, then the fund solution looks more likely to be chosen.

However, any policy for LNG ferries in particular seems to be a lot less likely. Though natural gas in ferries has been stimulated and encouraged, there seems to be a general reluctance to actively encourage or request LNG ferries. This is based in the idea that the market and its actors know best what will be the most cost efficient means to reduce NO_x and maintain adequate services. On the other hand, if you want to develop new and better environmental technology, there could be some synergy effects in a larger scale. If every single case of the profitability of LNG ferries is evaluated in isolation, that may not take into account the effects that we could have had with a more thorough and large scale change. The additional costs could be lower, and relative costs of research would be lower, if there was a more unified effort for LNG ferries. This could affect the picture of which environmental technological investments are the most cost efficient.

5.4 Are institutions in place? And what are they?

In many ways we can see the struggle to deal with NO_x emissions dealing with sins of the past. Especially at sea, traffic has been allowed to expand and continue business as usual. The problems surrounding NO_x emissions and the effects of acid rain has been known for decades. And though there has been significant improvement the last 20 years in the amount of landmass that is affected beyond the threshold limit of acidification, the efforts to reduce emissions of NO_x has stagnated. National emissions have remained the same in later years (SSB, 2006b).

In this context we can see the proposed tax from 2007 as *reactive*. Only when really drastic

means were necessary to meet international agreements, were they announced, and then perhaps too harsh, too late and unrealistic.

In ferry traffic there seems to be a limited concern for and attention put to the underlying problems of traffic increase. New ferries are simply made to accommodate for larger traffic flows, without seriously asking if there are possibilities for reducing it. Thus, when making new and more environmentally friendly ferries, these will have a higher capacity, even to accommodate further growth. This is what Carter (2001) calls *predict and provide* policies – where policy makers simply acknowledge the fact that economic growth means increased volumes.

Also, objections have been made to the way research funds have been put to use in environmental technology projects. The Norwegian Board of Technology[9] has criticized how funding for and focus on innovation for sustainable development has been fragmented and uncoordinated (Teknologirådet, 2005, p. 9). Such an example can to some extent be made of the "Glutra" project, which was officially financed to *show the way* for possibilities with gas in ferries, and to supply new technology. As it seems now, there will be little official *demand* for this technology – though depending on future policies for bid rounds for ferries.

This is all resemblant of the *traditional policy paradigm* which Carter (2001) speaks of, where policies are reactive, piecemeal, and tactical. Why is this taking so long, despite a considerable environmental consensus, and the awareness of political measures available? Drawing from Johnson's (2002) theory on *policy learning* we can see how processes of change in policy thinking and implementation is slow: While almost 20 years have passed since the *World Commission on Environment and Development* (WCED) published their report, we have not yet stepped into a sustainable policy paradigm. *Learning* is still necessary.

9 Teknologirådet: www.teknologiradet.no

First of all, policy makers are reluctant to introduce environmental policies. They are often unpopular, and their effects on other activities are not known. As Bressers and Huitema (1999) note, the rationale and effects of modern MBIs are mostly limited to theoretical assumptions. Policy makers lack experience and practice in making and adjusting policies for improvement of the environment. Policies to adjust interest, inflation and employment have been practiced and modified for decades, and in this context, environmental policies are still quite young.

Secondly, building up competencies and relations takes time. Environmental organizations have changed from radical groups to large organizations. Their opinions are an increasingly important source of information for and critique of politicians. Organizations such as *Friends of the Earth*, *Nature and Youth* and *Bellona* have a stronger voice in debates, and in providing consequential arguments for policy making. Similarly, businesses and other organizations are building up competence and environmental knowledge to add to the discourse of politics for sustainable development, with feedback and ideas, and bringing the topic to the agenda. Even if businesses only reluctantly support policies that will limit their freedom, their participation still adds to the the learning process of sustainable development policies.

Finally, indicators of the environment, such as measurements of NO_x and CO_2 emissions, its damaging impact of the soil, vegetation and building, are important to this process or learning. Only recently, as of this summer (2006) has a comprehensive set of indicators for sustainable development come in place in Norway. These provide feedback on a broad range of social and physical environmental topics for (among others) policy makers to better see if, and how policies actually affect our environment (SSB, 2006b). Such good indicators are necessary for the policy learning of sustainable development, as *national accounts* and other indicators were for economists in the Keynesian United States.

