



The City of Midnight Sun and Motorized Vehicles

Sustainable Transport in Reykjavík, a City of Urban Sprawl and Immense Private Car Ownership, where Hydrogen Promises to Solve the Problem of Pollution



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Author:

Elva Rakel Jónsdóttir

Lund University Master of
Environmental Studies, LUMES

Sölvegatan 10, Lund
elvarakel@hotmail.com

Supervisor:

Doktorand Andreas Persson

Lunds Tekniska Högskola,
Institution för Teknik och Samhälle

Lilla Tvärgatan 11, Lund
Andreas.Persson@tft.lth.se

Abstract

This paper contains a case study description and analysis of the public and private transport in the area in and around the capital of Iceland, Reykjavík. It also contains a prediction of the future prospect for socially and environmentally sustainable transportation in the capital area, with regard to the advent of environmentally friendly hydrogen fuel. The historical development of the urban settlement around Reykjavík is discussed, as well as the current land use in the region. The reasons for why the capital area is experiencing urban sprawl are analyzed from the view point of settlement history, land use policy and current life style choices of the inhabitants. The situation of the public transport system in the area is described and analyzed with regard to land use policy, private car ownership, life style choices and the image of public transportation in Iceland. The effects of urban sprawl and low percentage usage of the public transport system are analyzed, specially focusing on environmental effects, such as air pollution, as well as social implications of mobility culture. The future of transportation in Reykjavík is discussed with regard to new vehicle fuel technology in the form of hydrogen fuel, produced from the renewable energy sources of Iceland. Attempts are made to predict the effect that a fuel change would have on otherwise unaltered transportation in the area. A conclusion is reached that Reykjavík would benefit, both environmentally, socially and economically from trying to limit urban sprawl at the same time as improving public transportation and accessibility for pedestrians. The environmental benefits of the city to be gained from hydrogenising the entire bus and car fleet of the area, without taking other precautions regarding the traffic, would almost be cancelled from the continuing sprawl, traffic jams and social effects that would result from increasing private car ownership. Therefore hydrogen may solve the problem of emission, but it is not the magic solution for the problems of transportation in the Reykjavík area.

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Introduction

Humans are social beings and have always sought out contact with others in their daily lives. For approximately 6000 years this human urge to interact has given birth to the practical arrangement of living in close contact within urban settlements. Such settlements or cities have risen, flourished and vanished through the ages but recent development in industry, commerce and culture have drastically spurred the advent of numerous cities as the wave of urbanization has spread across the world (Cavalli-Sforza and Cavalli-Sforza, 1995: 158-159). Cities are currently the fastest growing perimeter of human societies, especially in the developing countries. While approximately one out of every 40 people lived in cities in 1900, one out of eight lived in cities in 1950 and in the year 2000, every other person lived in a city or urban environment (Wärneryd et al., 2002: 15).

Although cities in many ways offer a very convenient living arrangement for a limited number of people, rapid growth which often results in cities of millions give rise to numerous problems. Within the recent discussion of sustainability, it has been pointed out that large cities are rarely sustainable since the inflow of products and energy is much greater than the outflow. The current population of cities in the world occupies only 2% of the planet's surface but consume around 75% of the earth's natural resources (Miller, 2004: 668). This is an escalating pattern and therefore it is foreseeable that without intervention there is little hope that the cities of the future will in any way be more sustainable than those of today.

When sustainability is mentioned, most people recognize the word but seem to have a vague idea of what it implies. Sustainability has been defined in various ways. Undoubtedly the most famous definition is the one given in the WCED(1987), or the Brundtland Report, which claims that "Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 43). Pierce et al.(1989) introduced another perspective on the idea of sustainability by focusing on the economic side of sustainable development and suggesting the existence of natural capital which should be maintained at an even balance (Pierce et al., 1989: 181). Other authors have justly reminded us that the idea of sustainability is always abstract

and varies when you apply it to different people, at different times, in different places, levels or systems (Svedin, 1992: 296).

The idea of sustainable development can easily be applied to cities, both as social and economic sustainability since within large cities you often find great differences in income and affluence, and regarding environmental sustainability, cities produce vast amounts of pollution and disrupt the ecosystem (Miller, 2004: 663-665). It is almost impossible to separate these dimensions of the sustainability issue since a city is a system in which all aspects interact. For example, when looking at the issues of passenger transportation, urban sprawl and alternative fuels in the greater Reykjavík area, all these aspects are intertwined and form different sides of the problem.

The issue that this paper addresses is the unsustainable transport situation in the greater Reykjavík area, which suffers from urban sprawl and immense private car ownership, making viable public transportation almost impossible. Furthermore, the introduction of hydrogen fuel is by many viewed as the ultimate solution to transport problems, although it would only solve part of the problem and so far environmental effects of traffic in the area have been minor while other issues pose a greater threat to the sustainability of the transport situation. The first two chapters, “The historical development of the urban settlement in the Reykjavík area” and “The advent of motorized vehicles and urban planning”, serve as an introduction to the forces that have through time shaped the physical appearance and the preference for specific transport modes. The chapters concerning “The private car in the growing city”, “Current land use planning in the Reykjavík area” and “The politics of urban planning and transport policy formulating” describe and analyze the different aspects of increasing car ownership and urban sprawl. The following chapter, “Public transportation – a loser’s choice” brings up the most relevant solutions to the problem, in the form of alternative modes of transport and land use planning. The next chapter regarding “Environmental effects of current transport policy” describes the effects that the before mentioned problems have on the environment and possible elimination of these effects are proposed in the chapters about “Energy saving and fuel potentials” and “Hydrogen in the Icelandic setting”. Finally, in “Discussion”, the author brings up contemplations on the various aspects of the area’s transport situation and “Conclusions” sums up the content of the paper and offers a solution to the problems raised.

A conclusion is reached that the municipalities in the greater Reykjavík area need to work together towards the goal of making transportation more sustainable without limiting the mobility of the inhabitants. The lack of reasonable alternatives to the private car, as well as the current life style of the inhabitants, is seen as the main problem in the regions transport system. The environmental effect of excessive private car ownership can be eliminated by the introduction of hydrogen fuelled vehicles, but since air pollution has so far not been a great problem in the area, a complete fuel switch may be a big and expensive solution to a currently small problem. More importantly, urban sprawl should be kept under control in the entire area by constructing more dense and mixed neighborhoods, which would offer pedestrians a more human environment and give the public transport system a possibility to operate and provide an attractive alternative to private cars.

Methods

The paper is to a great extent a literature study. It is based on journal, article and book reviewing, two semi-structured interviews, media analysis for discourse detection and personal insight in private and public modes of transport in the greater Reykjavík area. The capital area is viewed as a case study for trends in transportation modes. The scope is nevertheless limited as to mainly focusing on Reykjavík and viewing the other municipalities only as they are connected to Reykjavík and mentioned in the regional land use plan, since reviewing all eight of them separately would have been too large a task for the time frame that this assignment offers. The system boundary is, with regard to space, Reykjavík and the seven surrounding municipalities in the region, and with regard to time, the development of the urban area from the time of the settlement until approximately 2024, as the current land use plans extend to that year. Further more, the boundaries of the main factors of the paper are the current transport modes present in the area, as they affect environmental and social sustainability in the area.

A useful way of looking at multilayered problems is to shift the perspective to the system surrounding the problem. By using for example systems analysis to focus on the various aspects of a certain problems and setting the system boundaries, one can more easily detect different influences in the system and hopefully decide which

former two are also interconnected, so that an increase in “pub. pref. for pub. transport” would automatically result in a decrease in the “pub. pref. for private cars” and vice versa. A decrease in “pub. pref. for pub. transport” leads to a decrease in “passengers on buses”, which would lead to a continual increase in “city planning with focus on the private car”. The relationship between these variables is constantly reinforced, which is displayed by the “R” in the clockwise circle. The same relationship is present between “pub. pref. for private cars”, “city planning with focus on the private car” and “urban sprawl”. Similarly, an increase in “traffic infrastructure” will increase the “pub. pref. for private cars”, which will then start a reinforcing loop with the following increase in various “effects of heavy traffic” such as traffic jams. This will then increase the “need for larger traffic infrastructure”, leading to an increase in the presence of “traffic infrastructure”.

An increase in the “pub. pref. for private cars” also leads to an increase in “environmental effects of private transport”, which triggers a reaction where more “environmental effects of private transport” increases both the “environmental regulations”, enforced by state or municipality, as well as “public awareness”. Increases in both of these would lead to increasing the pressure of introducing “hydrogen fuelled vehicles” on the streets, which would decrease the “environmental effects of private transport”. The relationship between these variables can be described as balancing, as can the relationship between the increasing “environmental regulations”, which decrease the “city planning with a focus on the private car” and thereby in relation with “urban sprawl” and “pub. pref. for private cars” forms a balancing relationship. The whole system is connected together through the increase in “public awareness”, caused by both “environmental effects of private transport” and “effects of heavy traffic”, which increases the “pub. pref. for pub. transport”. Therefore, the outer arrows of the model form a balancing loop, which balances the entire system by increasing “passengers on buses”, decreasing “city planning with focus on the private car” and decreasing the “environmental effects of private transport” as well as “effects of heavy traffic”.

A visual model of the current system could be used to clarify the dynamics of the problem described in the paper. The thicker lines represent a present situation, while the thinner, dotted lines represent changes that will or might come about. For example in my view, the “environmental effects of private transport” are rather more likely to spur “public awareness” than “effects of heavy traffic”, since narrow streets

rather than the increasing number of cars have by many been regarded as the main source of heavy traffic. Further more, according to the solutions in the paper, the arrow leading from “public awareness” to “hydrogen fuelled vehicles” is stronger than the one leading to “pub. pref. for pub. transport”, since even people with high awareness about environmental effects of transport are unwilling to give up their private cars for alternative modes of transport. However, a model such as this does not take all aspects into consideration, such as the aspect of time. Therefore it is necessary to view the CLD as an addition to the text offered, since the model can not for example describe the historical development in the area, leading up to the current problem.

The historical development of the urban settlement in the area

Historically, urban development in various places in the world has tended to follow certain patterns. Settlements have grown and established themselves with the introduction of for example centralized worldly or religious authorities, service and commerce surrounding agriculture and fishing, presence of industry, culture and leisure (Valsson, 2002: 93).

