

University of Hertfordshire

Implementation of Hydrogen Technologies in Slovenia:
Identification of Resistance to Change Factors by a Comparative
Study

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by

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"Essentially the champion must be a man willing to put himself on the line for an idea of doubtful success. He is willing to fail. But he is capable of using any means to succeed. No ordinary involvement with new idea provides the energy required to cope with the indifference and resistance that major technical change provokes. It is characteristics of champions of new developments that they identify with the idea as their own, and with its promotion as a cause, to a degree that goes far beyond the requirements of their jobs. In fact, many display a persistence and courage of heroic quality. For a number of them the price of failure is professional suicide, and few become martyrs to the championed ideas". (Schon, 1963)

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List of abbreviations

BEV- battery electric vehicles

C- Celsius

CCS- Carbon capture and storage

CO- Carbon Oxide

CO₂- Carbon Dioxide

DMFC- Direct methanol fuel cell

EPA- Environmental Protection Agency

FCV_NO- number of hydrogen fuel cell vehicles per one million of population

FCV- fuel cell vehicles

FCEV- fuel cell electric vehicle

GDP- Gross Domestic Product

GDP in PPS- gross domestic product per capita

GDP_EDU- total expenditure on educational institutions for all levels of education as percentage of GDP

GDP_RD- gross domestic expenditure on R&D as percentage of GDP

H2_PROD- hydrogen production per year and per one million of population

H2_STNO- number of hydrogen filling stations per one million of population

ICE- Internal Combustion Engine

JTI- Joint Technology Initiative

kWh- kilowatt hour

kWel- Kilowatt Electric

MWel- Megawatt Electric

MCFC- Molten carbonate fuel cell

Mton- million ton

MW- mega watt

NGO- none governmental organization

NH₃- ammonia

NO_x- nitrogen oxides

NOW- NOW GmbH (National Organisation Hydrogen and Fuel Cell Technology)

OECD- Organization for Economic Cooperation and Development

PAT_NO- total number of patents per million populations

PEFC- proton exchange fuel cell

PEM- The Proton Exchange Membrane

PHD_NO- total number of PhD graduates in science and engineering per million populations

PM₁₀- Particulate Matter

PPM- Parts Per Million

REN_EN- contribution of renewables to energy supply as percentage of total primary energy supply

RES_NO- researchers, per thousand fulltime employed

R&D- Research and Development

SOFC- Solid oxide fuel cell

TOT_EN- total energy consumption per capita

UPS- uninterruptible power supply

VOC- volatile organic compounds

Abstract

This thesis outlines the implementation processes for a new technology in selected countries and identifies the resistance to change can a change agent can come up against during the implementations process. The starting point for the thesis takes hydrogen as a breakthrough technology, and through the literature review process identifies certain obstacles to change. The implementation of a new technology brings with it resistance to change in the working structure (Ministry) as a whole or by individuals at the expert or political level.

The sources of such evidence are found throughout the literature review related to change, change agents, political and organizational change and the implementation of new technology and case study analysis. The thesis develops a concept around typical cases (sampling groups) and is based on qualitative research on three levels of actors in the decision-making and implementation process (experts, political decision makers, and directors of public agencies that are implementing measures on a national scale). In accordance with the research design scheme four European countries were chosen for (case study) comparison: Slovenia, Germany, Denmark and Norway. The purpose and aim of these typical cases is to contribute to the central subject and aim of this thesis – to better understand the systems in the selected countries and, based on the experiences of those countries, together with Slovenia, to ultimately propose a practical approach to developing national programs in Slovenia.

The aim of this thesis is not to argue whether hydrogen is the energy source of the future. Instead the aim is to show, through the use of hydrogen and fuel cells, an example of how Slovenia should react with measures designed to implement new technologies. The implementation of a new technology is a long-term process, where measures need to be considered that involve all sectors of society. Every country has its own unique environment (economy, industry and similar) where different approaches to specific implementation scenarios are required. The unique environment of each respective country is seen as a defining limit to the thesis, when the implementation practices of the selected countries are identified and, based on the analysis, new measures are proposed for Slovenia.

The methodology used here is based on a time “snapshot” that shows the degree of early market penetration of hydrogen and fuel cell technologies in mobile and stationary applications in three

developed countries that lead in the development and early adoption of these technologies, together with the same for Slovenia.

Qualitative methods are also effective in identifying intangible factors, such as social norms, socioeconomic status, gender roles, ethnicity, and religion. When used along with quantitative methods, qualitative research can help us to interpret and better understand the complex reality of a given situation and the implications of quantitative data” (Mack, 2005).

The thesis confirms the theory of resistance to change through the responses by actors involved in the decision and implementation process. This result is also implication for theory. The results of the analysis outline the structure of the government procedures in each country and how the government determines national priorities and allocates the proper financial and human resources for continued related activities through the years ahead. Evidence from the analysis show that all three compared countries understand that national priorities need to be realised through efficient national programs that include collaboration between the experts and ministry staff who work on preparing the program. It is vital to assure continuity, ongoing financial resources and precise goals for the efficient implementation of new technology.

The thesis provides implication for practice aimed at improving the implementation process of new technology by improving implementation steps in horizontal coordination and communication, accepting the fact that resistance is part of the process, and such resistance might be overcome. Other EU countries that are in the early stages of implementing hydrogen and fuel cell technologies on the national level could well benefit from this approach.

Evidence indicates that in the process of qualitative research, researchers sample targets directly to gather data that will fit the aim of the work instead of following statistical representation.

Targeted research aims to simultaneously create solutions for practical people problems and opens goals for future science research which is also implication for theory and practice. In order to achieve this, the researcher must on the one hand understand the system that is the subject of the research and in addition, work with people working in the system to produce a solution that is both people-friendly and efficient. Using such an approach, end results will help change the implementation processes applied to new technologies and also show how theoretical work can be transferred to practical implementation.

In the research process the author was confronted with several limitations: limitations related to the scope of the research; connected to the hypothesis and research questions; to the choice and

number of reference countries. Limitations regarding the methodology included the choice of interviewee groups, the types of interviews, the construction of questionnaires, the collection of responses, limitations regarding the analysis: qualitative research (vs. quantitative), decisions on valid (or invalid) responses with regard to the posed questions, and how this might influence the conviction behind one's conclusions. Similarly, there are limitations related to the proposed action plan for Slovenia: how strongly is the action plan connected to the conclusions of the research; and which items in the action plan are the direct consequences of the conclusions and which follow as a logical consequence of the previous plans.

1. Introduction

The energy sector is categorically the one, single sector upon which nearly all human activity depends. The production of heat and electricity for stationary applications (residential, industry, public institutions, etc.) is currently based on gas, heating oil or district heating. Vehicles with internal combustion engines (ICE) are using liquid fuels. In addition, modern information and communication technologies make use of various power sources supplied by a primary energy source-mix in which fossil fuels play a dominant role.

“If we would like to achieve an 80% reduction in greenhouse gases down to below 1990 levels, eliminate most oil imports and most urban air pollution, then society must transition to all-electric vehicles powered by some combination of fuel cells and batteries” (Thomas, 2009).

The problem is the whole of society is dependent on fossil fuels and in turn, on the existing infrastructure that supports the production, transportation, storage and use of such fuels.

Hydrogen as an alternative energy solution will change the whole of society and our way of living, from the actual process of hydrogen production (central, dispersed, home/local) to transportation and end-use in mobile, stationary and portable applications. This development will make existing infrastructure unusable, which will create the need for new planning. Such changes will come over time, and long-term planning is crucial for smooth implementation.

The development and market penetration of any new technology follows a sigmoidal saturation curve, which can be roughly divided into three sections: the “incubation period” with little growth and the accumulation of necessary knowledge and know-how; a faster market penetration

period in which the potential market is conquered; and the saturation period in which the market becomes saturated with the products of the new technology.

Slovenia does not have the financial and economic potential to become a leader in the development of certain new technologies, but it can become an early adopter of such technologies, given a level of socioeconomic development and certain boundary values for system development being fulfilled.

Hydrogen can be one of the future energy sources that have the potential to reduce our dependency on fossil fuels. The aim of the thesis is not to argue whether hydrogen is the quintessential answer. The aim of this thesis, through a thorough review of the literature, questionnaire-based research and a typical case study, was to develop and improve our understanding of new technology implementation processes in the countries compared herein. The result of the thesis is a proposal for a new, practical process for the easier adoption of a new technology that the Slovenian Government may give serious consideration. Here, hydrogen is used as an example; the next chapter features a brief introduction to hydrogen in order to put it into a context relevant to and telling for this thesis. The benefits and drawbacks of hydrogen are presented more broadly in Chapter 3.

This thesis researches resistance to change in the process of implementation of new technology on the national level. The thesis links resistance to change of new technology to resistance in the political arena. This research is based on qualitative analysis and a case study of four countries and three target groups in each of the countries.

Research question: How to improve the deployment environment to increase the level of hydrogen and fuel cell technology implementation?

The thesis aims to work on definition of practical sub-problem: The first problem is dispersed government support (wide selection of technologies) for the deployment of new technologies. The second problem is the lack of a clear national roadmap for lowering GHG emissions. Both problems result in slowing down the implementation of hydrogen and fuel cell technology. Thus the research sub-question: How to develop a national road map?

Definition of the conceptual problem: Confirmed national action plans indicate an implementation deficit in planned measures from the political sphere. The political sphere does not show sufficient support for the inclusion of the required financials in the national budget to

carry out the planned measures. Thus the research sub-question: How to select potential new technologies that will enable achieving the goals as outlined in the road map?

This thesis has three objectives: to gather the responses from all four countries by all three target groups on how implementation of new technology is processed; to explore the theoretical grounds behind resistance to change of new technology and linking this to political resistance; and to propose a more practical implementation process for new technology in Slovenia.

The thesis includes case studies using three target groups. This approach presents many good outcomes, because it is personal and responses are gathered from actors included in the actual implementation process in each country. An international comparison among countries that have similar conditions is beneficial, and from here on a qualitative approach is developed with the aim to improve relevant conditions in Slovenia.

The literature review covered topics such as technical and economic issues related to hydrogen and fuel cells, hydrogen infrastructure, environmental benefits, political and non-political actions, change, resistance and social acceptance. Such topics help explain the factors and concepts in terms of where implementation of “new” things have an impact. This thesis authors’ criticism of the different concepts of resistance is considerable, because theory does not work in practical applications in which the change agent would like to implement a new technology and such implementation doesn’t grant power to a particular politician or political party or serves to demonstrate a lack of knowledge on the part of ministries or state secretaries. Resistance is a variable that exists in every process of change and should be treated as a source of information with which to improve the implementation process.

By employing a case study approach with target groups, I attempt to demonstrate that political actors in the selected countries are aware that experts are there for expert support; on the other hand, in Slovenia neither ministries nor state secretaries include experts enough in the decision making process – instead, decisions tend to be taken on the basis of political points, personal opinion or pressure from interest groups.

Resistance to change was identified as a major factor in decision-making related to personal involvement at a high level in Slovenia. Many developments in the decision-making process indicate that “new” approaches or technologies are not well accepted and it takes much longer to overcome the resistance factor.

This thesis does not focus on what the literature says about the different sides of resistance and how it is included in the analysis of processes or people. For the purposes of this thesis, resistance to change is simply linked to opposition to something new. Literature shows that when it comes to technologies, the term “resistance” has been changed to “acceptance”.

The thesis argument hypothesis on resistance to change provides added value for further research because it based on a case study with specific target groups using a specific new technology.

The starting point for the thesis takes hydrogen as a breakthrough technology and through the literature review determines the obstacles related to the resistance to change. The implementation of new technology brings resistance to change to the working structure (ministry) as a whole or the individual on the expert or political level.

The thesis develops a concept built around typical cases (sampling groups) and is based on qualitative research on three levels of actors in the decision and implementation process (experts, political decision makers, directors of public agencies charged with implementing national measures. In accordance with the research design scheme four European countries were selected for (case study) comparison: Slovenia, Germany, Denmark and Norway. The purpose of the such typical cases is to contribute to the central aim and subject of the thesis – to better understand the system in the selected countries and, based on the experiences of those countries, together with Slovenia, to propose a practical approach for the development of national programs in Slovenia. The Conclusion part of the thesis provides a practical process proposal for the implementation of new technology in Slovenia. The entire process is laid out with a short description of each step and responsible organization.

The thesis begins with the introduction in Chapter 1 and explanation of the background in Chapter 2. The Literature Review in Chapter 3 covers topics such as technical and economic issues related to hydrogen and fuel cells, hydrogen infrastructure, environmental benefits, political and non-political actions, change, resistance and social acceptance. Chapter 4 includes the research question and sub-question. Chapter 5 presents the Methodology of the research designed to answer the research question. Chapter 6 includes the Results and an analysis of primary data. Chapter 7 is a Proposal for the program preparation process. Chapter 8 consist of Conclusions, and Chapter 9 provides References.

2. Background information

Hydrogen is a potential energy carrier that can be used more widely in the future. Together with fuel cells can form potential for use as energy production in transportation, Uninterruptible Power Supply (UPS), domestic and other. For the purpose of this thesis hydrogen is used as an example; as technology which is new and needs different kind of measures (economic, technical, policy, etc) for wide spread implementation. This chapter will show to the reader what hydrogen is, what kind of timeline EC has for its implementation and in brief what was done in Slovenia. Hydrogen is than deeper introduced in literature review section.

Hydrogen is treated as one of the energy carriers for the transition to low carbon society, as it is seen from the analysis “Correlation between national development indicators and the implementation of a hydrogen economy in Slovenia” (Leben, 2011).

Hydrogen is a secondary energy carrier that can be obtained from any primary energy source and used in mobile, stationary and portable applications. The largest quantities of hydrogen are stored in water, in hydrocarbons containing fossil-based primary energy sources (coal, oil and natural gas), and is further found in all living organisms as part of organic compounds. Unlike electricity, hydrogen, once produced, can be stored in large quantities for long periods of time. “The energy conversion device that uses hydrogen and oxygen (air) to produce electricity directly is an electrochemical device called a fuel cell. Hydrogen and electricity share the remarkable property of being complementary and exchangeable thanks to technologies based on electrochemical engineering – the fuel cell and the electrolyzer” (Aline, 2008).

Climate change and air quality issues (quality of air and legislation constraints) are increasingly compelling society to find energy solutions that produce fewer emissions in both the production and end-use phase.

Coming from hay, wood, coal and oil we can conclude that the next step is naturally hydrogen. Development of fuels is presented in brief in figure 1 below.

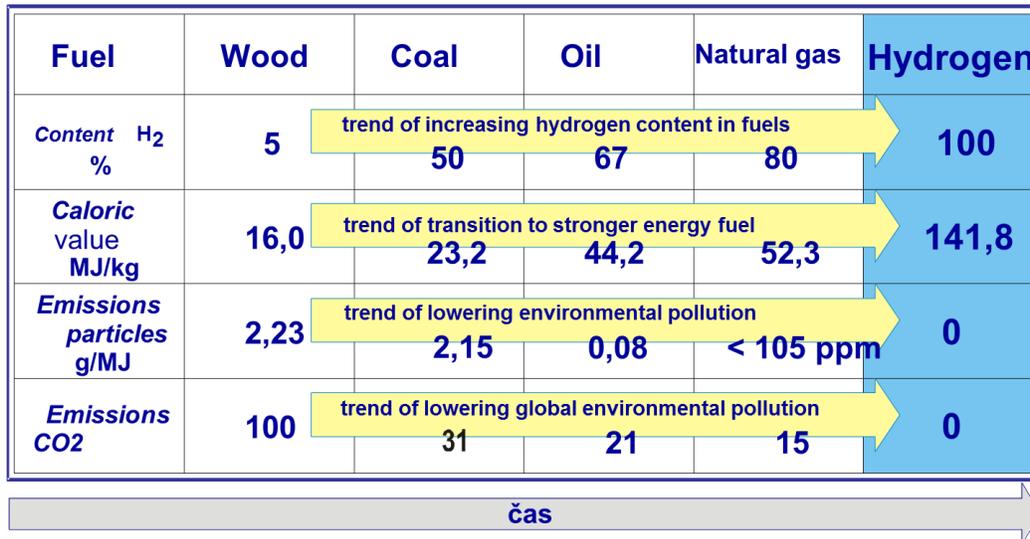


Figure 1: Development of fuels, Source: SIHFC, 2008

Advantage of hydrogen comparing to electricity is that once produced it can be stored for longer time. This hydrogen can be then used for production of electricity and heat using fuel cell. At this moment technology for hydrogen production, storage, transportation and end use already exists. Future hydrogen production need to be focused on sustainable production from biomass, by electrolysis with electricity obtained from solar, wind, geothermal or hydro power.

‘The production of hydrogen from renewable energy sources is often stated to be the long-term goal of mature hydrogen economy’ (Badwal, 2006).

In the Figure 2 below we can see implementation plan of EU Hydrogen Fuel Platform.

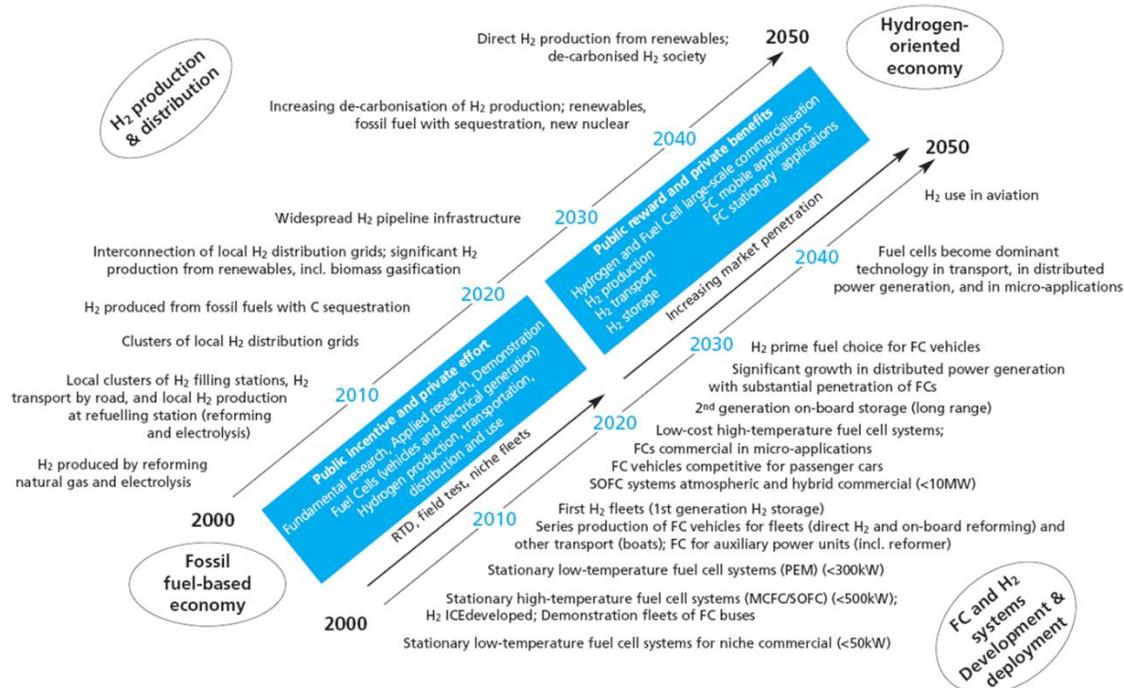


Figure 2: Implementation plan of EU Hydrogen Fuel Platform, Source: HyWays, 2006

It can be seen from the analysis of development indicators that Slovenia is ranked in the middle among chosen countries; table with development indicators is presented in Table 5 of this thesis.

The development of hydrogen and fuel cell technology depends on economic resources, on technological and economic development, and social (public) and political awareness.

Hydrogen technology represents a breakthrough of infrastructure technology touching all fields of human endeavour and development; education requires new paradigms in sustainable development, in medicine with cyborg components replacing human parts (limbs, heart, lungs) employing micro fuel cells for energy, Information Technology (ICT) sourcing UPS hydrogen energy supplies, the energy sector with renewable energy and energy storage technologies, and transportation exploiting low- or zero-emission hydrogen fuel.

Evidence from the economic, environmental and social realms described in previous sections speaks in favour of implementation of this technology. The technology behind hydrogen and fuel cells is not new. It has a long history of implementation around the world in different applications, and implementation trends are quickly progressing in developed economies.

Slovenia ranks, according to the Human Development Index (HDI) (UNDP, 2014) among the 25 most developed countries in the world.

Slovenia has an ambition to become a technology leader in certain high-tech areas defined by priority sectors in the Smart Specialization Strategy (SVRK, 2015)¹. At the same time, Slovenia is socially-grounded country with particular environmental awareness focused on sustainable development that must provide for the general needs of its population. To be able to implement such technology, an efficient complex system of horizontal cooperation linking all of the relevant ministries is required, as well as a long-term national implementation strategy.

In view of this (above), Slovenia should consider the implementation of hydrogen and fuel cells as one of the technologies integral to and enabling sustainable development. Based on its ranking among the developed economies, we would expect that Slovenia has already implemented, to some degree, hydrogen and fuel cell technology, since it has the entire base necessary for the development and implementation of a hydrogen economy in place. It has companies working on research, developing components and building infrastructure. The Development Centre for Hydrogen Technologies (DCHT) was founded by companies and research institutes to boost research, development and applicable projects in the field of hydrogen and fuel cells in Slovenia. In order to make efficient implementation of new technologies a reality the organization of the public sector (parliament, government, ministries) and long-term strategies with precise goals and identified responsible bodies for the monitoring of the implementation process, together with the necessary funding in the annual national budget are all important factors.

All of this (above) is supported by the latest Organization for economic Cooperation and Development (OECD) Economic Survey for Slovenia of May 2015, where among other key recommendations is the following: “Implement the government's unified innovation policy and monitor its progress. Improve collaborative links between major stakeholders of innovation policy”. (OECD, 2015)

However, the approach to organization of the public sector in Slovenia – from the perspective of the country’s politicians – is well illustrated by the following attitude: “A managerial leader will tend to pay primary attention to power, conflict, negotiating over scarce resources, the messy marketplace of ideas, and the organization as a battlefield. As with the symbolic lens, change is viewed as normal, though often sudden, opportunistic, and unpredictable” (Corlett, 2000). This

¹ National and regional authorities across Europe shall design smart specialization strategies in entrepreneurial discovery process, so that the European Structural Investment Funds (ESIF) can be used more efficiently and synergies between different EU, national and regional policies, as well as public and private investments can be increased

attitude is a consequence of the absence of a clear long-term national development strategy with elaborated roadmaps charting consensual societal priorities.

3. Literature review

This section shows covered critical literature research of technical publications, books and journals. Focus of the literature review was on finding research literature on technical issues about hydrogen and fuel cells, environmental impact and linking politics to the organizational management and resistance to change in the context of implementation of new technology. To start preparing a methodology for introduction of new technology and with that introducing change, it needs to be distinguished first a difference between political and non-political actions. In Slovenia is between people, scientists and public workers a specific opinion about the politics. The most appropriate definition of organization politics is from Allen et al where it says that in politics are shown influential actions which are used to protect individual interest or interest of certain groups (Allen, 1979). In reference section is a list of all documents reviewed during the preparation of this thesis research.

3.1. Technical and economic issues on hydrogen and fuel cells

3.1.1. Fuel cell

A review of literature at this stage shows that activities can be divided into several categories: performance, working duration, and cost of the technology. This sub chapter shows to the reader how fuel cell is constructed and what recent studies looked at in the research.

“Fuel cells are devices that produce electricity in an electrochemical reaction between hydrogen and oxygen. Fuel cells hold strong promise as commercially viable, clean and efficient electrochemical power sources” (William, 2000). All of the world’s major automobile manufacturers are developing hydrogen fuel cell vehicles (Leben, personal work on EU hydrogen regulation, 2006). Other applications for fuel cell systems in stationary applications are designed to generate environmentally friendly electricity and heat, and for use in portable equipment.

Fuel cells have a very simple structure comprised of three layers, one above the other:

- The first layer is the anode
- The second is an electrolyte
- And the third layer is the cathode

Source: EG&G, 2004

“The anode and cathode serve as a catalyst. The layer in the middle consists of a gas-impermeable ion conducting membrane. In different types of fuel cells, different substances are used as the electrolyte. Some electrolytes are liquid immobilized in a porous membrane. Some are solid, with a gas-impermeable membrane structure” (Timm, 2000).

“As a result, a voltage is created between the two electrodes. If the electrodes are connected to the load, then a direct current is generated. A number of these individual cells can be connected in series, one behind the other, thereby creating a ‘fuel cell stack’” (EG&G, 2004).

The concept of the hydrogen economy is closely connected to renewable energy production. Electricity produced from renewable sources is hard to store. Storing electricity in the form of hydrogen is more efficient than in batteries. Implementing renewable production goes hand in hand with implementation of a hydrogen economy. It is vital to create political regulations to adjust such an economy around renewable and hydrogen energy. This approach should not be seen as a reorganization burden; instead it needs to be seen as a new business opportunity based on energy independence.

“It is currently believed that fuel cells need at least five more years of testing and improvement before large scale commercialization can begin” (Veziroglu, 2010).

As we see from the above, fuel cell technology is still in the midst of a great development process. The configuration of fuel cell systems depends on the operating environment, working needs and the size of the vehicle. A large amount of research (which can be seen from the number of research papers published at FC EXPO 2012 in Tokyo), is devoted to Proton Exchange Fuel Cell (PEFC) and degradation in vehicular applications over time. Figure 3 below presents a list of recent studies on PEFC degradation.

PEFC component	Degradation effect
Entire fuel cell	Trade-off between efficiency and degradation performance Review of literature on effects and potential mitigation of various degradation modes Catalyst decay and membrane failure under near open circuit conditions Freeze/thaw cycles Driving cycle dynamic loading Difference between reversible and irreversible voltage degradation under open circuit conditions Sub-zero operation effect on ice formation Bus city driving cycles effect on voltage degradation
Catalyst layer	Surface area loss due to carbon corrosion and increasing platinum particle size Fuel and oxidant starvation effects on catalyst and carbon-support degradation Platinum dissolution and deposition on cathode, Pt diffusion in MEA, hydrogen permeation Pt catalyst ripening, electrocatalyst loss or re-distribution, carbon corrosion, electrolyte and interfacial degradation Effect of static and step potential conditions on platinum dissolution and carbon corrosion CO and CO ₂ poisoning Toluene-induced cathode degradation Catalyst treatment with acid; effect on decreasing oxygen reduction reaction; Pt/C/MnO ₂ hybrid catalyst Increasing particle size of Pt/C catalyst due to dissolution mechanism, oxygen electroreduction at cathode catalyst Degradation due to Cl ⁻ , F ⁻ , SO ₄ ²⁻ , or NO ₃ ⁻ Degradation effect on oxygen diffusion polarizations High temperature operation effect on carbon corrosion, platinum dissolution, and sintering; Pt/C and PtCo/C catalysts
Membrane electrode assembly	Air-air start-up, platinum crystallite precipitation Structural changes in PEM and catalyst layers due to platinum oxidation or catalyst contamination under open circuit conditions Excess air bleeding, anode catalyst On/off cyclic operation under different humid conditions Cell reversal during operation with fuel starvation Cathode flooding, membrane drying, and anode catalyst poisoning by CO
Membranes	Imide function hydrolysis inducing polymer chain scissions, comparison of sulfonated polyimide membranes with Nafion membranes Increasing hydrogen gas crossover, comparing Nafion 212 and Nafion 112 membranes Effect of water uptake on cyclic stress and dimensional change, hydrogen crossover; Nafion NR111 membrane Effect of hygro-thermal cycle on membrane stresses
Diffusion media	Elevated temperature and flow rate effect on mechanical stress and material loss
Sealing materials	Exposure time effect on de-crosslinking and chain scission; silicone rubber Sealing decomposition effect on catalysts

Figure 3: List of recent studies on PEFC degradation, Source: (Veziroglu, 2010)

Production of hydrogen is widely known and is already used in industrial processes and medicine. A good presentation of production sources of hydrogen is shown in Figure 4 below.

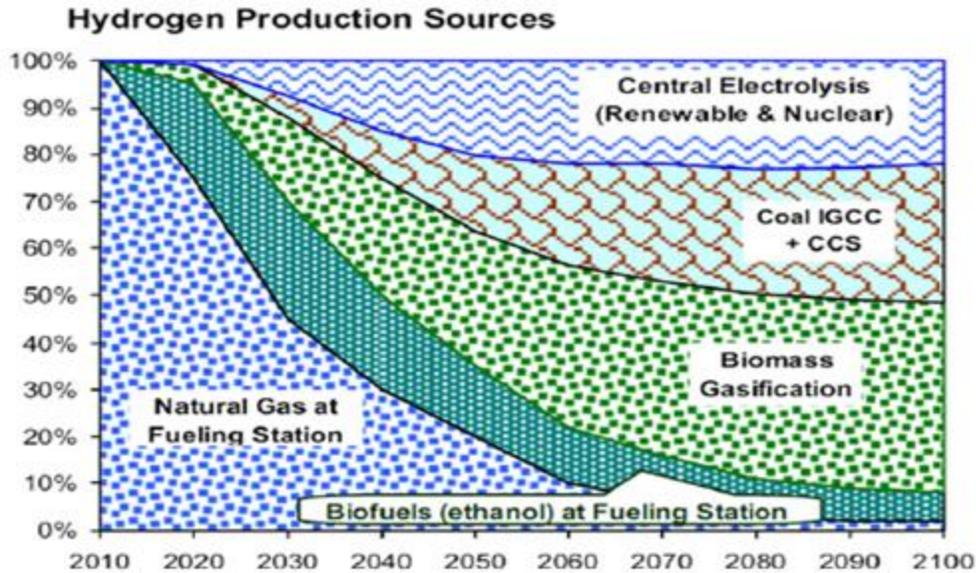


Figure 4: Production sources of hydrogen, Source: (Thomas, 2009)

It is vital to understand the structure of the fuel cell, what technical issues are involved and what future work should be done on the research level for a smoother transition to widespread (mass) use. The next two chapters show potential uses for fuel cells together with hydrogen in mobile and stationary applications.

3.1.2. Mobile applications

Hydrogen has a great potential as an energy carrier together with the fuel cell in the transport sector. This section shows what studies has been done (cold star, emissions, etc.) and what are the predictions regarding the volume of these vehicles on the roads in the future years.

The passenger car market has the greatest potential to introduce hydrogen and fuel cells in the transportation sector. The HyWays report shows that the transportation sector will have the biggest influence on hydrogen applications over the next 50 years (HyWays, 2006).

“The consortium of the HyWays project decided to deviate from the Energy Trends 2030-based numbers, particularly for passenger cars, as growth there is considered too high. Alternatively it is assumed that average car ownership and usage in all member states will become comparable to levels in present-day Germany. The resulting specific assumptions of HyWays are compared to extrapolations from the original Energy Trends 2030 in Figure 5 below” (HyWays, 2006).

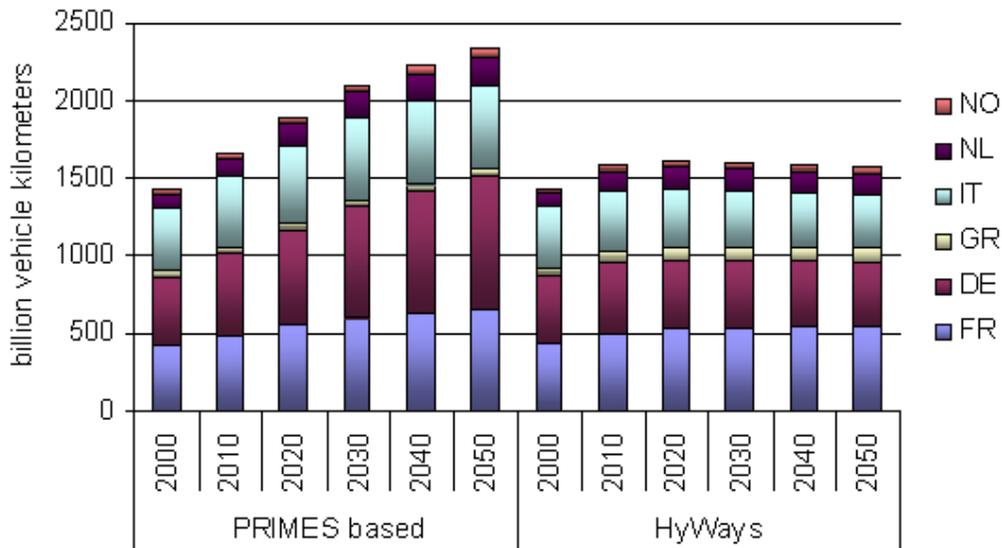


Figure 5: Resulting Hy Ways specific assumptions compared to extrapolations from the original Energy Trends 2030, Source: (HyWays, 2006)

There are several basic fuel cell designs for use in mobile applications such as passenger cars, busses and delivery vehicles. The fuel cell reverses the process of electrolysis that we know from basic school physics or chemistry. In the process of electrolysis, by applying electric power, water is decomposed into the gaseous components oxygen and hydrogen.

“The Proton Exchange Membrane (PEM) fuel cell is widely used in vehicles” (Norbeck, 1996).

The PEM fuel cell is structured as a sandwich. In the centre is a thin plastic film, the ‘PEM’.

“This membrane is coated on both sides with a thin catalyst layer and a gas-permeable electrode. The membrane is surrounded by two ‘bipolar plates’. Gas ducts in these plates allow hydrogen to flow on one side, and oxygen on the other. The catalyst breaks down the hydrogen atoms into protons and electrons. The protons can pass by inner circuit through the membrane, but the electrons cannot. The electrons can pass through the external circuit consisting of an electric motor” (Aline, 2008).

During the last 10 years much research has been done on fuel cells and Battery Electric Vehicles (BEV). It should be understood that on a broader scale Fuel Cell Vehicles (FCV) are still in the research and development stage. Existing papers cover specific areas such as working

mechanisms or comparisons between fuel cells and other power sources. In addition, environmental impact and economic viability is also being covered and supported on one side or discredited on the other.

One of the biggest problems in the FCV puzzle – to be competitive with Internal Combustion Engines (ICE) – is on-board storage. Storage options include metal hydrides, carbon nanotubes, compressed gas and liquid hydrogen. At the moment all of these options are far larger than gasoline storage in ICEs. Figure 6 below shows a comparison of ICE storage and FCV storage options for hydrogen.