We see thus, that *policy learning* for sustainable development is happening, and as I can see it, these three points are leading us in the direction of sustainable development. This policy testing, the broad discourse of policies, and the building of a firm and quantitative set of indicators are processes in the *institutionalization* of sustainable development. However, the announced and unpopular tax from 2007 is perhaps a sign that there is still a way to go in designing efficient policies.

5.5 What can be accomplished?

Looking into the future about LNG ferries is difficult: There are a number of unknown factors in policies, tax or fund, for instance; technological development of LNG ferries, and alternative technologies; the cost of fuel, etc.

5.5.1 What will it cost?

Today it does not cost anything to emit NO_x from ferries. This will change, it will change radically, and there is no way back. The only ferry running so far, which was a research project was about 30 %, or NOK 30 million (€ 3.8 million) more expensive than a diesel equivalent. This is a lot, but it will drop, some say to 10 or 20 % extra, some say below 10 %. Let us compare these costs with what the tax from 2007 will inflict. Ferries emit about 6 200 tonnes of NO_x yearly. A tax of NOK 50 per kilogram will then cost NOK 310 000 000 (€ 39 million). This puts investments in LNG ferries in a wholly different light; the yearly tax is roughly equivalent to the extra cost of 10 new LNG ferries. The question is whether ferry companies can handle this costs, and if they have the economic freedom to choose the long term more profitable solution. If they are not, the costs of this tax will be pushed back on the state, in the bidding round, as the state is the buyer of the services.

This is where a fund could have positive effects. Even with a much lower tax, or “fee”, it

could provide a strong push towards investment in LNG ferries, and at the same time help those who would have the most cost efficient investments, but not the capacity to make them. A fund could also more actively support LNG ferries stronger, as a technological system to help it achieve momentum. It could assess if there are synergy effects worthy of a more holistic approach than just examining each ferry and each stretch individually.

Investing in LNG ferries is bound to cost. However, if we allow ourselves to include our environment into the cost of transport, LNG ferries could be an investment to cut costs, and even a good one at that.

5.5.2 Breakthrough? What is success?

Advocates of LNG ferries think it is a better option than cleaning diesel, because it in the long term may be cheaper, and has a more stably clean output – its cleanliness not equally depending on maintenance as diesel alternatives. In such a perspective the success of the LNG ferry will be when no ferries run on diesel – and the whole technological system has changed its style to a more sustainable path.

If all ferries were to run on natural gas this would have a significant impact on the Gothenburg protocol goals. While LNG ferries might be a cost efficient NO_x reducing investment, it will only be so as the ferries are taken out of service and replaced by new ones. Norwegian ferries are getting very old, and a replacement is due, though only about two is scheduled for replacement yearly, according to national transport plans (BT, 2005). Høibye in NHO thinks this will have to change in the near future, otherwise the age of some of the ferries is going to pose a security issue. However, in terms of the international NO_x-agreement, the deadline is very near. By 2010 LNG ferries are still not likely to be a common sight. Perhaps this acknowledgment that LNG-ferries are not going to be significant in

reaching these environmental goals is hampering any ambitions in this field.

However, in a longer term LNG ferries can create yearly reductions NO_x emissions. In twenty or thirty years LNG ferries could be as common as diesel ferries. What is important, I believe, is to quickly get more experience in this field, and clearly encourage the diffusion of new this new technology where it is needed, to create a setting of policies and signals that is conducive to a momentum so we can benefit the most out of this technology.

6 Conclusion

Environmental problems are not easily measured and quantifiable. While there is an increasing ability to control and supervise toxic emissions, it is difficult to accurately calculate the economic impact of the problems they cause. We don't have environmental indicators of the same consequence as unemployment rates, or interest rates. This makes environmental problems less tangible and more easily swept under the rug.