In the Reykjavík area, the process of urban development took place over a long period of time and only in the last century did the settlement reach the size and display the degree of organization that are generally present in urban centres or towns. There are various reasons for why this process took so long in Reykjavík and Iceland as a whole. The most obvious one is that the country is divided into very clear regions due to physical barriers in nature. The settlement is located mostly around the coastline and on the lowland, surrounded by either high mountains or strong rivers. The geography makes communication and transportation of goods and people fairly difficult and therefore serves to maintain a disperse population throughout the country (Valsson, 2002: 96).

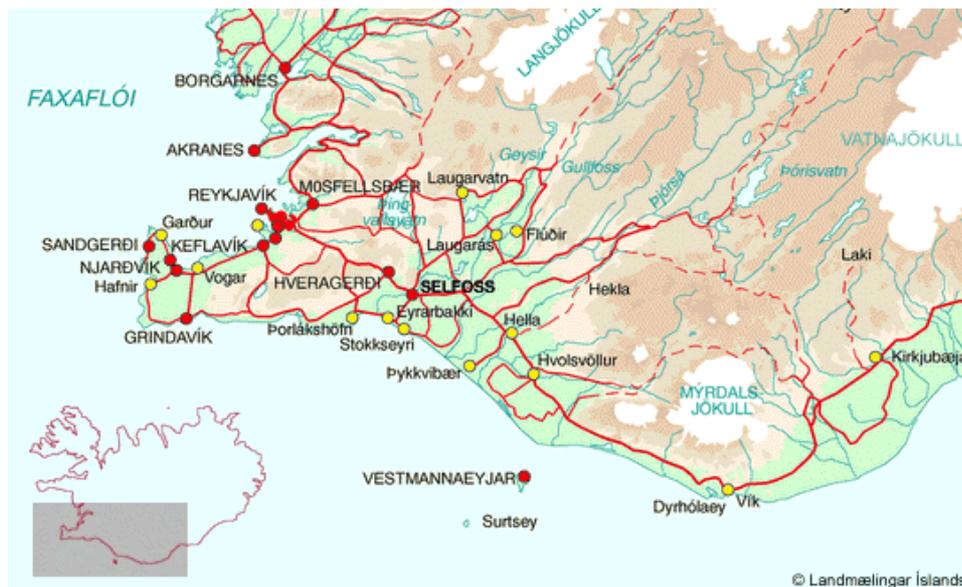


Figure 2 - The greater Reykjavik area (South Iceland, 2004)

More specific historical reasons for the disperse population in Iceland are for example that the old Nordic religion, practiced in Iceland during the first centuries after the settlement, did not create centers of authority or urban settlement. Additionally, the form of local government practiced in Iceland was fairly decentralized as it was a representative democracy where the representatives of various regions only met at parliament once a year. This form of government was practiced until after 1262, at which time the center of authority had shifted to Norway, when the countries formed a union, and later to Denmark which colonized Iceland until 1944. This did little to increase urban development in Iceland (Valsson, 2002: 94).

Another common requirement for urban development is the service and commerce that builds up around agriculture and fishing but although Iceland has always had both, neither of them created permanent centers of settlement until at a later date. Because of the cold climate, Icelanders did not practice crop agriculture and therefore did not achieve the population density that follows cooperative farming but instead practiced livestock agriculture which requires vast space. The fishing in Iceland was more or less conducted on small open boats that were not very efficient and the villages that developed around them were mostly seasonal, until the early 19th century, when with technological innovations in agriculture there was less need for workers in the country side. A prerequisite for a flourishing fishing industry in Iceland was the establishment of stable foreign markets for the Icelandic fish products. This was the case during a short period of time in the 15th century when Icelanders could sell their sea products to England and Germany but in 1602 the Danish king

introduced a commercial monopoly where only Danish merchants could sell and buy from the Icelandic people, which lowered the export value of Icelandic products. Nevertheless, there were several small harbor towns present in the current Reykjavík area, which gradually grew or diminished during a period of a couple of hundred years (Valsson, 2002: 95).

A final variable that often spurs urban development; industry, was only attempted in Reykjavík during the early 18th century. This was an industry that made products suited for exportation, like rope made from agricultural raw material. Although this industry only lasted for a short period of time, it formed a foundation for the village that over the next 200 years would develop into Reykjavík, the capital of Iceland (Valsson, 2002: 96).

Urbanization is often due to any number of factors which make it appealing to live in an urban settlement, but equally important are the circumstances where poverty or natural disasters force people to resettle and seek employment in an urban setting (Miller, 2005: 661). This was the case in the late 18th century in Iceland when the country had witnessed the most devastating volcanic eruption since the settlement, where a large proportion of the population died, as did their stock and crops. One of the main reasons for the establishment of townships was that owing to the immense poverty of the period, there was an incentive to decrease the number of commercial harbors in order to make them more cost effective and to develop job opportunities. Reykjavík, among several other urban settlements, was declared a township in 1786. In an attempt to make the towns appealing, the first bourgeois got certain privileges such as not having to pay taxes to the state for 20 years but only to the town itself. Because of the deep recession, this did not have a significant effect until the monopoly on commerce was lifted in 1855 (Valsson, 2002: 106-113).

Around that same time, several administrative establishments were moved to Reykjavík, among them the seat of the bishop, the Latin school and the resurrected parliament. These were the first steps towards establishing Reykjavík as the capital of Iceland, although the town could not claim the title while Iceland was under the rule of the Danish. In fact, there was a rather strong opposition against declaring Reykjavík the capital of the country since it was perceived as being strongly affected by Danish influence, both commercially and culturally (Valsson, 2002: 106-113). Moreover, Icelanders have until very recently considered the countryside, rather than the towns and cities, to be the center of higher culture, prosperity, education and

virtuous living. It follows that since towns in Iceland have always been associated with the seaside, that many would rather have had the capital situated in the countryside or at least that the parliament would have been reestablished in its old settings in the inlands of Þingvellir. Nevertheless, the practical situation of the city as a harbor city weighed more when the final decision was made. It is safe to say that some romanticism was involved as well, since Reykjavík is believed to be the place where the first settler of Iceland, Ingólfur Arnarson, went ashore and claimed land (Árbæjarsafn, 2000: 13).

In the year 1904, Iceland was granted a limited independence from Denmark, which among other things meant that Reykjavík, instead of Copenhagen, could formally claim to be the capital of Iceland. In 1908, the mayor was formally declared to be the mayor of the city instead of the town. Such a declaration reflected the future role that Reykjavík was expected to have, despite the fact that at this time, there were only 10 thousand people living in Reykjavík (Reykjavíkurborg, 2004).

The advent of motorized vehicles and urban planning

In the beginning of the 20th century, only the very center of Reykjavík had any sort of structured streets while the immediate outskirts contained turf houses of the poor. Farms that supplied the inhabitants of Reykjavík with agricultural goods were situated very close to the city, since there were no means of transporting such goods from the country side within a reasonable time span. With the new century came optimism and ideals of progress which were manifested in that it was forbidden to build more turf houses, as they were considered unhygienic, water distribution and sewer systems were constructed, one street was asphalted and pavements were added to several streets (Árbæjarsafn, 2000: 16). During the First World War, agricultural products were for the first time transported from the areas east of Reykjavík by trucks which meant that the demand for large farming spaces in immediate proximity of the city decreased, and indeed within the city as well in the form of e.g. potato fields. This led to an increase in the supply of building land in the area and thereby called for a greater cooperation between consisting municipalities concerning land use planning (Valsson, 2002: 121).

The Danish engineer, Alfred Raavad Jensen was the first person to come up with the idea of conducting coordinated planning in the area around Reykjavík in 1908. He proposed that the bulk of the building land should be situated in the valleys of the area and leave the ridges open as sites for transportation such as railways or trams. Unfortunately, his ideas were not followed through and instead, the ridges of Reykjavík were for a long time the main building land of the area and the valleys in between the current municipalities remained untouched. There have never been operated passenger trains or trams in Iceland, such as Jensen might have visualized, but cars and buses have been the main modes of passenger transport from the beginning of motorized transportation in the country (Þorsteinsson, 1999: 11-12).

The first car came to Iceland in 1904 and by 1930 there were 800 cars in the city. Such a radical change from horse and carriage traffic to motorized modes of transport called for an adaptation of the infrastructure in the city (Reykjavíkurborg, 1984). The first city land use plan was drawn up in 1927 and was largely based on a contemporary plan of Copenhagen, where streets lined with houses divided areas into squares, which would facilitate motorized traffic to navigate through the city. By now, Reykjavík had grown to the extent where it was no longer optimal to travel everywhere on foot, which had been the main mode of transport so far, and some form of public transport had to be established (Valsson, 2002: 122). The Reykjavík Buses Ltd., or Strætisvagnar Reykjavíkur hf., were formed in 1931, operating 6 buses that drove to the more remote parts of Reykjavík. What followed this advent of public transport and increase in private vehicles on the streets was an extensive improvement and enlargement of the streets and infrastructure (Reykjavíkurborg, 1984). The manifestation of this was for example zoning of building land and the division of streets into traffic streets and residential streets. Among other measures that were taken up in Reykjavík was e.g. that all the northern shore of Reykjavík was to be reserved for industry and harbor related activity which restricted all construction of residential neighborhoods on this very attractive piece of land. The idea behind the zoning of land originated in large and heavily polluted industrial cities but had little relevance in a small city that was relying, to an ever increasing extent, on geothermal power and therefore smaller industries and households emitted a minimum amount of pollutants (Valsson, 2002: 127-139).

During the 20 years after the Second World War, there was an incredible 700% increase in the size of the city, while there was only about 70% increase in

population. This immense growth in the Reykjavík area over such a short period of time is due to various things. Among them the increasing availability of public transport, which made it possible for people that were moving in from the country side to settle down at a reasonable distance from the city center, where space was abundant. Therefore, the large new neighborhoods were considerably far from the center. After the Second World War, car ownership became increasingly common, owing to the fact that the American army left behind a large number of motorized vehicles in the country. This not only facilitated, but accelerated the expansion of Reykjavík. At this time, the streets very getting increasingly larger and more removed from the residential areas. Each street was also lined with green areas or trees, which decreased the areas available for new constructions. Following the planning document of 1927, a number of land use planning documents for Reykjavík were issued, none of which were fully realized. All of them put a great emphasis on infrastructure that facilitated the ownership of private cars, since owning a car of your own was considered to be everyone's civil right (Valsson, 2002: 127-139).