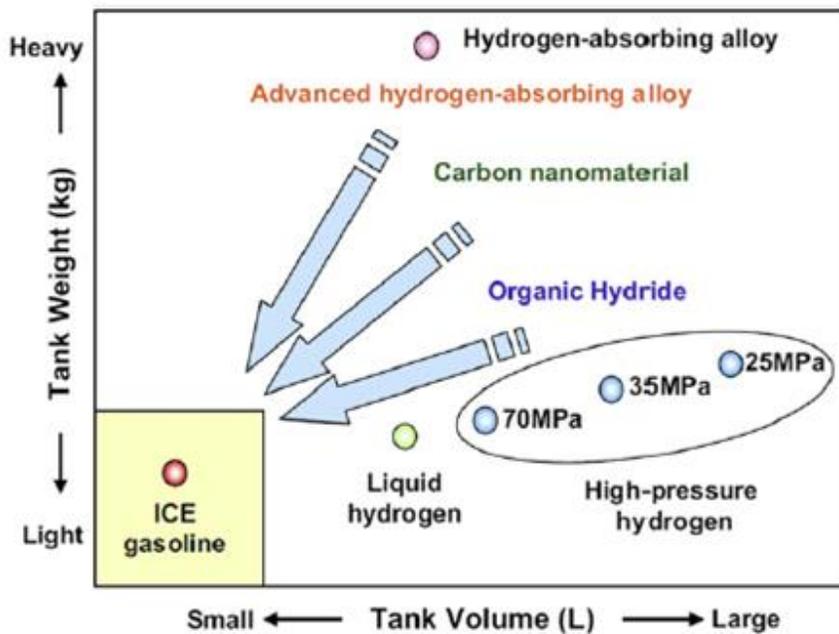


Figure 6: Comparison between ICE storage and FCV storage options for hydrogen, Source: (Thomas, 2009)

Another important issue explored in research work is the working conditions of the FCV. In order to be competitive with ICE, FCV needs to start at -20 C. The biggest challenge is preventing water from freezing in the catalyst layer of the membrane. One solution is to strategize shut-down, including a 30 min purge with dry gases (Schiebwohl, 2009). In Figure 7 below other research that looked into start-up and shut-down procedures for PEFCs and their effect on performance and durability is summarized.

Research area	Effect(s) studied and general results
Cold start	<p>Adding hydrophilic nano-oxide SiO₂ to catalyst layer of cathode to increase water storing capacity.</p> <p>Results: Cold start process is strongly related to cathode water storage capacity; SiO₂ slightly decreases cell performance under normal operating conditions but drastically improves cold start (-10 °C) running time before cell voltage drops to zero; SiO₂ does not accelerate cell degradation compared with cells without SiO₂ layer.</p> <p>Cell voltage, initial water content and distribution, anode inlet relative humidity, heat transfer coefficients, cell temperatures.</p> <p>Results: Heat-up time can be reduced by decreasing cell voltage; effective purge is critical; humidification of the supplied hydrogen has negligible effect; surrounding heat transfer coefficients significantly affect heat-up time.</p> <p>Product water: absorbed in ionomer in catalyst layer, taken away as vapor in gas flow, and frozen into ice in catalyst layer pores.</p> <p>Results: Increasing membrane thickness increases water capacity but decreases water absorption process, increasing ionomer volume fraction increases ionomer water capacity and enhances membrane water absorption; cell start-up is better under potentiostatic condition than galvanostatic condition.</p> <p>Ionomer content in catalyst layer in galvanostatic cold start.</p> <p>Results: Start-up from -30 °C improves significantly with higher ionomer content in catalyst layer due to increased oxygen permeation of ice formation in catalyst layer.</p> <p>Operation under constant current and constant cell voltage conditions.</p> <p>Results: Water vapor concentration in cathode gas channel affects ice formation in cathode catalyst layer; the membrane plays important role in start-up by absorbing product water and becoming hydrated.</p> <p>Residual water effects on performance, electrode electrochemical characteristics, and cell components.</p> <p>Results: During start-up from -5 °C, residual water did not alter the electrochemically active surface area or charge resistance at low current density; less water was stored in the catalyst layer than in the rest of the cell.</p> <p>Energy requirement based on one-dimensional thermal model.</p> <p>Results: An optimum range exists for current density given a stack design for rapid cold start-up; thermal isolation of the stack reduces start-up time; end plate thickness has no effect beyond a certain threshold; of internal/external heating options, flow of heated coolant above 0 °C is the most effective way to achieve rapid start-up.</p> <p>Start current density dependence on membrane hydration, operation voltage, and gas flows.</p> <p>Results: Start-up below 0 °C depends on membrane hydration and operation voltage; current decay depends on constant gas flows of reactant gases; ice formation does cause degradation effects in the porous structures that leads to performance loss.</p> <p>Shut-down strategy importance on freezing of process water on catalyst layer of membrane electrode assembly.</p> <p>Results: The degree of dryness in the stack significantly influences cold start-up ability, increasing dryness improves performance; the optimal shut-down strategy allows start-up from -6 °C without any performance loss, lower temperatures will see temporary performance loss.</p> <p>Ice formation and inner-cell temperature increase dependence on water vapor concentration in cathode gas channel, initial water content in membrane, current density, and start-up temperature.</p> <p>Results: Ice precipitation can be delayed by decreasing interfacial water vapor concentration at gas diffusion layer and gas channel surface on cathode side; start-up performance improves by decreasing operation current density, decreasing initial water content in membrane, and increasing start-up cell temperature.</p> <p>Buildup of ice in cathode catalyst and electrode structure, operations near short-circuit conditions.</p> <p>Results: Near short-circuit conditions improves start-up below -20 °C by maximizing hydrogen utilization, producing waste heat absorbed by stack, and delaying loss of electrochemical surface area to ice formation; bipolar plates should be made from metal instead of graphite.</p> <p>Water freezing phenomena at interface between gas diffusion layer and membrane electrode assembly.</p> <p>Results: Ice formation at the gas diffusion layer and membrane electrode assembly interface causes gas stoppage, causing a drop in cell performance.</p> <p>Develop procedure to assist start-up: react hydrogen and oxygen in the FC flow channel to heat it up.</p> <p>Results: At temperatures below -20 °C, a catalytic hydrogen reaction in fuel cell flow channel is an effective and safe way to heat up the fuel cell, hydrogen concentration must be less than 20 vol%; gas flow rate, gas concentration, and active area are the key interdependent factors in this process.</p> <p>Initial water in membrane, operating voltage, cell temperature, current.</p> <p>Results: Ice formation in cathode layer pores and in active reaction sites increases electrical resistance and decreases performance; performance reduces less than 1% per cold start-up.</p>

Research area	Effect(s) studied and general results
Normal start	<p>Endplate effects on temperature profile. Results: An asymmetric temperature profile develops due to greater heat generation on cathode side; membrane swelling phenomena, caused by continuous water content variation, increases electrical and thermal resistance; latent water heat produced at catalysts can be stored in the stack; the non-uniform temperature distribution can be minimized by coupling coolant for central cells with the end cells.</p> <p>Liquid water, temperature, gas diffusion layer thickness and porosity. Results: Liquid water increases time for current density to reach steady state; temperature does not have significant effect on current density; increasing porosity decreases mass transport time scale; increasing gas diffusion layer thickness delays influence of liquid water.</p> <p>Cathode, anode, and membrane potentials during startup and shut-down. Results: Hydrogen/air boundary at anode creates voltage between membrane inlet/outlet and voltage at interface of cathode and membrane outlet, causing carbon corrosion.</p> <p>Internal currents during open circuit conditions. Results: Internal currents are caused primarily by capacitive effects; carbon oxidation occurs simultaneously and has negligible contribution to internal currents.</p> <p>Gasoline, methanol, ethanol, dimethyl ether and methane effects on hydrogen production. Results: Modeled overall efficiencies were 37% for gasoline, 38.3% for methanol, 34.5% for ethanol, 38.5% for dimethyl ether, and 33.2% for methane.</p> <p>Hydrophobic treatment (HT) and micro-porous layer (MPL) addition to gas diffusion layer (GDL) effect on water balance. Results: HT without MPL increases liquid water accumulation at electrode, limiting oxygen transport to catalyst and lowering cell voltage, also decreases water at GDL; HT with MPL addition suppresses water accumulation at electrode, increasing current; increasing air permeability of GDL increases current, also improving start-up performance.</p>
Normal shut-down	<p>Close/open state of outlets and application of dummy load effect on degradation of membrane electrode assembly. Results: Using a thin electrolyte membrane, outlets should be closed to limit degradation during on/off operation; using a thick electrolyte membrane, the dummy load should be applied to limit degradation.</p>

Figure 7: Research looked into start-up and shut-down procedures for PEFCs and their effect on performance and durability, Source: (Veziroglu, 2010)

We need to know that there is great deal of research that looks into the use and operation of hydrogen and fuel cells (Crabtree, 2004) for passenger vehicles.

The Foundation report deployment strategy shows what kind of penetration rates for hydrogen vehicles can be expected on our roads, as follows:

- Today until 2010: Demonstration of fuel cell powered vehicles in captive fleets
- >2010: Series production of fuel cell powered vehicles for fleets (1st generation on-board hydrogen storage)
- > 2020: Series production of fuel cell powered vehicles in broad applications (2nd generation on-board hydrogen storage and low-cost high-temperature fuel cell systems)
- >2030 - 2040: Fuel cells become dominant technology in transport

Source: (HFP, 2004)

Several companies such as Hyundai, Daimler, Honda and Toyota have plans to introduce Fuel Cell electric Vehicle (FCEVs) commercially by 2015. The majority of vehicle stock produced will go to Europe, Asia, California, and Hawaii where governments are coordinating efforts to build hydrogen infrastructures (National Academy of Sciences, 2013).

The Green book² for the national energy program estimates that the year 2030 will see 100,000 electric hybrids running on hydrogen and batteries in Slovenia and 100,000 vehicles on hydrogen and fuel cells for longer drives (Ministry for economic development, 2009).

Work from Ricardo Consulting Engineers path shows that hydrogen fuel cell vehicles have the potential to be zero emission producers when hydrogen is produced from renewable sources. Moreover, already, fuel cell vehicles boast zero NO_x, and Particulate matter 10 (PM₁₀) exhaust emissions (Ricardo Consulting Engineers, 2002).

The key advantages of FCEVs include the following:

- High energy efficiency;
- No tailpipe emissions—neither GHG nor criteria pollutants—other than water;
- Quiet operation;
- Hydrogen fuel can be produced from multiple sources, thereby enabling diversity in energy sources (including low carbon and renewable energy sources) away from near-total reliance on petroleum;
- Full vehicle functionality for safe on-road driving, including 300-mile driving range;
- Rapid refuelling;
- Source of portable electrical power generation for off-vehicle use.

Source: National Academy of Sciences, 2013

Literature reviewed so far shows that there great potential for use of hydrogen and fuel cells in mobile applications. This approach can reduce our dependency on fossil fuels in the transportation sector and have positive environmental benefits. Environmental benefits will be outlined in following chapters.

² Zelena knjiga za Nacionalni energetska program Slovenije, MG 2009

3.1.3. Stationary hydrogen and fuel cell applications

Hydrogen can be also used in stationary applications for cogeneration of heat and power. The advantage of using both products – electric power and heat – is the very high overall system efficiency that makes the best possible use of the primary energy sources.

“Even though combined heat and power stations are nothing new, the technology using fuel cells is still in the demonstration/learning stage. Many companies around the world are implementing small-scale projects to show how a future energy supply could work” (Winter, 2000).

During the day, hydrogen can be generated by electrolysis using renewable energy. The hydrogen can then be stored. At night, hydrogen can be converted in a fuel cell into electric power and heat. In so doing, the renewable energy collected during the day has been stored for use during the night. We can easily imagine how our energy system would change if thousands of such applications were installed directly in residential buildings. “This would provide decentralized generation of electric power, and would provide more efficient use of the primary energy source. Importantly, overall energy consumption and GHG would decrease significantly, even if fuel cells, initially, operate together with a reformer, converting natural gas” (Veziroglu, 2000).

As an example, we can take our hospitals. Every hospital has backup diesel generators for the production of electricity. These generators produce and release harmful emissions into the environment and produce noise while running. They also require regular maintenance and periodic start-up to make sure that the generators are in suitable condition.

On the other hand, hydrogen stationary applications represent a big step forward. In particular, hydrogen generators:

- Do not need regular start-up and need very little maintenance.
- They are far more efficient and reliable than diesel generators.
- And they do not produce harmful emissions and noise while in use. Instead, water vapor is the only end product.

Source: (Cox, 1979)

In the early phases of implementation, fuel cell power generation can also be very efficient using natural gas or renewable fuels. This approach will contribute importantly in achieving Carbon Dioxide (CO₂) reductions and providing opportunity for market penetration (HFP, 2006).

A report from the HFP shows that houses and apartment buildings will use Proton exchange membrane fuel cell (PEMFC) and Solid Oxide Fuel Cell (SOFC) technologies, with an estimated 50-50 split in use (HFP, 2006).

For larger units on the other hand, ranging from 10 kW to 1 Mega Watt (MW), Molten Carbonate Fuel Cell (MCFC) and SOFC will be used. In the early stages of implementation, MCFC technology was more developed; now SOFC is more in use. “Similarly, units of more than 1 MW will primarily use MCFC, but SOFC units could play a greater part closer to 2015” (HFP, 2006). As with any new technology, regulations, codes, financing schemes and standards for stationary applications need to be defined and instituted by governments first before any widespread implementation of stationary fuel cell technology on the energy market.

A variety of stationary fuel cell applications can be employed that have a great impact on reducing CO₂ emissions and significantly improving energy efficiency. Figure 8 below indicates the main market segments for stationary fuel cell applications.

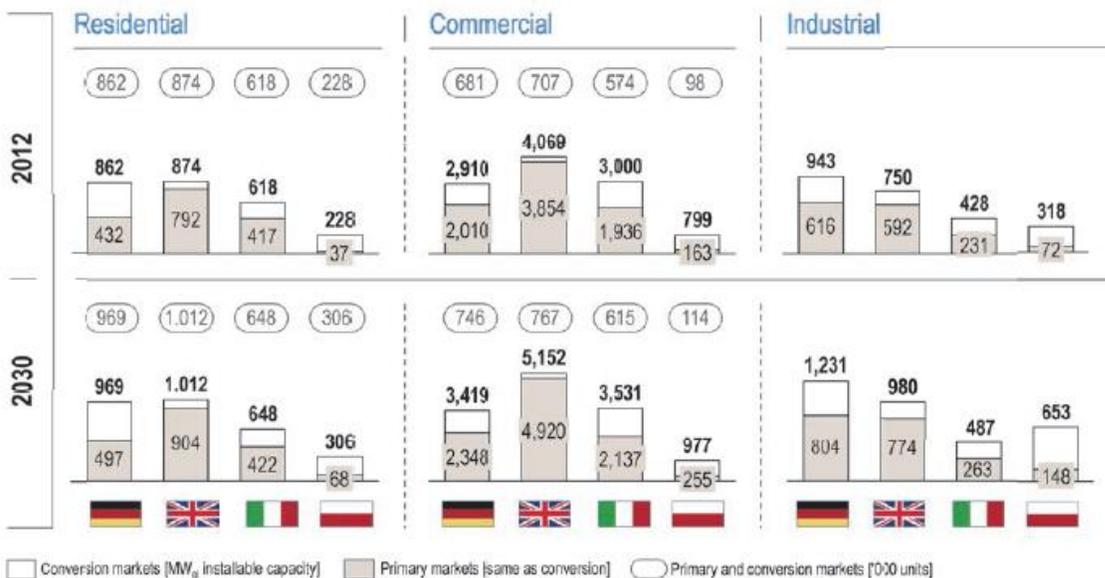


Figure 8: Main market segments for stationary fuel cell applications, Source: (FCH, 2015)

In Table 1 and 2 below we see two potential penetration scenarios for stationary applications on the European level:

Table 1: Scenarios for the potential development of stationary hydrogen applications in the residential sector

Total share of households	2010	2020	2030	2040	2050
High penetration	-	1 %	4 %	8 %	10 %
Low penetration	-	0.1 %	0.5 %	2 %	5 %

Source: FCH, 2015

Table 2: Scenarios for the possible development of stationary hydrogen applications in the commercial and services sector

Total share of commercial demand	2010	2020	2030	2040	2050
High penetration	-	0.3 %	1.3 %	2.7 %	3.3 %
Low penetration	-	>0 %	0.2 %	0.7 %	1.7 %

Source: FCH, 2015

Stationary fuel cell applications can also contribute towards better energy efficiency in buildings. As the FCH report shows, the growing importance of energy efficiency is outlined in European government goals – and stationary fuel cells are highly efficient. The EU has confirmed its commitment to strive for a cleaner and more efficient energy sector, with a confirmed target of 27% by the year 2030 (FCH, 2015).

Figure 9 (below) shows a summary of the major benefits of stationary fuel cells revolving around the role they can play in the context of Europe’s future energy system.

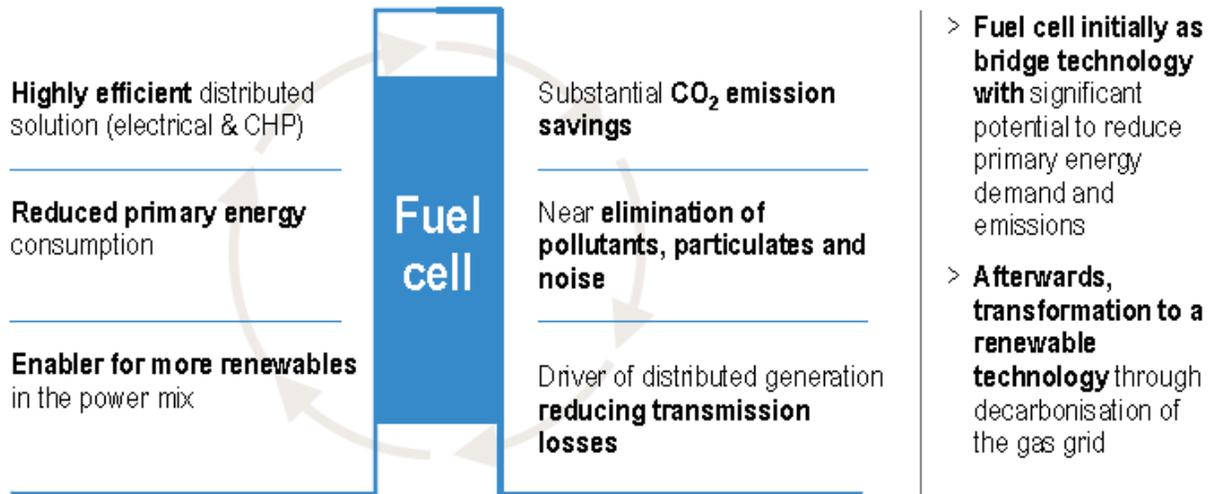


Figure 9: Major benefits of stationary fuel cells revolving around the role they can play in the context of Europe’s future energy system, Source: (FCH, 2015)

Research from the FCH report shows that in e.g. Germany for example, “primary and conversion markets amounted to 874,000 units in 2012³. Assuming an average fuel cell system size of 1 Kilowatt Electric (kW_{el}) the total addressable primary market is approximately 900 Megawatt Electric (MW_{el}). In 2030, the market is expected to increase to 904,000 replacements and 904 MW_{el}” (FCH, 2015).

As we have seen, stationary hydrogen and fuel cell applications are already in use and ready for greater volume penetration. Following sections and a proposal for practical implementation processes will show how implementation can be introduced at the national level.

3.1.4. Economic analysis of hydrogen fuel cell vehicles compared with conventional vehicles

The costs estimates for hydrogen drive systems are the most important factor after oil prices, hydrogen feedstock and production processes. In addition, it’s also necessary to include CO2 emissions as a factor.

A question mark still remains regarding the cost of the drive system; on the other hand, however, we can estimate infrastructure costs based on recent hydrogen projects. The aim of development

³ Primary markets comprise gas heating technologies; conversion markets include coal, wood and oil heating systems as well as heat pumps

should be to bring the cost of hydrogen vehicles down close to the price of conventional vehicles.

There are four factors that influence competitiveness of hydrogen and petrol or diesel vehicles:

- Price of crude oil
- Price of hydrogen (infrastructure costs)
- Internalization of CO₂ emissions
- Hydrogen drive system costs.

Source: (HFP, 2006)

Figure 10 (below) shows specific additional costs and savings for a FCV compared with a conventional vehicle. The higher cost of CO₂ emissions and the cost of crude oil can save costs during the implementation process.

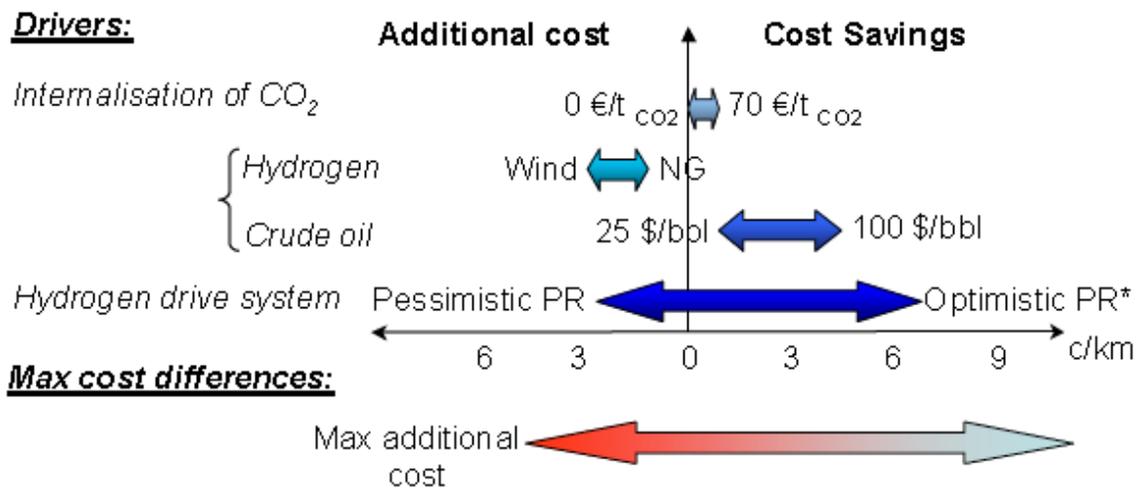


Figure 10: Specific additional costs and savings for a FCV compared with a conventional vehicle, Source: (HFP, 2006)

A good example is the capital city of Slovenia, Ljubljana. On the outskirts of the city is the industrial complex Belinka, where hydrogen is used in their industrial processes. Analysis showed that this hydrogen can also be used for fuel cell hydrogen vehicles. This approach can reduce initial costs (no hydrogen production required), when a refuelling station already exists in Ljubljana and only distribution and storage need be put in place.

Competition between hydrogen and fuel cell vehicles and conventional vehicles running on petrol and diesel is fierce. One should note that this new technology will not take over the entire vehicle market but only a portion of the vehicle sector. The next two chapters will briefly cover infrastructure requirements and what codes and standards need to be updated to allow the new technology to be used.

3.1.5. Infrastructure

In hydrogen implementation, infrastructure consists of the production, distribution, storage and refuelling of hydrogen. Production and distribution of hydrogen is already in place and employed in industry. Infrastructure for conventional petrol and diesel vehicles already exists. Building an infrastructure of a similar size for hydrogen and fuel cell vehicles will take time and require considerable financial investments. In the early stages existing infrastructure (industry, pharmaceutical, and gas transport vehicles) should be used to reduce the cost of transition and service first several vehicles in use. This section already shows that government with its policy or technical measures can greatly support implementation of new technology.

Therefore, the literature review will briefly cover only major topics for consideration, while each infrastructure component could well warrant its own thesis treatment.

Hydrogen is produced in large quantities in many countries. “The amount of hydrogen produced is over 50 million tons per year worldwide” (Raman, 2004; IEA, 2007).

A report from the American National Academy of Science shows that building of refuelling stations for hydrogen will grow in proportion to vehicle demand. Initially, when there are only few vehicles in use, it is very likely that distribution of hydrogen from the production facility to refuelling station will be done by truck. When the number of vehicles increases, hydrogen refuelling stations will be built with production of hydrogen on site. This approach will eliminate the need for distribution and on-site production capacity will be built according to demand.

(National Academy of Sciences, 2013)

There are already technologies available for on-site hydrogen production that work in the existing infrastructure:

- Natural-gas reforming – The process is the same as that used in today’s large natural-gas reforming facilities, with smaller reforming apparatus for fuel and packaged such that it

looks like a large appliance. These reformers have been demonstrated at a number of hydrogen-fuelling stations in the United States, Europe, and Japan.

- Water electrolysis – Commercial alkaline water electrolysis units are available and have been demonstrated in small hydrogen stations.
- Biofuel reforming – Ethanol reforming and other biofuel reforming have been demonstrated in laboratories, but Research and Development (R&D) is still needed to increase hydrogen yields and lower costs to be competitive with small natural-gas reformers and small water-electrolysis methods.

Source: (National Academy of Sciences, 2013)

The clean hydrogen cycle consists of producing hydrogen from renewable energy, then storing it, and transporting it to the end consumer, where it can be converted into electricity and heat using a fuel cell. Most of the techniques for this cyclic process are available today. However, they are not yet cost-competitive with fossil fuel technologies (Hočevár, 2008).

In 2006 was in Slovenia carried out national research project “Slovenia in transition to hydrogen economy” (SPEV). Project was one of the “targeted projects” (CRP) carried out by the Slovenian platform for hydrogen and fuel cell. Main objectives of the project were:

- Current state analysis of potentials and development trends in the field of biomass in the world and in Slovenia in light of using hydrogen technologies;
- Current state analysis of potentials and development trends in the field of fuel cell systems for mobile applications;
- Current state analysis of potentials and development trends in the field of fuel cell stationary applications
- Development of price model for fossil fuels from 2007 to 2023 on global and national level;
- Potential for production of hydrogen in Slovenia

Based on the project SPEV outcomes, three potential options of hydrogen production in Slovenia are presented here without going into details: nuclear energy, water electrolysis and hydrogen from biomass. Slovenia already has a working nuclear power plant. Nuclear energy is possible option for production of hydrogen without GHG emissions. Advantage of hydrogen production

from nuclear energy is in large quantities that can be used for large populated areas. Because of the Slovenia's size, this could be an option for centralized production and distribution. There are two methods for production of hydrogen from nuclear energy. Low temperature electrolysis is a proven commercial process which is inefficient and highly dependent on the price of electricity. Second, long term option is production of hydrogen 'using high temperatures from an advanced nuclear reactor. These advanced nuclear reactors are known as generation IV nuclear reactors and they are designed to be more efficient, safer, and more economical than the current version of light-water reactors' (Hočevar, 2008).

In 2006 Slovenia produced 43, 1 % of electricity from hydropower (Slovenian Environmental Agency, 2011) and this is one of the most feasible renewable options for future hydrogen production. Hydrogen can be produced from water using the process of electrolysis to split water in oxygen and hydrogen. Electrolysis is considered to be potentially cost-effective means of producing hydrogen on a distributed scale and at costs appropriate to meet the challenges of supplying the hydrogen needed by the early generations of fuel cell vehicles. Electrolyzers are compact and may be situated at existing fuelling stations (Spath, 2001).

In 2008 Slovenia's land was covered in 58, 2 % by wood biomass (Slovenian Environmental Agency, 2011) This is a great renewable potential also for hydrogen production. Among the options for production of hydrogen from wood biomass is gasification or pyrolysis. Current technologies converting biomass into molecular hydrogen include following main conversion processes:

- Indirect heated gasification
- Oxygen-blown gasification
- Pyrolysis
- Biological gasification (anaerobic fermentation) (Hočevar, 2008)

Produced hydrogen needs to be distributed and stored in safe and efficient manner. It can be distributed over the pipelines (gaseous) or in tanks with the trailers in gaseous or liquid form. At the end use facility, hydrogen can be stored above and underground in liquid, gaseous and solid form. Form and position of the storage depends on quantity and purpose of the hydrogen use. For the purpose of this paper, storage will not be discussed further.

Work from Achtnicht shows a link between the availability of infrastructure for new fuels and the amount of implemented vehicles. Moreover, new technology vehicle prices are far higher than conventional vehicles. Therefore, if construction of infrastructure is not adequately supported, the implementation of new technology will be delayed (Achtnicht, 2008).

Following the benefits that come with the introduction of hydrogen and fuel cells, leading energy companies have started to prepare strategies for the introduction of hydrogen fuel. Preparing such strategies is a challenging task that must also consider cost-effective pathways and consumer demand. Because hydrogen introduction is a reality, researchers have even started to develop programs to help with the development of inputs like pathways, and to include cost, operability, reliability, environmental impact, social and safety implications in the decision making process. Such programs can work on multiple performance criteria, including optimization of investment and environmental criteria (Andre, 2005).

The implementation of hydrogen infrastructure depends on the country's economic conditions, energy demand and requirements, transportation issues and more. Such modelling could be applied to different scenarios, geographical regions and case studies (Andre, 2005).

A positive implementation process scenario for hydrogen and fuel cell technology is, among other things, heavily linked to the availability of low cost hydrogen. All three infrastructure components – production, distribution and storage – are developed in the research environment and deployed in demonstration projects. The missing link is actual infrastructure for everyday users (Moore, 1998).

The government needs to take into consideration the fact that alongside developing the technology it needs to find solutions as to how growing fleets of such vehicles can be supplied with hydrogen (Moore, 1998).

The work of Gross, Melaina, Bush, GermanHy and the EU project show that fuel costs will be competitive with gasoline or diesel. In addition, results show that future business scenario for hydrogen can be compared to today's petrol and diesel business, and hydrogen will be sold in the same product group at the refuelling station alongside conventional fuels (Gross, 2012; Melaina, 2008; Bush, 2012; GermanHy, 2012; HyWays, 2008).

The work of Eberle shows that demonstration projects reveal obstacles that need to be resolved during the transition from demonstration to real customer purchase of vehicles on the market, the two most common being:

- Cars are more costly than conventional cars
- The refuelling infrastructure is less dense.

Source: (Eberle, 2012)

At the time of writing this thesis, the price of a hydrogen vehicle is around €65,000, while for a conventional vehicle the price is closer to €20,000.

As seen in previous sections herein, the government can introduce tax incentives and subsidies to overcome the challenge of the higher costs for hydrogen and fuel cell vehicles.

The work of Gross shows that production and distribution of hydrogen already exists for other hydrogen applications and industrial processes. Their extension/expansion into the transportation sector for vehicle refuelling supply would be profitable from the very beginning (Gross, 2012). Governments need to be involved in the planning of refuelling stations and harmonize this with the number of user-vehicles. Geographic concentration of the technology and deployment of coordinated infrastructure is part of the larger solution, and governments will play an important role (Eberle, 2012). “Germany is a good example; the H2Mobility coalition is a joint industry and government-driven approach to achieve this alignment” (Eberle, 2011).

In smaller countries, such as Slovenia, governments are debating how many new refuelling stations should be supported. A report by GermanHy on customer needs shows that only a small number of refuelling stations are needed to support the first wave of implementation. “With this approach, considering Germany again, as few as 140–220 refuelling stations would be sufficient to roll out the first 100.000 fuel cell cars” (GermanHy, 2012). “Complete area coverage could be achieved with as few as 1,000 hydrogen stations, which would be able to serve the first million FCEVs” (GermanHy, 2012). A similar study on the European level (HyWays, 2008) states: “Since these stations do not provide a return on investment due to the so-called “retail station dilemma”, government support for the companies setting up such a structure is needed” (Eberle, 2012).

As has already been said, in order to use this new technology on our roads, existing codes and standards need to be updated for the safety of the new users. The next chapter provides an introduction into this issue.

3.1.6. Hydrogen and fuel cell codes and standards

We already have confirmed codes and standards for hydrogen and fuel cell vehicles and stationary applications. Codes and standards help decision-makers; local authorities and industry develop and implement this technology safely and efficiently.

The list of all codes and standards is extensive. Work from fuel cell standards shows which codes and standards exist, and countries have frames of regulations for the implementation of the technology without boundaries. Codes and standards can be accessed at

www.fuelcellstandards.com. (Fuel cell standards, 2015)

The distribution and delivery of hydrogen is well known in industry, as are industrial filling installations. There is a challenge for inclusion in the environment (urban sites, public) and improved performance of the new technology (autonomy, fast filling). Environmental policies will need to be updated to support the inclusion of refuelling stations in the spatial planning scheme (e.g. safety distances around LH2 storage).

Developing infrastructures for hydrogen supply will require:

- Better harmonization and standardization in risk assessment analysis methodology – worst case accident scenarios
- Standardization for implementation of new technologies and new components
- Improving feedback from Hydrogen projects
- Sharing and harmonization of RC&S programs between Europe, USA and Japan

Source: (Wurster, 2004)

A look at the link above reveals the great number of codes and standards that were updates so we consumers can use the new technology safely and efficiently. Some codes and standards are also linked to environmental requirements. Already a decade ago, Jeremy Riffkin said that the hydrogen economy also has enormous potential to become a CO₂-free economy. The next chapter shows the environmental benefits of introducing hydrogen and fuel cells.

3.2. Environmental Benefits

Use of hydrogen has a great potential on the Environment; air quality and PM10 particles can be reduced significantly when used in transportation or home energy generation for heating. The

following chapter shows to the reader environmental benefits of using hydrogen together with the fuel cell.

The fact that we reproduce and live in a finite world with limited resources served as the starting point of many largely sound discussions and hypotheses on the evolution of mankind throughout history. But only relatively new data on mankind's impact on the environment has triggered a far more serious, scientific approach to studying the anthropogenic changes of the environment in which we all live. "There is no doubt now that the enormously fast (exponential) growth of prevalently Western societies in the last hundred years was due to a unique, relatively secure and above all cheap energy source – oil. However, we are facing the universal oil peak, after which the supply of oil will lag substantially behind demand" (Kenneth, 2006).

Other sources also point to the same direction: "If we want to survive, we need to half the present emission levels of greenhouse gasses by 2050" (Ernst, 1997). What is evident from all of these studies is the fact that whatever scenario one decides to implement, changing only a single fundamental parameter (e.g. lower population growth or boosting food production or increasing material production) while the other inputs remain intact at the "business as usual" level, results in mankind sooner or later facing an environmental pollution crisis, which will eventually result in the collapse of mankind, returning population levels and its corresponding activity to pre-1900 levels! (Ernst, 1997). Only the right combination of properly timed preventive actions can lead this complex system dynamic to a stationary state in which sustainable life on Earth is possible. However, all of these analyses agree at least on one point: there is no time left for "wait and see" behaviour, we all must act now, if it's not already too late.