However, once in a while environmental problems pose enough threat, and gain enough attention to generate concern and action. Ozone layer depletion, smog and acid rain, radioactive fallout and global warming have all caused enough worry to spur action and international cooperation. One example of this is the Gothenburg protocol where one of the goals was to reduce the emission of nitrogen oxides, understanding the long range and far reaching effects of tall smokestacks.

The agreement to reduce NO_x emissions creates a very tangible goal for environmental initiatives. In Norway the importance of setting an example in complying to these goals is not underestimated as Norway is a net receiver of airborne nitrogen oxides.

LNG ferries could help reduce the emissions of NOx, but how helpful is it to substitute one fossil fuel for another – and is it part of a sustainable development? First of all, no other alternative to diesel ferries is available, and technically most agree that LNG is a better long term solution than cleaning diesel emissions. Also, ferries are not going to be phased out any time soon, LNG ferries could be a very long term investment, so the earlier we replace old an technological system with new, the more environmental benefit we will get.

Many technologies appear as solutions to environmental problems to some, and the causes of problems to others – like nuclear power plants and wind mills. Feelings around LNG ferries are perhaps less black and white, and they are perceived as a more pragmatic middle

way solution. It is a sustainable use of energy because it is applied where necessary and where there is a lack of better alternatives. However, if LNG ferries are made possible because of heavy investments in new industry based on natural gas, the sustainability aspect gets much weaker – economic growth in developed countries based on industry with a large physical throughput is hardly within the proviso of sustainable development. Similarly, if LNG ferries lead to extensive use of natural gas where there are other better alternatives, such as for indoors heating, they may not have an overall positive impact.

Until now there has been little economic incentive to build and use LNG ferries, except the assumption that NO_x emissions will be taxed in the future. From 2007 there will most likely be either a direct tax per kilogram NO_x emitted, or an arrangement where polluters will have to pay to a fund. The latter will perhaps provide a more cost efficient transition to more environmentally friendly technology in industry and transport, but neither guarantees for an increased priority towards LNG ferries over diesel with cleaning technologies, or other investments. The government is very reluctant to set technology specific standards, and actors in the market are not willing or capable to make nation-wide investments in LNG infrastructure. What we risk then is that LNG ferries remain a rare sight, and that investments are scattered. It is well outside the scope of this paper to calculate where investments for NO_x reductions would be the most efficient. However, the people I have interviewed, especially the environmentalists and the NHO would like to see a development where we have a bigger perspective that would stop unwanted side effects and reap the synergy effects of a more comprehensive plan for LNG ferries.

In 2010 the NO_x reductions targets should be reached according to the Gothenburg protocol. If Norway will reach these goals remains to be seen – but what happens afterwards is very important. What is needed is a further institutionalization of sustainable development,

where environmental values are more deeply ingrained in economic decisions. Policy learning, that is, increasing the understanding the mechanisms of environmental politics, alongside improved statistical indicators for sustainable development may not lead to more LNG ferries, but it may help determine if it is cost efficient and recommendable to pursue their diffusion.

Though NO_x problems are important and LNG ferries are interesting they catch little attention compared to larger issues like global warming and biological degradation. However, the efforts for a political change towards sustainable development interlinks all these issues, and all have to be addressed. It may seem expensive and difficult, but in the end it comes down to intergenerational and international justice, and ultimately the quality of life.

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Appendix – List of Interviewees

- Pål-Tore Berg, deputy secretary at the Ministry of Transport and Communications. Interviewed at the government offices, Akersgata 59, Oslo. June 14, 2006.
- A senior advisor and a head of department at the Ministry of the Environment. Interview at the government offices, Myntgata 2, Oslo. June 14, 2006.
- John Martin Jacobsen, Friends of the Earth, and Erik Natvig, Nature and Youth. Interviewed at their offices at "Det Grønne Loftet", Jacobsfjorden Bergen. June 13, 2006.
- Geir Høibye, Senior advisor, innovation, energy and environment. Confederation of Norwegian Enterprise. Interviewed at their head office, Essendrops gate 6, Oslo. June 16, 2006.
- Espen Søilen, assistant director of the RLF. Initial talks at Essendrops gate 6, Oslo. January 26, 2006.
- Per M. Einang, researcher at SINTEF. Correspondance, June 16, 2006.