One of the planning obstacles facing Reykjavík in the previous decades was that it was forced to expand along the northern shores since the southern shores were already occupied by other municipalities, which have gradually come to resemble small satellite cities of Reykjavík. The largest of these, Kópavogur, is a young town that was established after the Second World War during a period where there was a peak in immigration of people from the country side, moving to the capital area in search

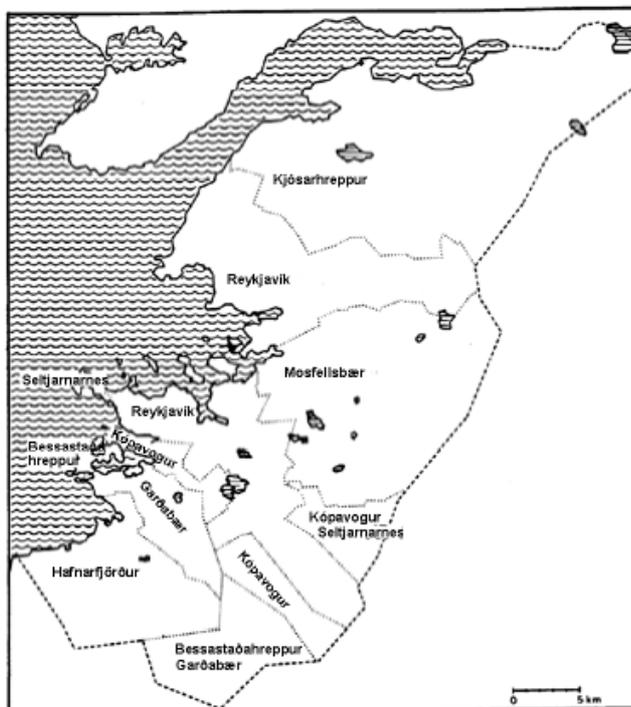


Figure 3 - The municipalities in the Reykjavik area (SSH, 2004)

of job opportunities. The availability and cheap prices of the land in Kópavogur lead to a fast growing residential area in this neighboring community of Reykjavík. The same happened with the other small towns around Reykjavík, except Hafnarfjörður, which is an old harbor town, much like Reykjavík. When these towns were developing there were hardly any jobs or service to be found in the area except in Reykjavík, which lead to the fact that roads connecting these towns to Reykjavík were built fairly quickly. The result was a growing need for common regional planning amongst these municipalities, making the planning process much more complicated (Þorsteinsson, 1999: 14-16).

From 1965 to 1986 there were several attempts at coordinating cooperation around a regional land use plan for the capital area but they never made it past the politics governing the different municipalities. It seemed that no matter how insignificant the common denominator was, the politicians were afraid to sign a binding commitment that could in any way decrease their independence in years to come (Þorsteinsson, 1999: 14-16). There have always been deep political differences between the municipalities and cooperation has often seemed wholly impossible. In the present day, large proportions of the commercial activities have spread out of Reykjavík and more than ever, the greater Reykjavík area is one whole where people seek jobs and services freely between the towns and the city. In recent years, there has been a trend towards building large malls in the capital area, which decreases the market share of the local stores. People therefore have to travel a greater distance to seek service, which increases the private car usage and the already ongoing urban sprawl in the capital area. The sprawl presents serious difficulties for the public transport system and increases social injustice by limiting the mobility of those that can not afford to, or can not operate a car (Valsson, 2002: 161-183).

The growth and urban sprawl in Reykjavík has continued throughout the 20th century. In the beginning of the 20th century, Reykjavík had 6000 inhabitants while at the end of the century, the number of inhabitants in Reykjavík had increased to 106 000 and in the whole area to 167 000 inhabitants. The main reason for this rapid growth was the increasing efficiency in the fishing due to new technologies which eventually lead to the fact that fishing replaced agriculture as the main industry in Iceland and the migration from the country side to the fishing villages increased (SH, 2002). Today, Reykjavík has reached a proportionally large size. If compared to

Sweden, where it is estimated that one of every five people lives in one of the three largest cities (Wärneryd et al., 2002: 82), the Reykjavík area contains around 170 000 out of Iceland's total 290 000 inhabitants, resulting in more than half the country's population living in the greater Reykjavík area. The rapid growth and the current sheer size of the city calls for increasingly extensive road infrastructure, it changes the mobility pattern of the inhabitants and brings about the need for both general land use planning for each municipality and regional land use planning for the whole capital area. Land use planning on all levels needs to take into consideration the increasing private car ownership, preferably without giving the private car a too central role in the cityscape.

The private car in the growing city

Cities are known to have existed for at least 5000 years and archeologists tend to base their definition of whether an ancient settlement can be recognized as a city or not on the presence of a city center of some sort, be it a market place or a religious temple. In the current growing cities of the world where, facilitated by the presence of private cars, people have been moving ever further from the city center while the center itself has effectively been degraded, there seems to be a trend towards the development of anti cities, that no longer have well defined centers of activity (Wärneryd et al., 2002: 54). It would be curious to know how the archaeologists of the future will define the ruins of our settlements and whether their physical appearance will fulfill the criteria of cities.

The physical appearance of Reykjavík can to some extent be contributed to the fact that Reykjavík is such a young city, but it is more so due to the peculiar nature of the development of the Reykjavík area in the 20th century, where as before mentioned the urbanization occurred in little clusters all around the city center due to e.g. the need for agricultural products and the availability of cheap land. It could therefore be said that there has been a densification going on for over 70 years as the city gradually grew together into a connected whole (Sigurðsson, 2003: 34). At the same time however, there has been an outward growth of the city, calling for ever more transport infrastructure with larger and wider roads, the effects of which are gradually becoming obvious to both the public and the politicians.

In many younger western cities, such as Reykjavík, the purpose of the road has changed during the last century from being the arena for human interaction, into having the sole purpose of transporting vehicles to their destination (Sigurðsson, 1995: 26). This is the result of the current mobility culture dominant in western societies, which implies that people travel frequently out of either necessity or free will. The functional differentiation of society has led to the fact that work, service and leisure has moved out of the homestead and people have to and are willing to travel an ever greater distance in their daily lives to seek jobs, service and leisure (Hultman and Wärneryd, 1999: 29-37). It is rather more difficult to discern whether or not people generally choose to use their private cars for all their travels or if they would rather be able to walk or bicycle to their jobs and service, since the city planning of today rarely offers that possibility. In fast growing, young cities, the highways have become physical barriers for pedestrians or bicyclers in the cityscape, much like the large rivers used to be for the Icelandic farmers or merchants less than a century ago (Reynarsson, 1995: 32).

Inhabitants that do neither have access to private cars nor sufficient public transportation systems are effectively stranded in their homes. Modern day transport infrastructure with heavy traffic through large intersections and a near absence of sidewalks present serious physical barriers to a pedestrian (Miller, 2004:676), as is the case in the Reykjavík capital area. Vast and sparsely populated cities contribute to social isolation, not only of individuals who are not in a situation to own a car, but even those that can, since in a society where the private car has become the principal means of interacting with other people, human contact outside the home is limited to the work place and possible services that may be sought out. Deprived of contact with the rest of the society, people may seek out various ways of communicating such as with the help of mobile- and IT technology and multimedia. The private car has therefore in a sense given birth to a new consumer based culture, which in a sense allows people to fulfill their needs of interaction and communication without actual physical contact with other people.

Along with the growth of the city, there has been a drastic increase in the number of private cars in Reykjavík during the last decades. In 1960 there were 16 persons per car, in 1994 that number was down to 2, 3 persons per car (Reynarsson, 1995: 33). Car ownership did not follow normal population increase but rather escalated with every decade. From 1960 to 1997, the population of Reykjavík

increased by 47% and the road system grew by 128%, while the number of private cars increased by 634%. The number of cars is expected to increase further, as will the need for more extensive infrastructure. In the Reykjavík area there are clear limits to how much the roads can be enlarged which leaves only the options of building more bridges, tunnels and shafts (Skúlasón, 2000: 66). There are plans to build bridges that would connect different parts of the capital area to the center of Reykjavík and thereby decrease the traffic on the main road that leads to the center (Haraldsson, 2003: 54), but at the same time offer more road space for a possible increase in private cars. But building larger roads and more complicated infrastructure is rarely the answer to decreasing heavy traffic. It is more likely that increased road space will function as an incentive for people to use their private cars even more or for more people to start using cars as opposed to public transport, since increasing road space enhances the comforts of private modes of transport. As economist Robert Samuelson said: “Cars expand to fill the available concrete” (Miller, 2004: 673) and therefore larger streets only call for an ever increasing amount of vehicles.

Currently, Iceland is almost infamous for a very high percentage of private car ownership. If Reykjavík were to be compared to cities in other parts of the world, it could be compared to Australian cities with regard to petrol consumption and urban density while it could be compared to American cities with regard to the preference of transport (Reynarsson, 1995: 33).

	Stock-holm	Göteborg	Malmö	Oslo	København	Reykjavík	Helsinki
Drive own car (%)	21	36	48	48	30	74	41
Go by public transport (%)	65	31	9	38	33	5	43
Car ownership (per 1000 inhabitants)	369	355	365	358	225	615	346
Transport work (per inhabitant and year in kms)	1440	No data	3380	No data	3340	6680	4250

Figure 4 - Comparison of Reykjavík with other nordic cities (NSM, 2004: 6)

The number of private cars for each 1000 inhabitants in Reykjavík has increased by 37% between 1996 and 2003. In the year 2003, there were 615 private cars per 1000 inhabitants in Reykjavík, which is a staggering number compared to other Nordic countries, where the number of cars mostly ranges between 200 and 400 cars per 1000

inhabitants (Guðmundsson, 2004: 6). Reykjavík has the dubious honor of having the highest number of private cars per 1000 inhabitants and the lowest percentage of travelers with public transport systems of all the Nordic cities that were included in a recent report on transport and pollution conducted by the Board of Nordic Ministers (NSM, 2004: 6). The report also showed that in Reykjavík, 74% of all travels are conducted by car but only 5% with public transport, the opposite being Stockholm, where 21% travel by car but 65% with public transport. Further more, inhabitants in Reykjavík are the ones that drive the most during the whole year, or 6.680 km/inhabitant/year, while in Stockholm that distance amounts to only 1.440 km/inhabitants/year. It is however pointed out that Reykjavík has the disadvantage of covering a large area with a low density population, having only 420 inhabitants/km² compared to Stockholm's 4.030 inhabitants/km². In this sense, Reykjavík is considered to be more compatible with cities in the USA than cities in Northern Europe. Having witnessed the amount of private cars in Reykjavík double over 30 years and facing an estimated increase of 40%-50% over the next 20 years, Reykjavík certainly has a very different profile when it comes to transport issues than the other Nordic cities (NSM, 2004: 14-25).