Building the initial infrastructure for FCV demands high levels of investment. On the other hand the environmental impact of fuel cell vehicles is very small compared to petroleum-fuelled vehicles.

One research paper studied the change in emissions in a case wherein FCVs came to dominate the US market. It was assumed that fossil fuel ICEs would be replaced by hydrogen FCVs. Emissions were analysed after the production of hydrogen using decentralized steam reforming of natural gas, decentralized electrolysis powered by wind power, and centralized coal gasification. Conservative estimates were made to strengthen the credibility of results, which were compared to a 1999 vehicle fleet base case (Colella, 2005).

Reduced emissions are the distinct advantage of FCVs over ICE fossil fuel vehicles. In nearly every case, net quantities of Nitrogen Oxides (NO_x), Volatile Organic Compounds (VOCs), particulate matter (PM_{2.5} and PM_{2.5e10}), Ammonia (NH₃), and Carbon Monoxide (CO) would decrease significantly. The conversion to either hybrid vehicles or to hydrogen vehicles derived from natural gas, wind, or coal would reduce the global-warming-impact of GHGs by 6, 14, 23, and 1%, respectively. Moreover, even for an inefficient hydrogen supply chain, where the FCVs are fuelled by natural gas, no carbon is sequestered, and we allow for a 1% methane leak from feedstock, the scenario still achieves a reduction of 14% in CO₂ equivalent greenhouse gases (Colella, 2005).

A report by HyWays shows that “hydrogen can become a cost-effective option for the reduction of CO₂ in the long term (total well-to-wheel reduction of CO₂ emissions will amount to 190 – 410 Million Ton (Mton) per year in 2050 for the 10 countries analysed in the report). Secondly, it indicates that hydrogen introduction may lead to a substantial improvement in the security of energy supply (the total oil consumption of road transport would fall by around 40% by the year 2050 compared to today’s levels if 80% of the conventional vehicles on the road were replaced by hydrogen vehicles). Thirdly, the project highlights that hydrogen, if produced through sustainable pathways, offers the opportunity to increase renewable energy utilization in Europe (hydrogen could also act as a temporary energy storage option and might thus facilitate the large-scale introduction of intermittent resources such as wind energy)” (HyWays, 2008).

The work of McKinsey & Company shows that hydrogen and fuel cell vehicles can reduce local CO₂ emissions under the condition that hydrogen is sustainably produced (McKinsey & Company, 2010).

A report by the HFP shows that reducing CO₂ emissions does not play a major role in the financial decisions of consumers. CO₂ emissions can be a decisive factor for consumers only when hydrogen and fuel cell vehicles are the same price as or competitive with conventional vehicles. Looking forward, hydrogen and fuel cell vehicles coming onto the market will lead to a great reduction in CO₂ emissions (up to a factor of 10 for every vehicle substituted). The environmental benefits will not end with CO₂ emissions, but other emissions such as PM₁₀ and local noise impact, too, will be reduced (HFP, 2006).

A report from Tyndall shows that hydrogen has the potential to reduce the various environmental impacts of transport and enhance energy security as well as reduce CO₂ emissions (Tyndall, 2002).

Recent research showed progress in the field with modelled information for battery-powered electric vehicles (BEV) and for FCV. One single technology will not resolve the problem with GHG. This is why modelling scenarios are very important. Below we see a “model output showing greenhouse gas pollution over the century for a reference case with no alternative vehicles, for the four main vehicle scenarios, and for two secondary scenarios; the upper dotted horizontal line corresponds to the 1990 light duty vehicle GHG pollution, and the lower line represents an 80% reduction to below 1990 levels” (Veziroglu, 2010). In Figure 11 below we can see GHG pollution for light duty vehicles.

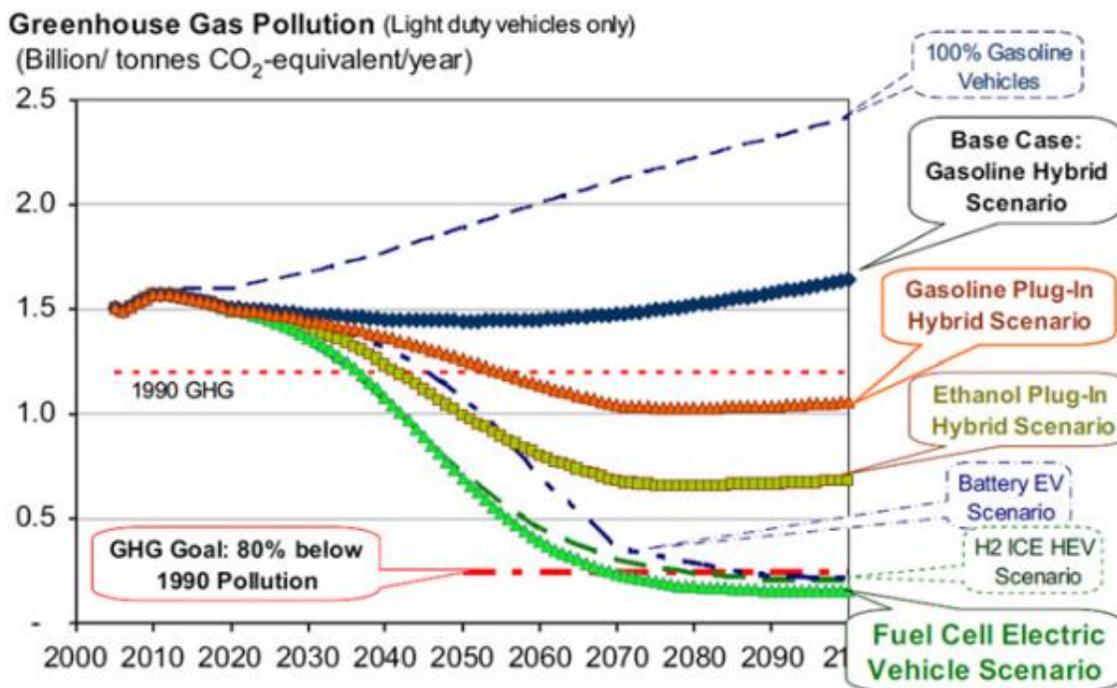


Figure 11: GHG pollution for light duty vehicles, Source: (Mori, 2009)

To meet stringent climate change targets, such as stabilizing CO₂ concentrations below 550 Parts Per Million (PPM), or limiting the global temperature rise to 2 C above pre-industrial levels requires drastic CO₂ reductions of 60–80% in 2050 compared to 1990 emissions, which is a daunting challenge (Ball, 2009). To achieve this we need to start thinking about cleaner

technologies and mitigation actions across all sectors, such as improving energy efficiency, Carbon Capture and Storage (CCS) and the use of renewable energies or nuclear power. Countering these environmental concerns, one such solution is the transition to a hydrogen economy (Ball, 2009).

One important environmental problem alongside global pollution is local air pollution and air quality, which impact human health and the cost of urban emissions needs to be separated from total quantified emissions.

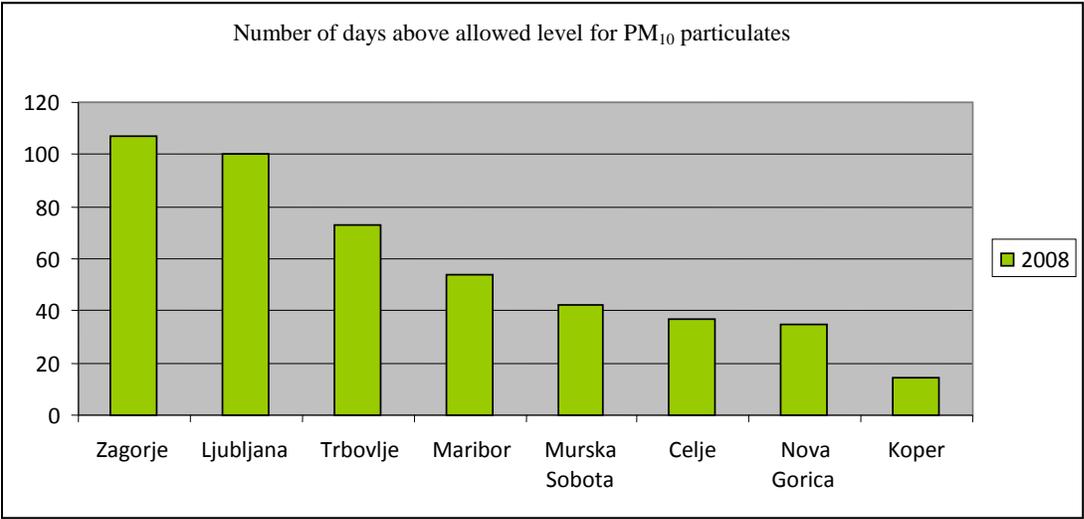


Figure 12: Slovenian cities with the number of days above the levels allowed for PM₁₀ particulates, Source: (SVPS, 2010)

Figure 12 above shows Slovenian cities with the number of days above the levels allowed for PM₁₀ particulates; 38% of these emissions derive from transport (SVPS, 2010).

The total cost of urban emissions will depend greatly on our choice of future vehicle platform. In Figure 13 below we can see the costs of urban air pollution for the major alternative vehicle scenarios over the century; the bottom line shows the particulate matter costs from brake and tire wear common to all vehicles.

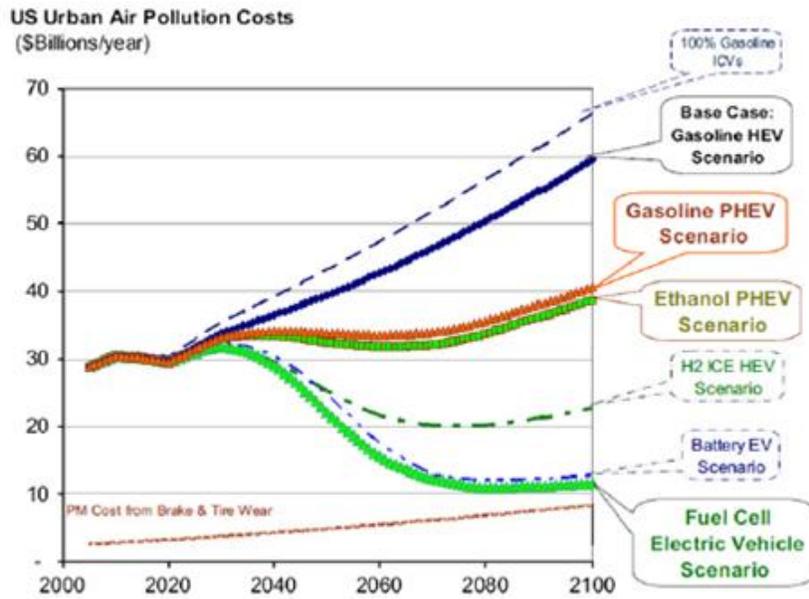


Figure 13: The costs of urban air pollution for the major alternative vehicle scenarios over the century, Source: (Mori, 2009)

Stationary applications can significantly contribute to the lowering of CO₂ emissions.

The image below shows the environmental benefits of a stationary fuel cell compared to the conventional technology in use today. A renovated home in Germany e.g. has an annual heat demand of some 21,400 Kilowatt Hours (kWh). Four residents could lower annual CO₂ emissions by about 1/3 if they chose a stationary fuel cell application over the conventional condensing boiler (FCH, 2015).

In Figure 14 below we can see an example from the FCH report – the environmental benchmarking of a stationary fuel cell application in German residential buildings.

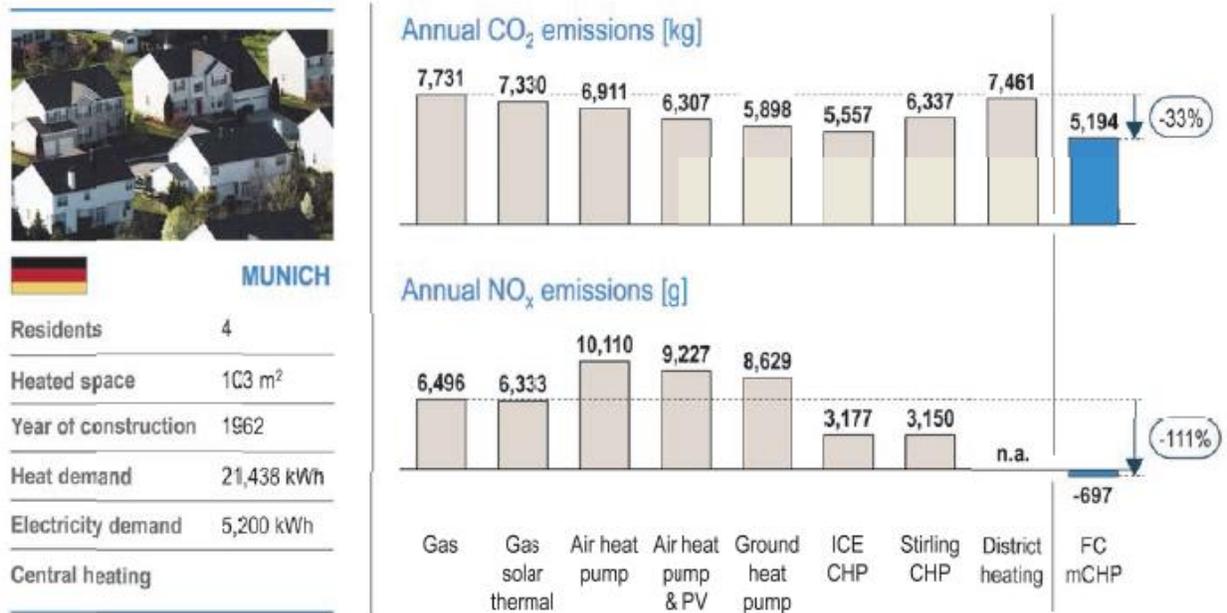


Figure 14: The environmental benchmarking of a stationary fuel cell application in German residential buildings, Source: (FCH, 2015)

One should know that at the moment 95% of research or work is focused on the development and improvement of components in fuel cells or in the process of hydrogen production. This is evidenced by Fuel Cell Expo 2012 in Tokyo, Japan or World Hydrogen Energy Conference 2012 in Toronto, Canada. The focus of the presented work was on technical improvements and not on implementation models on a national scale.

Some countries did present demonstration projects; however, they were not on a national scale. Future work should focus more on the development of implementation models to broaden the implementation of hydrogen and fuel cells.

The above-mentioned passages outline the problems with air quality and other emissions that are produced in the energy, domestic and transport sectors. Politicians should consider this information when considering new advanced technologies. As is shown, hydrogen and fuel cell mobile and stationary applications hold great potential for reducing emissions in the environment and can play an important part in the transition to a low-carbon society.

Governments and politicians play an important role in the implementation process of certain technologies with policy, policy development and other legislative support. But first we need to understand how the political game is played and why sometimes it takes so much time to

introduce markedly straightforward solutions. The next few chapters offer a peek into the political world and how it is managed. As with other issues tackled herein, the following chapter provides only a sample of the dynamic that is politics. More extensive research on each of the following chapters requires specific individual thesis work.

3.3. Political and non-political actions

This chapter presents to the reader the context of politics and how political actions can greatly support implementation of new technology. It also shows how new technology shifts powers of the political parties and thus resistance for implementation of certain technology can come up if one loses power to another.

The work of Buchanan shows (Buchanan, 2013) that influence extends far beyond personal acts such as requests or the exchanging of favours. Influence can also be seen in actions such as blocking, delaying, or closing off access to information – all in order to push through particular ideas and priorities (Buchanan, 2013). Self-interest is one of the political features that can influence decision-making concerning new technologies. Self-interest has traditionally been recognised as the single main defining feature of political behaviour (Burns, 1961). Self-interest can be seen as benefitting an organization or simply serving a personal goal.

Misuse or abuse of political process and privilege can be damaging and measures presented as necessary can have negative consequences. It is necessary to evaluate implementation measures in terms of both positive and negative effects. Negative effects need to be minimized and the consequences of poor decision-making need to be accepted. At the end of the day, ministers are people and they will make mistakes or take bad decisions in the management of any particular ministry.

Power in politics can be described as a tool of politicians employed to implement their own ideas over those of others. Politics can be seen as power in action using different techniques and tactics to influence and achieve certain (one's own) goals (Badham, 1999). In most cases ministers from certain political parties are trying to achieve goals that are set out in the party's program.

There is no such thing as personal autonomy when dealing with politics. Personal autonomy is only a term in the political game. "Most individuals are not merely the subjects of power but play a part in its operations" (Rose, 1992).

Elected government needs to establish its operations through ministries to achieve its program priorities. New technology can receive the support of the government if the government decides so. This can be done owing to “an elaborate network of relations formed amongst the complex of institutions, organizations and apparatuses that make it up” (Harden, 1986; Schmitter, 1974).

Government is a source of strategies, techniques and procedures with which different “influences” seek to make programs operational and by means of which a multitude of cooperation is established between the authorities and individuals or groups. In the literature this is called ‘Technologies of Government’ (Miller, 1990; Harden, 1986).

Further, the structural frame of government and of connections reflects on power as an effect of such structure (Latour, 1986). A minister can, through political action, successfully “enroll and mobilize persons, procedures and artefacts in the pursuit of its goals” (Latour, 1987).

The personal experience of the author of this thesis shows that Slovenian politicians do not like experts, nor like them to be included in the process of forming policy or technology implementation. Experts are included in the process of policy development only as a “must”. Experts pose a problem for political authority. “Experts have the capacity to generate what we term enclosures: relatively bounded locales or types of judgement within which their power and authority is concentrated, intensified and defended” (Giddens, 1985).

Again, the author’s personal experience shows that decision-making in the Slovenian government is not a matter of choosing between adopting and not adopting a certain technology. It is a choice between adopting now or postponing the decision until later. In many cases the second choice can be reduced to: “until I am on position this will not happen, and if it happens later it is not my concern any more”. Thus it is effectively reduced to the first choice but in a “smarter” way.

The work of Bronwyn shows that government institutions have a powerful influence on the adoption of certain technologies in the form of incentives, policy development and adoption, and/or in executing PR campaigns to increase public support. (Bronwyn, 2003)

The work of the Bruegel Institute shows that government shall consider pursuing course of continuity with policy development while implementing new technology (Bruegel Institute, 2012). Policy development (clean air, new alternative fuels, climate change, etc.) is necessary to bring new technology on the market. The existing legislative framework supports conventional petrol and diesel vehicles which are strongly embedded in our everyday lives and lifestyles. The

work of the Bruegel Institute study suggests three steps for easier implementation of new technology where government can play a role:

- First, the scope, geographical coverage and duration of carbon pricing should be extended. By setting a higher carbon price, incentives for developing and investing in new low-carbon technologies are created.
- Second, temporary consortia for new infrastructure to solve early-phase market failures could be put in place.
- Third, an open and public transition model is required so that transport solutions do not go ahead and are later reversed.

Source: Bruegel Institute, 2012

In 2001, Laurence Baker produced a study where he researched the influence of health insurance on the uptake of new medical procedures. He showed that if the government introduces the reimbursement of a certain procedure then this new policy will be adopted by the players on the insurance field (Baker, 2001).

Other factors and regulations, besides market development, also influence the uptake of certain new technologies. One of them is environmental regulation. The Minister for the Environment has the power to implement technologies. He/she can propose certain environmental laws or decrees that can directly affect the adoption of certain technologies. With policy development, laws can either directly prohibit or require the use of certain technology or production methods” (Bronwyn, 2003).

The work of McKinsey & Company shows that governments play a vital role in creating a supportive implementation environment. “All electric vehicles are viable alternatives to ICEs by 2025, with BEVs suited to smaller cars and shorter trips, FCEVs for medium/larger cars and longer trips. With tax incentives, BEVs and FCEVs could be cost-competitive with ICEs as early as 2020” (McKinsey & Company, 2010).

Studies were carried out that support the above conclusions (Gray, 1998). In 1970, the Environmental Protection Agency (EPA) was formed and the Government began taking the primary role in setting and enforcing environmental regulations with much stricter implementation policies. (Bronwyn, 2003) The American environmental regulations of the 1970s and 1980s affected the types of technology the paper and pulp industry chose to adopt and employ.

Many ministers and ministry people were/still are technocrats working according to the notion – Fewer decisions will bring fewer mistakes. Therefore, result: good minister. This is too often the case, which is closely linked to securing votes in the next election cycle.

Theoretical background on the political dynamic aside, the work of e.g. Foley shows that political support in the form of policy development plays an important role in the process of implementing new technology.

Emissions policies in the transport sector are crucial for a proper assessment of all of the benefits of hydrogen. The European Commission has the power to exert enormous influence in the implementation of alternative fuels through passenger and light duty emission standards and energy efficiency targets and goals.

Refuelling infrastructure is, according to the work of Foley, overshadowed by the notion of “what came before, the chicken or the egg” (Foley, 2001). On one side, vehicle manufacturers do not want to produce the vehicles because of the lack of infrastructure; on the other side, fuel suppliers do not want to build infrastructure because the demand for (their) fuel is too low. The government shall be the one to introduce new policies to support the introduction of new vehicles and the building of infrastructure (Foley, 2001). Foley continues that introduction of the vehicles should start with bus fleets, and continue with public authority and corporate fleets. As we have noted in this chapter, politicians and ministers have a decision-making “remote in their hands”. Implementation of the technology is solely in their hands. Theory supports this, as does the personal experience of the author, who was involved in just such processes where certain decisions escalated or buried a certain topic. The next chapter introduces some theory-based background on change and naming the person who starts with the change process.

3.4. Change and change agents

People see new thing as a change and the one who suggested new thing as a change agent. This chapter shows to the reader what theory says about the change and change agent. One should understand the theory first before implementation process of new technology is prepared.

The Oxford dictionary defines change as follows: “make or become different”. In the context of this thesis, change needs to be involved in management of the organization and in the relationship between the minister responsible and the administration. Each change has a starting point, called a change agent. A change agent is most commonly a person that introduces the idea

for a change into procedure. In the case of corporations, senior managers or even chief executives are chosen to introduce change because of their ability to effect change (Fischer, 2015). In the case of ministry management, it is ministers (or organizational management) who can the start change of a subject (changing laws or decrees).

In the context of this thesis, a change agent also needs to be identified as an outside influence on the decision-making in the country, in the form of EU regulations, OECD advice, None Governmental Organizations (NGO) proposals and market requirements. However, these change agents will not be analysed further herein.

Literature review shows a body of research from different philosophies of organizational change to analysing individual theory and looking for pros and cons.

Organizational change philosophies can be divided according to Aaron, 2011 as follows:

- Rational philosophy
- Biological philosophy
- Institutional philosophy
- Resource philosophy
- Psychological philosophy
- Systems philosophy
- Cultural philosophy
- Dualities philosophy
- Critical philosophy

Source: (Aaron, 2011)

There are literatures that support or reject the form of change agent in politics.

Voyer (Voyer, 1994) and Peled (Peled, 1999) offer that the change agent must be included in the management process of organization, and Hardy (Hardy, 1996) argues that power provides the energy for change. This is especially true for the minister. The minister at the responsible ministry has the levers to propose or stall a change if this is in the interest of him/her or his/her political party.

On the other hand, Ferris and King (King, 2010) argue that change agents should avoid politics. For the purpose of this work, the question is not whether the involvement of politics is a positive or negative thing in the process nor where the change agent should be. The question is how to

propose a system that will enable the change agent to shift, after every election, the national strategy for the development of certain technological fields in another direction.

Kumar and Thibodeaux (Kumar, 1990) argue that change agents have to adjust their political game according to the degree of change. For the first level, change that involves improving the effectiveness of work can be the responsible head of department. Second level change involves introducing new perspectives that can be introduced by the State Secretary or Minister. The Head of Department usually does not have the power for this kind of introduction. Third level change concerns large shifts in values and working practices in an organization that can be introduced by the State Secretary or the Minister. The more significant the change and its implications, the greater the political involvement required by the change agent” (Buchanan, 2013).

Change on the organization level requires a development strategy. The strategy needs to have the support of the Minister and requires certain specific tasks, clearly assigned responsibilities among the support staff, achievable deadlines, monitoring, a contingency plan in case of problems, monitoring and communication activities (David, 1998).

Change starts with the managers or directors of the company, based on their work experience or outside influence (in government agencies changes based on political decisions) (Carnall, 1995; Car, 1996).

Resistance to change can also be seen in the industrial sector of certain countries. At this point government shall consider addressing the issue and deciding what instruments should be employed to encourage industry to adopt the new technology or to make a shift in research, development, production and implementation.

All changes need an efficient execution plan. A change model for making change work is presented in Figure 15 below.

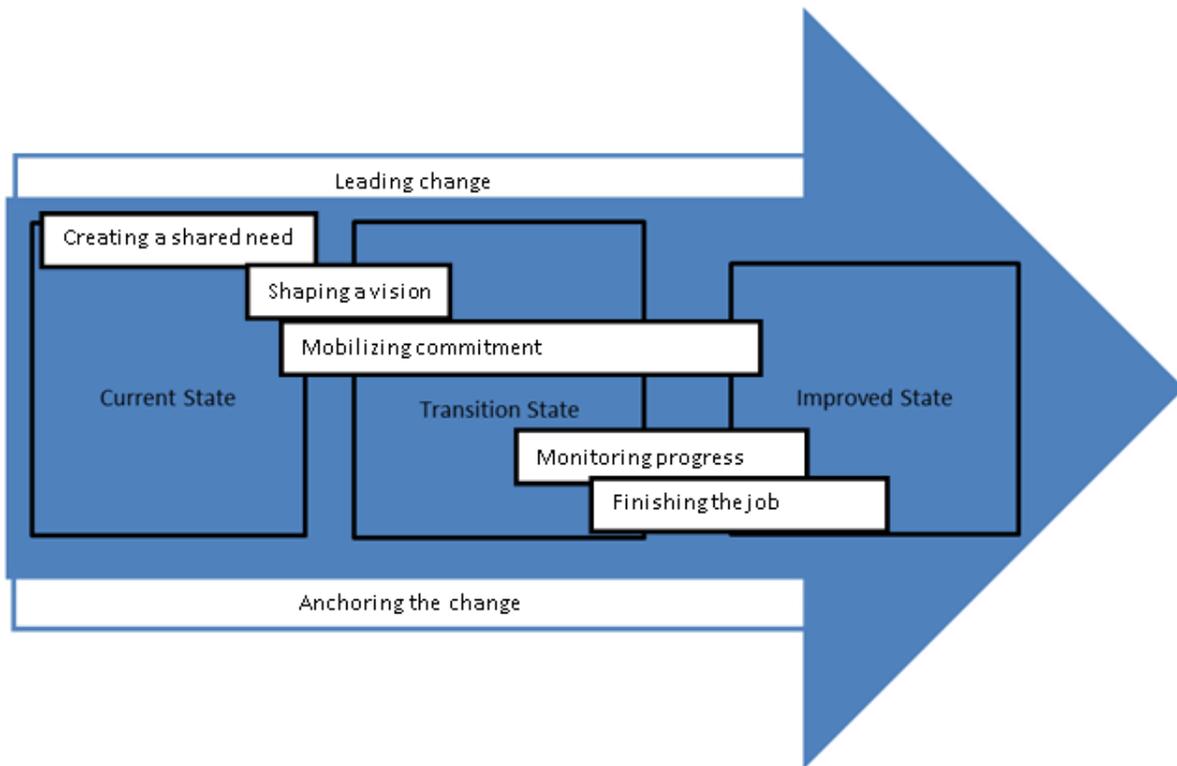


Figure 15: Change model for making change work (Palmer, 2003)

All changes proceed from the current condition through a transition step, concluding in the desired state. At the outset we need to create a shared need that is clearly understood, together with the results of change. When the change starts to take place, it is vital that there are sufficient resources that can dedicate their time to carry out the task efficiently proficiently. When the work is completed, monitoring tasks need to be in place to track new conditions and check whether the process is completed. In addition and most importantly, the change process needs to have the backing of top management people to assure smooth transition.

Governments need to intervene and encourage the implementation of hydrogen and fuel cells to overcome the initial high costs of hydrogen usage (Tyndall, 2002). Governments need to emphasise the importance of perception and the challenge in presenting hydrogen as the intelligent and current, smart option (Willson, 2002).

Outlining the information gathered from the review on organizational change, we find different opinions and assumptions – what organizational change is, its nature, and proposed solutions for execution. Research shows that introducing change requires different approaches to

implementation and a firm understanding of the current environment and the topics/subjects we would like to change (Morgan, 1997). A minister cannot manage a ministry the same way a worker in industry manages machines. A ministry needs to be run as a living organism and different complementary concepts need to be fused. Flexibility is important in the operating environment, bringing together different interests in order to find a way to innovate. However, an order must be established to ensure that innovation remains focussed and relevant (Aaron, 2011). Further literature review shows that change is introduced because it is necessary and because people did not do their job properly. Implementation of change is usually forced as a result of the failure of people to create continuously adaptive organizations (Dunphy, 1996). A minister can take the same approach if they produce results that conclude that a certain technology is no longer efficient or new technology can contribute to improving air quality, etc. All ministers should have knowledge of “behavioural science-based theories, values, strategies, and techniques”. Only in this way can he/she effect efficient organizational development, achieve the planned change and enhance the individual development and performance of the employees tasked with the job (Porras, 1992).

Implementation of technology also has background in organizational philosophy, which theory is called episodic change. “This form of change is called “episodic” because it tends to occur in distinct periods during which shifts are precipitated by external events such as technology change or internal events such as change in key personnel” (Weick, 1999).

In Figure 16 below we can see the elements of episodic change.

	Episodic change
Metaphor of organization	Organizations are inertial and change is infrequent, discontinuous, intentional.
Analytic framework	Change is an occasional interruption or divergence from equilibrium. It tends to be dramatic and it is driven externally. It is seen as a failure of the organization to adapt its deep structure to a changing environment. Perspective: macro, distant, global. Emphasis: short-run adaptation. Key concepts: inertia, deep structure of interrelated parts, triggering, replacement and substitution, discontinuity, revolution.
Ideal organization	The ideal organization is capable of continuous adaptation.
Intervention theory	The necessary change is created by intention. Change is Lewinian: inertial, linear, progressive, goal seeking, motivated by disequilibrium, and requires outsider intervention. 1. Unfreeze: disconfirmation of expectations, learning anxiety, provision of psychological safety. 2. Transition: cognitive restructuring, semantic redefinition, conceptual enlargement, new standards of judgment. 3. Refreeze: create supportive social norms, make change congruent with personality.
Role of change agent	Role: prime mover who creates change. Process: focuses on inertia and seeks points of central leverage. Changes meaning systems: speaks differently, communicates alternative schema, reinterprets revolutionary triggers, influences punctuation, builds coordination and commitment.

Figure 16: Elements of episodic change, Source: (Weick, 1999)

In his work Pfeffer shows his management model constructed around seven performance management practices that result in innovation, productivity and profitability, which are:

- job security
- selective hiring
- self-managed teams and decentralization

- extensive training
- narrowing differences in status
- sharing of information
- high and contingent compensation

Source: (Pfeffer, 1992)

Further literature review shows a connection between the theory and implementation of new technology. Implementation of new technology is infrequent and done once, is slower owing to system change and consumer uptake, incomplete because of the learning curve and through implementation problems are fixed, is strategic because with new technology the government would like to achieve certain of its goals, is more formal because policy needs to be formed, more disruptive because changes need to be made in conventional living practices, and initiated by change agents at higher levels such as those of minister or prime minister (Mintzberg, 1992). “The role of the change agent in episodic change is that of prime mover who creates change” (Weick, 1999).

It is evident that the success of the change process depends on the power of the change agent. The higher in the hierarchy the change agent is, the easier the change will be introduced. However, each change can come up against resistance to the change. Resistance can be seen in the administration of the ministry, if the change agent is the minister, or in the minister if the change agent is an administrator at the ministry, or if the suggestion comes from the general public, from experts, etc. The next chapter will therefore provide some background on resistance.

3.5. Resistance

Change and change agent one hand has resistance on the other. As presented in the previous chapter, change will create some resistance. Resistance can come up because of loss of power, lack of knowledge about certain technology or additional work. This chapter lays down theoretical examples on what the resistance is.

During the introduction of change by the change agent, resistance can arise among organization employees or political parties. User resistance can be defined as a psychological process on the personal level. (Jermier, 1994) It reflects one’s behaviour in reaction or relation to an ongoing situation it considers negative (Ang, 1994) or a threat (Kvale, 1996). When we try to understand

personal or group resistance, we need to understand that “at group level, users’ resistance is often socio-political, whereas at the individual level it is more psychological (Markus, 1983).

Resistance is the response of people to change, and will happen during the process whether the change agent likes it or not. To understand resistance, we need to understand that resistance is a response to an emotional process (Halley). The resistance response is triggered when we do not feel safe or do not know what the change will include (Prochaska, 1983). Many times resistance is triggered when people at a certain organization do not have proper information regarding the change process or do not have expert knowledge of a certain topic.

There is no solution with which to present resistance through numbers, as each example can have specific responses (Halley). The solution is to present resistance in the form of behavioural responses. Understanding responses can help us identify resistance and find solutions to overcome it. Some identified resistance behavioural responses appear in the form of requests for more details, attack and silence.

Resistance between parties involved in the implementation of new technology can escalate to the conflict stage. Conflict is described in research papers as “disagreement of persons or groups of persons considering a situation as inconsistent with their own interests” (Boulding, 1963; Robbins, 1974; Milton, 1982; Giddens, 1985). For purposes of the thesis work, while implementing new technology, government can be affected by two types of conflict: conflicts about the new professional skills required and conflicts due to a loss of power.

Conflicts related to new professional skills deal with the knowledge capacity that public administrators and politicians need to gain while implementing new technology in the country. This knowledge is vital for efficient implementation and for public administrators and politicians to be up to the task. The situation in public administration in Slovenia is not considered particularly well. Many employees have little knowledge of new technologies; further, they are not even aware what new technologies are being prepared for introduction onto the market. In addition, business as usual processes at the ministries does not enable employees to attend training seminars and workshops, which only further hinders access to information about new technologies. This type of conflict is identified as Task Oriented (Robey, 2002; Markus, 2000) conflicts and can be overcome with specific acts and efficient project management.