Despite problems such as escalating private car ownership, Reykjavík has the ambition to be known as the ecological capital of the north. According to the general land use plan 2001-2024 for Reykjavík, the city should strive to become a sustainable city in the sense that the built and natural environment should increase the quality of life for the inhabitants without in any way diminishing the possibilities of the following generations. (AR, 2002). With the current situation in transport issues in Reykjavík, it is going to be very hard to turn the tide around, since there is ongoing urban sprawl in the city and private car ownership continues to increase. Land use planning in the past has more often than not lead to further expansion of the city and therefore, if Reykjavík wants to become the ecological capital of the north, it has to make some drastic changes in the near future.

Current land use planning in the Reykjavík area

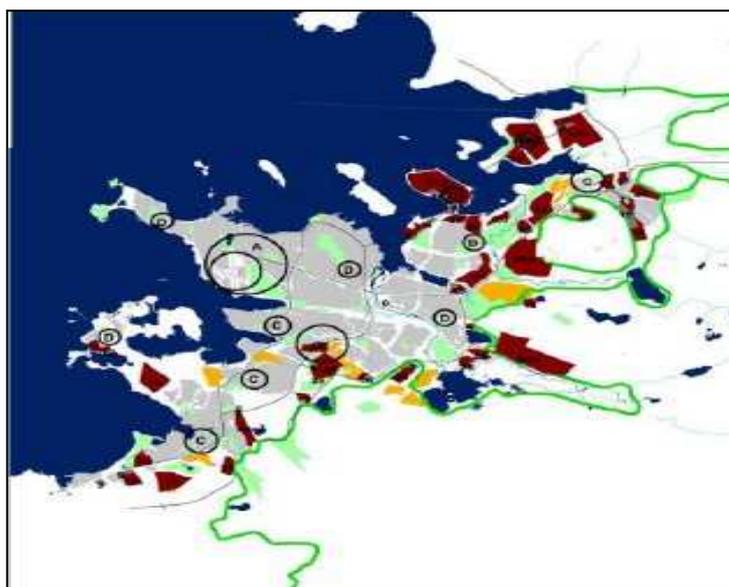
Planning for more density seems to be a relatively high priority among current land use planners in the capital. According to the Reykjavík land use plan, the city center of Reykjavík and some older industrial areas are planned to become more densely populated but at the same time the outskirts will continue to grow, containing more suburbs with a low density population. It is often problematic to determine when densification is taking place since there has to be a clear definition of what densification refers to. If it is assumed that densification refers to the net increase of buildings, inhabitants or jobs per square kilometer, it would still pose as a problem when we consider for example the alteration of industry sites to residential areas (Sigurðsson, 2003: 34). Several such changes have been planned within Reykjavík for the next planning era, with the construction of new residential areas and reorganization of ill used areas and by minor densification within the existing areas (AR, 2002). Such reorganization leaves the question of whether an area is denser with an industry providing 200 people jobs or housing for 100 people. Therefore, the most coherent way to measure densification would be to estimate the amount of unplanned land around the perimeter of the city that can be left untouched for some amount of time (Sigurðsson, 2003: 34). The definition of the densification planned in Reykjavík is not altogether obvious in the planning documents available.

There is considerable range in the current inhabitant density of the neighborhoods in Reykjavík, from e.g. 14,7 inhabitants/ha to 31 inh/ha. In the new neighborhoods, the planned density is estimated to reach 27 inh/ha and for the densest areas to be situated close to transit lines. The current mean density in the built land of the city is 32 inh/ha, or as stated before, 420 inhabitants/km² in the total available land of the city, which is considerably lower than in other Nordic cities (AR, 2002). The estimated population increase in the capital area is 56 thousand people during the next 20 years. Such an increase would require 2100 ha of additional building land, which is almost half of Reykjavík's current size. Since there has been a flow of people from the country side to the city, the discussion has only been focused on the difficulties of the smaller communities in the country rather than also reflecting on the problem this rapid growth causes for the capital area (Reynarsson, 1999: 34). Such fast growth is

not necessarily profitable for the capital area, which is why measures to maintain prosperity in the smaller country towns and villages should benefit the Reykjavík area as well as the country side (Gísladóttir, 1999: 19). Rapid growth calls for rapid decisions about increasing infrastructure investments and in such a situation it may be tempting for official planners to expand the city boundaries rather than overtake the more complicated issue of making the city denser.

Although Iceland is a large country and very sparsely populated, the capital area has very little physical room to grow (Gísladóttir, 1999: 19). The city of Reykjavík owns 275 km² but only a part of this land contains the actual city. In the general land use plan of 1996-2016 the limits to growth of the city were clearly defined. They are demonstrated in the idea of the “green scarf” that separates the possible building land from the future recreational areas of Reykjavík that should

remain in their natural state and not be part of the city building land.



Grey = Current urban settlement

Yellow and Red = Expansion of urban settlement

Black circles = Centres of commerce

Green line = “Green scarf”

Figure 5 - Land use plan for greater Reykjavík area, combining the various municipalities’ land use plans (SH, 2002: page 19 of the 7th part)

This was done to strengthen the sustainability aspect of the cities development and has set the tone for the current land use plan, which puts a certain amount of focus on sustainability issues in the form of densification, promoting environmentally friendly transportation and preserving the natural environment in the city (Axelsson, 2002: 65). It remains to be seen if the “green scarf” will hold and if the assigned building

land will be sufficient for future growth of the city. Therefore it seems logical to try to plan for more density in the area.

Despite the obvious advantages of planning for more density, intentions of reforming or reorganizing older neighborhoods to increase density have rarely been appreciated by the inhabitants of the neighborhoods (Reynarsson, 1999: 33). Another point of view that often opposes alteration of older neighborhoods is that Reykjavík must maintain its unique features which set it apart from other European capitals, culturally and socially, and should therefore alter as little as possible (Óskarsdóttir, 2003: 26). For example, in the general land use plan of Reykjavík for 2001-2024 it is assumed that the Reykjavík airport will be moved and a gradual development of a dense residential area will take place on the site. This is the most valuable building land in Reykjavík and therefore there are many proposals as to how to best utilize this area. Þorvaldur S. Þorvaldsson(2001), who is the head of land use planning for Reykjavík city, cautions against over densification of the area. He points out that in the planning of such a valuable neighborhood, the specific conditions of the physical surroundings have to be considered. He claims that merely achieving density is not enough, since there has to be shelter from the wind from the sea and the buildings can not be so tall or so dense as to create shadow, since for the greater part of the year the sun does not rise very high in the sky. He therefore recommends that Reykjavík should not be afraid to maintain its special feature of low houses since there is a physical reason why the city has developed in such a way (Þorvaldsson, 2001: 21). He raises a valid point, but continuing with a business-as-usual scenario nevertheless further accelerates the need for transportation while rendering efficient modes of public transportation ever more difficult to achieve.

It is not only the land use planning that has to change in order for people to choose alternative modes of transport. According to Pétur Fenger, the executive director of Strætó bs.–Greater Reykjavík Transport Ltd., the current land use planning process needs to take the first step to introducing more restrictions on the convenience of owning a car. Currently, you can park almost everywhere in capital area for free, excluding a small area in the immediate center of Reykjavík where there are parking meters. But even in the center, there are fairly abundant parking spaces and you rarely have to walk for more than two minutes from the parking lot to your destination (Fenger, 2004). Another alternative would be to make public transportation more attractive and accessible as an option to private transport. This can however prove to

be a rather difficult and time consuming task. An example of this was an attempt made to introduce the public transport system to the general public on the 22nd of September 2004, when there was an official “car free” day in the Reykjavík area. During this day it cost nothing to travel with the bus system and one of the streets in the center was closed to all vehicles but buses. Nevertheless, there was no measured decrease in the number of cars on the roads (Morgunbladid, 2004).

Improving public transportation and getting more people to choose buses as the preferred mode of transport, although difficult, should be in the public as well as the government’s best interest. According to Fenger, the government does not always fully realize the benefits for the national economy of sustaining efficient and widely used public transport (Fenger, 2004), despite the fact that a joint investigation done by the municipalities in the capital area shows that when taking into account the decrease in emissions, sound pollution and accidents, the state can save billions of Icelandic krónur by ensuring increasing use of public transport (Fenger, 2000). It is not only the state that will not commit to improving the urban environment by investing in public transportation, the municipalities that share the same road and public transportation system have also had difficulties in sharing the same goal when it comes to urban planning on a regional scale.

Most people would agree that an ongoing planning process of an ever changing city is necessary and that simple continuity without flexible solutions to new problems can not offer a solution to modern urban problems. It has also been pointed out that to be able to work towards long time goals, perhaps regional land use planning has to make a considerably longer prediction into the future than only 20 years. This would allow for the possibilities of drawing up different scenarios, with e.g. regard to public transport and how a switch from private cars to alternative modes of transport could come about (Reynarsson, 1999: 35). It could be useful to have a preliminary plan that continues at the point in time where the current regional or general land use plan ends, since this could hint about the further expansion of the city or the future changes that may have to be applied to the public transport system. When the areas mentioned in the land use plan 2001-2024 will be fully developed, the next building land of Reykjavík will be far north of the city, in Kjalarnes (Þorvaldsson, 2001: 21). This will mean an extreme addition to distances within the city and the affect it will have on sustainable public transport can be foreseen to some extent. The next twenty years will in many ways determine the future of public

transport in the capital area, but significant progress will be dramatically challenged if the next step in the development of the city will indeed be to continue to build north to Kjalarnes. Such a development will make further cooperation between municipalities necessary, both regarding land use planning and infrastructure constructions.

The politics of urban planning and transport policy formulating

The politics surrounding land use in the capital area has often been strained, to say the least. Most of the time, there has been a different political majority in Reykjavík than in the other municipalities, which along with the difference in size causes friction between Reykjavík and the rest. This competitive atmosphere causes each municipality to plan land use as if they were alone in the region and strive to offer complete service independent of Reykjavík. Such failure in cooperation has led to inefficiency in resource use in the area (Gísladóttir, 1999: 17). Each municipality has made its own general land use plan and the communications between the towns have been based on competition for building sites rather than cooperation in planning issues (Reynarsson, 1999: 33). The regional land use plan for 2001-2024 is in this sense historical, since for the first time Reykjavík and the seven surrounding municipalities worked together and thereby confirmed to some extent that the capital area is now a single zone of industry, jobs and commerce (Haraldsson, 2003: 54).

Such cooperation is highly important, since in many ways the capital area is the outward face of Iceland and competes with cities in the neighboring countries for human resources and tourists (Gísladóttir, 1999: 18). Therefore it is vital that the greater Reykjavík area offers an appealing urban environment and this in many cases means sheltered streets and plazas, as well as a high degree of mobility to service and leisure. The former mayor of Reykjavík, Ingibjörg Sólrún Gísladóttir, claims that the young people, to whom the capital area often appeals the most, do not care in which of the municipalities they live, as long as it is within this area. Therefore the municipalities should work together to greater extent and not be so unwilling to give up some of their independence to a regional administration (Gísladóttir, 1999: 18). This seems to be a rational claim, but since Reykjavík is the largest by far of these

municipalities, there has been a tendency among the other towns to stay their ground, so to say, against the influences of the more powerful city. Several of the municipalities in the area have witnessed rapid growth and increasing income in the last years, and it should therefore not come as a surprise that the offered olive branch of Reykjavík has not always been thankfully accepted.

In addition to tension between the municipalities in the capital area, there is also a disagreement between the view point of the state and the city concerning land use planning, e.g. in the case of the Reykjavík airport. As mentioned before, the airport, which was built for military flights in the Second World War and has since served internal air traffic, is situated very close to the center and therefore causes considerable noise pollution and occupies extremely valuable building land. In 2001 a public vote was conducted in Reykjavík concerning the possible relocation of the airport, where the inhabitants of Reykjavík chose not to move the airport. Recently, however, the minister of environment took on the assignment of proposing a land use plan for the area where the airport is situated, thereby overruling the power of the city officials and the results of the public vote (Haraldsson, 2003: 54).

A tendency towards inconsistency and rapid changes of the political leaders or parties in charge are among the problems that all official units, such as cities, have to deal with. Although politicians praise the idea of densification and sustainable transport in an environmentally friendly urban environment, their implementations rarely match their enthusiasms. The main reason for this is the fear of losing possible voters since politicians tend to work with short term solutions that can be shown as results when elections come up, rather than implementing long term solutions that can not be evaluated on the basis of one election term (Skarphéðinsdóttir, 2003: 46). What politicians often have to deal with is the cost aspect, when justifying various choices that are made. A prediction for the potential traffic increase in Reykjavík is conducted every few years and is considered necessary in order to estimate which investment in infrastructure will be needed and be profitable. The profitability estimation is based on whether or not there will be a decrease in traffic accidents, lower driving cost as a result of higher and more even speed, as well as timesaving for the driver. The estimation also takes into account the cost of construction and maintenance but it ignores factors such as pollution from emission and noise. It does not either take into account that by improving the infrastructure and widening streets, there is a greater incentive for people to drive their private cars, which eventually will cancel out the

benefits of improved infrastructure and increase the need for even wider streets (Sigurðsson, 1995: 28-30). This development increases the already ongoing urban sprawl, by making distances ever greater and streets ever larger, thereby reinforcing the current transport pattern.

Haraldur Sigurðsson claims that other cities in the world that face the problem of heavy private car traffic have postponed improvements in the infrastructure until increasing traffic jams cause people to choose to live closer to their work or choose alternative ways of traveling (Sigurðsson, 1995: 30). This is true for some cities, but other show the opposite development, where people for several reasons choose to live in the suburbs and instead put up with the traffic jams. Several European cities have joined together in a “Car Free City Club” and have been trying to decrease the negative effects of the private car usage but have so far had little success in decreasing the number of private vehicles on the streets (Reynarsson, 1995: 32). Rather than just postponing infrastructure improvements, it seems logical to offer alternative modes of transport that would render road infrastructure expansion unnecessary.

In the model town of Curitiba in Brazil, the cities population has doubled since 1974 but the car traffic has decreased by 30%. This is the result of combined land use planning, where only high rise buildings are constructed along major bus routes, which are connected to extensive bicycle paths and the exemplary bus system carries 75% of the cities commuters to their destinations. The result is that the city can boast of the lowest air pollution rates in Brazil, as well as a reduction in traffic congestions and increased energy savings (Miller, 2004: 678). The Curitiba example shows that change is possible, if preformed with consistency and a clear goal. Perhaps it is best to be realistic and set the aim a little lower to begin with, but the political leadership in the area can indeed make great changes come about, by investing in a strong public transport system as well as decreasing the distances between homes, service and jobs by mixing them within neighborhoods, as this would decrease the physical distances between social realities and thereby decrease travel distance and induce social intercourse (Axelsson, 2002: 66). Such investments need to be made with full commitment and with a clear goal in mind, so that rather than curing the symptoms, one should treat the cause. There is not enough to make a city denser without offering people a realistic alternative mode of transport, such as could be done by strengthening the already existing public transport system.

Public transport – a loser’s choice

According to Pétur Fenger of Strætó bs., taking the bus in Reykjavík is assumed to be the loser’s choice (Fenger, 2004). If one should venture to portray the public opinion, it could be said that if you are old enough to drive a car but do not have a drivers license or a car, you must be devastatingly poor, and if you have a car but choose to travel by any other mode, you must have lost your driver’s license. The image of the bus is therefore quite the opposite of the image of the private car. The mobility that is such an evident characteristic of our current culture is made possible by the private car and cars are to a great extent marketed as the solution to former geographical restrictions of every day life, since the car offers almost unprecedented personal freedom of travel. Unlimited mobility has therefore become an important factor of how people express their lifestyle, values and status in society (Wärneryd et al., 2002: 74 and 80). The image of the car has often been connected to material prosperity, power, social status and success (Miller, 2004: 673). This image also includes what has sometimes been called the American dream, which is to be prosperous enough to be able to own a one-family house with a surrounding garden in the quiet outskirts of a city. The car and the infrastructure it calls for is therefore one of the main reason for the urban sprawl that can be observed in younger western cities. The effects are that the neighborhoods become so sparsely populated, that local service has to be relocated in larger centers far from residential areas. This leads to the social isolation of those that can not for some reason own or drive a car, as the car becomes the symbol of freedom and mobility (Reynarsson, 1999: 33).

It is not an easy task to make people give up their car for alternative modes of transport, once they are used to the relative freedom that a private car offers, regardless of their environmental ambitions. According to a survey made in 1996 by Félagsvísindastofnun, The Icelandic University Institute of Social Sciences, around 60% of Icelanders think that the traffic in Reykjavík is problematic and has a harmful effect on the environment. Nevertheless, there seems to be a weak link between attitude and behavior in this case since 93,2% state that they do not believe that they

will use their private car any less in the future. Such unwillingness to change modes of transport can not be attributed to an insufficient public transport system since only 5,4% claimed that inefficient public transport or lack of other optional modes of transport was the reason for not wanting to abandon the private car (Skúlason, 2000: 66). Judging from these results, the environmental convictions of people and their attitudes towards public transportation do not affect their choice to drive private cars. Other reasons will therefore have to be sought.

In Fenger's view, public transport has so far had a negative image in Iceland, it is considered to be complicated to extract information from the time tables and that it does not offer frequent enough trips. Surprisingly low, buses only represent 4%-5% of the daily transport modes chosen by people in the Reykjavík area, as opposed to 16%-18% within similar sized European bus companies. There are currently plans to improve the information flow and offering more frequent trips on selected bus lines and by doing so increase the market share from 4% up to 8% in 20 years. The problem of a further increase being that a vast number of private cars are already available in the country and the infrastructure needed for a comfortable flow for cars in the city is constantly being improved (Fenger, 2004).

Fenger and Haraldur Sigurðsson, land use planning specialist of Reykjavík city, share the view that it will most likely never be possible to create a public transport system in the capital area that will fit every one's needs, and therefore be fully compatible with the private car in an expanding city, as a reasonable option for the majority of people (Fenger, 2004; Sigurðsson, 2004). Sigurðsson points out that to improve the market situation of the public transport system, it is not advisable to significantly improve the service of the public transport system in an otherwise status quo society, but rather to keep the service standard at a fairly constant level until other factors, such as urban density and private car preference show alteration that could lead to an increasing interest in using the public transport system. He claims that while there is not a willingness to use the buses, improvements in the current public transport system can only be seen as an act of social service for those who can not own or drive a car (Sigurðsson, 2004). This is mirrored in the policy of the capital area bus company, where they claim that they do not want to offer service for specific groups, such as the elderly, as the buses should be an available transport option for every inhabitant of the area. Nevertheless, the company does try to focus on the current customers, which are to a large degree young people that travel with the buses

to school. It has proven much cheaper and more likely to succeed to try to prevail a current 18 year old bus customer to continue using the bus for 4 more years than to try to get a 35 year old car owner to brake his habit and to start using the bus system (Fenger, 2004).

In speculating over the general reason for the little interest shown by Icelanders in public transport, Fenger states that habit plays a large roll, in saying that even if substantial improvements were to be made on the current public transport system, the greatest obstacle in getting people to start using the system offered is trying to break the habit of walking two meters to your car in the morning instead of up to 700 meters to the next bus stop and then having to wait for the bus for some minutes. The weather has also been a proclaimed obstacle in inducing people to use alternative methods of transport, since the Icelandic climate is rather harsh (Fenger, 2004). This is not a universal excuse since several other cities, among some in Sweden, have a similar climate but more public transport participation (NSM, 2004). There are actually more people that choose to walk to work, or 20%, than take the bus and therefore the weather can not be a determining factor (AR, 2002). Nevertheless, if offering some of my own experience of traveling by bus in Iceland, it is not so much the weather as the lack of planning for the effects of harsh weather that causes problems. An example are the large piles of snow that slowly mound the narrow sidewalks as the snow is removed from the streets to facilitate the advance of cars on the expense of bus riders who can hardly get into the bus shelters and must wade deep snow to enter the bus. Granted, this is not a continual state of things during the whole winter but after having been through this scenario several times a year, it makes you think twice about whether or not to stop traveling by bus and switching to car.