Work by Aaron shows that every change comes up against some resistance. Every leader should bear in mind that every change creates winners and losers. To overcome or mitigate this fact,

time should be invested during the planning of the change process, properly identifying who will gain and who will lose. Planning of the implementation process of new technology and leaders' understanding of who will gain and lose as a result of change allows those involved to choose the right steps to prevent or minimize severe resistance during the process of implementation. "At the heart of strategic change plans beats the confirmation of the mission, goals, objectives and strategies of the organization" (Aaron, 2011).

The work of Stoker shows that to overcome resistance, specification of objectives and cooperation among policy developers is essential (Stoker, 1983).

Conflicts due to a loss of or shift in power have an influence over individual autonomy and the power to influence certain developments. Implementation of new technology requires a horizontally harmonized approach between governmental bodies and their public administrators. One ministry is in charge of research policy; another is in charge of deployment and implementation on a larger scale, and the third for adopting new educational programs and topics in schools to make sure there is enough skilled labour available when the technology comes to market. This approach can take some power and personal recognition away from individuals; and on the political level in particular a lack of power be one determination regarding what technology will gain implementation support.

Resistance to change has long been recognized as a critically important factor that can influence the implementation process of "change" (Waddell, 1998).

Resistance to change is caused by a variety of factors, including:

- Rational factors: resistance can occur where the employees' own rational assessment of the outcomes of the proposed change differ from the outcomes envisaged by management. (Ansoff, 1988; Grusky, 1970; Kotter, 1986)
- Non-rational factors: the reaction of an individual to a proposed change is also a function of predispositions and preferences that are not necessarily based on a rational economic assessment of the change. These may include uncertainty over the outcomes of implementing new technology. (Judson, 1966; McMurry, 1973; Sayles, 1960)
- Political factors: resistance is also influenced by political factors such as favouritism or "point scoring" against those initiating the change effort. (Grusky, 1970; Ansoff, 1988)
- Management factors: inappropriate or poor management styles also contribute to resistance. (Judson, 1966; Lawrence. 1954)

When introducing innovation or implementing change, forces of change and resistance are present (Tichy, 1986). These forces are present in different degrees at different stages of implementation of change. At the beginning, forces of resistance are higher; when change is implemented this value changes and forces of change increase. A good example from Slovenia is the introduction of market valuation of real estate. Even 10 years after implementation, several certified appraisers and experts in the construction field were against the implemented changes (Kovač, 2006). Resistance to change is based on the magnitude of change and the volume of users it will effect (Tichy, 1986).

As we have seen, resistance can be a challenge at any level due to loss of power or support for different solutions. This chapter focused on resistance in public administration and among politicians. However, some level of resistance can be also seen at the level of the general public in the form of social acceptance.

3.6. Critique on resistance and change agent

From the literature research and personal experience, I see that resistance has its roots in the motivation of the employees at the ministries or in state secretaries and ministers. Extending these problems to the members of parliament of different political parties, this can be seen as a managerial problem of each political party head in parliament. The literature describes resistance as a process, a curve or slope, etc. The greater the slope, the larger the resistance. Moreover, research from Coch, 1948 shows that that the top-down approach to introducing change is not democratic, and in so doing management diminishes the value of its employees. For purposes of this thesis, I will not take sides as to whether this is democratic or not. New technology needs a top-down decision making approach. Only this way can employees understand the goal and prepare the implementation process that will achieve it. I fully support the active involvement of the employees involved and exercise this approach every day as State Secretary. Personal experience shows me that employee suggestions do not have the support of the top management (State Secretary or Minister) and are doomed to failure. Moreover, research from Lewin, 1920 for example presents field theory, where changes are seen as a field of different forces. With all due respect to researchers, when a manager comes to the practical day-to-day of management, a lot of theory is not applicable – especially theory that is particularly abstract.

I tend to support that research wherein resistance is based on the personal level, that introducing change takes power from one and gives it to another, and that as a result politically-linked actors like state secretaries and ministers do not like to introduce changes or new technology. The unwritten rule in Slovenian politics suggests change needs to be introduced at the beginning of the mandate so that the voters have forgotten it by the time the next elections come around. As seen in the combined research in the previous two chapters, the research covers change agents, conditions of change, and the objects of resistance. Resistance is seen as bad information that can close the project down. Currently, I am leading operational activities on the second track of the Divača-Koper project. There is a public initiative and their activities have links to theory. Resistance can come from the one with power or, on the other hand, from the one that is powerless. In the case of this public initiative, their experts from different fields (economy, engineering, etc.) are not involved in the project – which is why they foment resistance among the public towards the project.

Research shows that resistance can be seen as negative information on the one hand, or, as seen from the managerial perspective, as an obstacle in the implementation process that can be overcome in the process of achieving the desired goal.

3.7. Social acceptance of new technology (hydrogen and fuel cells)

Every technology is subject to implementation acceptance by the general public. When one looks at the history of the diffusion of many innovations, we can see two common features characteristic of the implementation process: very slow process of implementation and wide variations in the rates of acceptance of different technologies (Rosenberg, 1972).

Most papers concerning public evaluation of hydrogen technology find that the general public is generally supportive of hydrogen technology on the one hand, and on the other hand general knowledge about hydrogen is fairly low (Achterberg, 2010). Support can be seen when change agents present the technology and the public sees the potential and benefits of hydrogen and fuel cells compared to conventional technology. When the public is asked about specific topics related to the technology, knowledge is low. This is to be expected because the technology is new and is not widely presented to the public. It is good when the public understands the benefits of implementation and is not familiar with the specifics. In this case, public education can be effected with articles in newspapers or marketing events where the public can see the

technology. Implementation is far much difficult if public does not understand the benefits of the technology.

Work by Scheufele and NP show that actual knowledge about a certain technology is not particularly important or influential in determining who supports what particular type of technology (Scheufele, 2005; Melaina, 2008) which is borne out by the work of Martin. The general public will come to know the technology the same way we learned about photovoltaics, battery-powered electric vehicles or how to navigate traffic roundabouts. Studies show that short-term exposure to FCVs and refuelling can improve a variety of impressions among participants. It is encouraging to note, for the future of FCV acceptance, that impressions of FCVs improve with exposure as opposed to diminish (Martin, 2009).

Before we start thinking about the transition to a hydrogen economy, the technology needs to be ready for the broader market uptake; at any rate bigger demonstration projects are needed and social acceptance need to be positive and supportive. Public awareness and acceptance of hydrogen should be high enough to guarantee the uptake of the products. (Martin, 2009) (Schulte, 2004) Public acceptance is very important for the development of national policies – a particularly popular technology can influence government policies. (Stimson, 1995)

The general public often uses shortcuts in understanding new technologies, and tends to lean on ideological predispositions and media portrayals rather than refer to any scientific explanations. This way they form judgements about issues about which they know very little. (Scheufele, 2005) This is related to the notion of “low information rationality”, which explains why people are able to make decisions about issues they know little to nothing about. (Ganzeboom, 1989) Work by the National Academy of Sciences shows that there is potential on the market for new alternative technologies, fuels and refuelling infrastructure that is consistent with the goal of reducing greenhouse gas emissions and lowering our dependence on oil. (National Academy of Sciences, 2013)

Literature review points out that consumer purchasing patterns and decision-making has been researched for decades. “The common conclusion is that buyers’ economic concerns are one of the primary drivers of almost all transactions” (Caulfield, 2010; Egbue, 2012).

Work by Rogers shows that when a new green technology is introduced onto the market, early adopters, such as innovators or the environmentally aware, will be the first to buy the technology (Rogers, 1962). Additional review shows that these two groups make up 16% of the consumer

base. Moreover, they are the ones who reject or adopt the new technology and guide other consumers (Rogers, 2003). “They set the stage by removing uncertainty about new products, policies or technologies, and by establishing a level of peer acceptability that makes more risk-adverse consumers comfortable with accepting them as well “ (Rogers, 2003).

During the ECTOS project, which was funded by the EC, an assessment and evaluation of socio-economic factors was carried out.

“Passengers on the buses claimed that they might even be willing to pay a higher price for fuel during the first introductory phases of hydrogen. The respondents also think that hydrogen can reduce emissions, being a clean energy carrier, and most people connect hydrogen with other neutral or positive concepts like ‘water’. Most passengers feel the fuel cell hydrogen-powered buses to be safe transportation, and the majority claim them to be less noisy and less polluting than the more familiar diesel buses” (Ectos, 2007).

In addition to the above, work by DaimlerChrysler shows that since 2003, buses and passenger cars running on hydrogen and fuel cells are in use in the USA, Europe, China, Japan and Australia. “Throughout the world, several thousand people are experiencing this quiet, zero emissions technology as part of their everyday lives. Fuel cell vehicles are used to deliver letters and parcels, as service vehicles, or simply as a means of transportation. Mercedes-Benz passenger cars, buses and vans with fuel cell technology – in total more than 100 vehicles – are operated by a variety of public and private sector institutions. As of 2006 over two million kilometres had been accumulated” (DaimlerChrysler, 2006).

Work from INE show that “93% of Icelanders support the government drive towards a hydrogen economy, with people feeling positive that fuel cells will provide a sustainable answer to the island's energy requirements” (INE, 2003).

Every new technology needs early adopters, as seen from the text above and in the chapter below. However, new technology needs to be accessible to and for the general population in order to be successful and retain a certain market share, to develop and mature.

3.8. Development and market penetration

This chapter shows to the reader theoretical grounds for development and market penetration. To some extent every change agent should consider the theory before preparing market penetration strategy.

Development and market penetration of any new technology follows a sigmoidal saturation curve, which can be roughly divided into three stages: the “incubation period” with little growth and accumulation of necessary knowledge and know-how; the fast market penetration period in which the potential market is conquered; and the saturation period in which the market becomes saturated with products of the new technology. For any small economy, especially if it is open enough, determining the right time for the economy to enter the “game” is of paramount importance. A small economy, if well organized, is capable of concentrating substantial efforts in terms of investment to become an early adopter of new technologies, but not for a longer, extended period of time. The right timing and the right time frame are crucial for decision-making in such cases. Slovenia has not sufficient economic resources or potential to become a leader in certain new technology development, but it can become an early adopter of such technologies, provided a certain level of socioeconomic development is achieved and certain boundary values for system development are fulfilled. The case of hydrogen and fuel cell technologies is very attractive for Slovenia for several reasons, among which are the relatively high rate of energy consumption with a structure of primary energy sources moving towards liquid and gaseous fossil fuels, with a high rate of greenhouse gas emissions as a consequence. The introduction of a new energy carrier produced by a high efficiency renewable energy source is therefore one way to practicing and achieving sustainability in Slovenia.

A report by Tyndall shows that there are many measures that governments can introduce to help with the transition to a new technology, some of which are listed below:

- Minimal or no tax on fuel for a guaranteed fixed length of time
- Marketing to raise awareness of hydrogen as a fuel
- Government funding of research and development
- Grants to offset the cost of vehicle purchase
- Where workplace parking levies and congestion charging schemes are in place they should favour alternative/hydrogen fuelled vehicles

- Introduction of low emissions zones

Source: Tyndall, 2002

A report by Foresight shows that development scenarios for implementation of hydrogen and fuel cell technology are well on the way. In Table 3 below are four such scenarios:

Table 3: Scenarios development for implementation of hydrogen and fuel cell technology,

Socio-economic scenarios for Hydrogen use	
World Markets	People aspire to personal independence, material wealth and mobility to the exclusion of wider social goals. Integrated global markets are presumed to be the best way to deliver this. Internationally co-ordinated policy sets framework conditions for the efficient functioning of markets. The provision of goods and services is privatised wherever possible under the principle of ‘minimal government’. Rights of individuals to personal freedoms are enshrined in law.
Provincial Enterprise	People aspire to personal independence and material wealth within a nationally-rooted cultural identity. Liberalised markets, together with a commitment to build capabilities and resources to secure a high degree of national self-reliance and security, are believed best to deliver these goals. Political and cultural institutions are strengthened to buttress national autonomy in a more fragmented world.
Global Sustainability	People aspire to high levels of welfare within communities with shared values, more equally distributed opportunities and a sound environment. In the UK, there is a belief that these objectives are best achieved through active public policy and international co-operation within the European Union and at a global level. Social objectives are met through public provision, increasingly at an international level. Markets are regulated to encourage competition amongst national players. Personal and social behaviour is shaped by commonly held beliefs and customs.
Local Stewardship	People aspire to sustainable levels of welfare in federal and networked communities. Markets are subject to social regulation to ensure more equally distributed opportunities and a high quality local environment. Active public policy aims to promote economic activities that are small scale and regional in scope, and acts to constrain large-scale markets and technologies. Local

	communities are strengthened to ensure participative and transparent governance in a complex world.
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Source: (Foresight, 2003)

In section 3.2 we find evidence that shows there are triggers for consumers and the factors they take into consideration when deciding to purchase certain technology. Table 4 below shows examples of them.

Table 4: Triggers for consumers and the factors they take into consideration when deciding to purchase certain technology,

Drivers and inhibitors for Hydrogen to 2050	
Security of energy supply	This includes issues of resource depletion, especially of oil and natural gas, and energy diversity. It also covers the operational security of the energy system.
Environmental impacts	This includes local issues of urban air quality from vehicle and other emissions. It also covers the extent to which global issues such as climate change will provide an impetus for H development.
Quality of life	This includes individual quality of life as well as the overall ‘public good’. These two dimensions are often in conflict with each other, for example in personal transport.
Trade and competition	This covers issues that are directly related to the globalised/protectionist axis of the Foresight scenario framework. It includes the extent to which trade is free and competitive, and the implications this has for the availability of technologies and resources for H energy systems.
Technological change	This is related to the previous category, and covers the extent to which new technologies for H production, transport, storage and use will be developed.
Policy environment	This includes the extent to which there will be direct policy intervention to encourage H, and the balance between this and market-driven development.
Empowerment	This captures the extent to which individual decision-making about energy and transport choices will be possible by consumers, and the

implications of this for H use.

Source: (Tyndall, 2004)

The transition process from an established world to a new one can be dramatically accelerated by new disruptive technologies that offer attractive prospects for new businesses, products, and markets with additional customer benefits. Figure 17 below shows a comparison of microprocessors and fuel cells.

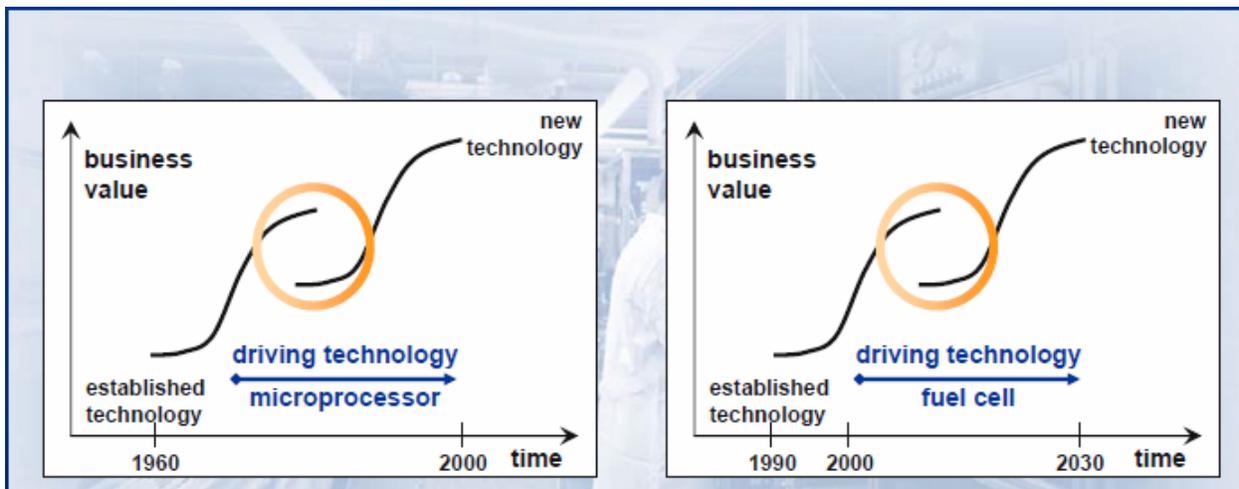


Figure 17: Comparison between microprocessors and fuel cells, Source: (Schuckert, 2006)

For new technologies governments can offer significant support for early market penetration in the form of policies, taxes or subsidies. Policies should support development of innovation and their deployment in everyday environments. The next chapter sets out some issues surrounding innovation.

3.9. Innovation

In view of the scope and context of this work, theories will not be explored in detail. Focus will remain on implementing innovations, and what the government's role in the process should be. Governments should have a favourable position on innovation.

Many theories deal with innovation – what innovation is how to explore it, and how to support its implementation? Work by Ettlie outlines the main four theories:

- Technology S-curve

- Punctuated equilibrium
- Dominant design
- Absorptive capacity

Source: (Ettlie, 2000)

Work by Smith shows that innovation is linked to the creation of new companies and ventures, which results in new jobs. Furthermore, innovation is linked to technology, which creates a need for high-skilled workers to fill high-income jobs (Smith, 2006).

There are several factors (Smith, 2006) government shall consider when planning interventions designed to assist during the implementation of innovation:

- Public nature of knowledge
- Uncertainty
- Complementary assets
- Network externalities
- Market inflexibility

There is a high level of uncertainty surrounding innovation/new technology. Uncertainty can be linked to technical issues or market preparation for implementation. Technical uncertainties arise when technology is not working properly in the research facility, and raises the question whether it will be working properly when introduced to the general public. Uncertainties in the market are linked with preparation designed to move the consumer to demand a certain technology or purchase a new technology at a certain price.

Afuah (2003) provides an example with the old technology in widespread use that can be, as an example, linked to hydrogen and fuel cells. When a certain technology is in widespread use (petrol-powered vehicles for example) consumers do not feel the need to switch to new technology. In this case, government can support the implementation of new technology with specific policies or subsidies. As a first adopter of the new technology, government can contribute significantly to faster implementation.

Government can support the adoption of certain innovations through a variety of policies:

- Technology forecasting
- Knowledge transfer
- Location

- Research and development
- Exploitation/licensing
- Lead user

Technology forecasting helps to spread and enhance knowledge at various ministries regarding current trends surrounding a certain technology and helps with future planning. Knowledge transfer is well demonstrated by an example from Slovenia, where knowledge is transferred from the Slovenian Research Agency to the government to help form policy and from there, to government agencies for implementation. Governments like that in the UK have had similar mechanisms in place since 1994 (Smith, 2006).

Work by Von Hippel (1988) shows that early users play an important role in the process of innovation. “Governments can have an important part to play, taking the role of lead user with activities such as:

- Allowing time for new/potential users to develop
- Acting as a demonstrator showing possible uses
- Interacting with the innovator to facilitate further development and improvement
- Stimulating demand.”

Source: (Smith, 2006)

Before we continue on to the practical process of the preparation of a national program for hydrogen and fuel cells, we need to understand the management hierarchy of the ministries and what influence each has. The next three chapters explain each of the management levels at the ministry and are linked to the government structure diagrams in section 5.2.

3.10. Political management

This chapter shows to the reader political decision making process or at least how should it look like. In politics sometimes decisions are not merely made on the outcomes of the researches, instead they are made also based on the political positioning to gain or lose power. This approach is more or less used on the ministry level.

Literature review shows us that there are different views and theories regarding political behaviour. Many conclude that politics is defined as the “behaviour of interest groups to use

power to influence decision making” (Pettigrew, 1973; Tushman, 1977), or coalition building and bargaining (Bacharach, 1980).

Politicians can use different means and tactics to influence the decision-making in organizations (Kipnis, 1980; Porter, 1981; Yukl, 1990). These tactics will not be researched in further details. However, it is important to know that the use of such tactics should be kept to a minimum. Decisions should be made based on research, with the inclusion of experts in the process. Only this way can policymakers ensure proper legislation that will work.

Work by Rosenfeld shows politicians also use an approach called impression management. This process refers to the process by which individuals try to influence the impressions others have of them (Rosenfeld, 1995). The aim of such tactics is to create a particular desired image in the minds of others. Similar are political skills. “Political skill is a relatively new construct that taps an individual’s ability in influence situations”. (Ferris, 1991) Political skills are linked to workplace interactions where individuals use the information of other people to his/her advantage” (Harris, 2007).

Political behaviour plays a more significant role in organizational life than is often recognized or in fact admitted. We like to think of our politics as being in order, rational, open, collaborative and trustworthy. The reality is on the other hand quite different. Many times we see self-interest and decisions defended in terms of political motives and behaviours (Buchanan, 2013).

It is vital to know that initiatives are followed, decisions are made and changes are implemented only to preserve and extend the power of individuals or groups.

“But change is often a significant element of the roles and responsibilities of most functional and general managers, as well as many other staff, at all levels” (Buchanan, 2013).

Research is scarce regarding the political influence on organizational change, and more focuses on the damage this kind of management can cause in the organization. Those who are involved in decision-making and change must realize that these are political processes and must get involved and act accordingly. “Before I served as a consultant to Kennedy, I had believed, like most academics, that the process of decision-making was largely intellectual and all one had to do was to walk into the President’s office and convince him of the correctness of one’s view. This perspective I soon realized is as dangerously immature as it is widely held” (Pfeffer, 1992). Work by Aaron shows that efficient change can only be introduced when leaders are actively involved in the process. “Leaders as implementers of change introduce new advantages and

disadvantages. Leaders hold responsibility and therefore invest their reputations in success“ (Aaron, 2011). In addition, success rests on the shoulders of the leader and his/hers personal involvement. Change of issues, topics or working processes lies in the hands of ministers and political parties. Ministers in particular can introduce proposals for new legislation or decrees that support the implementation of new technology.

Evidence from the research shows that technology is often seen as a neutral tool, something separate and distinct from political matters. However, one should know that technology implementation can have or create political issues, while technology itself is only the technical content component (Bloomfield, 1995). Implementation of new technology should have a political component only at the point of decision-making whether to go with a certain technology or not. The rest of the process should be based on formal analysis of the benefits of the technology and its benefits to for the people (Demarco, 1978).

Further, political involvement and poor management during the technology implementation process is seen as failure – especially if there is an alternative technology to consider. This needs to be done based on technical information and not on decisions that are political in nature (Bloomfield, 1995).

Further, the work of Bloomfield shows that every important issue regarding new technology implementation is dependent on the political and social interaction of different actors in the implementation process: ministers or horizontal ministry cooperation, administrative staff, experts, suppliers of the technology, etc (Bloomfield, 1995).

The minister and state secretary or political management as set out in this chapter are the two lead figures running the ministry. The minister decides the priorities the ministry will work on in a certain year and defends subjects and positions at government sessions led by the Prime Minister. The minister can provide development support for certain subjects or policies or simply shuts them down. The author adds from his personal experience that a minister may not know what kind of power they actually have and sometimes overreach his/her competences and scope with measures on issues that are covered by another ministry. The state secretary is the right hand of the minister who substitutes for the minister at government sessions and other official occasions when the minister is absent. State Secretary is a political and politically appointed position.

The next level down in the ministry hierarchy is the political/organizational management run by the Director General.

3.11. Political/organizational management

This chapter shows second level of the decision making at the ministries. Director General of different department more or less everytime accepts decisions based on the research results. Only in some cases the decisions are made based on the “political needs”. This chapter shows theoretical background to the reader.

Expert literature shows that field of organizational politics remains largely unexplored. (Ferris 1996)

Changing the balance of power is the main aim of organizational politics (Kakabadse 1984).

Pfeffer makes the connection between power and politics where he defines power as a means to influence one’s behaviour, to overcome resistance and to “do things that they would not do otherwise” (Pfeffer, 1992).

Sussman (Sussman, 2002) determined that different ways of communications are used by employees for distributing politically-framed and task-related messages. On one hand, face-to-face communication was used for political messages; on the other hand, written communication was only used for work-related content. This kind of approach is used to achieve political goals and not goals of the organization. “Informal influence tactics are considered a major dimension of organizational politics” (Allen, 1979; Buchanan, 1999; Gandz, 1980; Ralston, 1994; Sussman, 2002; Zanzi, 2001).

Reading through research papers it is clear that the main objective of political behaviour in an organization is to achieve personal goals and the goals of the group. Already in one of the first papers on organizational politics, Frost (Frost, 1977) writes that “political behaviour is used by the employees for their personal interest in the organizational processes”. “The nature of political behaviour is thus attributed to the intention of the employee using organizational politics” (Davis, 2004).

As mentioned above, personality characteristics are identified as the most important in the political involvement of employees. As Drory says (Drory, 1993), status is identified as playing an important role in predicting political behaviour. Employees with lower-tier positions in the organization are most negatively affected by organizational politics (Droy, 1993). This kind of

employee management creates dissatisfaction in the workplace (Drory, 1993; Novelli, 1994).

“The use of influence tactics in organizational politics was also found to be related to the status of political actors” (Kipnis, 1988; Sussman, 2002).

The second level of the ministry administration is in part still linked to the political management; however, in the majority of cases it comes down to the management of the directorate and involvement in policy development and running the “subject” part of the Ministry. At this level both political and organizational theories become mixed together, and the Director General should be experienced on how to juggle between political priorities and day-to-day subject work. The next level down are the sectors and sector leaders who have, in general, the least political involvement and are working closely on policy development and the preparation of expert background for them. Employees at this level are experts in certain fields, but this is not always the case.

3.12. Organizational management

This section describes to the reader organizational level at the ministries. This is expert level at the ministries where policy proposals are prepared. This is the level where political influence is the least.

Organizations are social phenomena (David, 1998). One of the most important issues in the organization is possibility and the level of human interaction. (David, 1998) If change is to be implemented on the organizational level, the following fields need to be taken in to account:

- Human psychology and personality
- Work organization
- General society

Human involvement in organizational structure and processes plays a vital role – achieving and implementing a change is even greater. The extent of employee involvement in influencing a planned change differs between companies and Government departments, so the “copy-paste” approach should not be taken. It is better to understand the theoretical approach and determine which is most applicable to the current organizational situation.

Two approaches to employee interaction are possible when planning organizational change.

In the first approach, organization director communicates the intent to change to the employees with the aim of effecting the most successful implementation. This is called the human relation type of approach and is the most frequently used in organizations these days (Brown, 1981).

Literature shows that this is not the only approach in the process of change implementation.

Taylor's model of personality and organization says that not everyone derives satisfaction from their work, and because of this they do not feel the need to be involved in organizational change (Braverman, 1974). Staffs in this case are motivated only by salary levels and are not interested in organizational change nor in the subject of the work are they carrying out.

Conditions in the Slovenian public sector, in the ministries working in the area covering hydrogen and fuel cells, reflect both approaches. Employees would like to see the first approach used in day-to-day business; instead a lack of communication and respect is present, which diminishes the desire to work and employees focus only on their monthly salary and putting in the required working hours. Many of these problems arise and persist because of poor management, a lack of knowledge and experience working with people.

Scientific literature points to cases where relations between management and employees are poor due to the lack of established authority and cooperation. Taylor argued that work designed rationally and in accordance with scientific principles would remove this conflict and would create a more cooperative working environment between management and staff (David 1998).

Work by Appelbaum shows that for an efficient transition to change, more than just leaders need to be personally involved – the transition works better when lower-tier public servants are also involved in the process (Appelbaum, 2008).

Organizational management in Slovenia can be more effective. A system for new technologies needs to be linked from policy and measure development at the Ministry with organizations that can implement measures – like a bank offering loans for new technologies. People appointed by the government sit on supervisory boards. They need to ensure measures in the form of loans are being offered by the banks such that companies can get access to them. Moreover, these appointed people also need to control how efficient implementation measures are, and report back annually to the policy developers on what should be changed to produce better results.

Work by Cline shows that the policy developer has control over the preparation and implementation process. The politics of implementation is viewed in terms of the administrative process, not as a basic contradiction of values (Cline, 2000). To overcome any objections in the

implementation process, leaders should improve communication, human resources and the bureaucratic process (Cline, 2000).

Work by Scheberle shows that communication processes are very important in the organization and among stakeholders to achieve successful policy implementation. As regards communication, organizational management leaders should think in and about two directions. The first is to clearly and consistently communicate policy content and goals that they would like to see implemented. This approach increases the likelihood of compliance and execution of a particular policy. Secondly, communication among the stakeholders is also very important. Policy should be developed for the people and administrative staff should know this. Clear cooperation among the stakeholders will result in better formed policies and decrees (Scheberle, 1997).

The personal experience of the author points to bad communication and cooperation between policy developers and stakeholders resulting in bad policy, delays in policy confirmation and practical problems after the policy is confirmed. At the organizational management level, policies and decrees are developed and in many cases stall if certain policy developments and resistance to change appears. Based on the work in the preceding chapters, the thesis is set out as shown below.

4. Research question and sub-question

Slovenia has the entire base necessary for the development and implementation of a hydrogen-based economy. It could be expected that Slovenia would already have implemented hydrogen stations and hydrogen fuel cell vehicles. Slovenia does not lag significantly behind other countries in terms of the selected structural (development) indicators, except in three areas, which reflects the considerable innovative potential of the country – as has been pointed out. Slovenia is lacking in the implementation of knowledge in technological development. Furthermore, during the implementation stage of new technologies, government organization is seen as a weak link. (Leben, 2008)

As seen in the register form, and as confirmed by the University, the objective of the thesis is:

- To develop a methodology for the creation of a national implementation program for hydrogen and fuel cells:
 - To have a clear understanding of the recent conditions in the country
 - Based on information gathered from other countries, to propose targets and plans to develop a national implementation program
 - To propose implementation measures and monitoring indicators
 - To identify the players on the national level that need to be included in the various steps of implementation

To be able to achieve these goals, I have proposed in the thesis registration process one research question and two research sub-questions with a practical sub-problem and the definition of conceptual problem.

Research question: How to improve the deployment environment in order to increase the implementation rate/level of hydrogen and fuel cell technology?

Definition of practical sub-problem: The first problem is dispersed government support (wide selection of technologies) for the deployment of new technologies. The second problem is the lack of a clear national roadmap for lowering GHG emissions. Both problems have conspired to slow the implementation of hydrogen and fuel cell technology. Thus arises the research sub-question: How to develop a national road map?

Definition of the conceptual problem: Confirmed national action plans indicate an implementation deficit of planned measures from the political sphere. The Political sphere is not

demonstrating their support for the inclusion of the financials in the national budget required to carry out the planned measures. Thus the research sub-question: How to select potential new technologies that will enable us to achieve the goals set out in the road map?

4.1. Explanation of the research question

The country's development strategy presents a path for the development of society. Slovenia's Development Strategy (SDS), confirmed by the Slovenian Government in 2005, sets out the vision and objectives of Slovenia's development, including five development priorities. At the forefront of the Strategy is the overall welfare of every individual. Therefore, the Strategy does not focus solely on economic issues but also involves social, environmental, political, legal and cultural issues. Due to such prioritisation of the objectives, the SDS (Slovenian Development Strategy, 2005) also serves as Slovenia's strategy for sustainable development.

The strategy sets out four strategic goals:

- To exceed the EU's average level of economic development.
- To improve the quality of living and the welfare of all individuals, as measured by indicators for human development.
- To enforce the sustainability principle as the fundamental quality measure in all areas of development, including the objective of a sustained increase in the population.
- To employ a distinct development pattern, cultural identity, and active engagement in the international community to become a recognisable and distinguished nation around the world.
- Source: Slovenian Development Strategy, 2005

The Development Strategy is an overarching document from which roadmaps for specific sectors are developed, based on the basic points set out in the Strategy. The Strategy does not include specific measures; instead it features statements or outlines a vision as to where the country would like to develop in certain sectors.

Each Roadmap should include different measures to achieve specific goals set out in the Strategy. The Roadmap is already more specific than the Strategy, and covers specific sectors and outlines the sector's goals (for example: 15% more vehicles on alternative fuels), timeframe and financing.

Further on, a more detailed document that continues from the Roadmap in the form of a Program for specific topics (e.g. Hydrogen and fuel cells).

Answering the research question will help to improve the preparation process and implementation of the specific Program.

5. Methodology of research to answer the research question

This chapter presents to the reader methodology of research and theoretical grounds.

Work on the thesis started with the decision to work with qualitative analysis and research questions. “The strength of qualitative research is its ability to provide complex textual descriptions of how people experience a given research issue. It provides information about the “human” side of an issue – that is, the often contradictory behaviours, beliefs, opinions, emotions, and relationships of individuals. Qualitative methods are also effective in identifying intangible factors, such as social norms, socioeconomic status, gender roles, ethnicity, and religion. When used along with quantitative methods, qualitative research can help us to interpret and better understand the complex reality of a given situation and the implications of quantitative data” (Mack, 2005).

Hydrogen technology is a new technology and there are not many experts who have horizontal experience on the implementation. “A good pragmatic reason for choosing a qualitative approach is that there are only a small number of people available to collect data from”. (Harding, 2013)

Work by Bryman indicates that qualitative research is largely unstructured, which is linked to an unspecified hypothesis. This is why qualitative research is, in all research structure, focussed on exploration. I agree with this statement, which is one of the reasons this approach was chosen.

Implementation of new technology involves unanswered questions and issues, especially when trying to gather information from different countries and transfer this knowledge to the Slovenian system. Qualitative research is in many cases focussed on discovering new fields of knowledge rather than on the proving or confirmation of certain data and facts. The result of such a research approach opens new fields and subjects for exploration that can be performed using the quantitative approach (Bryman, 2001). This statement further supports the decision to use a qualitative research approach for this thesis. Even when discussing the hypothesis, the exploration factor needs to be taken into account. It is more difficult to develop a hypothesis

around a new technology than around an established subject where years if not centuries of research has already been done.

Work by Carter shows that qualitative research is social research. The researcher works with textual data, not numerical data, and analyses it in a textual and not numerical way. This approach helps us to understand the social interaction component of human actions (Schwandt, 2000). As shown in previous chapters, resistance to change and change agents are linked to people – which constitutes the social component. This thesis could well be a social research project if one were to decide for such. Because we understand that people are taking decisions during the implementation, the personal approach (social research) component needs to be included. Qualitative research allowed me a wider field in which to interact with different respondents in each target group; naturally this is conditional on language and physical distance (in / from other countries).

This approach gives way to questions about certain discovered facts as they arise from the gathered data. On the other hand, the quantitative researcher tests out hypothesis set out in advance (Carter, 2007).