The problem is that the habit and comfort of each person driving their private vehicle to wherever they want to, whenever they want to, is not only unfortunate but it can simply not be maintained. With continued increase in car ownership and road infrastructure investments, the Reykjavík area will develop towards increasing urban sprawl, following in the footsteps of several cities in the United States and repeating mistakes which can be avoided. Both in Europe and the United States there is currently a trend towards trying to make cities denser. In many cases this is based around efficient transportation that is independent of the private car and goes by the name of Transit oriented development. This development can for example be seen in

Copenhagen which has built its public transport system along defined lines, leaving the city looking like a glove since the main urbanization follows the transport lines (Reynarsson, 1999: 34).

Often the first step towards inducing people to use public transport is to improve the access of pedestrians around public transport lines. According to Peter Calthorpe (1993), the solution to the ongoing urban sprawl is not only to make cities denser but to construct or reorganize neighborhoods to contain mixed and human size buildings that promote walking and the use of public transportation. In short, we should build for the individual pedestrian but not for the car by promoting mixed neighborhoods rather than simply denseness. Such planning would decrease automobile dependency while preserving the accessibility to service (Calthorpe, 1993: 16-17). In my view nevertheless, people that are in the habit of using their car for their everyday travel, do not always perceive the actual possibility to walk or use public transport and are predisposed to assume that not using the car will limit their freedom of travel. Calthorpe admits that pedestrians are not likely to replace car drivers in the nearest future but claims that planners need to take the first step in order for this transition ever to take place (Calthorpe, 1993: 17).

Most planners in Iceland would rather not witness a further development towards urban sprawl. A slight shift towards restricting the escalation of new constructions of transport infrastructure can be discerned in the general land use plans of Reykjavík and its neighboring communities. According to the Reykjavík general land use plan, the direction that Reykjavík will take over the next 20 years is to make the city generally denser and taking the need of public transport into account when planning new neighborhoods (AR, 2002). Several such promising statements are made in the planning document but it remains to be seen how many of them can actually be implemented. Specially, when considering that in the current regional land use plan it is assumed that the public focus will continue to be on private cars as the main mode of transport and public transportation is barely mentioned, although improvements in public transport is one of the main issues in most of the individual general land use plans of the different municipalities (Reynarsson, 1999: 35). If the urban sprawl is going to be kept under control and public transportation allowed to flourish, the regional planning cooperation needs to be a priority among all the municipalities in the greater Reykjavík area, since improving the situation in only one

or two of the towns or the city will do little to improve the overall situation in the region.

Another serious implication of both urban sprawl and excessive private car ownership is the environmental effect that vehicles have by emitting pollutants into the air. Although a widely used public transportation system can solve many of the current transportation problems in the Reykjavík area, it can not wholly eliminate air pollution, as a fossil fuelled bus also emits pollutants.

Environmental effects of current transport policy

So far it has been stated that urban sprawl with increasing private car ownership and diminishing public transportation brings on a vicious circle that effects the physical and social structure of the city. Further more, it is important to note, that transport of any kind has immense impact on the local and global environment. Passenger transportation world wide contributes in a great extent to local air pollution, climate change, land degradation, water pollution and rapid energy consumption (Miller, 2004: 666).

Motorized transportation, as it is conducted in most western countries today, is far from being sustainable. The largest source of energy in transport today is fossil fuel, yet human consumption of fossil fuel is six times faster than the natural production rate of fossil fuel material in the nature (Emmelin, 1997: 12). If the current transport system were to be made sustainable, as sustainability is described in the Brundtland report, almost every aspect of the system has to be changed. For example, the transport system introduces chemicals from the earths crust, such as CO_x and SO_x, at a much faster rate then they are absorbed from the atmosphere. The transport system also introduces man made chemicals into the atmosphere, such as NO_x and various other chemicals found in petrol and tires. Reversing this development will prove more difficult as every day goes by. If an attempt were to be made to stabilize the concentration of carbon dioxide in the atmosphere, emissions would need to be lowered by about 60% world wide in the next 100 years. The seven generation rule is also frequently broken since the transport system requires a destruction of land and ecosystems, which may in the future prove necessary to produce food for the ever growing population on this earth (Holmberg and Råde, 1997: 160-165). It is also

broken in the sense that green house gases emitted from motorized vehicles promote global climate change, which will effect generations to come, all over the world. The ultimate effects of global warming are difficult to predict. Some of them may even be welcomed, as the increasingly warm climate in Iceland has been. But far more serious are those effects which cause disturbance of the entire global climate and endangers the lives of humans and animals, for example the melting of the polar ice cap which cause floods, rise in sea level and altered ocean currents (Miller, 2004: 460-464).

It is the byproduct of transportation, the gaseous chemicals in the exhaust emission, which has such grave effects on the environment. The most common of these pollutants that originate from motorized vehicles are carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), particle matter (PM), volatile organic compounds (VOC) and lead (Pb). The chemicals present in exhaust emission can have various effects on human health, depending on the length of exposure and physical surroundings. The chemicals are most destructive when they are kept present around an urban area by the presence of surrounding mountains on three sides and the ocean on the fourth. The harmfulness of these chemicals is demonstrated in their capability to for example decrease the blood's capacity to transport oxygen to cells, cause impaired perception and thinking, as well as cause nausea and headaches. The chemicals are also suspected to increase vulnerability to flues and various types of respiratory irritations in the form of asthma, bronchitis and even lung cancer. As well as damaging human health, air pollution can have harmful effect on the ecosystem, through acid depositions and eutrophication, and it can damage the surface of human artifacts by destroying the color of buildings, corrode metal and dissolve stone (Miller, 2004: 420-426 and 438).

Air pollution occasionally lingers over the Reykjavík area, since it more or less has the characteristics of being surrounded by mountains and sea. But in the capital area, there are generally very strong winds and rather reliably unstable weather, which helps to sweep most of the chemicals out to sea. Because Reykjavík is not a city of many millions, the somewhat limited number of motorized vehicles that can ever be present in the city ensures that vehicle emission will most likely never have such serious effects on either human health or physical artifacts. Therefore, air pollution does not pose a serious threat in the area but the effects of traffic can nevertheless be felt.

The effects of the ongoing increase in private vehicles on the streets of the capital area are various, such as an increase in CO₂ emissions affecting the global climate, particle matter (PM) pollution in the air causing respiratory distress and sound pollution resulting in symptoms of stress among those that live close to large streets. Reykjavík is fairly unique when it comes to CO₂ emission since almost all the emission originates from transport (Guðmundsson, 2004: 2-3). Overall green house gas (GHG) emission has increased more rapidly than CO₂ emission, since the inhabitants in Reykjavík are buying more diesel cars, mostly in the form of large cars or SUV's with powerful motors. The emission of GHG, in this case CO₂, CH₄, and NO_x, in Reykjavík has increased by 10% from the year 1999 to 2002 which means a 1% increase in the whole country. This rapid increase can be attributed to increasing private car ownership and if this development continues, Iceland could have difficulties meeting the Kyoto agreement (Guðmundsson, 2004: 4 and 24).

According to the Kyoto agreement, Iceland should not exceed its 1990 level of CO₂ emission by more than 10% in the year 2008. There are several criteria that have to be fulfilled if this is to be achieved, such as further controlling emission from the aluminum industry and the fishing fleet as well as the on-land transport sector. The aim for fulfilling the Kyoto agreement in Iceland is for example to make small diesel cars more affordable by changing taxation as well as coordinating traffic lights, improving urban planning to decrease driving distances and improving public transportation options (Gíslason, 2002: 52). Increasing the relative number of diesel cars would indeed decrease the emission of carbon dioxide but it would increase the emission of other substances, such as NO_x and PM, which have so far been the main source of air pollution in Reykjavík.

PM are small dust particles that can be harmful to the human respiratory system. In the Reykjavík area, PM originates from erosion sites outside the city and from sea salt that blows in from the sea.

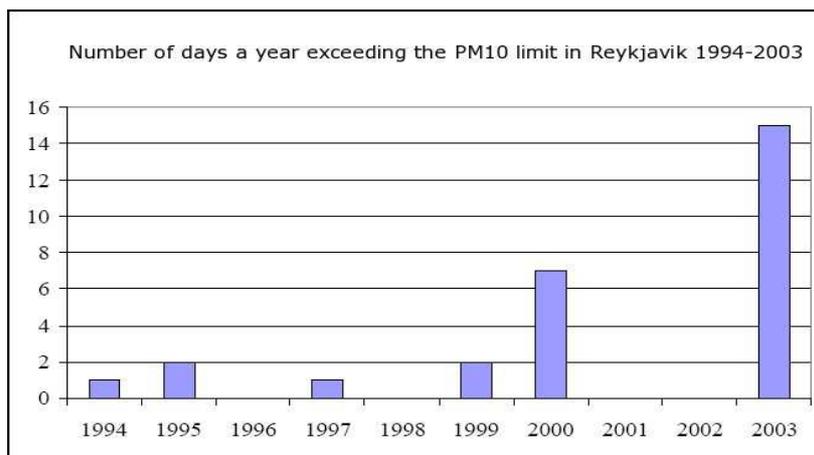


Figure 6 - PM₁₀ limit exceeded in Reykjavík (Guðmundsson, 2004: 14)

But PM also originates from vehicle emission, mostly diesel fuel emission, and the wear and tear of asphalt. PM₁₀, a particular size of PM, is increasing in the atmosphere in Reykjavík and several days a year, especially in calm, snow free winter days when studded tires grind the bare asphalt, the amount of PM₁₀ exceeds the acceptable atmosphere concentration (Guðmundsson, 2004: 14). The problems of increasing PM₁₀, like many other, will not disappear with the introduction of for example hydrogen fuelled cars and is therefore one of the things that planners and policy makers have to consider, when planning for a sustainable capital in the north. On the other hand, by promoting public modes of transport, both GHG emissions and overall PM concentration in the air could be decreased.

Besides the problem of emission, one of the greatest challenges of future sustainable transportation is how to improve the energy efficiency in motorized vehicles. Private transportation consumes a large part of energy related to transport. In the year 1994, private transport in Sweden consumed more than 40TWh, while buses consumed less than 5TWh (Steen and Åkerman, 1997: 63). Responding to this need, there is extensive research going on about how to make vehicles less energy consuming. But despite the marketing of ever more energy efficient vehicles, energy consumption in transport increases as a simple result of increasing transport and larger cars. An example of this could be seen in the USA, where vehicle energy efficiency was successfully increased between 1973 and 1985 with the help of the government mandated CAFÉ standards of vehicle motors and then later nullified by increasing car ownership and popularity of SUV's. The benefits of vehicle efficiency technology are also cancelled by urban sprawl, which calls for ever greater travel distances. Compact cities and urban areas such as Hong Kong and Tokyo are clearly more energy efficient

than disperse cities, like those usually found in USA, Canada and Australia. Ten times more energy is used for transport in such car centered cities compared to compact cities (Miller, 2004: 385 and 671).