To be able to build on the theory, case study approach using four countries Germany, Denmark, Norway and Slovenia – was chosen, with a focus on governmental structure and the organizational structures both between the ministries and inside the ministry's' operational structure. The three comparison countries are leaders in the implementation of hydrogen and fuel cell technology in Europe. They have already developed national strategies for hydrogen implementation and already using and have in place production and distribution of hydrogen, and fuel cell production systems for portable, stationary and mobile sector applications. The leadership of these countries is well reflected in their respective implemented hydrogen technology and national strategy documents. The next chapter explains the case study approach.

5.1. Case study

As a case study research design, four European countries were chosen for comparison (case study): Germany, Denmark and Norway, Slovenia. These four countries with three different target groups constitute this thesis sampling groups (typical cases). This approach will help me understand the field from the centre (Jamie, 2013).

The first three are leaders in the implementation of hydrogen and fuel cell technology in Europe. They have already developed national strategies for hydrogen implementation, are already using it, and have in place hydrogen production and distribution schemes, as well as fuel cell production systems for portable, stationary and mobile applications. The leadership of these countries is well reflected in their respective implemented hydrogen technology and national strategy documents. Moreover, the three selected countries – Germany, Norway and Denmark – are among the top 10 developed countries based on HDI. The only other EU country ranked in the top 10 is the Netherlands (UNDP, 2014). “Unlike Gross Domestic Product (GDP) per capita or per capita income, the HDI takes into account how income is turned into education and health opportunities and therefore into higher levels of human development” (UNDP, 2014).

In addition, part of the decision to select these three countries lies in the fact that Germany is the leading EU economy, and ranks fourth in the world in producing 22% of its electricity from solar and wind sources (as of first half of 2015 (Irenanewsroom, 2015)). Denmark meets 41% of its electricity demand with wind (roughly 39%) and solar (2%) (2014), and estimates see this number rising to nearly 90% over the next nine years (Irena newsroom, 2015); and Norway, despite its vast oil and gas reserves, has adopted a national program for hydrogen and fuel cells and focussed development on renewable energy.

These three countries, however different in size and population, geography, natural resources, economic structure, political makeup and similar, have demonstrated good practice in the implementation of hydrogen and fuel cell technology. In addition, as seen in chapter 5.3, governmental structure and decision-making processes (laws adopted by the Government also need to be ratified in parliament) are very similar in all four countries. Therefore, they constitute a solid reference and reference point with which to compare Slovenia, and with which to analyse the main differences in governmental organizational levels that might hinder fast and comprehensive implementation of these technologies in Slovenia.

The purpose of the case study is to contribute to the aim of this thesis, and not to generalise the subject (Yin, 2003). The purpose of the case study is to better understand the systems in place in the selected countries and, based on the experiences of those countries, to propose an approach for the establishing of analogous system development in Slovenia. The targeted research aims to create both solutions to practical people problems and open goals for future scientific research. To achieve this, the researcher must on the one hand understand the system that is being

researched, and to cooperate with people working within this system to produce a solution that is people-friendly and efficient (Gilmore, 1986). With this approach in mind, the end results, practical process, of this thesis will help to change the implementation processes for new technologies.

During the qualitative research, the researcher samples targets directly to gather data that will answer the aim of the work instead of following some statistical representation scheme (Ritchie, 2003).

To be able to create an efficient national program one should know how ministries are structured and understand their daily business process. The government structure in chapter 5.3 deals only with ministries whose area of operations covers implementation of hydrogen and fuel cells.

Outside or external influence-factors presented in the figures is only intended as a reminder that EU Member States need to implement EU decisions and that governments will be reminded by the EU Commission or NGOs that the implementation process is bad. Similar structures can be created for different kinds of technologies or measures.

5.2. Methodology of country selection

More developed countries, in terms of higher education, investment in research and development of new technologies and the number of PhD researchers and engineers, are in a better position to develop efficient implementation programs for new technologies on the national level. (Leben, 2008) Furthermore, these countries also enjoy a supportive environment, with a more socially progressive approach to the technology to be implemented once it has been developed.

It is vital to understand that investments in research and development require large sums of money, which are more easily and readily devoted to such in countries like Germany and much less so in countries like Slovenia. In more developed countries, it is also easier to overcome the fear and uncertainties surrounding the outcomes of the new technology.

The methodology used here is based on a time “snapshot” that shows the degree of early market penetration of hydrogen and fuel cell technologies in mobile and stationary applications in three developed countries that lead in the development and early adoption of these technologies, together with the same for Slovenia. Socioeconomic development indicators were used to characterize these countries. Slovenia is characterized in this time “snapshot” with the same set of socioeconomic development indicators. “The classical approach of following the indicators in

time series for different countries and then statistically analysing them (using e.g. the time-distance methodology)” (Sicherl, 2007) is not possible in this case, since the introduction of hydrogen and fuel cell technology to the market in most countries is very recent (only a few years) and the time intervals differ from country to country.

The list of development indicators used by the European Commission has been followed in order to retain methodological coherence with existing statistical data for EU countries (Commission of the European Communities, Development indicators, Communication from the Commission COM (2001) 619 final, Brussels, 30.10.2001). The indicators are first divided according to the indicators of general economic background and specialized domains (Employment, Innovation and Research, Economic Reform, Social Cohesion, Environment). Balance between the domains listed is achieved using six indicators for each of the five domains and six general economic background indicators for a total of 36 indicators. For the purposes of this study only a limited number of indicators were used. These indicators were chosen to cover the following domains: general economic background, innovation and research, and environment.

In the earliest stages of hydrogen and fuel cell technology only these domains can be expected to reveal some degree of correlation with the specific technological indicators described below.

From the list of indicators in these three domains only those were chosen which link to the subject of this study:

- 1 indicator from the General Economic Background domain of indicators (GDP per capita in PPS)
- 5 indicators from the Innovation and Research domain of indicators (public expenditure on education, R&D expenditure, number of researchers, science and technology doctorates, patents)
- 5 indicators from the Environment domain of indicators (total energy consumption per capita, total energy consumption per capita / GDP per capita, percentage of renewables as percentage of total primary energy supply, greenhouse gas emissions, GHG emissions by country / GDP per capita).

Two indicators have been added that are not on the usual list of indicators: total energy consumption per capita and greenhouse gas emission. The first is used in the domain of General Economic Background indicators and the second in the domain of Environment. The total energy consumption per capita indicator is not on the list of EC indicators. The greenhouse gas emission

intensity of the economy indicator is a composite indicator analogous with energy intensity of the economy indicator used by the EC, and reflects how much GHG are emitted per unit of GDP for a certain country. The following chapter briefly explains the structural indicators.

5.2.1. Structural indicators as a basis for comparison

Comparing countries on the basis of the amount of implemented hydrogen technology is very difficult, because the technology is still either in the development or in the demonstration stage. This chapter shows to the reader structural indicators and its explanation.

The countries that have been chosen differ in size, wealth and governmental decision-making structure. Furthermore, these are European countries that need to follow EU directives on hydrogen and fuel cells and which Slovenia, too, should follow. They were chosen precisely for their active involvement in implementation in hydrogen and the amount/degree of implemented hydrogen technology. The size of the countries and/or their economies may be different, but fundamental issues such as education, research, number of patents and number of PhDs is integral to every country's structure and structural profile.

The list of development indicators used by the European Commission has been followed in order to retain methodological coherence with existing statistical data for EU countries. The indicators were first divided on the indicators of General economic background and on specialized domains (Employment, Innovation and research, Economic Reform, Social Cohesion, Environment).

Balance between the domains in this list is achieved with six indicators for each of the five domains and six general economic background indicators. This would give altogether thirty six indicators. These indicators were chosen to cover the following domains: General economic background, Innovation and research, and Environment. At the dawn of hydrogen and fuel cells technology only these domains can be expected to reveal some degree of correlation with the specific technological indicators described below. From the list of indicators in these three domains only those pertinent to the subject of the study were used, and these are:

- 1 (one) indicator from the General economic background domain of indicators (GDP per capita in PPS)

- 4 (four) indicators from the Innovation and research domain of indicators (public expenditure on education, R&D expenditure, number of researchers, science and technology doctorates, patents)
- 2 (two) indicators from the Environment domain of indicators (greenhouse gasses emissions, energy intensity of the economy).

Two additional indicators were added: total energy consumption per capita and greenhouse gasses emission intensity of the economy. The first one is used in the domain of General economic background indicators and the second one in the domain of Environment. The indicator of total energy consumption per capita is not present in the list of EC indicators. The indicator of greenhouse gasses emission intensity of the economy is a composite indicator analogous to energy intensity of the economy indicator used by EC. It reflects how much GHG are emitted per unit of GDP for certain country.

For the purpose of following the link between the above indicators and the implementation of the new hydrogen and fuel cells technology 3 (three) additional technology specific indicators have been used: production of hydrogen, number of hydrogen filling stations, and the number of hydrogen fuel cell vehicles (all per one million of population).

The indicators used in this study may be grouped hierarchically as follows:

- At the highest level are the most common development indicators Total Energy consumption per capita (TOT_EN) and the contribution of Renewables to Energy supply as percentage of total primary energy supply (REN_EN).
- On the level beneath are two indicators: Gross Domestic Product per capita (GDP in PPS) and GreenHouse gas Emissions per capita (GHG).
- On the next lower level are the indicators that presumably depend on GDP: total expenditure on educational institutions for all levels of education as percentage of GDP (GDP_EDU), gross domestic expenditure on R&D as percentage of GDP (GDP_RD).
- The next lower level belongs to the indicators that measure the effectiveness of these investments in terms of the total number of PhD graduates in science and engineering per million populations (PHD_NO) and in terms of Researchers, per thousand fulltime employed (RES_NO).

- At the bottom level are specific indicators which are “product oriented” like total number of Patents per million populations (PAT_NO) or indicators, which are pertinent to the specific technology development, like Hydrogen Production per year and per one million of population (H2_PROD), number of Hydrogen filling Stations per one million of population (H2_STNO) and number of hydrogen fuel cell vehicles per one million of population (FCV_NO).

Sources of information for purposes of statistical analysis included personal communication with the selected governments and national documents available on the Internet. I established personal contacts during personal work on the EU regulation of hydrogen vehicles representing Slovenia in Brussels as the national member of the Joint Technology Initiative (JTI) for hydrogen and fuel cells, and as the head of the Slovenian government group for hydrogen. Additional information and input came from personal communication with the automotive industry on exact figures for hydrogen vehicles on the road.

Slovenia is placed in the middle among EU member states according to development indicators but we are, at the moment, the only country without a national hydrogen strategy and implemented hydrogen technology on a broader scale.

From this we find an interest in comparing EU Member State models for the implementation of a hydrogen economy and motivation for the proposal and development of a national model for the implementation of hydrogen technology in Slovenia. The model should be based on the “environment” (politics, economy, industry, research) in Slovenia, with but a single objective: to produce a model that is not theoretical, but a practical model for implementation.

To date, no specific analysis or comparison of states exists, nor a definitive explanation why one country enjoys a higher level of implementation than another. Today only a broad picture of the current state of implemented hydrogen technology has been prepared of EU countries and the rest of the world. No extended background research has been done on the reasons behind the respective levels of implemented technologies and what approaches to implementation work better than others.

Furthermore, the work of Leben shows that a correlation between the overall development status of the country and implemented hydrogen technology exists (Leben, 2010).

Research contributed to further successful implementation of hydrogen technologies in EU countries and around the world.

Background information constitutes part of the fundamental structure of the thesis, which contributes to a better understanding of the development indicators and explains why certain countries were chosen for comparison. In the Methodology section the system of country selection is explained in more detail. Hydrogen and fuel cells are new technology, and there is no joint model with which to compare countries in terms of why and when implementation measures were introduced. Existing research should be linked and combined for easier implementation of new technologies.

The cross-national comparative study approach used represents a trial designed to identify a connection between a standardized set of national structural and innovativeness indicators using the indicators related specifically to the market penetration of hydrogen and fuel cell technology. There are at least two methodological problems here that must be dealt with:

- “The classical cross-national comparative study would involve the statistical analysis of indicators time-series. The simultaneous two-dimensional comparisons of time series data, vertically (standard measures of static difference) as well as horizontally (Sicherl, 2003), is a very practical application tool for monitoring the approach to targets at national as well as international levels” (Sicherl, 2008). However, this method could not be applied in this study since there is no time-series data for indicators of hydrogen and fuel cell technology market penetration for sufficiently long time periods (e.g. 10 years) in all four countries with which to compare.
- On the other side, starting time for the implementation of hydrogen and fuel cell technology in each of these four countries is different and inherently reflects the “maturity” (stage of development, innovativeness) of these countries to implement this new technology. We are in the earliest stages of market penetration for this technology, where each country has its own different starting position in time. In this way the time-distance factor is inherent to the cross-national analysis of indicators, and the “snapshot” in time used in this study in reality represents the time evolution of hydrogen and fuel cell technology market penetration in different countries according to their structural and innovativeness indicators.

This section explains the reader how the countries were chosen based on the development indicators. It is also vital to understand that there are limitations in this approach because to date, no specific analysis or comparison of states exists, nor a definitive explanation why one country enjoys a higher level of implementation than another. Units for each individual indicator are displayed in Table 5 below. In the next chapters, all eleven indicators are described.

5.2.1.1. Total energy consumption per capita

“Total energy consumption per capita refers to use of primary energy before transformation to other end-use fuels, which is equal to national production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport” (Bank 2015).

5.2.1.2. GDP per capita as a basis for comparison

“Gross domestic product (GDP) is a measure of the size of an economy. It is defined as "an aggregate measure of production equal to the sum of the gross values added of all resident, institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs)" by the OECD. GDP estimates are commonly used to measure the economic performance of a whole country or region, but can also measure the relative contribution of an industry sector. This is possible because GDP is a measure of 'value added' rather than sales; it adds each firm's value added (the value of its output minus the value of goods that are used up in producing it)". (OECD, 2014)

5.2.1.3. Total energy consumption per capita / GDP per capita

This is an indicator added the author aimed at gaining an understanding of how much energy can be purchased by residents on the national level based on the national GDP.

5.2.1.4. Percentage of renewables as percentage of total primary energy supply

Increased production of renewable energy is the only solution for minimizing the effects of GHG. This will result in slowing down the impacts of climate change. More governments are recognizing that the promotion of sustainable development is very important while developing national energy policies. Human development demands increased production of electricity, which results in big increases in harmful emissions.

Renewable sources are classified as hydro, geothermal, biomass, solar, wind, tidal and wave activity. Hydrogen can be produced using electrolysis, with the help/involvement of these sources. Together they offer an excellent solution to ensuring lower emissions from transport, households and industry. The implementation of hydrogen also supports the implementation of renewable energy where hydrogen is used as an energy carrier.

5.2.1.5. GHG emissions by country

Humankind, through population and industrial growth since the industrial revolution has raised the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 400 ppm in 2015. (Laboratory, 2015) This increase has occurred, regardless of the natural absorption process of gasses in forests etc. in the carbon cycle. Carbon dioxide (CO₂) emissions (i.e. emissions produced by human activity) is produced in the combustion of carbon-based fuels, principally wood, coal, oil, and natural gas. (Lindeburgh, 2006) It has been estimated that if greenhouse gas emissions continue at the present rate, the earth's surface temperature could exceed historical values as early as 2047, with potentially harmful effects on ecosystems, biodiversity and the livelihoods of people worldwide (Mora, 2013).

5.2.1.6. GHG emissions by country / GDP per capita

This is another indicator introduced by the author aimed at gaining an understanding of the amount of emissions produced in relation to the national level based on the national GDP.

5.2.1.7. Total expenditure per education as percentage of GDP

With this indicator we can establish the level of investment in a country that supports economic growth, improves productivity, works to improve personal and social development and reduces the disparity between its constituent groups. Investment in education is a priority in developed countries.

This indicator also includes investment (grants) through schools for students coming from low-income families. These grants provide such with the possibility of gaining a higher education. Furthermore, investment in research and development performed by educational institutions is also included in this indicator.

With this indicator we can establish the level of investment in a country that supports economic growth, improves productivity, works to improve personal and social development and reduces the disparity between its constituent groups. Investment in education is a priority in developed countries.

5.2.1.8. Gross domestic expenditure on R&D as percentage of GDP

Investment in research and development (R&D) is very important for the government and the private sector, which efforts lead to gaining a competitive advantage in science and technology. R&D includes innovative work undertaken during specific planned projects and initiatives with the objective of increasing knowledge among researchers, the general public and society as a whole. This new level of knowledge is then used to create new technologies and applications that can then be implemented in everyday use.

R&D needs to include:

- Experimental development as stage one;
- Further basic research as stage two;
- Applied research as demonstration projects in stage three.

During stage one work is focused to create the foundations of new technology for further research work. Most of this is theoretical work. During the further basic research stage, work already creates objectives for the practical use of researched technology. In the third stage of

applied research, practical ideas developed during the second stage are produced or installed as demonstration projects in a live environment.

R&D includes innovative work carried out with objective of increasing knowledge among researchers, the general public and society as a whole. The capacity that researchers build can help create an environment where young students can learn and gain experience with new technology. This is especially important for the implementation of new technologies like hydrogen.

In the early stage of the implementation and operation of new technology, countries like Slovenia need to go abroad and learn about the technology from foreign experts. Investment in the research and development sector is vital to support the development of knowledge that is brought in to the country from abroad. In this way, it is possible to ensure that capacity will increase steadily, and that knowledge will develop further in the country. The end result of a settled research environment in the long run is the country is able to research and operate technology on its own and develop further applications.

5.2.1.9. Total number of PhD graduates in science and engineering per million population

Doctoral recipients are those most likely to contribute to the development and distribution of knowledge, science and technology in a specific country. Doctorate holders are expected to contribute significantly to advancements in science, and are expected to pass on their hard-earned knowledge to other parts of society.

5.2.1.10. Researchers, per thousand full-time employed

Research personnel are a vital component in the research and development equation of certain technologies on the local, national, regional level. Researchers represent an outcome point for the development of knowledge, research process and new technologies. Researchers are needed in many sectors, including the military, universities and commercial institutions.

During the implementation of hydrogen technology, researchers play a vital role in explaining and helping understand how a technology works. A good understanding of the technology will help make decisions related to the actions required to create an environment that supports the implementation of the technology. First the technology needs to be understood. Only then will

politicians, governments and other institutions form a clear picture of how policies and strategies need to be developed to support implementation.

5.2.1.11. Total number of granted patents per one million population

The economies of every country are becoming increasingly dependent on intellectual property and patents, which play a vital role. The growing number of patent applications is coming from individual inventors, small and medium-sized enterprises, and research institutions. They are realizing the importance and economic impact of patenting their innovations. Only this way can industry mark is knowledge and make it recognizable around the world.

Countries recognize that the more patents that are granted on the national scale, the higher will be the level of innovations. High innovation rates result in economic growth. As a consequence, more money can be invested in research, development and deployment (R&D&D) in the future. Bigger companies have an advantage over smaller companies because of the costs associated with the patenting process. Industry has recognized that competition is strong, and that a small change in a product can represent an advantage in the market. As a result, companies are submitting applications for several variations of the same product.

Alongside industry, research institutions too are starting to patent their inventions and knowledge, which helps to transfer the knowledge from universities to the public.

Slovenian procedures for granting patents are different than in other EU countries; here the focus is only the granted patent and not on the process of confirmation.

Table 5: National development Indicators

Country name	Total energy consumption per capita in 2012 (Units: <i>kg of oil equivalent (kgoe) per person</i>)	GDP per capita in 2014 (Units: American Dollars)	Total energy consumption per capita / GDP per capita (Units: kgoe/\$)	Percentage of renewables as a percentage of total primary energy supply in 2013	GHG emissions by country in 2010 (Units: per capita (t))	GHG emissions by country/ GDP per capita (Units: tonnes of CO2 equivalents per person)	Total expenditure per education as percentage of GDP in 2011	Gross domestic expenditure on R&D as percentage of GDP in 2012	Total number of PhD graduates in science and engineering in 2004 per million population	Researchers, per thousand full-time employed in 2004	Total number of granted patents per one million population in 2005 or the latest available year
Germany	3,882	47,627.4	0,0815	25,4	9,115	0,1913	4,8	2,92	36,7	12,2	158,3
Norway	5,942	97,363.1	0,610	97	11,696	0,1201	6,6	1,65	35,2	17,26	37,2
Denmark	3,048	60,634.4	0,0502	30	8,346	0,1376	8,5	2,98	40,2	18,72	106,4
Slovenia	3,472	23,962.6	0,1448	21,52	7,482	0,3122	5,6	2,8	48,7	7,4	24,7

Sources:

Green House Gas emissions per country: https://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions

GDP per capita: <http://data.worldbank.org/indicator/NY.GDP.PCAP.CD>

Total energy consumption per capita:

http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?order=wbapi_data_value_2012+wbapi_data_value+wbapi_data_value-last&sort=asc

Source: Statistics for Slovenia received from Statistical Office of the Republic of Slovenia, other countries source is OECD

Source: Green House Gas emissions per country: <http://globalis.gvu.unu.edu/indicator.cfm?IndicatorID=199>, Energy consumption per capita: <http://earthtrends.wri.org/text/energy-resources/variable-351.html>

Total expenditure per education: <http://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS>

Gross domestic expenditure on R&D: <http://data.uis.unesco.org/?queryid=74>

Data for doctorate holders are taken from a working paper based on the first results from the data collection of the Career of Doctorate Holders (CDH) project launched in 2004 jointly by the OECD/Eurostat/UNESCO Institute for Statistics (UIS) (Auriol, 2007)

Statistics for Slovenia received from Mag. Rajko Sabo, Ministry of higher education, science and technology (MVZT), other countries source is OECD [2]

[http://documents.epo.org/projects/babylon/eponet.nsf/0/1EB44C9D02D1E04BC1257314004A60AC/\\$File/Total_european_applications_2006_inventors_residence.pdf](http://documents.epo.org/projects/babylon/eponet.nsf/0/1EB44C9D02D1E04BC1257314004A60AC/$File/Total_european_applications_2006_inventors_residence.pdf)

Source for Norway: http://www.patentstyret.no/upload/Filarkiv/aarsrapport2005/annual_report2005.pdf

Source for Canada: http://strategis.ic.gc.ca/sc_mrksv/cipo/corp/annual0405/report0405_part3-e.html#pt

Percentage of renewables as percentage of total primary energy supply in 2013 in Germany:

https://en.wikipedia.org/wiki/Renewable_energy_in_Germany#Statistics

Percentage of renewables as percentage of total primary energy supply in 2013 in Slovenia: <http://www.stat.si/StatWeb/pregled-podrocja?id=5&headerbar=4>

Percentage of renewables as percentage of total primary energy supply in 2013 in Denmark:

https://en.wikipedia.org/wiki/Renewable_energy_in_the_European_Union

http://www.nytimes.com/interactive/2013/03/24/sunday-review/how-much-electricity-comes-from-renewable-sources.html?ref=sunday-review&_r=0

Science and engineering graduates at doctorate level, 2009 As a percentage of all new degrees awarded at doctorate level:

http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011-en/02/01/g2-1-02.html?contentType=&itemId=%2Fcontent%2Fchapter%2Fsti_scoreboard-2011-12-en&mimeType=text%2Fhtml&containerItemId=%2Fcontent%2Fserial%2F20725345&accessItemIds=&_csp_=a382c3af48d8e5da1012b9268fb0890e

Stock of researchers: Head Count per 1 000 active labour force (2010) in Germany:

http://ec.europa.eu/euraxess/pdf/research_policies/country_files/Germany_Country_Profile_RR2013_FINAL.pdf

Stock of researchers: Head Count per 1 000 active labour force (2010) in Norway:

http://ec.europa.eu/euraxess/pdf/research_policies/country_files/Norway_Country_Profile_RR2013_FINAL.pdf

Stock of researchers: Head Count per 1 000 active labour force (2010) in Denmark:

http://ec.europa.eu/euraxess/pdf/research_policies/country_files/Denmark_Country_Profile_RR2013_FINAL.pdf

Stock of researchers: Head Count per 1 000 active labour force (2010) in Slovenia:

http://ec.europa.eu/euraxess/pdf/research_policies/Scorecards.pdf

European patent granted 2014 per country of residence of the first named applicant per one million population in 2005 or the latest available year: <http://www.epo.org/about-us/annual-reports-statistics/statistics/granted-patents.html>

5.3. Government structure

The next three chapters present government structure of chosen countries. The chapters present to the reader short description of the country and the decision making process. Preparation of the implementation plan needs to go in line with the decision making process to be the most efficient.

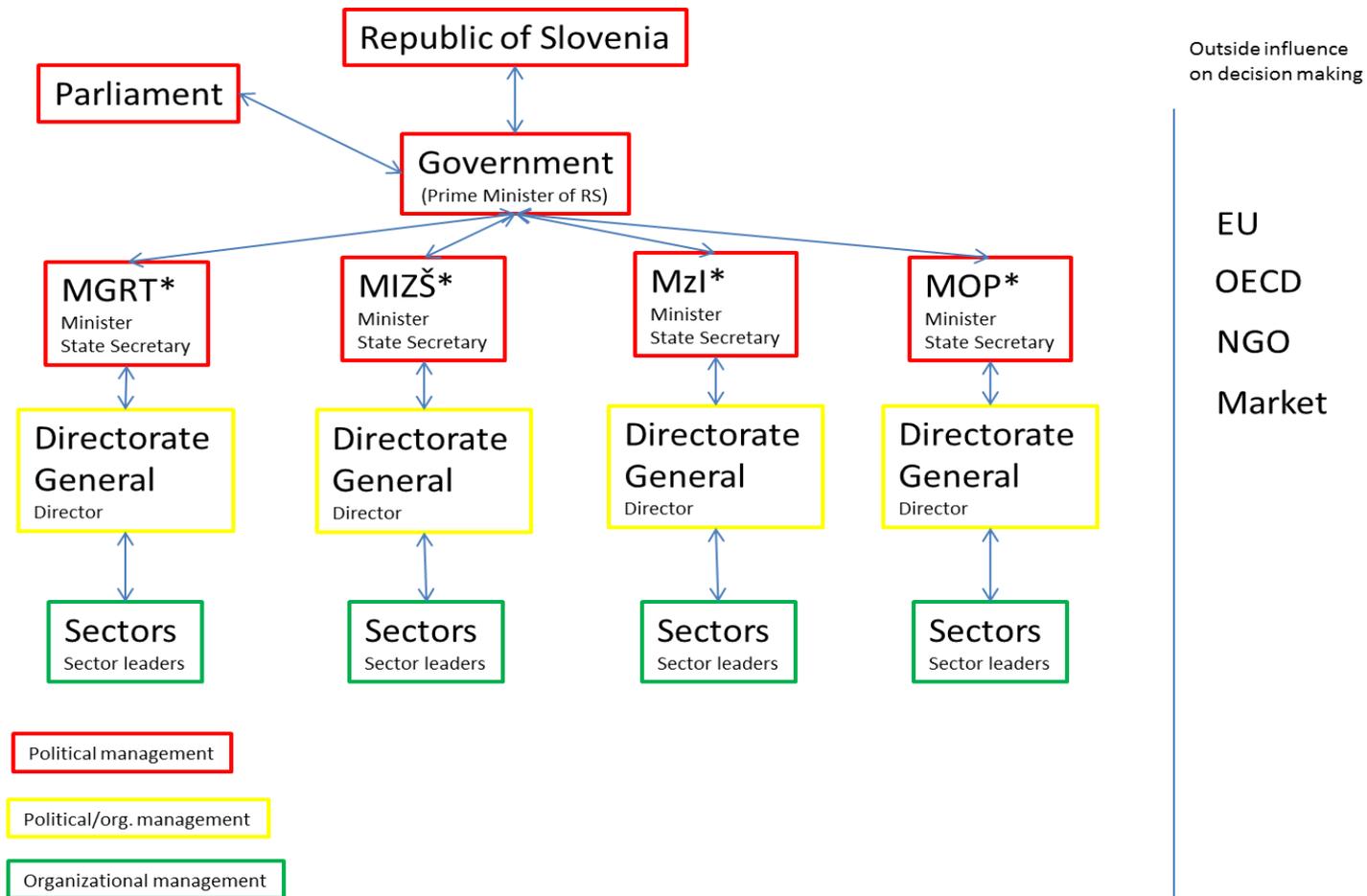
5.3.1. Slovenia

Slovenia is a democratic republic. The state's authority is based on the principle of separation between the legislative, executive and judicial branches. The highest legislative authority is the Parliament, which has the right to confirm laws (Government of Slovenia Communication Office, 2011).

The Parliament is composed of 90 members, with one representative for each of the Hungarian and Italian minorities. Members are elected to a four-year term; they represent all the people of Slovenia and are “not bound by any instructions” (Government of Slovenia Communication Office, 2011).

The Government of the Republic of Slovenia is a body with executive power and the highest body of the state administration. It determines, guides, and coordinates the implementation of state policies in accordance with the Constitution and with laws and other general acts passed by the Parliament. As the highest body of the state administration it passes regulations and adopts legal, political, economic, financial, organizational and similar measures for regulating areas within the state's jurisdiction. With regard to the EU, the Government represents the Republic of Slovenia and makes submissions to EU institutions. The Government functions are led by a Prime Minister and Ministers as heads of the Ministries (Government of Slovenia Communication Office, 2011).

The Slovenian decision-making process is very complex and it has its own country-specifics making it difficult for one to understand the process of developing strategies, laws and decrees. Figure 18 (below) presents the system of government and the type of decision-making. For the purposes of this work only ministries are included whose work covers the field of hydrogen and fuel cells.



*Ministry for economic development and Technology, Ministry for education, science and sport, Ministry for infrastructure, Ministry for the Environment and spatial planning

Figure 18: Government system and type of decision-making.

5.3.2. Germany

The head of the German Government is the Chancellor. Every four years, after national elections and the convocation of the newly-elected members of the Bundestag, the chancellor is elected by a majority of the members of the Bundestag upon the proposal of the President (Tatsachen, 2014).

Since Germany has a system of proportional representation for the election of its lower house, no one party wins an absolute majority of the seats and all German governments are therefore coalitions (Tatsachen, 2014).

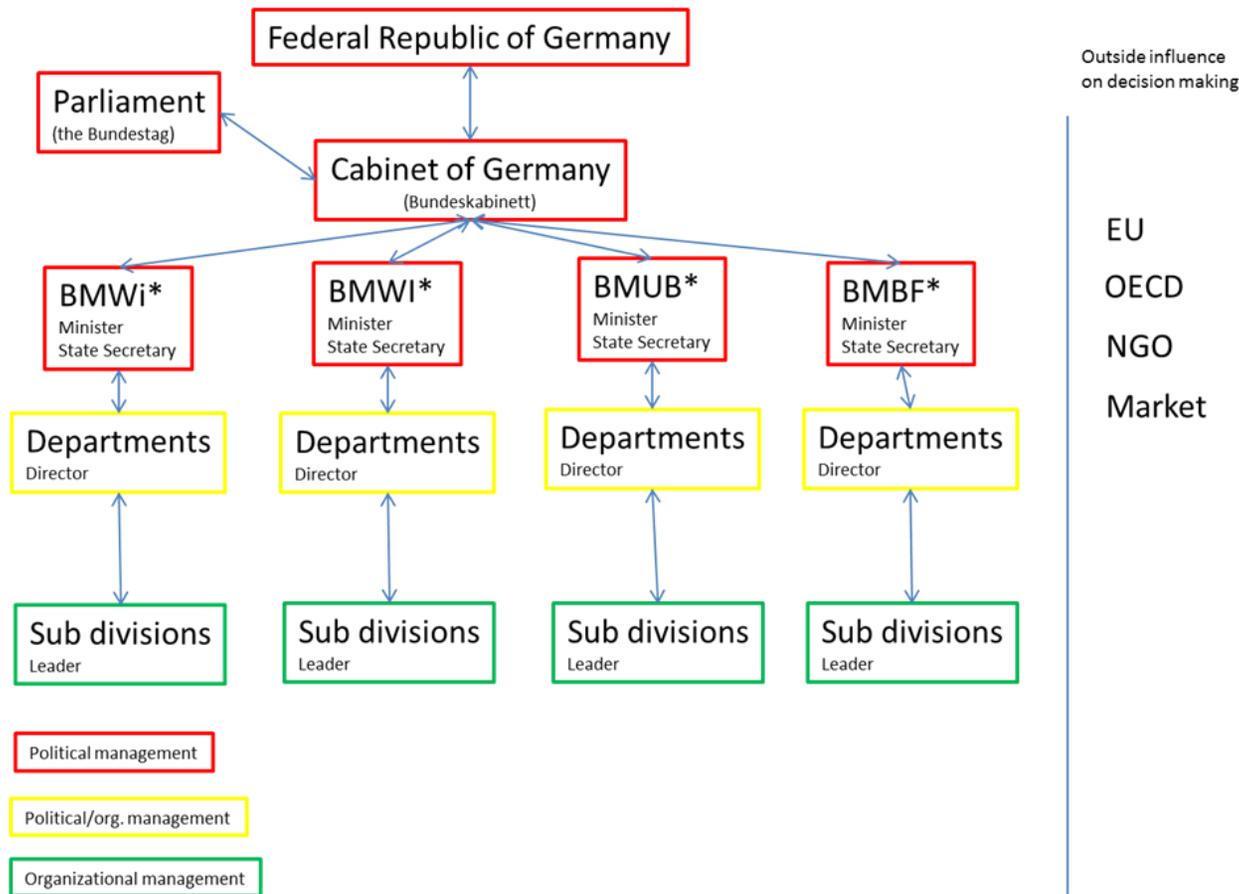
The lower house in the German political system is the Bundestag. Its members are elected for four-year terms (Tatsachen, 2014).

Half of the members of the Bundestag are elected directly from 299 constituencies. The other half – another 299 – are elected from the list of the parties on the basis of each Land (the 16 regions that make up Germany). The 598 seats are only distributed among the parties that have gained more than 5% of the second votes or at least 3 direct mandates. Each of these parties is allocated seats in the Bundestag in proportion to the number of votes it has received (Tatsachen, 2014).

The Bundestag elects the Chancellor for a four-year term and is the main legislative body.

The new German Federal Cabinet in 2014 includes a total of 14 ministers.

Figure 19 (below) presents the system of government and type of decision-making. For the purposes of this work only ministries are included whose work covers the field of hydrogen and fuel cell.



*Federal Ministry for Economic Affairs and Energy, Federal Ministry of Transport and Digital Infrastructure, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Federal Ministry of Education and Research

Figure 19: Government system and type of decision-making, Source: ⁴, ⁵, ⁶, ⁷

⁴ Federal Ministry for Economic Affairs and Energy <http://www.bmwi.de/EN/root.html>

⁵ Federal Ministry of Transport and Digital Infrastructure http://www.bundesregierung.de/Webs/Breg/EN/FederalGovernment/Ministries/BMVBS/_node.html

⁶ Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety <http://www.bmub.bund.de/en/>

⁷ Federal Ministry of Education and Research <http://www.bmbf.de/en/>

5.3.3. Norway

Norway is a constitutional monarchy with a parliamentary system where the executive power is dependent on the direct or indirect support of the Parliament (Stortinget). The constitution grants executive powers to the king, but these rights are exercised by the cabinet (executive) (Jakobsen, 6.5.2013).

Members of the parliament are elected every fourth year. A majority of the Parliament can at any time vote the sitting Government out of office. The Government must have the backing of the Parliament to be able to govern (Jakobsen, 6.5.2013).

The Government is composed of 20 ministers and is led by the prime minister. The Government is head of the civil service, and can appoint people to the bureaucracy. The Government also presents a budget to the parliament every October, and prepares proposals for new laws. The Government is appointed by the king. There are three ways for the Government to leave office: a) defeat in election; b) parties leaving a governing coalition; or c) a vote of no confidence by the parliament (Jakobsen, 6.5.2013).

Figure 20 (below) presents the system of government and type of decision-making. For the purposes of this work only ministries are included whose work covers the field of hydrogen and fuel cell.

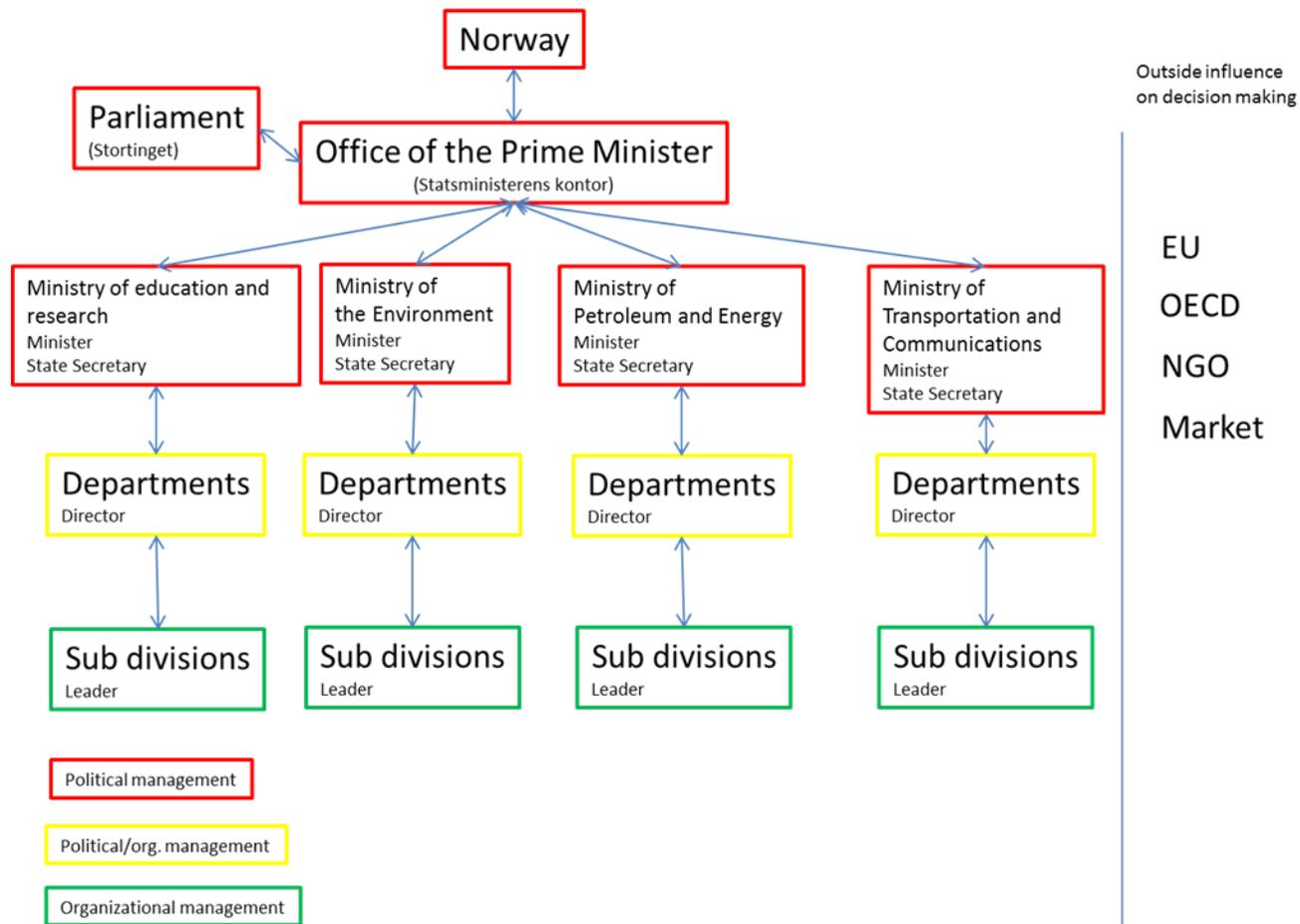


Figure 20: Government system and type of decision-making, Source: ⁸, ⁹, ¹⁰, ¹¹

⁸ Ministry of Education and Research <https://www.regjeringen.no/en/dep/kd/id586/>

⁹ Ministry of Climate and Environment <https://www.regjeringen.no/en/dep/kld/id668/>

¹⁰ Ministry of Petroleum and Energy <https://www.regjeringen.no/en/dep/oed/id750/>

¹¹ Ministry of Transport and Communication <https://www.regjeringen.no/en/dep/sd/id791/>

5.3.4. Denmark

The Danish Constitution divides power into three independent branches: Government, Parliament and the courts (Jayasinghe, 2012).

The Danish Parliament exercises legislative power, which means that it passes the laws. The Parliament is also responsible for adopting the state's budgets, approving the state's accounts, exercising control of the Government and taking part in international cooperation (Jayasinghe, 2012).

The Government exercises executive power and governs the country in accordance with the laws enacted by the Parliament. The Danish Government normally comprises about 20 Ministers and is headed by the Prime Minister.

The Prime Minister decides on the structure of the Government with respect to the number of Ministers (Jayasinghe, 2012).

In the majority of cases, Ministers are Members of Parliament, but this is not a requirement. If a Minister is appointed who is not an MP he or she may of course speak in the Chamber during debates, but is not entitled to vote.

All MPs are entitled to introduce bills and proposals for other decisions that the Parliament must consider. In practice, however, the majority of bills approved by the Parliament have been drawn up by the Government. Since the Government usually has the support of a majority in the Parliament, or has reached a political agreement or a compromise prior to presenting a bill, it is sure to obtain majority support for the bill. In addition, the Government can rely on help from the various ministries where a large number of experts are engaged in drawing up bills (Jayasinghe, 2012).

Ministers govern Denmark through their ministries and ensure that laws are not just rules on paper, but are in fact implemented (Jayasinghe, 2012).

Figure 21 (below) presents the system of government and type of decision-making. For the purposes of this work only ministries are included whose work covers the field of hydrogen and fuel cell.

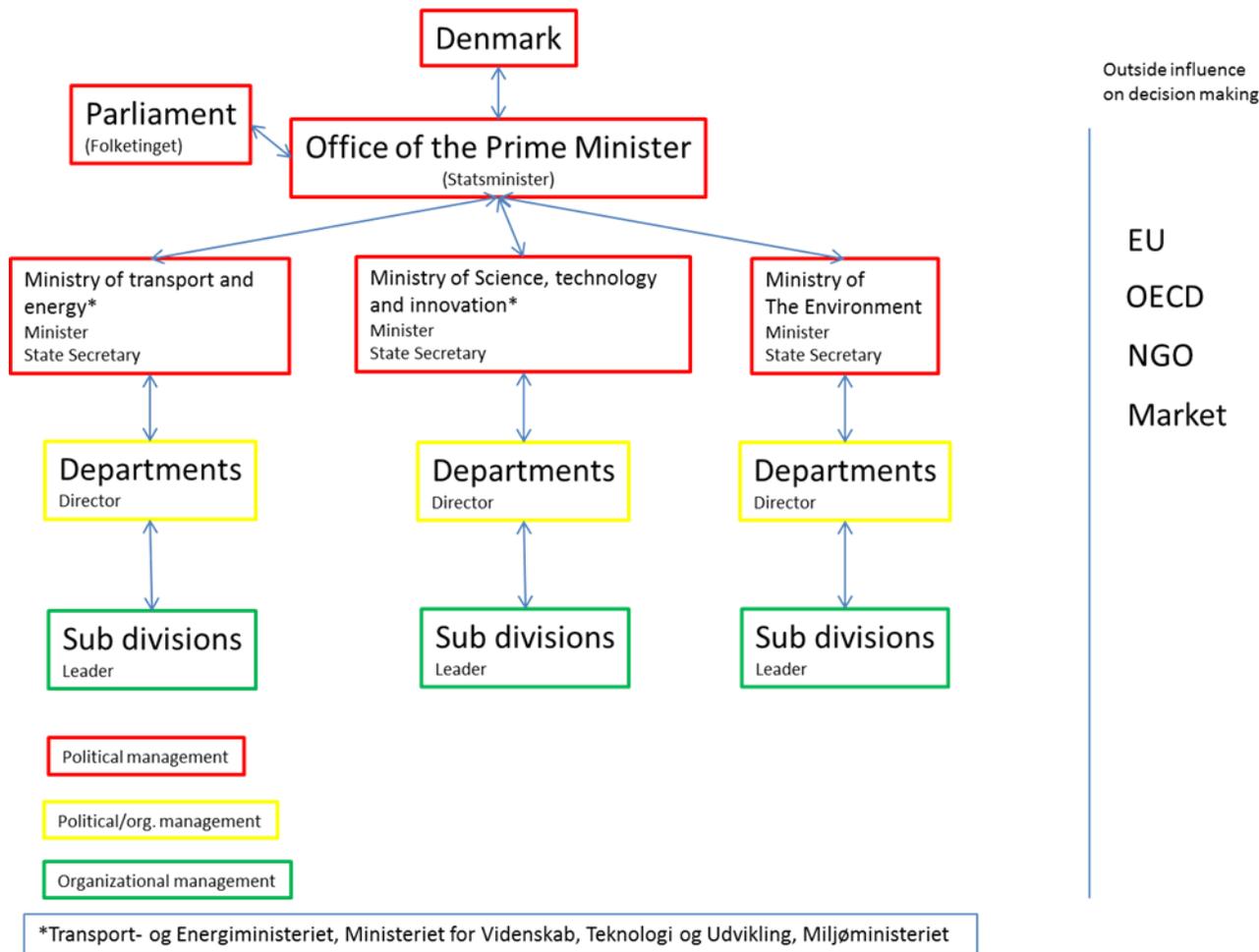


Figure 21: Government system and type of decision-making, Source: ¹², ¹³, ¹⁴

¹² Ministry of Transport <http://www.trm.dk/en>

¹³ Ministry of Higher education and Science <http://ufm.dk/en>

¹⁴ Ministry of the Environment <http://eng.mim.dk/>

5.4. Target groups

The following chapter explains to the reader what target groups were chosen for the analysis. Theory is also presented while vital to decide on the right target groups to receive proper input data for research.

It is not possible to expect to collect responses from all of the representatives of the chosen target groups because resources are insufficient and time does not permit, such as for extended research. The following sample was chosen:

Primary data was gathered in the form of interviews aimed at 3 different target groups:

Table 6: Description of participants in each target group

Group	Description
A	Experts provided answers on the recent stage of the technology and necessary measures to support further research and development of the technology.
B	Ministry employees involved in horizontal coordination between priority policies of different ministries and in the inclusion of those priorities in the national budget
C	Leading employees involved in the preparation of national priorities provided answers on how to make priorities such concrete that they are not changed with every government elections

Source: Jure Leben, Thesis

The resulting sample is: 4 countries covering 3 groups of people (3 decision levels) with 5 interviewed people in each group. The aim of the research was to interview 60 people, which is enough to collect an understanding of the country's system. At the conclusion of the research, 48 responses had been gathered.

Theory shows that the selection of subjects in qualitative studies is often flexible, developing once research begins (Jamie, 2013). (Fetterman, 1989) argues that ethnographers use a process that he describes as judgemental sampling, relying on judgement to select the most appropriate members of the unit, based on the research question. The aim of the research was to gain as many responses as possible in order to form a clear picture of how certain processes develop in the compared countries. The following chapter outlines the methods used for maximising response rate.

5.5. Maximizing responses

There are several methods by which to increase response rates. The following measures were used to maximise the response rate:

- Regular contact by phone, email and face-to-face:
- Covering topics that are of interest to the respondent (questionnaire questions were targeted to specific groups);
- Giving as much notice/time as possible in which to respond;
- Explaining to contacted respondents how were they chosen and the importance of their response to the research;
- Gave them clear assurance of confidentiality following university ethics guidelines;

I increased the response rate by “being in touch with the target people all the time”.

At this point the methodology for country selection has been laid out, structural indicators have been explained and target groups in each country chosen. The following chapter lays the ground for how the results were collected.

5.6. Collection of the results

From this chapter on collection of the results is explained. Primary data was gathered through the interviews. In the following chapter are presented interview questions for each target group and also a flow chart for the interview process.

Interviews are a systematic way of talking and listening to people and are a way to gather data from people through conversations. Open questions were used to open questions that helped gather opinions and views on certain topics. The interview approach employed was flexible and dynamic and was tied to this specific research.

Open questions were chosen to gather greater response and information than just yes or no. With open questions I aimed for the respondent to think and reflect and to give me their opinion.

Interviewing is a way to collect data as well as to gain knowledge from individuals. Kvale regarded an interview as “... an interchange of views between two or more people on a topic of mutual interest, sees the centrality of human interaction for knowledge production, and emphasizes the social situatedness of research data.” (Kvale, 1996)

5.6.1. Modes of data collection

The biggest challenge during the research was to ensure a sufficiently high response rate to the questionnaires in each target group. In order to increase response rate, different methods of data collection were combined; face-to-face, telephone and email interviews. This approach proved optimal as covering all four target-countries and their respective respondents would have required considerable financial investment in order to carry out all interviews in person. Given the level of ICT today I was able to efficiently carry out 48 of the 60 planned interviews in the chosen countries across Europe, from among various research institutions, government agencies and ministries.

As seen in the outline of thesis proposal to the University, aim of the research was to have as many face-to-face interviews as possible. Approach was based on, at the time of the thesis submission; professional position, which allowed me to have access to many of the respondents during the meetings of different working groups in the European Commission. When work conditions changed, I also needed to adopt my approach to arranging and organising interviews. There is an assumption in much of the literature on qualitative interviews that they will be conducted face-to-face if possible: arguments in favour of other forms tend to be made entirely

on the basis of expediency, i.e. costs are lower and access easier (Gillham, 2005). Where possible, face-to-face interviews were carried out, owing to the easier “execution” process of the interview. However, due to the straightforward nature of the questions, interviews over Skype, phone or email were also easily conducted.

One of the reasons for aiming to have as many face-to-face interviews as possible was to exploit a wider range of communication experiences and to be able to respond to non-verbal reactions. Non-verbal reactions were counted in the data gathering process and were included in the research process early in the planning stages. Once the interviews started, it was soon evident the questions were very straightforward and that non-verbal reactions would not play a decisive role in the process.

Telephone communication also proved to be efficient. By using the telephone I was able to overcome the geographical distance between the respondents and myself. At the beginning of the interview I clearly outlined the aims of the interview and set the ground rules for the duration of the call, further explaining that answers should be to the point and specific, not too general.

Email interviews were also used in thesis research. Some of the respondents were very busy due to the nature of their work, so email proved the easiest way to conduct said interviews. Concerns over the quality of the rapport that can be achieved in online interviewing have diminished with time as the amount of communication that takes place via email has increased substantially (King, 2010). The email sent to interviewees included an explanation of the work, the aim of the questions and the date by which responders were asked to submit their written replies. One of the advantages of email interviews is that there is no need for transcription (King, 2010).

Work by Johnson shows that “validity standards in qualitative research are even more challenging because of the necessity to incorporate both rigor and subjectivity as well as creativity into the scientific process” (Johnson, 1999).

Alongside primary data collection, secondary data collection was used to discern specific national goals for the development of hydrogen and fuel cells in the compared countries.

5.6.2. Type of questions: open and closed

For the purpose of this thesis, the difference between open and closed questions will be discussed. In the questionnaires are used both open and closed questions.

There are many different views among the researchers when to use open or closed questions. First different among these two options is the role of the responded. When using closed questions we limit the responded with the answer. However, offering to the responded open question, we allow him/her to have a free way for expressing the opinion. (Foddy, 1993) I think that approach with mix set of questions is more useful when researching the policy system and comparing the countries approaches together. This approach was used for the thesis in cases when closed question such as, for group B, Is there a penalty for not implement agreed measures. The next question was then open to gather information on wider picture in the country, to have personal response from the respondent which able to gather information which can be used to develop sound practical proposal.

Open and closed questions have also some disadvantages. Closed questions can result in bias responses, because the answers are already offered. On the other hand, open questions can lead to not answered questions and questions answered as simply as yes or no. In addition, using open questions creates more challenges when doing the transcription (if recorded- validity) and sorting the answers for the analysis. Research shows (Lazarsfeld, 1944) that combination of questions is possible and not a deviation from the practice.

5.7. Interviews (primary data collection)

This paragraph explains to the reader what kind of process for primary data collection was chosen. For the collection of primary data semi-structured interviews that are non-standardized and are frequently used in qualitative analysis were chosen. In chapter 5.4, Table 6 is presented with the description of participants in each target group. Issues such as new technology, price of energy and future development infer and entail interactions between many sectors of industry on the one hand and government decision-making on the other hand. Two advantages of qualitative interviews are:

- I was able to encourage respondents to discuss issues for an extended period of time. With this I was able to ascertain and gather what was important to them (personal responses).
- I was able to ask new, unplanned questions based on the respondents' answers.

Semi-structured interviews offer structured guidance of the interview and leave room for discussion between the topics. The interviewer does not do the research to test a specific hypothesis (David, 2003). In this type of interview the order of the questions can be changed depending on the direction of the interview.

The length of the interview depended on the time constraints of the interviewee, but did not exceed one hour. The interviews were recorded for purposes of easier transcription. If the interviewee did not agree to be recorded, extensive notes were taken during the interview. Many interviewees were not native English speakers, so every question was explained if not fully understood.

It is important to say that although the approach is based on qualitative analysis and semi-structured interviews, there were specific issues that the author of this thesis wanted to discuss with the respondents.

Overall there was no need for follow-up questions. Some questions required explanation owing to language issues and the topic of discussion.

Table 7: Responses on the questionnaires in each group in summary and by country

Group	Responses summary	Slovenia responses	Germany responses	Norway responses	Denmark responses
A	18 interviews out of 20. Two interviews from Norway are missing. In many cases there was no negotiation over access to institutions or individuals. All the contacted persons understood the aim of the work and there were no problems gathering	There were 5 interviews gathered. Out of 5 interviewees, 1 interviewee answered all the questions and 4	There were 5 interviews gathered. Out of 5 interviewees, 2 interviewees answered all the questions and 3	There were 3 interviews gathered. Out of 3 interviewees, 1 interviewee answered all the questions beside	There were 5 interviews gathered. Out of 5 interviewees, 2 interviewees answered all the questions, 2

	<p>responses. The size of the country determines the number of experts working in the field of hydrogen and fuel cell technology, which posed a challenge in the case of both Denmark and Norway.</p>	<p>interviewees answered all other questions beside question 7 because previous question was answered by no.</p>	<p>interviewees answered all other questions beside question 8 because previous question was answered by yes.</p>	<p>question 7 despite answering yes the previous question. 1 interviewee did not answer question 7 because previous question was answered by no. 1 interviewee did not answer question 8 because previous question was answered by yes.</p>	<p>interviewees answered all the questions beside question 8 because previous question was answered by yes. 1 interviewee did not answer question 7 despite answering previous question with yes; this interviewee also did not answer questions 8 and 9.</p>
B	<p>14 interviews out of 20. Three interviews from Norway are missing and three from Denmark. Gaining access to individuals in group B took</p>	<p>There were 5 interviews gathered. 3 interviewees did not answer</p>	<p>There were 5 interviews gathered. 3 interviewees answered all the</p>	<p>There were 2 interviews gathered. 1 interviewee did not answer</p>	<p>There were 2 interviews gathered. 1 interviewee did not answer</p>

	<p>the most time and effort. Help was provided by colleagues from different EU working groups to ensure as many responses as possible.</p>	<p>question 10 because previous was answered by no. 2. Interviewees did not answer question 12. 1 interviewee did not answer question 5.</p>	<p>questions. 1 interviewee answered question 12 by question mark. 1 interviewee did not answer questions 10, 11, 12.</p>	<p>question 5 because previous answer was no. 1 interviewee did not answer question 10 because previous answer was no; question 12 was also not answered.</p>	<p>question 4 because previous answer was yes; question 11 not answered because previous answered by yes; question 5 and 12 not answered. 1 interviewee did not answer questions 4, 5, 10, 12.</p>
C	<p>16 interviews out of 20. One interview from Norway is missing and three from Denmark. The biggest challenge in this group was the interviewee understanding how and/or why his/her position is important in the process.</p>	<p>There were 5 interviews gathered. 2 interviewees answered all the questions. 2 interviewees did not answer question 7 and 8 because</p>	<p>There were 5 interviews gathered. 3 interviewees answered all the questions. 1 interviewee did not answer question 8. 1 interviewee did not</p>	<p>There were 4 interviews gathered. 2 of the interviewees answered all the questions. 2 interviewees did not answer questions 7 and 8</p>	<p>There were 2 interviews gathered. 1 interviewee did not answer questions 4, 5, 6 because previous answer was no. 1 interviewee did not</p>

		previous answer was yes. 1 interviewee did not answer question 4 and 5.	answer questions 7 and 8 because previous answer was yes.	because previous answer was yes.	answer question 4, 5, because previous answer was no; question 7 and 8 was not answered because previous question was answered by yes.
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During the preparation of the interviews I needed to ask myself three important questions connected to the central topic/subject of the research:

- Why: to improve the implementation environment for new technologies in Slovenia.
- What: to propose a suitable methodology for the preparation of a national program for hydrogen and fuel cell implementation.
- How: with semi-structured interviews and meaningful condensed analysis

Source: why, what, how: (Kvale, 2009)

After the interviews were carried out, the interviews were combined by group, and for those recorded transcriptions were made. Transcriptions were made word for word, so no words were lost neither in translation nor, with that in mind, the meanings of any responses.

Work by Bryman shows that it is possible to establish a relationship with the interviewees and to understand their way of working in the system, which is of great added value. Taking this approach will provide data of real value and rich in information (Bryman, 2001).

Work by Ambert shows that qualitative research is focussed more on the richness of information and not on the size of the survey group, and on exploring smaller, specific facts rather than

simply amassing data. (Ambert, 1995) Qualitative research is about the context and people and not about generalization. (Whittemore, 2001)

Personal responses to the questionnaire lend the research the live experience of day-to-day business in the three selected target groups. Work by Sandelowski shows that the richness of responses increases as a result of including people actually working in the system. This approach offers a look into experiences taken from their daily business (Sandelowski, 1986).

The order in which the various topics are dealt with and the wording of the questions was left to me to decide during the interview. Questions in the questionnaire are very straightforward and interviewees were selected for each target group A, B and C on the basis of their work and expertise.

As shown in chapter 4, the following research question was used: How to improve deployment environment to increase level of implemented hydrogen and fuel cell technology?

To clarify the discussion, the following sub research question was used: How to develop national road map?

To clarify conceptual topic, the following additional sub research question was used: How to select potential new technologies which will enable the achievement of road map goals?

For example, group A is gathering knowledge on the recent stage of hydrogen and fuel cell technology implementation. Here experts on the technology were chosen for interviews, not people working on the public administration side on the national budget. Having the right experts in each group also minimised deviating from the formulation and wording set out in the questionnaires. For each topic I conducted the conversation as I saw fit and asked the questions I felt as the most appropriate or telling. Furthermore, I also explained the questions and asked for further clarification where necessary. For those interviews not conducted face-to-face I provided respondents with additional explanation when required. Out of the total of 48 interviews, 8 were conducted in person and recorded with a Dictaphone, 5 were conducted in person without recording, 25 over Skype and 10 over email.

Having had some 10 years of experience with Slovenian government administration additional questions for the sake of clarification were only used to understand the system in that particular country and for comparison with case Slovenia. The development of a national system for any new technology requires governmental focus on various diverse subjects, such as percentage of GDP invested in research, energy prices, national issues and circumstances, the school system,

customer demand and technology readiness. During the interviews, new country-specific issues came up that raised additional questions. The interviews were recorded using a digital Dictaphone, with the assurance that recorded interviews would only be used for purposes of the study, and that the names of the respondents would only be made known to advisors in Slovenia and at the University of Hertfordshire. For purposes of the analysis each respondent was assigned a code, such that names would not be floating around in the working documents. Where interviews were recorded, this explanation is heard on the recording. I feel that the semi-structured interview scheme led to deeper conversations about certain topics.

Systematic text condensation is a descriptive and explorative method for thematic cross-case analysis of different types of qualitative data, such as interview studies, observational studies, and analysis of written texts. The method represents a pragmatic approach, although inspired by phenomenological ideas, and various theoretical frameworks can be applied. The procedure consists of the following steps: 1) total impression - from chaos to themes; 2) identifying and sorting meaning units - from themes to codes; 3) condensation - from code to meaning; 4) synthesizing - from condensation to descriptions and concepts (Malterud, 2012).

Each of the target groups A, B and C has a set of specific questions. The questions for group A dealt with recent stages of the technology and the measures necessary to support further research and development of the technology. The questions for group B dealt with the process of horizontal coordination of priority policies amongst the various ministries, and the inclusion of those priorities in the national budget provided information on the frame of the national system to support such work. The questions for group C dealt with the process of determining and preparing national priorities and how to establish said priorities so as not to be changed with every change in government. The questions in the questionnaire are not time-specific nor linked to specific ministers; they could well be asked/used again sometime in the future. An example of the interview questions for Groups A, B and C and the respective flow charts for each group are presented in the sections that follow. In appendix 2: Flow charts of interviews are presented.

5.8. Interview guide

Interviews were carried out and recorded using a Dictaphone, and by telephone, Skype or email. The length of the interviews depended on the time constraints imposed by the interviewees but did not exceed one hour. Interviews conducted in person were recorded for the purposes of easier transcription. If the interviewee did not consent to being recorded, notes were taken during the interview. Many interviewees were not native English speakers, so questions were explained if not fully understood.

At the beginning of each interview an outline of the work, some background and the specific purpose of the research was explained to the interviewee.

Some of the interviewees did not have time for active interviews. For those, a written explanation of the work was provided and questionnaires were sent to them for response. An explanation of the work is set out below.

5.8.1. Explanation of the work to the interviewees

At the beginning of the interview the researcher outlined the context surrounding problems related to GHG emissions, dependence on fossil fuels, social acceptance, political resistance to change and the challenges related to implementation of new hydrogen and fuel cell technology. Further, he explained the research outline and the correlation between development indicators and the level of implemented hydrogen and fuel cell technology, together with the results of the study and the recommendations for decision-makers.

After an initial explanation and laying out the background, he explained the link between the recommendations from previous research and the research outline for the thesis.

Once such explanations were finished time was devoted to outlining the thesis research and the related steps planned. For the purposes of an efficient interview, different methods of data collection, as set out below, were employed.

5.9. Secondary data collection

Secondary data collection focussed on reviewing the national strategies of the three other compared countries and EU documents that give hydrogen a development and implementation

framework on the EU level. Inputs from secondary data collection will show what other countries included in their national strategies, and that these countries already have confirmed national strategies for hydrogen and fuel cells in place.

National hydrogen and fuel cell strategies will add considerable value to the work by providing a better understanding of how extensive the horizontal connection between and among the sectors involved (mobility, energy, etc) really is in the process of implementing this technology.

Primary data will provide insight into the processes of government administration work, into the status and current stage of technology today, and how the deployment process through government agencies is structured. Secondary data will help illustrate the content and focus of these strategies. Combining primary and secondary research then forms the basis of a proposal for Slovenia, including an array of issues that should be taken into consideration in the preparation of a national program for hydrogen and fuel cells. The following three chapters present an overview of national strategies for hydrogen and fuel cells.

5.9.1. National hydrogen and fuel cells strategies

5.9.1.1. Germany

The Mobility and Fuels Strategy of the German Government (MFS) is not overarching strategy. MFS is contributing towards achieving the national Energy Concept goals that are set out also for the transport sector. MFS provides for the first time analysis of the fuels and technologies and options on when and how certain modes can be implemented on German roads. “Ultimately, its purpose – as a “learning strategy” – is to identify ways in which the Energiewende can be implemented for transport in the future”. (Federal Ministry of Transport, Building and Urban Development, 2013)

The strategy sets out the understanding that changes need to be implemented in efficient steps with the focus to increase energy efficiency and notion that new technologies need to be implemented now. New alternative fuels are closing the gap between the energy and transport sector. Cooperation between these two sectors should be optimised and the challenges for market penetration of new technology eliminated.

The main points of the strategy are:

- Electrification of the drive train (BEV’s and FCEV’s) is a key issue to reach the targets

- Targets only achievable with PtG-H₂ and PtG-Methane
- Further increase of renewable energies beyond current planning is needed
- Large scale storage for hydrogen is inevitable

Source: Federal Ministry of Transport, Building and Urban Development, 2013

MFS strategy includes also perspectives for the Germany. Passenger cars have a great potential to lower CO₂ emissions. “Extensive decarbonisation of public road transport and private motor vehicle transport is technically possible in the long term through the increased use of electricity and hydrogen as well as battery and fuel cell technology and the use of renewable sources of energy, supplemented by measures on the vehicle. This development is indeed necessary in order to meet the German government’s energy and climate targets up to 2050.” (Federal Ministry of Transport, Building and Urban Development, 2013)

Future energy systems in Germany will be based on the renewable energy and better cooperation needs to be developed between electricity, heat and mobility. (“One noteworthy example here is the growing need for the transport sector to make a contribution to network stability (keyword: battery technology and hydrogen as a storage medium)”. (Federal Ministry of Transport, Building and Urban Development, 2013)

Germany is planning to have from 2017 on the market the first series-produced fuel cell vehicles. “The industry is currently also working on concepts to expand the hydrogen infrastructure in Germany. In view of this, the German government will investigate whether steps should be implemented to support the market introduction of hydrogen as a fuel used in fuel cell vehicles, and if so, what these steps should be.” (Federal Ministry of Transport, Building and Urban Development, 2013)

At the moment there are 15 fuelling stations for hydrogen across Germany and a further 35 will be built by the end of 2015. (Federal Ministry of Transport, Building and Urban Development, 2013)

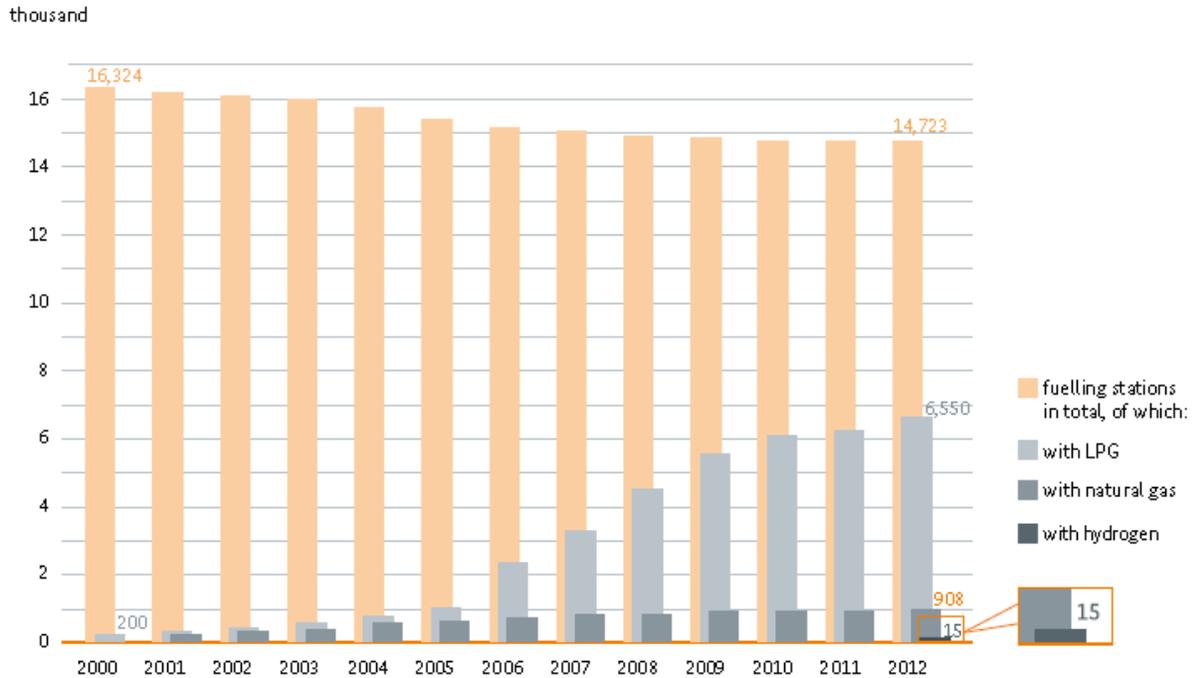


Figure 22: Fuelling stations in Germany, Source: (Federal Ministry of Transport, Building and Urban Development, 2013)

First wider penetration for hydrogen is expected after 2010 where industrial by-product hydrogen can significantly contribute to a faster use of hydrogen energy.

In the first early years for hydrogen, which are seen after 2010, industrial by-product hydrogen can significantly contribute to a wider use of hydrogen energy. Demand centres in densely populated areas will arise and for the transport of hydrogen liquid or compressed hydrogen trucks will play a relevant role.

‘The concept of early user centres will envision hydrogen applications in population centres where main players are situated and demonstration projects are already in operation (e.g. Berlin, Hamburg, Rhein/ Main-Area, Rhein/Ruhr-Area, Stuttgart and Munich)’ (HyWays, 2006).