Increasing amounts of private cars, followed by the inevitable increase in emissions and energy consumption has to some extent opened the Icelandic government's eyes to this part of the problem associated with car ownership and urban sprawl. Therefore, research of possible alternative fuels, such as hydrogen, have become increasingly important.

Energy saving and fuel potentials

There are several fuels that can be used as alternatives to fossil fuels. One of them, hydrogen, is an environmentally friendly fuel. By using hydrogen for fuelling vehicles, the emissions of air pollution would drastically decrease and the global climate change could be reduced since hydrogen releases no GHG emission. It is also safe to say that hydrogen offers a promising solution to the energy crisis of the future. Nevertheless, there are several aspects that need to be considered before a world wide hydrogen economy will be established (Miller, 2004: 405).

It is important to realize that hydrogen is not the new renewable energy source that the world needs but simply an electrical power carrier. Moreover, although hydrogen is the world's most common element, it does not occur in a pure form anywhere in nature and therefore has to be produced by for example separation of water by electrolysis. In order for hydrogen to live up to the environmentally friendly image that it has been given, it is vital that the process of producing the hydrogen itself is conducted by using renewable energy sources. By burning oil or coal to obtain hydrogen from water, the end result is approximately the same as burning oil directly in a vehicle combustion engine. Although the potential for harvesting renewable energy in the form of sun and wind power are theoretically almost unlimited, the current technology available does not offer that possibility (Bossel et al., 2003: 2-8). Therefore, several countries have no means of producing their own hydrogen today, both for lack of renewable energy sources and for lack of water,

which is by no means easily accessible in all corners of the world (Miller, 2004: 317). Moreover, water used in hydrogen production needs to be clean, which requires an energy consuming distilling process, and then the packaging, transporting and storing all require further energy (Bossel et al., 2003: 10-12). Hydrogen production therefore calls for the presence of renewable energy sources as well as finance to set up facilities and gain access to appropriate know-how.

Another problem with hydrogen is the current technology available. Hydrogen fuelled vehicles are equipped with a fuel cell stack and a electric motor, to convert electrical energy into mechanical energy, instead of a traditional internal combustion engine present in modern day vehicle. A chemical reaction in the fuel cell between hydrogen stored in the car and oxygen from the air releases electrical energy, used to power the car, and a byproduct of water vapor (Miller, 2004: 387). The amount of hydrogen needed to fuel a vehicle for a reasonable distance can currently only be fitted into larger vehicles such as buses, since it takes up too much space and adds too much weight to a regular private vehicle. Although the hydrogen technology is generally more energy efficient than the current internal combustion engine run on fossil fuels, this only applies when volume is not an issue. The fact is that current hydrogen tanks can only have limited volume on board vehicles and therefore it becomes more logical to focus on the energy content per unit volume instead of heating value per unit mass. When such a comparison is made, synthetic liquid hydrocarbons, such as methanol and ethanol, surpass the heating value per volume of both liquid and gaseous hydrogen. Additionally, extensive infrastructure changes have to be made to adapt the society to a hydrogen economy, while the present infrastructure and distribution system could function with almost any synthetic liquid hydrocarbon (Bossel et al., 2003: 8-10). Moreover, the technology is comparatively expensive and will remain so until both the engine components and the fuel can be mass produced, making it compatible on the market. Some would say that hydrogen has therefore become something of a rather expensive political fuel of choice, as it can certainly facilitate states to remain within the boundaries of international GHG emission levels as well as secure national independence of fossil fuel import (Bossel et al., 2003: 4).

It is difficult to predict how long it will take before hydrogen fuel cell technology will become an affordable option. Therefore it is by no means sure that hydrogen will become the main substitute for fossil fuels or that there will ever be one

fuel that will come to be completely dominant in the future. In the mean time, several other fuels are being promoted, such as liquid ethanol and methanol, and other technologies than the fuel cell are being considered (Srinivasan et al., 1999: 308-309 and 322). Car manufacturers like Toyota and Honda are currently marketing hybrid vehicles that run on a fossil based fuel, but also contain a battery that is charged by all excess energy produced by the combustion engine and therefore have much greater energy efficiency than any current conventional vehicle (Miller, 2004: 387-388).

There are several incentives for pushing for research on new technology in the transport sector. Contrary from what some believe, it is not only the predicted depletion of the world's oil reserves that spurs the search for new technology. The oil crisis in the 70's was a wake up call, reminding everyone that the oil resources would not last for ever and that the world had to develop an alternative fuel. In the 80's the oil did not seem to be depleting as fast as anticipated and therefore the focus shifted towards the need for alternative fuel because of the damaging effect that the continual burning of fossil fuel was having on the global climate (Þorsteinsson, 2003: 30). Therefore, it is rather the search for more efficient engines, cleaner fuel technology and in some cases an attempt to bring about more energy security that drives the development of new types of fuels and vehicles, which could come to rule the market in the near future (Srinivasan et al. 1999: 315). In Iceland, the fuel of the future is believed to have been already found.

Hydrogen in the Icelandic setting

In Iceland, hydrogen poses as an excellent energy carrier, an energy efficient fuel, an opportunity to decrease the nation's dependence on imported fuels and a way to promote more environmentally friendly transport technology. Obviously, the impact of the emission released from vehicles in Reykjavík has trivial effect on the overall global pollution and climate change, owing to the fairly low population in the city. Nevertheless, green house gases such as CO₂, like other air borne pollution, have a long range effect and can upset the balance of earth's whole climate system (Miller, 2004: 421). It would therefore be futile and highly irresponsible if all smaller states such as Iceland would rid themselves of any responsibility for global pollution.

Most nations are currently occupied in finding ways to produce green energy or saving energy produced by traditional measures. Iceland, on the other hand, has an abundance of energy from renewable energy sources. Geothermal power is used for almost 90% of all heating and out of Iceland's gross energy usages, 72% comes from renewable energy sources (VistOrka, 2003). Iceland is currently only utilizing 15%-20% of its usable hydropower and 2% of its usable geothermal power. Therefore, Iceland has the task of finding a suitable energy carrier. The environmental benefits of switching to hydrogen fuel in a location like Iceland, where renewable energy to produce hydrogen is abundant, are indisputable. If the land and sea transport became fully hydrogenised, the CO₂ emission in Iceland is estimated to decrease by 65% and by 95% in Reykjavík (Guðmundsson, 2003: 19).

The idea of using hydrogen in Iceland to fuel vehicles was first introduced by a chemical professor named Bragi Árnason in 1970, who predicted that a fuel switch could begin around the turn of the century. It took roughly 20 years before this idea became generally accepted but today the phrase "hydrogen economy" has been coined and is frequently used by the general public, scientists and politicians (Þorsteinsson, 2003: 30). In the year 1999, the Icelandic government made an official commitment to promote production of hydrogen from the abundant local energy sources. By utilizing the energy already available, the import of fossil fuel and emission of CO₂ could be decreased and by launching a hydrogen project, Iceland could establish a profitable base of know-how concerning hydrogen technology and implementation. Having already witnessed an energy source switch within the last 60 years from coal and oil to geothermal- and hydropower, little Iceland is a convenient site for trying the pros and cons of a hydrogen fuel society (VistOrka, 2003).

The Icelandic government has therefore proclaimed its interest in paving the way for making Iceland a hydrogenised society and have officially set up the ambitious goal of having 20% of Iceland's vehicle and ship fleet running on hydrogen by 2020 (SÁ, 2003). The Icelandic hydrogen project, under the leadership of the Icelandic government, is run in cooperation between national energy research institutions, national power companies, The University of Iceland and foreign companies such as Daimler Chrysler, Norsk Hydro and Shell International Hydrogen. The hydrogen project operates under the name Icelandic New Energy Ltd., which focuses on research and development of the technological and social aspects of hydrogen as an alternative fuel option. The vision of Icelandic New Energy Ltd. is to

hydrogenise the Icelandic society by various means. These include cooperating in ECTOS, Ecological City Transport System, in testing hydrogen buses on site, and further on, replacing all the buses in Reykjavík with hydrogen fueled buses, introducing private cars fueled by hydrogen as well as developing and introducing hydrogen fueled ships (Guðmundsson, 2003: 17-18).

The experimentation with hydrogen fuelled buses has been very successful in Reykjavík and despite minor complications with the new technology in the beginning the buses showed that they are well capable of coping with the fluctuating weather in Iceland. Fenger nevertheless states that the hydrogen solution is not a viable current option. The buses themselves are very expensive, as is the maintenance. Hydrogen buses will most likely not be cost effective for the next 10 to 20 years and although hydrogen will in all likelihood be the solution of the future, for the time being the focus will be on other solutions, such as biogas fuelled buses (Fenger, 2004). Biogas has been used to fuel for example garbage trucks since 2000 and in 2003 there were 43 biogas driven vehicles registered in Iceland. The amount of biogas currently produced is sufficient to fuel one fourth of the public buses in the capital area and the production of the gas will in the nearest future increase somewhat. Although vehicles run on biogas do currently not have to pay certain “weight taxes”, they are generally more expensive to run and maintain. Nevertheless, they emit fewer pollutants than fossil based fuel, and similarly to hydrogen, using biogas lessens the need for importing foreign fossil fuel (Guðmundsson, 2003: 6-9). Fuels, such as biogas, might therefore be more appropriate for the time being than hydrogen and certainly exceeds traditional fossil fuels.

When planning for a switch to a hydrogen economy, it should be considered that the process of producing hydrogen is highly energy consuming. In order to supply the whole Icelandic car and ship fleet, the equivalent of a 550 MW hydropower dam would be required. This should nevertheless be manageable, since it is estimated that the remaining energy in Iceland that could be harvested, amounts to around 50 TWh. It is not only the cost of producing hydrogen that should be considered, since the advent of a hydrogenised society would call for several changes in the social infrastructure, such as service and maintenance of vehicles. Nevertheless, likely future scenarios, such as the introduction of an international carbon dioxide quota, will further justify any initial costs of change that hydrogenising of an entire country will call for (Guðmundsson, 2003: 19).