Potential user centres are so close to each other that they could easily be connected and further extended in neighbouring countries as seen in Figure 26 below.

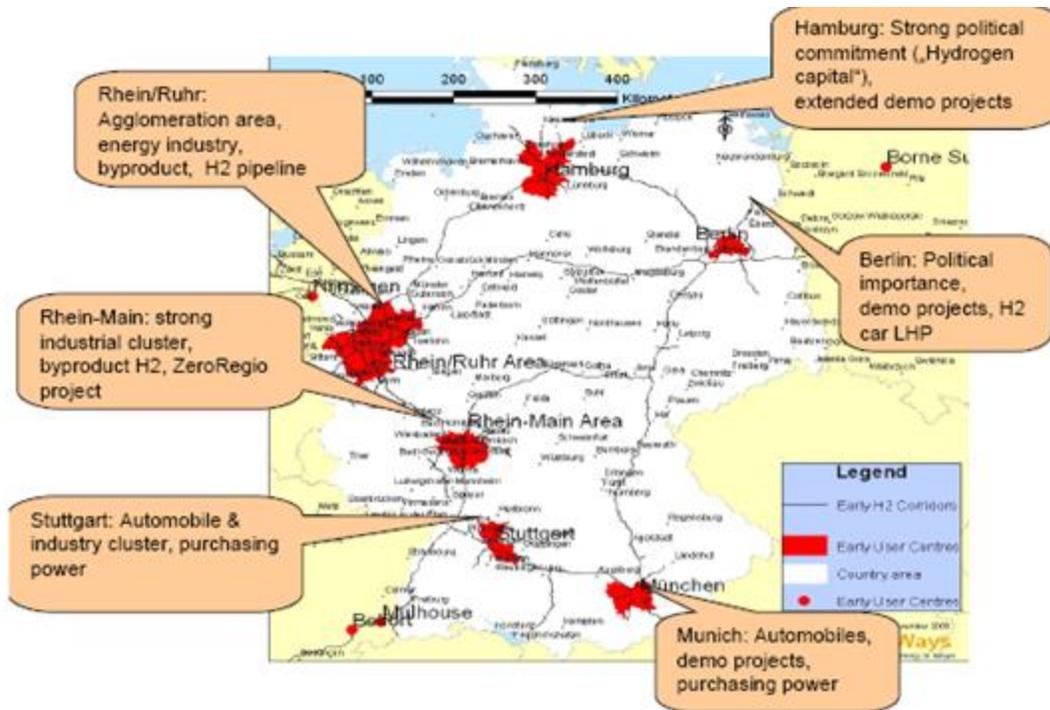


Figure 23: Early user centres for hydrogen and fuel cells, Source: (HyWays, 2006)

It is very important that national activities are coordinated with the neighbouring countries to establish a network for efficient transportation. In Figure 27 below we can see as example activities in neighbouring countries of Germany.



Figure 24: Activities in neighbouring countries of Germany, Source: (Bonhoff, 2014)

Germany already has high level of heating technology with low temperature and condensing boilers. ‘Combined heat and power generation with fuel cells present next technological step in heating sector. Research showed that generation of power and heat in houses, apartments, and business with fuel cells presents possibility to achieve higher efficiency rates of >85% of the main energy input’ (German Government, 2009). Furthermore, power generated can be used in households or it can be transferred back in the electricity grid. ‘This can result in reduction in CO2 emissions between 20 and 30 % compared to modern conventional supply systems (gas condensing boilers and electricity from the grid)’ (German Government, 2009)

In Germany is at the moment tested more than 100 stationary systems under real life conditions (Federal German States of Lower Saxony, Baden-Württemberg and North-Rhine Westphalia) (German Government, 2009). The fuel used in these tests is natural gas. Advantage of stationary fuel cells is that they do not need a hydrogen infrastructure to be installed for their operation.

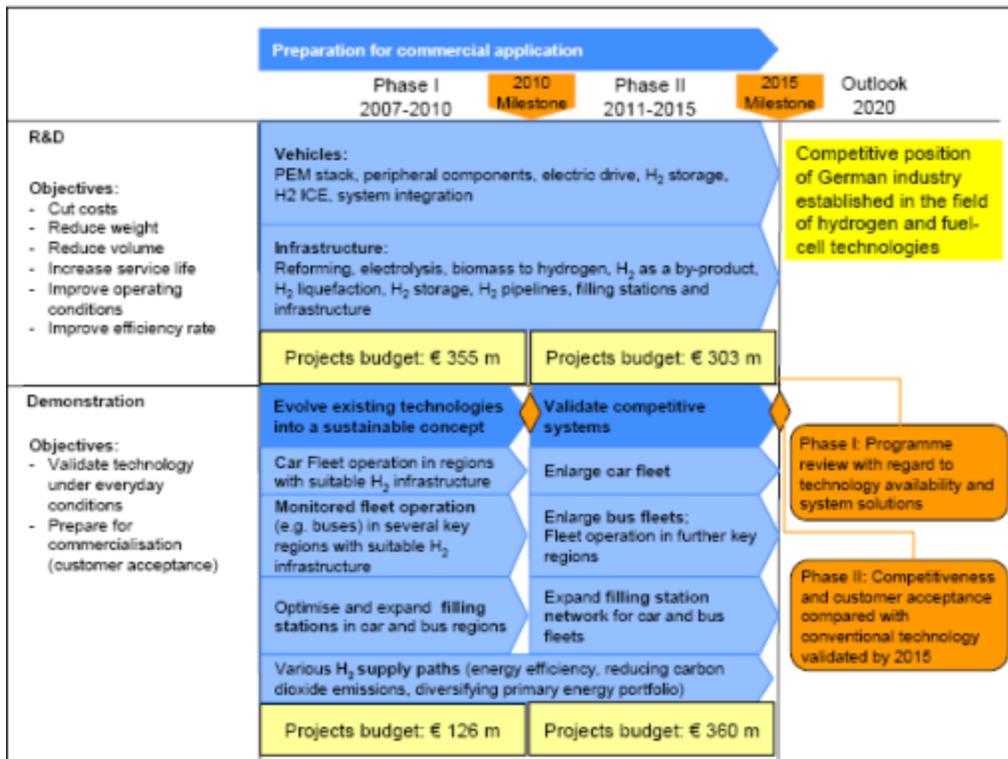


Figure 25: German implementation plan, Source: (German Government, 2009)

The plan is set out in two phases as seen in Figure 28 above. Phase one focuses on deployment of existing concepts, including innovations, phase two focuses on validation and demonstration of system solutions. Demonstration projects are very important stage between research and commercialization, because of the testing of the systems and technical performance which needs to compete with now day's technology. Demonstration phase also brings an answer on the balance between infrastructure density and optimal returns on investments. Demonstration projects also serve as a tool for social acceptance which is very important for efficient market penetration. Moreover, demonstration also helps to finalize regulative requirements and standards for the new technology.

5.9.1.2. Norway

Norway has accepted to cut national Green House Gasses (GHG) for 20 % by 2020. The long-term goal is to become without emissions by 2050.

Hydrogen will play an important part of this transition in transportation sector. “Fuel cell vehicles are considered the best solution for at least 50% of Norway’s passenger transportation”. (Fuel Cell Today, 2013)

Norwegian Government confirmed a committee with the task to prepare National Hydrogen Programme. The committee cooperated with the industry, researchers and experts from the field of hydrogen and fuel cells focussing on stationary application and transportation. (Norwegian Ministry of Petroleum and Energy, 2004)

The following goals were prepared:

- Production of hydrogen from natural gas with carbon capture, at a cost that is competitive with petrol or diesel, for use in Europe;
- Early introduction of hydrogen vehicles in Norway;
- Development of internationally-leading competence in hydrogen storage, with competitive products and services;
- Development of a ‘hydrogen technology industry’, comprising: participation of Norwegian companies in international supply chains for hydrogen technology; the supply of hydrogen refuelling stations using electrolysis; competence in the use of fuel cells on ships; and R&D of an international standard in fields related to hydrogen.

Source: (Norwegian Ministry of Petroleum and Energy, 2004)

The main focus on hydrogen energy in Norway is on production and storage of hydrogen. Industrial companies such as Statoil, Hydro and Statkraft are active together with a number of research institutes and other organizations. The NorWays project is aiming at providing decision support for introduction of hydrogen in the Norwegian energy system. The NorWays project builds upon experience from and is carried out in cooperation with the HyWays project. Norwegian government supports hydrogen development and implementation with government subsidies for research, development and demonstration. The following ministries are supporting the development:

- The Ministry of Petroleum and Energy awards funding to hydrogen research in general through the Research Council of Norway's Clean Energy for the Future Program (RENERGI)
- The Ministry of Education and Research awards funding to hydrogen-related materials research through the Research Council of Norway's Nanotechnology and New Materials Program (NANOMAT)
- The Ministry of Transport and Communications awards funding to research on technologies in the transport sector involving no or very low emissions through the RENERGI program.
- Through Gassnova (Centre for Sustainable Gas Technologies) and the Research Council of Norway's Program for Natural Gas Power with Improved Environmental Performance (CLIMIT), funding is awarded to hydrogen related gas scrubbing technologies. The funds come partly from the Ministry of Petroleum and Energy and partly from the Gas Technology Fund. Enova has awarded funding from the Energy Fund to demonstration projects linked to the production of hydrogen based on new renewable sources of energy.
Source: (Fuel Cell Today, 2013)

Many players with different roles are involved in hydrogen implementation in Norway. They are all linked to the hydrogen platform through different activities. 'The most central agencies are the Research Council of Norway, Enova, Gassnova, Innovation Norway, the Norwegian Water Resources and Energy Directorate, the Directorate of Civil Defence and Emergency Planning, the Directorate of Public Roads and the Norwegian State Pollution Control Authority' (Fuel Cell Today, 2013).

Norway has at the moment 6 operational hydrogen stations which 5 of them were built during the project HyNOR and 1 under the project H2moves Scandinavian project. In addition, Norway emerged as one of the early markets for the commercial deployment of hydrogen fuel busses and vehicles. At the moment Norway has 5 fuel cell buses and 17 fuel cell cars.

Norwegian Government understands that road transportation sector is the one with great advantage for emission reduction. "The government is investing in improved public transport and other measures to combat growing numbers of passenger vehicles on urban roads."

(Norwegian Government, 2012) There is big potential to lower the emissions through new alternative fuels and more efficient green drivetrains.

“There is policy support on the purchase side: biofuels, biogas, CNG and hydrogen are all subject to lower, or exempt from, fuel and CO₂ taxes”. (Clean Vehicle Europe)

Government have already incentives for electric vehicles which follow the goal to have 50.000 zero-emission vehicles on the road by 2018. At the moment are all electric vehicles exempt from purchase tax and VAT, have 90% discount on annual road tax, user do not need to pay tolls or parking fees, have free ferry passage and can drive on bus only lanes. (The Norwegian Electric Vehicle Association)

“Norway has one of the highest vehicle purchase tax levels in the world, rendering the cost of a family car around twice as expensive as in countries like Sweden or Germany. The fact that this tax is not applied to EV and FCEV is a major driver for the introduction of these vehicles.”

(Views and News from Norway, 2011)

Norway in now concluding the second Action Plan from the Norwegian Hydrogen Council published in May 2012, allocating 218 million eur in the period 2012-2015. (Norway – a Global Leader in Hydrogen, 2012)

The recommendations are grouped as follows:

- Business Development for Increased Value Creation, including measures to involve Norwegian SMEs in the emerging hydrogen technology market;
- Research and Development, Network and Infrastructure, including extending and focusing R&D in hydrogen production, storage, distribution and use, as well as the creation of a national network of test laboratories;
- National Facilitation, involving: the strengthening of Transnova to reflect the challenges it is handling, funded through an gradual increase in the fuel tax; the creation of a national plan for fuel supply for future vehicles, including incentives and support for hydrogen refuelling stations; and the investigation of the potential for large-scale export of sustainable hydrogen from Norway based on Norwegian energy resources;
- Effective Tools for Early Introduction of Hydrogen Vehicles’, including incentives for zero emission vehicles, with a required proportion of these vehicles in public fleets, subsidies for hydrogen cars until they are competitive, and coordinated procurement of FCEV with a focus on hydrogen in urban transport or fleet vehicles.

Source: (Norway – a Global Leader in Hydrogen, 2012)

By 2025 Norway should have a sufficiently established network which forms a basis for a national and Nordic infrastructure for FCEVs. The number of FCEVs will have surpassed 10.000 and the number of hydrogen buses 100. Simultaneously the Oslo region should be internationally known for innovation and technology development related to fossil free transport. (Fuel Cell Today, 2013)

5.9.1.3. Denmark

Long term goal for the Danish hydrogen strategy is to: ‘That Denmark develops and demonstrates effective and competitive technologies and systems that integrate hydrogen – primarily based on renewable energy sources – as an energy carrier in a clean, effective and reliable energy supply, and that Denmark takes on a leading position in this field’ (Danish Energy Authority, 2003).

Denmark already has a strong position internationally because of its research and development since 1990s. The strategy document describes existing and future technologies for hydrogen production, distribution and use. The strategy highlights the areas in which Danish R&D can help promote Danish industry in the future global market for hydrogen and fuel cell technologies. The strategy indicates the tools necessary for hydrogen to become part of the public Danish energy system.

Most of the development works in Denmark will focus on fuel cells and on demonstration for developed components. It is recognized in Denmark that many hydrogen applications are still at the stage where basic research is needed to ensure market penetration.

If Denmark would like to compete on the global market, they will need to develop specific segments of the technology or identify other global needs where Denmark could compete and provide solutions to the problems for implementation.

‘Costs in Danish hydrogen strategy are presented as related to each other and identified that hydrogen technology will be implemented together with the development of fuel cells. If Denmark would like to make significant implementation and development, public sector also needs to invest around 1.5-2.0 billion DDK over 10 years for R&D and implementation of hydrogen and fuel cell projects’ (Danish Energy Authority, 2003). ‘The total annual Danish

investment in 2004 is estimated at around DKK 130 million, of which approximately DKK 60 million represent public funding' (Danish Energy Authority, 2003). It is also identified that most of the funding will be allocated to the fuel cell technology area, which has an immediate and growing need for funds for demonstration.

Acceptance of hydrogen as an energy carrier depends on availability of the technology on the market. It is expected that the market for fuel cells and hydrogen application in transport will be steadily developing until 2020.

“The development and use of solutions within fuel cell application is also expected to create opportunities for Danish growth and export of energy technologies. The market for fuel cells will be significant if the technology becomes generally accepted internationally.” (Danish Energy Authority, 2003). Below in Figure 29 we can see example of cumulative Danish investment in R&D and demonstration in hydrogen and fuel cell technologies over a 10-year period.

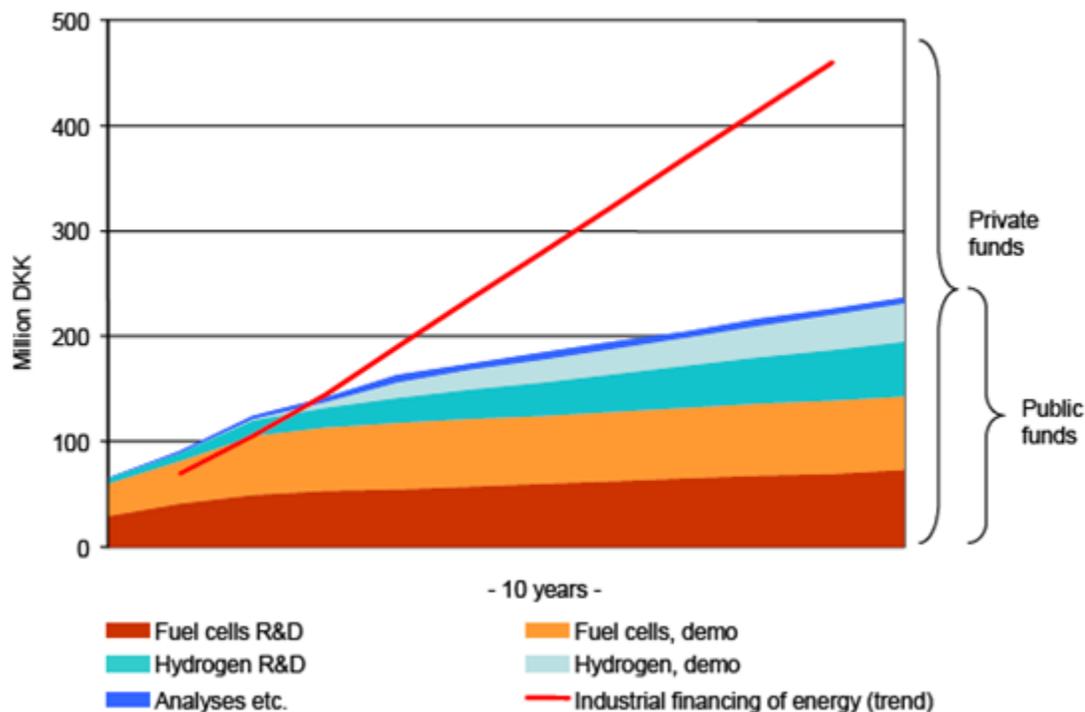


Figure 26: Cumulative Danish investment in R&D and demonstration in hydrogen and fuel cell technologies over a 10-year period, Source: (Danish Energy Authority, 2003)

5.10. Reliability checks and significance

In order to strengthen the thesis and infuse the project with a certain rigour, a discussion of reliability checks in general and transcript reliability checks specifically on the data collected is necessary. Reviewing the research one sees that the reliability and validity criteria for qualitative and quantitative research are very similar (Altheide, 1998; Leininger, 1994). Thus researchers suggest that the adoption of new criteria for enhanced reliability and validity would introduce the required rigour into the qualitative research (Lincoln, 1985; Leininger, 1994; Rubin, 1995). Validation or verification is a step/process with which a researcher checks to ensure and be certain that their research is properly grounded and is reliable.

In the case of this thesis, the methodology employed was chosen together with the research questions and confirmed by the University at the very outset – and these constituted the grounds for the development of the thesis. The methodology includes the qualitative research, followed by the research questions and the case study with the sample groups (target groups) in each country. The various steps involved in the research process are described in more detail in the previous chapters.

The next step was to carefully select target groups (sample) of people who best represented the content of each target group and with that, the research subject itself. The target groups and the purpose of involving them was cleared and confirmed by the University (ethics procedures were taken into account). Targets groups are presented in more detail in the previous chapter.

Questionnaires for each target group are included in the appendices.

Once the methodology and target groups were defined, interviews were carried out as a data collection process. Interviews that were recorded were transcribed word-for-word. I am aware that this approach presents some obstacles when it comes to translating from the Slovenian into English. However, this way the validity of the responses is ensured and nothing is “lost in translation.” Responses are included in the appendix. They are coded such that the names of the interviewees remain anonymous.

Once the data was collected, the results were analysed. The aim of the research was to carry out 60 interviews (60 people). Each group had 20 participants from 4 countries. In the end, 48 responses were collected (18 in group A, 14 in group B, and 16 in group C). This amount of data is large enough to ensure the research is valid and serves as firm ground for rigid analysis.

As proposed to the University at the beginning of the thesis research process, the aim of thesis, through the literature review, questionnaire-based research and a typical case study, was to develop and improve our understanding of new technology implementation processes in certain compared countries. The result of the thesis is a proposal for a new, practical process for easier adoption of new technologies that the Slovenian government will take into serious consideration. This step answers the question of the significance of the thesis research. The thesis is not a conventional thesis with a straightforward theoretical component or related impact. Existing theory is well developed and there is little room for improvement. However, a gap was found in the implementation of the theory, where the significance of both the policy and the implementation in practice is shown. Responses from the target groups clearly shows that the development process for policies and their implementation is far clearer in the selected case countries than in Slovenia. This is first significance stage of the proposed thesis. The utility of the research is further confirmed in the continuation of the research, when the responses of each individual group were analysed. There is no doubt as to whether the results of the analysis could be used in practice. Thus the proposed practical process for a more efficient implementation of new technology gives rise to the results of the thesis.

5.11. Limitations of the research

During the thesis research, several limitations were identified. These limitations need to be taken into account in the analysis phase of the responses and during the development of the proposal for a practical process. The limitations were as follows:

5.11.1. Limitations regarding the scope of research

The thesis develops a concept based on typical cases (sampling groups) and is based on the qualitative research of three levels of actors in the decision-making and implementation process (experts, political decision-makers, directors of public agencies that involved in implementing national measures). In accordance with the research design scheme four European countries were chosen for (case study) comparison: Slovenia, Germany, Denmark and Norway. The purpose and aim of these typical cases is to contribute to the central aim and subject of this thesis – to better understand the system in the selected countries and, based on the experiences of those countries,

together with Slovenia, propose a practical approach for the development of national programs in Slovenia

Research question: How to improve the deployment environment to increase the level of hydrogen and fuel cell technology implementation?

Definition of practical sub-problem: The first problem is dispersed government support (wide selection of technologies) for the deployment of new technologies. The second problem is the lack of a clear national roadmap for lowering GHG emissions. Both problems result in slowing down the implementation of hydrogen and fuel cell technology. Thus the research sub-question: How to develop a national road map?

Definition of the conceptual problem: Confirmed national action plans indicate an implementation deficit in planned measures from the political sphere. The political sphere does not show sufficient support for the inclusion of the required financials in the national budget to carry out the planned measures. Thus the research sub-question: How to select potential new technologies that will enable achieving the goals as outlined in the road map?

As seen from the previous indicators section, countries for the case study are comparable, thus their being selected for the research. This thesis research has gathered only a select segment of the countries from which primary data was collected. With this kind of approach, a broader picture was obtained illustrating how countries are implementing new technologies today. One could raise the question – why not gather information from a wider selection of countries? I agree that for a more specific and detailed study focussing on one stage of the process or more specific tasks, a wider selection of countries would be useful and fruitful. As a result, these topics are proposed in the further research section for future work. For the purposes of this thesis, the approach employed and presented is robust enough to show the operational approaches and the division of tasks and responsibilities.

5.11.2. Limitations regarding the methodology

For the purposes of the thesis research, three groups of people were chosen. All three groups are interlinked during the preparation of the implementation process for new technologies.

The following sample was chosen:

- Group A: Experts provided answers on the current state of the technology and the measures necessary to support further research and development of the technology.
- Group B: Ministry staff involved in horizontal coordination between priority policies of different ministries and involved in including those priorities in the national strategy.
- Group C: Leading staff involved in the preparation of national priorities provide answers on how to make priorities sufficiently concrete, such that they don't change with every change of the government.

The resulting sample is: 4 countries covering 3 groups of people (3 decision levels) with 5 interviewees in each group. The aim of the research was to interview 60 people, which is enough to establish an understanding of the country's system. At the conclusion of the research, 48 responses had been gathered.

It cannot be expected to collect responses from all of the representatives of the chosen target groups, because resources are insufficient and time does not permit – such as for extended research. In addition, change in staff positions also had an influence on the possibility of collecting all the of the responses with relative ease.

Once the target groups had been chosen, the challenge was to prepare rigid questionnaires that would enable collecting data across from the EU, among various countries and in their respective languages.

Views differ among researchers when to use open questions and when closed. The first difference is the role of the respondent. When using closed questions, we limit the respondent's answer. I think that an approach employing a mixed set of questions is more useful when researching policy systems and comparing country approaches together. This approach was used for the thesis in cases when closed question, such as for group B – Is there a penalty for not implementing the agreed measures? The next question was then left open in order to gather a wider sample of information in the country, to gain a personal response from the respondent in order to gather information that can be used to develop a sound and practical proposal.

Open and closed questions also have some disadvantages. Closed questions can result in biased responses, because only a certain, defined set of answers is offered for consideration. On the other hand, open questions can lead to unanswered questions or questions answered in only the affirmative or negative. In addition, using open questions creates more challenges when performing the transcription (if recorded - validity) and in sorting the answers for analysis.

The biggest challenge in the research process was ensuring a sufficiently high response rate to the questionnaires in each target group. In order to improve the response rate, different methods of data collection were combined; face-to-face, telephone and email interviews. This approach proved optimal, as covering all four target countries and their respective respondents would have required considerable financial investment in order to carry out all of the interviews in person. Given the level of ICT today I was able to efficiently perform 48 of the 60 planned interviews in the chosen countries across Europe, from among various research institutions, government agencies and ministries.

5.11.3. Limitations regarding the analysis

The thesis develops a concept around typical cases (sampling groups) and is based on the qualitative research of three levels of actors in the decision-making and implementation process (experts, political decision-makers, directors of public agencies involved in implementing national measures). Both open and closed questions were used in the questionnaires used to gather the data.

Reading the research we see that the criteria for reliability and validity are very much the same for both qualitative and quantitative research (Altheide, 1998; Leininger, 1994). The process of policy development should be based on a qualitative approach in order to consider all of the necessary aspects of the implementation environment. Semi-structured interviews offer structured guidance and leave room for discussion between the specific topic-question. In this type of interview, the question order can be changed, depending on the direction of the interview. Both open and closed questions also have some disadvantages. Closed questions can result in biased responses, because only a specific set of answers is offered. On the other hand, open questions can lead to unanswered questions and questions answered simply in the affirmative or negative. In addition, using open questions creates more challenges when performing the transcription (if recorded - validity) and later sorting the answers for analysis.

Table 7 presents responses to the questionnaires in each group in the summary and by country. Chapter 6.2.4 on features a detailed analysis of the answers from the target groups. One can see that there is not a problem of consistently coherent answers between the groups, which leaves us to conclude that the answers are valid. There are clear differences from the responses why other case study countries have already implemented the technology and Slovenia has not. There

would be a problem if one group of respondents answered differently than another group in the same country. But this is not the case – which underlines the validity of the conclusions drawn.

5.11.4. Limitations regarding the proposed action plan for Slovenia

The proposal for a practical process that is the result of the thesis is comprehensively connected to the responses and conclusions of the research. The responses clearly show what each case study country is doing and how, as well as what is lacking in Slovenia. An efficient institutional system and political support are needed for the implementation of new technologies.

The most important outcome of the research and the comparison with case-study countries appears in step one, when governments (politicians) determine priorities and targets for a specific technology. Here specific aims need to be very clear, and the ministries responsible need to be identified with and assigned specific tasks. Once political support is in place, the second most important issue in the implementation process is to see horizontal cooperation between the responsible ministries in order to be able to prepare an efficient implementation process. These two factors are the most important inputs that emerge from the responses and the country comparisons. This is why every step in the practical proposal also includes the responsible ministries that should be involved in the implementation process.

All of the other steps are but a logical continuation of the previous steps.

6. Results and analysis of primary data

Chapters up to now give us background about research that has been done so far on the specific fields as seen in the literature review chapter, why decided countries were chosen and how is implementation of hydrogen and fuel cell included in national strategies.

Chapters before also set out methodology of the research, questionnaires and what groups of people were targeted. The next chapters include results, discussion and methodology for practical process proposal.

6.1. Results

For purposes of the research a decision was made to employ Meaning Condensation; thus the meaning of the interviews was compressed into shorter formulations. Long answers were rephrased as shorter statements without changing or compromising the substance or meaning of the answers. “This form of meaning condensation can serve to analyse extensive and often complex interview text by looking for natural meaning units and explicating their main themes” (Kvale, 2009).

Work by Johnson shows that “the subjectivity of interpretive research values the investigator as a person who may interpret data uniquely” (Johnson, 1999).

The first step was to establish a coding system for each of the respondents, which observed the rule of ethics not to include the names of the respondents in the analysis. The names of the respondents are known to the author and to my advisors in Slovenia and the UK. For example: the code ‘A1s’ stands for group A, 1st respondent, and the letter S for Slovenia.

The second step in the analysis was to prepare flow sheets for each set of questions in all three target groups. Flow sheets for each group are presented in the following pages: in 106 for group A, in 107 for group B, and in 108 for group C. The flow sheets show the flow of questions during the interview and will help during the analysis to understand the consistency of the answers among the interviewees in each target group.

The third step was to develop a legend for positive, negative and neutral answers. P was chosen to represent positive answers, n for neutral answers and m for negative.

The next step was to review all of the answers and assign them positive, neutral or negative designations as characterisations of the responses and answers. For example: Does your country have a system for instituting long-term government priorities that cannot be changed or repealed by the next elected government? If the answer was yes, a letter ‘p’ was assigned to the response. The next step was to create a coding and influence factors scheme to determine the weight of the person and with that the importance of their answer. Not all five respondents in any country are weighted equally. The weight of a response is linked to the person’s position and the knowledge they bring to it. Responses are weighted from 1 to 5, with 1 the lowest and 5 the highest weight. An influence factor was determined for each person by combining the sum of all weights in a group and dividing each person’s weight by the sum of all weights in a group. This way an influence factor was determined (for example 0.21) that would indicate which answer is more relevant than another.

The next step was to gather all five responses (five people in a group for each country) for each question and derive from them a common focus or emphasis that was grouped in the “conclusion of answers”. This way, a common emphasis from among all five responses included combined information that respondents wished to communicate for each specific answer.

For purposes of the research, three target groups were chosen. Questionnaires for each target group are presented on pages 103 for group A, 104 for group B and 105 for group C. Below the emphasis for each group and country by each question is shown. Question 1 (Do you agree to take part in this interview and have the information gathered from it used for the purposes of the PhD work?). Is not included in the table below. Question 1 is necessary as part of the ethics procedure and have no influence on the responses.

6.1.1. Group A- Experts provided answers on the recent stage of the technology and necessary measures to support further research and development of the technology

6.1.1.1. Norway

From the emphasis in Table 6 below, it is clear that Norway has a national program for hydrogen and fuel cells and a responsible body on the Norwegian research council that is in charge for the distribution of finances. Norway has already implemented hydrogen fuel cell vehicles, buses and

refuelling infrastructure. Experts in the field of hydrogen and fuel cells are aware of the obstacles – on both the national and EU level – that must be overcome for easier, more effective implementation of hydrogen and fuel cell technology.

Table 8: Emphasis in answers on questions in Group A for Norway.

Question	Emphasis
3. At what stage of the implementation process is mobile, stationary and portable hydrogen technology in your country?	In total some 25 fuel cell-powered passenger vehicles and 5 fuel cell-powered buses; Norway has many tax and traffic incentives that make hydrogen vehicles more commercially competitive.
4. What obstacles exist for their broader implementation in EU?	Financial support schemes, public support to overcome the gap, a synchronized introduction of filling stations and cars in selected hubs and areas in the country, the availability and cost of hydrogen.
5. What obstacles exist for their broader implementation at your national level?	Financial instruments for early implementation of hydrogen refuelling stations, public support to overcome the gap, a synchronized introduction of filling stations and cars in selected hubs and areas, tax breaks similar to that for electrical cars. Subsidising the hydrogen fuel.
6. Do you have a national program for hydrogen and fuel cell research and implementation?	Yes, the Norwegian research council has programs where hydrogen technology is a priority field.
7. If yes, which body is responsible for it and what was the procedure for the adoption of such a program?	The research council of Norway is in charge. Entities need to apply for funding through calls organised by the council.
8. If no, why not, and who should adopt such a program?	The Research Council of Norway is the natural institution to lead this, funded by the relevant government ministries.

9. What measures would be requires on the national level (of your country) for broader national implementation of these technologies?	Continue to support and expand the existing hub with more stations and cars, and keep the tax and traffic incentives in place. Start research and development on hydrogen for green ships, since shipping is an important industry in Norway.
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Source: Carried out interviews

6.1.1.2. Slovenia

From the emphasis in Table 7 below it is clear that Slovenia does not have National program for hydrogen and fuel cells. Slovenia also does not have implemented mobile applications. It only has industrial scale hydrogen production. There is some research present in universities and institutes. Slovenian research institutes and industry see hydrogen technology as reserve solution and they do not invest all the money and personnel in its development. This is because there are no clear signals on the national level that such as technology would be a priority for Slovenia. Slovenian experts state what obstacles exist on the EU level and in Slovenia for easier implementation of such technology. Compared to other three countries, listed obstacles are broader and not specifically focused on certain measure or component. It is shown from the emphasis that National program for hydrogen and fuel cells needs to be horizontal, prepared with the cooperation of several ministries.

Table 9: Emphasis in answers on questions in Group A for Slovenia.

Question	Emphasis
3. At what stage of the implementation process is mobile, stationary and portable hydrogen technology in your country?	<p>Mobile: There is no mobile applications in Slovenia</p> <p>Stationary: there are some facilities for hydrogen production on industrial scale,</p> <p>Research activities: In Slovenia are present only particles of this technology in research departments in universities or institutes.</p> <p>Slovenian research institutes and industry see</p>

	<p>hydrogen technology as reserve solution and they do not invest all the money and personal in its development. This is because there is no clear signals on the national level that such as technology would be a priority for Slovenia.</p> <p>Research infrastructure: some laboratories for testing hydrogen technologies have been built in the last few years</p> <p>Prototypes: have been developed (auxiliary 7kW power supply for a military vehicle, 30 kW Uninterruptable Power Supply system, 7kW PEM FC based cogeneration system)</p> <p>Industry: World-established producer of blowers for FC systems, company dealing with prototype PEM stack production</p>
<p>4. What obstacles exist for their broader implementation in EU?</p>	<p>economy of scale and prices of the technology, complex technology, new skills needed, production, distribution and fuelling infrastructure needed, lack of promotion, public fear, subsidies needed for demonstration projects</p>
<p>5. What obstacles exist for their broader implementation at your national level?</p>	<p>Dispersion of ideas and non-authoritative decision making in transport sector, economy if scale and prices of the technology, complex technology, new skills needed, production, distribution and fuelling infrastructure needed, lack of promotion, public fear, subsidies needed for demonstration projects</p>
<p>6. Do you have national program for hydrogen and fuel cell research and</p>	<p>No</p>

implementation?	
7. If yes, which body is in charge for it and which was the procedure for adoption such program?	
8. If no, why not and who should adopt such program?	Horizontal implementation among all the ministries. Ministry for education needs to incorporate school programs for new skills; Ministry for the research needs to support research on certain field, etc. The whole cycle needs to be closed for the implementation to be successful. Refrain from inclusion of self-called expert.
9. What measures would you require on the national level for broader national implementation of these technologies?	

Source: Carried out interviews

6.1.1.3. Denmark

From the emphasis in Table 8 below it is clear that Denmark has strategies for various fuel cell types, hydrogen technologies and for various applications, and the activities are well supported by national programs. Denmark has mobile and stationary applications in use. Experts are aware of obstacles on the EU and national level. Ministries are working horizontally together for easier implementation of hydrogen and fuel cells technology.