Since hydrogen seems to be offering Iceland a reasonable option with regard to decreasing emissions and gaining independence from fossil fuel import, it could be useful to speculate how such a development might affect the overall sustainable transport in the Reykjavík area. For example, there have to be around 8 passengers in a fossil fuelled bus in order for it to be a more environmentally friendly transport mode than the private car and obviously that number will be lower in a hydrogen fuelled bus. But if private cars will also be fuelled with hydrogen, the bus loses this advantage of being an environmental choice of travel with regard to emission (Sigurðsson, 2004). However, even if both buses and private cars become hydrogen fuelled, public transport is still better suited to maintain a sustainable urban environment and hold urban sprawl at bay, than private modes of transport.

Nevertheless, public preference for a certain mode of transport is not likely to change as a result of the introduction of hydrogen fuelled vehicles. Introducing hydrogen buses in the capital area has not led to an increase in passengers choosing to travel with bus. According to Fenger, the introduction of hydrogen buses in Reykjavík has mainly resulted in positive publicity for the public transport company and thereby helped to strengthen the image of buses in the capital area somewhat (Fenger, 2004). The amount of people that choose buses, as a preferred mode of travel because it is environmentally friendly, are fairly few and some of them may choose to bicycle or walk to achieve the same means. Traveling alone by car to work or school is becoming more common while using the bus for the same travels has become less common. On the other hand, more people seem to walk to work and school (Guðmundsson, 2004: 16). Similarly, there are not so many people that choose to take the bus for economic reasons. Fenger believes this can be explained by the fact that Icelanders are less cost aware than many other Europeans, since the negative stigma of traveling by bus and the comforts offered by traveling by private car pose a stronger incentive for people to use private cars than low prices on bus fares (Fenger, 2004). What needs to be considered is whether by implementing hydrogen fuel into the transport system, there will be some negative aspects of the current transport situation, such as urban sprawl and social inequality, which will go unnoticed and forgotten in the shadow of the hydrogen solution and left to escalate on their own.

Discussion

In our present society, the private car not only dominates our physical environment, dictates how our cities look and where we build our houses. It has also divided our community through land uses policies by separating jobs and service from homes as well as dividing rich from poor and young from old. The car also causes contamination in our physical environment by emitting pollutants which upset the balance of the climate and endanger our health (Calthorpe, 1993: 27 and 34). As well as needing large quantities of energy, terrestrial transport systems require immense areas of land that are effectively destroyed or disrupted when paved over (Miller, 2004: 672). This is one of the reasons why changes in the transport system occur rather slowly, as the infrastructure consists of permanent physical structures that are expensive to build or alter. Changes can also be complicated in praxis since transport systems frequently override the boundaries of municipalities and contain various modes of transport. Although it may be problematic to work towards a sustainable transport system, it is important to look ahead, since today's solutions may prove to be the main obstacle in the future development of the transport system (Holmberg and Råde, 1997: 160-161).

Changing individual preferences can be even more difficult than changing the physical infrastructure. Most people support the idea of sustainability but very few adapt their live styles to it. Instead of making serious alterations in their behavior pattern, they personally agree with the principles of sustainable living but would rather wait for technology to provide solutions that will allow them to live their lives much as they do today. It has been pointed out that the reason for the slow reactions of people is rooted in the fact that they have not felt the absolute necessity of changing their lives (Wärneryd et al., 2002: 17). The most difficult aspect of changing public preferences for mode of transport is that although people may have a high degree of awareness about environmental problems caused by the transport system, they are always faced with the problem of making choices based either on their own short term or long term interests. Most people will act out of habit or with their short term interests in mind, even though it is not the most logical choice to make (Gärling, Biel and Gärling, 1997: 131-133).

Nevertheless, the need to discuss environmental issues has become too widely accepted, as they have become a part of a political correct discourse of which all political parties and industrial leaders have to part take. For some, this could be perceived as somewhat risky in the case of environmental issues, since situating an in many ways marginalized topic in the mainstream discourse has been known to cause it to lose its edge and becomes one of the many things that governments and leaders claim they will address but in reality will at most be an election promise. An example of this might be the fight for gender equality, where many claim that as soon as political women's parties became established, and later on became more or less integrated within other large political parties, they lost their legitimacy as spokesmen for a marginalized issue (Connelly and Smith, 1999: 62 and 86).

Others might point out that instead of approaching environmental issues as activists, a more lasting solution could be found by focusing on the path of ecological modernization, which implies that instead of looking at the present situation as a crisis one should to perceive the possibilities available for change that would benefit most parties (Connelly and Smith, 1999: 65-69). In the case of the transport system in the Reykjavík area, this approach could lead all parties involved to appreciate the economic benefits, as well as the social and environmental benefits, of improving public transportation and thus being able to reduce the cost of building and maintaining ever larger infrastructure surrounding automobiles and the pollution they produce.

The public of the Reykjavík area is also waking up to the current problems present in the transport sector. The general discourse about the current transport situation in Reykjavík, as it can be perceived in the media, is hardly optimistic. Several articles that could be read in the news papers during the last 6 months reveal that the people in the capital area are becoming increasingly worried about heavy traffic and resulting pollution and accidents. This can for example be seen in an article, written at the request of a news paper by an employee at Reykjavík City Environmental Health and Protection Office, which brings attention to the unacceptable volumes of NO_x and PM in the capital, as well as the annoying habit of many Icelanders to leave their car running in the parking lot while they do their shopping. The writer claims that if it were not for the unstable and windy weather in the capital area, the effects of the emissions from traffic would be much greater. The article is written as a sort of response to the declaration that Reykjavík city made in

June 2004, proclaiming that Reykjavík will aim at becoming the cleanest capital in Europe under the slogan “Reykjavík - pure energy” (Gústafsson, 2004: 22). Another article addresses the increasingly heavy traffic in the capital area, interviewing three people, among them one taxi driver, that have noticed a clear increase in congestions and overall travel time needed to reach the destination. One of them mentions the need for multilayered intersections to speed up the traffic and decrease the likelihood of traffic accidents (Fréttablaðið, 2004: 4).

It seems to be quite common perception that building larger streets with multilayered intersections is the optimal solution to heavy traffic, as well as introducing hydrogen fuel to solve the problem of emission. In the hydrogen fuelled cars, Icelanders would perhaps receive a solution that they would to some extent neither treasure nor appreciate as the environmentally friendly fuel technology deserves. The hydrogen solution is a possibility in Iceland, thanks to its already abundant amounts of renewable energy that only wants for a sustainable energy carrier to be applicable in most areas of human actions. Despite this fortunate situation which Iceland finds itself in, it does seemingly less than it could to eliminate or soften other effects of modern transport that can not be altered simply by this new technology, such as the social implications, environmental degradation and visual pollution of urban sprawl and increasing private car ownership. It would be a shame if Iceland were successfully to implement this revolutionary technology, on sufficiently various levels to be able to call itself a hydrogen society, and then having eliminated one negative aspect of the private car by replacing the combustion engine, would do little else to address the other implications of mobility culture.

Although Iceland may seem a harsh and unfriendly island to inhabit, it is blessed in its natural resources to a degree of which few can boast, but just as Icelanders do not lament themselves about the whether, they do not always seem to fully appreciate their fortune in natural riches. Although Icelanders seem to be fairly well aware of the danger that excessive transport poses to the environment, they do not go to any troubles to exhibit environmentally friendly behavior. There is nevertheless a high degree of optimism surrounding the aim of turning Iceland into a hydrogen society. This optimism is not always due to only the prospect of the advent of environmentally friendly transportation but rather due to the prospect of becoming the only country in the world that can boast of such a thing. Like engineer Þorsteinn

Þorsteinsson said, hydrogen would perhaps bring Iceland fame for something else than cod and sagas (Þorsteinsson, 2003: 31).

Conclusions

The greater Reykjavík area has only recently become fully urbanized and various aspects in the urban development process, as well as the abundant amount of private cars available in and around the city at an early date, have led to an ongoing urban sprawl in the area. The increasing private car ownership is now locked into a vicious circle with the current urban development, since more cars call for larger streets, which facilitate the expansion of the area and thereby calls for more cars and larger roads. The dispersed settlement and high percentage of private car ownership has made public transportation almost impossible to pursue. The main implications of this are the decreased mobility of those that can not own or operate a car, the disturbance of the cityscape by impenetrable highways and intersections, increasing cost of traffic infrastructure as the sprawl continues, as well as increasing air pollution caused by the vehicle emission.

To address these problems it is important to make the urban settlement denser and mixed within the neighborhoods, while investing in making the public transport system fully compatible as an available mode of transport for all inhabitants in the area. The leaders in Reykjavík have professed a willingness to develop more dense neighborhoods in some parts of the city, but most of the other municipalities are still focusing on expansion. While certain measures are being taken to make public transport more accessible, no drastic improvements are scheduled for the public transport system that can reasonably be expected to increase the preference for public transport to such a degree that it can be viewed as a real alternative to the private car. The part of the transport problem that seems to be attracting full political attention is the problem of air pollution as a result of vehicle emissions, despite the fact that there is fairly little air pollution in the area as a result of the swift winds around the capital. Air pollution from emission is to be eradicated with the introduction of hydrogen fuelled vehicles in the next decades and will serve to make Iceland the world's first hydrogen economy.

It is the conclusion of this paper that the introduction of hydrogen into the transport system will serve to eliminate air pollution in an efficient way, but the cost of implementing a new fuel system will be high, while the problem it eliminates is rather small. However, although it is particularly useful to utilize hydrogen in the specific settings of Iceland, there are several aspects of the transportation system that a fuel switch can not change. Specifically, there need to be more drastic measures in making the city area denser and thereby more viable for public transportation, more coordination between the municipalities and a change in the lifestyle choices of Icelanders if there is to be any change in the transport patterns. The greater Reykjavík area will continue to grow as there is still an increasing demand for housing in the city, but the area can not grow forever and therefore the issues of urban sprawl and transport patterns, based on private cars as the only transport mode available, have to be taken into consideration. Introducing hydrogen will undoubtedly have a more direct public relations value for the area than investments in public transport and urban planning. Nevertheless, a city covered with large streets and intersections that are impenetrable for pedestrians will not be an attractive place to live in, despite the presence of environmentally friendly vehicles. Therefore, the question we should be asking ourselves is not whether we can afford to invest in making the urban structure and the transport situation more sustainable, but whether we can afford not to.

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