Table 10: Emphasis in answers on questions in Group A for Denmark.

Question	Emphasis
3. At what stage of the implementation process is mobile, stationary and portable hydrogen technology in your country?	Mobile: several hydrogen vehicles are running, and a number of hydrogen tanking stations in place. Stationary: Many (hundreds) of UPS for telecom back-up is installed in Denmark, by

	Danish company (Dantherm Power). Same company is selling UPS in e.g. Canada and China Portable: none
4. What obstacles exist for their broader implementation in EU?	more demos, infrastructure, political
5. What obstacles exist for their broader implementation at your national level?	more demos, infrastructure, political, price of a fuel cell car
6. Do you have national program for hydrogen and fuel cell research and implementation?	there are strategies for various fuel cell types, hydrogen technologies and for various applications, and the activities are well supported by national programs
7. If yes, which body is in charge for it and which was the procedure for adoption such program?	The Ministry of Climate, Energy and building and the ministry for Education and Science, DEO
8. If no, why not and who should adopt such program?	Everything works ok today.
9. What measures would you require on the national level for broader national implementation of these technologies?	More demos, testing and more R&D Politics (taxation, public programs for buying products) Information to the public

Source: Carried out interviews

6.1.1.4. Germany

From the emphasis in Table 9 below it is clear that Germany has National program for hydrogen and fuel cells and it is funded by different federal ministries. Germany has implemented mobile, stationary and portable applications. Experts are aware of obstacles on the EU and national level. They list specific obstacles for specific field, component and needed measure on the national level.

Table 11: Emphasis in answers on questions in Group A for Germany

Question	Emphasis
<p>3. At what stage of the implementation process is mobile, stationary and portable hydrogen technology in your country?</p>	<p>Mobile: research and demonstration, commercialization in niche markets, Daimler announced to introduce hydrogen fueled cars to the market in 2017.</p> <p>Stationary: research and demonstration, About 500 stationary devices have been tested in a field test with funding. These devices are now offered by the companies. Demonstration project for fuel cell heating systems (Callux), current procurement of fuel cell back-up public safety digital radio service station (BDBOS). Use of Direct methanol fuel cell (DMFC) with parts of German Army forces.</p> <p>Portable: Portable fuel cells have been commercialized first by Smart Fuel Cell, about 30.000 devices have been sold.</p>
<p>4. What obstacles exist for their broader implementation in EU?</p>	<p>Cheaper alternative technologies like combustion engines. Absence of infrastructure on a large level, demand of huge investments. Issues with complex technology, Missing funding schemes for market introduction</p>
<p>5. What obstacles exist for their broader implementation at your national level?</p>	<p>Cheaper alternative technologies like combustion engines. Absence of infrastructure on a large level, demand of huge investments. Issues with complex technology, Missing funding schemes for market introduction</p>

6. Do you have national program for hydrogen and fuel cell research and implementation?	Yes
7. If yes, which body is in charge for it and which was the procedure for adoption such program?	Program is managed by National Organisation Hydrogen and Fuel Cell Technology (NOW), a non for profit company and funded by different federal ministries.
8. If no, why not and who should adopt such program?	
9. What measures would you require on the national level for broader national implementation of these technologies?	More directed, long-term funding of fundamental research, R&D projects must be funded which support to decrease the costs of fuel cell, Implementation of a public hydrogen infrastructure, Incentives for stationary applications for at home electricity production

Source: Carried out interviews

6.1.2. Group B- Ministry employees involved in horizontal coordination between priority policies of different ministries and in the inclusion of those priorities in the nation budget

6.1.2.1. Norway

From the emphasis in Table 10 below it is clear that Norway has long term strategies and action plans that will guide their priorities independent of elected Government. For specific topics such as climate change, they see the need for a system to accept long term Government priorities that cannot be changed by the next elected Government. In addition, they support implementation of penalties if the agreed measures are not implemented.

Table 12: Emphasis in answers on questions in Group B for Norway.

Question	Emphasis
3. Does your country have a system to accept long term Government priorities that cannot be changed by the next elected Government?	No, there are long term strategies and action plans that will guide their priorities independent of elected Government
4. If not, by your opinion is it needed or not?	Yes and no. Depending on the topic. (for example: Climate change yes)
5. If needed, what do you think that would be good approach to implement it?	Consensus among political parties forming the parliament
6. Does your Government have office for horizontal coordination between national policies and required inclusion in national budget?	No
7. Who is assuring that agreed required measures in accepted Action Plans has required support in yearly national budget?	It cannot be assured
8. Who is checking implementation of agreed measures?	The Research Council of Norway
9. Is there a penalty for not implement agreed measures?	No
10. If yes, what is the process of assessment?	
11. If not, do you support its implementation?	Yes
12. If yes, how should be framed?	
13. Why are Government documents accepted if there is not enough money for planned measures assured in yearly national budget?	

Source: Carried out interviews

6.1.2.2. Slovenia

From the emphasis in Table 11 below it is clear that Slovenia does not have measures to prevent new Government for changing strategic documents or development priorities. Every new

Government can change its priorities. It is common emphasis that Slovenia needs clear strategic development strategy with political consensus for key issues. There should be one main document and from it derived programs for specific sector. There is no penalty and responsibility for not executed measures; only political obligation; fewer votes on the elections. It is common emphasis that there should be a penalty for not implementing agreed measures. Respondents also offer some solutions how the penalty measure should look like.

Table 13: Emphasis in answers on questions in Group B for Slovenia.

Question	Emphasis
3. Does your country have a system to accept long term Government priorities that cannot be changed by the next elected Government?	There is no system to prevent new Government for changing strategic documents or development priorities. Every new Government can change its priorities.
4. If not, by your opinion is it needed or not?	Slovenia needs clear strategic development strategy with political consensus for key issues.
5. If needed, what do you think that would be good approach to implement it?	It should be a document that will not have consensus only among coalition but also among opposition political partners. For implementation of such as document is important for public administration to gain more expertise which will result in better programs which will have long term support. One main document and from it derived programs for specific sector. All the sub documents with measures need to have indicators that will show how combined contribute towards the goal from the main document.
6. Does your Government have office for horizontal coordination between national	There is no special office for horizontal coordination

<p>policies and required inclusion in national budget?</p>	
<p>7. Who is assuring that agreed required measures in accepted Action Plans has required support in yearly national budget?</p>	<p>Ministry in charge for the specific measure should assure enough budget for implementation of measures.</p>
<p>8. Who is checking implementation of agreed measures?</p>	<p>There is no content check only technical administrative issues. General Secretariat follows implementation of the decisions. To some extent, efficiency of the measures is checked by the Court of Audit. The problem of the Court of Audit is that they check past measures and its conclusions come too late to be implemented.</p>
<p>9. Is there a penalty for not implement agreed measures?</p>	<p>There is no penalty and responsibility for not executed measures. Only political obligation, less votes on the elections.</p>
<p>10. If yes, what is the process of assessment?</p>	
<p>11. If not, do you support its implementation?</p>	<p>Yes</p>
<p>12. If yes, how should be framed?</p>	<p>There needs to be clear division for the role in the organization. Minister is politician and only responsible for the efficient working processes at the Ministry. This is not good. There should be a financial officer who will be in charge for distribution of public money in the ministry. Such as person need to inform the minister that the yearly budget can only support, for example, 50 % of the planned measures.</p>
<p>13. Why are Government documents accepted if there is not enough money for planned measures assured in yearly national budget?</p>	<p>It often happen, that documents are confirmed only to provide tick for EU and to be used for marketing needs. It was many times</p>

	acknowledged by outside revision, that Slovenia should have less realistic documents instead of many of them that are not executed.
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Source: Carried out interviews

6.1.2.3. Denmark

From the emphasis in Table 12 below it is clear that the Danish Parliament decides the Danish priorities and that agreement is formed. Ministry of finance is horizontally coordinating between national policies and required inclusion in national budget. There is understanding that there is no other option than the agreed measures just to be implemented. If there is not enough budget, measures are not accepted.

Table 14: Emphasis in answers on questions in Group B for Denmark

Question	Emphasis
3. Does your country have a system to accept long term Government priorities that cannot be changed by the next elected Government?	the Parliament that decides the Danish priorities, the more political parties that are included in the agreement - the better for the current Government, since their politics will continue in some form after next election.
4. If not, by your opinion is it needed or not?	
5. If needed, what do you think that would be good approach to implement it?	
6. Does your Government have office for horizontal coordination between national policies and required inclusion in national budget?	Ministry of finance
7. Who is assuring that agreed required measures in accepted Action Plans has required support in yearly national budget?	the politicians and the ministry
8. Who is checking implementation of agreed	measures just have to be implemented

measures?	
9. Is there a penalty for not implement agreed measures?	No
10. If yes, what is the process of assessment?	
11. If not, do you support its implementation?	political agreements should be implemented
12. If yes, how should be framed?	
13. Why are Government documents accepted if there is not enough money for planned measures assured in yearly national budget?	Budget is there for the measures. If there is no budget, measures are not accepted.

Source: Carried out interviews

6.1.2.4. *Germany*

From the emphasis in Table 13 below it is clear that there are long ranging commitments with very high continuity and minor adjustments due to the changing Government. However, elected Parliament has the freedom to change laws or even to stop ongoing projects. It is common emphasis that long term priorities are crucial for excellent results. Employees of the Federal Ministry of Finance and Budget Committee of the Parliament sit down and discuss how overall topic should be framed to be in line with all included ministries and budget. It is common emphasis that there are penalties for individual cases if the measures are not implemented. Some times are projects confirmed in the budget even if there is no financial cover because those projects need extensive development phase.

Table 15: Emphasis in answers on questions in Group B for Germany.

Question	Emphasis
3. Does your country have a system to accept long term Government priorities that cannot be changed by the next elected Government?	Long ranging commitments, very high continuity, minor adjustments due to the changing Government, the (next) elected parliament has the freedom to change laws or (even) to stop ongoing projects
4. If not, by your opinion is it needed or not?	crucial for getting excellent results
5. If needed, what do you think that would be	(no idea, one response)

good approach to implement it?	
6. Does your Government have office for horizontal coordination between national policies and required inclusion in national budget?	No special offices for coordinating measures, Yes, they call it “Federal Ministry of Finance” and “Budget Committee” of the parliament, employees sit down and discuss how overall topic should be framed to be in line with all included ministries. The Foreign Ministry is often coordinating, coordinated not on the highest level i. e. rather on the unit level.
7. Who is assuring that agreed required measures in accepted Action Plans has required support in yearly national budget?	industry sends project proposals that than Project Management Organizations includes in the budget, each ministry for their own, Ministry of Finance, majority in the parliament
8. Who is checking implementation of agreed measures?	advisory council and ministry divisions, Government, own ministry and ministry of finance,
9. Is there a penalty for not implement agreed measures?	no, depending on the individual cases
10. If yes, what is the process of assessment?	depending on the individual cases
11. If not, do you support its implementation?	not necessary
12. If yes, how should be framed?	(do not know, one response)
13. Why are Government documents accepted if there is not enough money for planned measures assured in yearly national budget?	Two main reasons: First, projects, such as major infrastructure projects in particular, tend to require an extensive development phase before they are set to be carried out. This complex development phase is – due to its very nature – difficult to be anticipated precisely. Second, with respect to the aforementioned argument, there is a certain

	churn rate of projects. For this reason, it seems advisable to have a ‘pool’ of reserve projects at hand that could be pursued in case other projects have to be cancelled or delayed.
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Source: Carried out interviews

6.1.3. Group C- Leading employees involved in the preparation of national priorities provided answers on how to make priorities such concrete that they are not changed with every government elections

6.1.3.1. Norway

From the emphasis in Table 14 below it is clear that Norway has for specific subject such as hydrogen, road, rail, air, and sea transport group of experts who create development priorities of a country. Preparation of development priorities for the country can be shown from two examples: For hydrogen: The Hydrogen Council uses their internal resources as well as external advisors to suggest strategies and priorities on a national level. These has been compiled into a report and presented for the Government. For transport sector: Every four years expert groups conduct a strategic planning process for about two years; a analysis phase for one year followed by a planning phase lasting about one year. The work is done on the basis of a detailed mission formed by the Government. Agreement on the priorities is made with the consensus or voting. Priority program can be changed by the next Government unless there is a settlement between all parties in the parliament that the policy or program should remain unchanged. Emphasis is shown that such as expert group is needed on the national level and that the politicians should decide based on insights provided by advisory groups of professionals. It is also shown from the responses that that long term development priorities are needed in a form of strategy confirmed by the parliament.

Table 16: Emphasis in answers on questions in Group C for Norway.

Question	Emphasis
3. Does your Government have group of experts who create development priorities of a country?	Yes, for hydrogen and fuel cells is responsible the Hydrogen Council. For road, rail, air, and sea transport are

	responsible joint expert planning groups on national level in cooperation with the Governmental Department for Transport
4. If yes, how does expert group prepare development priorities for the country?	<p>For hydrogen: The Hydrogen Council uses their internal resources as well as external advisors to suggest strategies and priorities on a national level. These has been complied into a report and presented for the Government.</p> <p>For transport sector: Every four years expert groups conduct a strategic planning process for about two years; a analysis phase for one year followed by a planning phase lasting about one year. The work is done on the basis of a detailed mission formed by the Government.</p>
5. If yes, how does expert agree on chosen priorities?	Consensus based decisions in the group about what should be in the documents prepared. Sometimes dissent opinions are presented as the view of individual members or organizations. Process is concluded by voting.
6. If yes, can priority program be changed by the next Government?	Yes, unless there is a settlement between all parties in the parliament that the policy or program should remain unchanged.
7. If no, do you think that such as group is needed on the national level?	The politicians should decide based on insights provided by advisory groups of professionals. Expert groups are needed if planning and execution shall be based on facts and professional analysis

8. If no, how does your Government prepare priorities for national development?	The politicians should decide based on insights provided by advisory groups of professionals.
9. Do you think that long term development priorities are needed in a form of strategy confirmed by the parliament?	Yes. The parliament carries the responsibility for the priorities through its confirmation of the long term, strategic priorities.

6.1.3.2. *Slovenia*

From the emphasis in table 15 below it is clear that only some Governments in Slovenia had experts groups but they were more or less extended arm of the political influence. Experts groups in many cases only provide opinion on the current policy proposals and overall work in line with priorities of the Government. Emphasis show that next Government can change priority program and that expert group is needed on the national level. It is also shown from the emphasis that long term development priorities are needed in a form of strategy confirmed by the parliament.

Table 17: Emphasis in answers on questions in Group C for Slovenia.

Question	Emphasis
3. Does your Government have group of experts who create development priorities of a country?	Some of the Governments did have it but it was more or less extended arm of the political influence. Science and technology council does distribution of research funds.
4. If yes, how does expert group prepare development priorities for the country?	Examples from Science and technology council: Expert groups are typically assembled in a way that all the relevant stakeholders are represented in the group. The work of expert groups is in general conducted in a way that firstly gathers all the needs, all challenges, identifies weaknesses and strengths in the certain area and then through various rounds of debate (which is ideally

	complemented by the consultation and feedback by stakeholders' community in between each round) come to the common agreement on priorities or at least main framings of broader issues that are agreed to have a high importance. Priority-setting is a complex process and typically priorities reflect more of a compromise than real-time priorities.
5. If yes, how does expert agree on chosen priorities?	More provides opinion on the current policy proposals and overall work in line with priorities of the Government, consensus.
6. If yes, can priority program be changed by the next Government?	Yes
7. If no, do you think that such as group is needed on the national level?	Yes
8. If no, how does your Government prepare priorities for national development?	We do not know yet
9. Do you think that long term development priorities are needed in a form of strategy confirmed by the parliament?	Yes

Source: Carried out interviews

6.1.3.3. Denmark

From the emphasis in Table 16 below it is clear that Denmark has expert group for specific topics. Danish Government appointed a Commission on Climate Change consisted of 10 experts possessing special knowledge in the fields of climate, agriculture, transportation and economics. The task of the Commission was to present proposals for new proactive instruments for an energy and climate change policy with global and market-based perspectives that contribute to cost-effective attainment of the long-term vision. In the area of energy there is a long tradition in Denmark for broad agreements in the Parliament which provide a solid and stable framework for

private and public investments in the sector, although the Government will be replaced. Emphases show that expert group is needed on the national level and that long term development priorities are needed in a form of strategy confirmed by the parliament.

Table 18: Emphasis in answers on questions in Group C for Denmark.

Question	Emphasis
3. Does your Government have group of experts who create development priorities of a country?	No, there is not a special group of experts advising the Government. However, in 2008 the Danish Government appointed a Commission on Climate Change consisted of 10 experts possessing special knowledge in the fields of climate, agriculture, transportation and economics. The task of the Commission was to present proposals for new proactive instruments for an energy and climate change policy with global and market-based perspectives that contribute to cost-effective attainment of the long-term vision.
4. If yes, how does expert group prepare development priorities for the country?	
5. If yes, how does expert agree on chosen priorities?	In the area of energy there is a long tradition in Denmark for broad agreements in the Parliament which provide a solid and stable framework for private and public investments in the sector, although the Government will be replaced
6. If yes, can priority program be changed by the next Government?	
7. If no, do you think that such as group is needed on the national level	Yes

8. If no, how does your Government prepare priorities for national development?	There can be other political influences on which areas of interest is prioritized in the different funding programs
9. Do you think that long term development priorities are needed in a form of strategy confirmed by the parliament?	Yes, on technology development

Source: Carried out interviews

6.1.3.4. *Germany*

From the emphasis in Table 17 below it is clear that Germany has experts groups for specific subjects. Advisory Board has the task of providing both content and technical consultation support to the management of the program partners for the implementation of the “National Innovation Program for Hydrogen and Fuel Cell Technology. The Federal Ministry of Transport and Digital Infrastructure have an advisory board of external experts on research. For hydrogen as an example: Industry and ministries have agreed on a National Implementation Plan (NIP) with topics, a total budget and an annual budget allocation also by topical area, which is adhered to by an ordinary planning process by NOW. The NOW Advisory Council meets on a regular basis (3-4 times per year). Members include representatives from different industry sectors (automotive, infrastructure, energy, stationary, suppliers) – each of these members reports to a respective industry group to assure a company independent view. Priorities are being discussed and prepared in these groups including the program managers of NOW. Emphasis show that experts groups are needed on the national level and that long term development priorities are needed in a form of strategy confirmed by the parliament.

Table 19: Emphasis in answers on questions in Group C for Germany.

Question	Emphasis
3. Does your Government have group of experts who create development priorities of a country?	Advisory Board has the task of providing both content and technical consultation support to the management of the program partners for the implementation of the “National Innovation Program for Hydrogen

	<p>and Fuel Cell Technology</p> <p>The Federal Ministry of Transport and Digital Infrastructure has an advisory board of external experts on research. Apart from that there is no group of experts or advisory board continuously working for the ministry. In singular cases there might be adhoc-groups, but not as a rule.</p>
4. If yes, how does expert group prepare development priorities for the country?	<p>The NOW Advisory Council meets on a regular basis (3-4 times per year). Members include representatives from different industry sectors (automotive, infrastructure, energy, stationary, suppliers) – each of these members reports to a respective industry group to assure a company independent view. Priorities are being discussed and prepared in these groups including the program managers of NOW</p>
5. If yes, how does expert agree on chosen priorities?	<p>Industry and ministries have agreed on a National Implementation Plan (NIP) with topics, a total budget and an annual budget allocation also by topical area, which is adhered to by an ordinary planning process by NOW, supported by the national body Project Office Jülich (PtJ) which helps with the formal funding processes.</p>
6. If yes, can priority program be changed by the next Government?	<p>Yes</p>
7. If no, do you think that such as group is needed on the national level?	<p>Yes</p>
8. If no, how does your Government prepare	

priorities for national development?	
9. Do you think that long term development priorities are needed in a form of strategy confirmed by the parliament?	Absolutely yes. We are convinced that we need a balanced mix of long-term planning (back casting by first defining and following a long-term goal) as well as short term roll-out/acting (forecasting). This is basically well-established to follow at least some continuity in otherwise extremely dynamic times. For us only a signal that we are in a period of new orientation, as we are hitting some physical barriers (world population, fossil resource depletion, climate threat).

Source: Carried out interviews

6.2. Discussion

The Discussion section is based solely on responses to the questionnaires. Qualitative and quantitative information is not supplemented with actual data on the current status/situation of hydrogen and fuel cell technology.

6.2.1. Group A- Experts provided answers on the recent stage of the technology and necessary measures to support further research and development of the technology

Questions in the questionnaires are formed in a meaningful way. The flow of questions provides a better understanding of the conditions in each country in each particular group. A flow sheet of questions for target group A is presented on pages 106.

On the **question** “At what stage of the implementation process is mobile, stationary and portable hydrogen technology in your country?”

“Norway answered that the country has 25 fuel cell-powered passenger vehicles, 5 fuel cell-powered buses and 7 fuelling stations for hydrogen”. Norway has many tax and traffic incentives that make hydrogen vehicles commercially more competitive.

In Denmark, several hydrogen vehicles are in operation, and a number of hydrogen tanking stations are in place. Denmark also has hundreds of UPS for telecoms back-up installed. Some companies are selling UPS in Canada and China.

In Germany there are research and demonstration projects with hydrogen vehicles running with a view towards commercialization. Daimler announced the introduction of hydrogen-powered cars to the market for 2017. Germany also has about 500 stationary devices that have been tested in field tests. In addition, in Germany there are demonstration projects running for fuel cell heating systems (Callux), fuel cell powered back-up public safety digital radio service stations (BDBOS) and use of direct methanol fuel cell (DMFC) in parts of the German armed forces. German companies have sold about 30,000 such portable devices around the world.

On the other hand, there are no such mobile applications in Slovenia. There are some hydrogen production facilities in Slovenia serving industry that are not part of any larger strategic hydrogen implementation scheme, but serving industry needs alone. In Slovenia there are only fragments of this technology present in research departments in universities and/or institutes. Some laboratories for testing hydrogen technologies have been built in the last few years. Some fuel cell systems have been purchased for national demonstration projects (a 1.3 kW fuel cell system, a 30 kW Uninterruptable Power Supply system) and some systems have been upgraded with nationally developed and produced components (auxiliary 7kW power supply for a military vehicle, 7 kW PEM FC-based cogeneration system for auxiliary power supply in heavy trucks). Slovenia has one company that is a globally-established producer of cathode blowers for FC systems and one that is dealing with prototype small PEM stack production.

On the **question** “What are the obstacles to their broader implementation in the EU?” one can see that there is a difference in how countries see existing obstacles to easier implementation of hydrogen and fuel cell technology on the EU level. A combination of emphasis from Germany, Norway and Denmark names obstacles such as financial support schemes for market introduction, public support, synchronized introduction of filling stations and cars in selected hubs and larger areas in the country, and the cost and availability of hydrogen. These obstacles are directly linked to the implementation of the technology. On the other hand, emphasis in Slovenian is linked more to system development factors such as the price of the technology, new skills, lack of promotion, public fear, and subsidies required for demonstration projects.

Knowledge capacity in Slovenia is still in the “how to approach” phase compared to the other

three countries, where thinking is focused on the measures required for easier implementation of the technology. This problem is linked to a complete absence of a national program and national priorities.

Similar emphases were given for the **question** “What obstacles exist for their broader implementation at your national level?” Again, all three comparison countries emphasised obstacles such as “tax breaks/incentives similar to those for electric cars and subsidising the hydrogen fuel”; on the other hand Slovenia emphasized obstacles such as dispersion of ideas and non-authoritative decision-making in the transport sector, the new skills that are needed, public fear, and subsidies required for demonstration projects.

It would not be incorrect to conclude that the level of implemented technology in a country is linked to the existence of a national program for hydrogen and fuel cells. On the **question** “Do you have a national program for hydrogen and fuel cell research and implementation” and “If yes, which body is responsible for it and what was the procedure for the adoption of such a program” Norway, Denmark and Germany emphasized that they have in place national programs for hydrogen and fuel cells, and mechanisms such as research councils, horizontal ministerial cooperation and government organizations that are in charge of hydrogen implementation on the national level. Slovenia on the other hand does not have a national program for hydrogen and fuel cells, which results in no implemented technology.

Slovenian research institutes and industry see hydrogen technology as a reserve solution and do not invest vast financial and personal capacities in the development of such. This is because there are no clear signals on the national level that such a technology would be a priority for Slovenia. On the **question** “What measures would you require on the national level for broader national implementation of these technologies?” the other three countries emphasized that they are carrying out implementation of national programs where measures such as lower taxes, more demonstration projects, public programs for purchase and adoption etc. are planned.

Slovenia on the other hand emphasized that it needs a long-term energy strategy that will provide guidance and a framework for national priorities as well as social education, public awareness campaigns that address the safety and availability of the technology and the inclusion of hydrogen in the development strategies of the relevant ministries (transportation, infrastructure, research, etc). On the political level, Slovenia also needs to practice faster decision-making.

6.2.2. Group B- Ministry employees involved in horizontal coordination between priority policies of different ministries and in the inclusion of those priorities in the nation budget

A flow sheet for the following questions is presented on page 107.

To the **question** “Does your country have a system to implement long-term government priorities that cannot be changed by/with the next elected government?” Norway emphasized that there is no formal system that ensures long-term government priorities cannot simply be changed or repealed by the next elected government. However, there are long-term strategies and action plans that will guide priorities independent of the elected government. Slovenia does not have a system to prevent new governments from changing strategic documents or repealing development priorities, regardless of the fact that such documents would be established by Parliament.

In Denmark, the Parliament determines Danish priorities; the more political parties included in the agreement the better for the current government, since their political line will continue in some form after the next elections.

Germany has long-ranging commitments, very high continuity and only minor adjustments with the change of government. The (next) elected Parliament has the freedom to change laws or (even) stop current or ongoing projects.

Long-term priorities, continuity and strategic development separate these three other EU countries from Slovenia. Every new technology has an implementation rate that is linked to its complexity – the more complex a new technology is the longer its implementation takes.

Hydrogen and fuel cell technology has a very complex implementation profile. A country needs to have or put hydrogen production and distribution infrastructure in place. It needs to provide education and training for new skills and prepare the public for its acceptance. All of these tasks require strategic planning, horizontal coordination among different ministries and continuity.

Continuity is very important. A new/changed government with different views and priorities can slow the rate of implementation to a minimum.

To the **question** “If not, in your opinion is this necessary or not?” countries emphasized that a system for implementing and assuring long-term government priorities that cannot simply be changed by the next elected government is indeed needed. Such a system is crucial to producing

excellent results. Even emphases for Slovenia show that the country needs a clear strategic development strategy with broad political consensus and support for key issues.

With the **question** “Does your Government have an office for the horizontal coordination between national policies and required inclusion in the national budget?” countries emphasized that they do not have specific offices for horizontal coordination of national policies and required inclusion in the national budget. However, they do have mechanisms for coordination.

In Germany, work is shared between the Federal Ministry of Finance and Parliament’s Budget Committee. Employees sit down and discuss how a topic should be framed overall in order that it is in line with all included ministries.

In Denmark this task is carried out by the Ministry of Finance.

Slovenia does not have such an office. The ministry in charge of a specific measure, policy/initiative, should ensure there are the appropriate budgets for the measures to be implemented.

Nevertheless, countries check the implementation of agreed measures very precisely. On the **question** “Who is checking the implementation of agreed measures?” Norway emphasized that this task is entrusted to the Research Council of Norway.

In Denmark there is an understanding among the ministries that agreed measures simply need to be implemented and that there is no other solution.

Germany has several stages at which checks are made: in advisory councils and ministry divisions, government, the ministry and the Ministry of Finance.

In Slovenia there is no check of/on content, but only the issue of technical administration. The General Secretariat follows the implementation of government decisions but not the individual measures or initiatives of each ministry. To some extent, the efficiency of said measures is checked by the Court of Audit. The problem of the Court of Audit is that they check past measures and its conclusions come too late to be implemented.

A system for the monitoring of implemented measures is required. That way the progress of a particular development can be monitored and any possible obstacles for which solutions can be prepared immediately can be identified. The checking of agreed measures leads back to budgetary planning and the strategic focus of the country. In order to identify goals for 2020, the country needs to track back to the current time and the steps that are now required, identify specific milestones and human capacity requirements, and finally, ensure the appropriate budget

every year. On the **question** “Is there a penalty for not implementing agreed measures?” and “If not, would you support implementing one?” countries emphasized that specific systems for assessment are not in place. However, case-by-case assessment of implemented measures is performed as required, and countries agree that such a system is needed. Political agreements need to be implemented.

On the **question** “Why are government documents accepted if there is not enough funds required for the planned measures in the annual national budget?” countries emphasized that measures cannot be agreed on if there is not an appropriate budget available.

In Denmark, without the necessary budget, measures are not adopted.

In Germany they are systematically aware that there can be reason for such a situation: projects, such as major infrastructure projects in particular, tend to require an extensive development phase before they are set to be carried out. This complex development phase is, due to its very nature, difficult to anticipate precisely.

From the responses we see that this often happens in Slovenia, that documents are confirmed only to appease the EU and to be used for marketing/public relations needs. For examples it can be used Action plan for renewable energy. Action plan was confirmed by the government but not enough money was planned in the national budget for the implementation of its measures. Many times it has been acknowledged, in instances of outside/external review, that Slovenia should produce less yet more realistic documents instead of the many produced yet which are not executed. Government documents that are sent for government approval include sections called financial obligations or financial impact. It often happens that government documents do not have the financial consequences, impacts or requirements included in the documents, but only the measures and the planned/forecasted results.

Accepting measures with the relevant constituent budgets is linked to high rates of successful implementation of measures. Insufficient budget efficiency rates tumble and implementation periods stretch well into the future. Nor is it financially/economically sound to initiate work/projects (construction of hydrogen production) and not assure sufficient funds/budgets to continue with distribution infrastructure. Each project should have identified project steps, timeline and required budget.

6.2.3. Group C- Leading employees involved in the preparation of national priorities provided answers on how to make priorities such concrete that they are not changed with every government elections

A flow sheet for the following questions is presented on page 108.

On the **question** “Does your Government have a group of experts that creates the development priorities for the country?”

Norway emphasized that for specific subjects such as hydrogen, road, rail, air, and sea transport there are groups of experts who create development priorities for the country. Preparation of development priorities for the country can be shown from two examples:

Hydrogen: The Hydrogen Council uses their own internal resources as well as external advisors to propose strategies and priorities on a national level. These are compiled into a report and presented to the government.

For the transport sector: Every four years expert groups conduct a strategic planning process for roughly two years, consisting of a one-year analysis phase followed by a planning phase that also lasts roughly one year. The work is done on the basis of a detailed mission drawn up by the government.

There is no special group of experts advising the Danish Government. However, in 2008 the Danish Government appointed a Commission on Climate Change consisting of 10 experts with special knowledge in the fields of climate, agriculture, transportation and economics. The task of the Commission was to present proposals for new proactive instruments for an energy and climate change policy with global and market-based perspectives that contribute to cost-effective realisation of the long-term vision.

Germany has expert groups for specific subjects/fields. The Advisory Board is tasked with providing both content and technical consulting support to the management of the program partners for the implementation of the ‘National Innovation Program for Hydrogen and Fuel Cell Technology’. The Federal Ministry of Transport and Digital Infrastructure have an advisory board of external experts for research. Slovenia, for its part, does not have a group of experts who formulate the development priorities of the country. Some past governments have had one

but it was more or less a simple extension of political reach and influence. The council for science and technology manages the distribution of funds for research.

To the **question** “If yes, how does the expert group prepare development priorities for the country?” Norway emphasized that they have a clear process for expert groups preparing development priorities for the country. For hydrogen: The Hydrogen Council uses their internal resources as well as external advisors to formulate and propose strategies and priorities on the national level. These have been compiled into a report and presented to the government. Slovenia does not have an expert group for the preparation of national priorities. No ad hoc expert groups have or observe any specific processes. As an example the council for science and technology has a set procedure wherein expert groups are typically assembled such that all of the relevant stakeholders are represented in the group. The work of expert groups is in general conducted in a way that first gathers all of the needs, lists all of the challenges, identifies the strengths and weaknesses in the area in question and then, through various rounds of debate (which is ideally complemented by consultation and feedback from the community of stakeholders between each round), arrive at a common agreement on priorities or at least the main frameworks for broader issues that are agreed have high priority. Priority-setting is a complex process and typically the resulting priorities are more a reflection of compromise than they are relevant priorities.

For hydrogen in Germany, the NOW Advisory Council meets on a regular basis (3-4 times per year). Members include representatives from different industry sectors (automotive, infrastructure, energy, stationary, suppliers), and each of these members reports to the respective industry group to assure an unbiased independent view. Priorities are discussed and prepared in these groups and includes the program managers from NOW.

In order to achieve efficient implementation of new technology a country needs to have an agreed procedure by which development priorities for the country are decided. If this process is subject to a political competition the end result is typically a mere wish list of subjects, as many politicians simply do not have the knowledge or capacity to effect and manage such implementation.

To the **question** “If yes, how do experts agree on the chosen priorities?” all 3 countries (Germany, Norway and Denmark) emphasized that they have a clear understanding of the process by which priorities are chosen.

Norway observes agreements based on consensus in the group regarding what should be in the documents prepared. Sometimes dissenting opinions are presented as the view of individual members or organizations. The process is concluded with a vote.

There is a long-standing tradition in Denmark for broad agreements related to energy in the country's Parliament, which provides a solid and stable framework for private and public investments in the sector, regardless of changes in/to government.

In Germany, the ministries and industry agree on a National Implementation Plan (NIP) with specific subjects and goals, a total budget, and an annual subject-specific budget allocation, which is set out and followed by an ordinary planning process formulated by NOW, and supported by the national body Project Office Jülich (PtJ), which assists with the formal funding processes.

Even though a science and technology council exists in Slovenia and does have a process in place designed to identify priorities, the council provides only opinion on current policy proposals instead of proposing its own priorities to the Government.

Including stakeholders in developing priorities, together with broad consensus among political parties, can be key to identifying the best and most viable priorities on the national level. Once priorities are set, the government works with industry to plot a path forward for national implementation. Based on well-formulated priorities, industry is well equipped to form a policy and plan for investment in research and development. If the government does not set clear national priorities or changes them every four years, industry cannot manage investments effectively, which in turn means their chances of becoming leaders or important players in certain field are poor.

On **question** "If no, do you think that such a group is needed on the national level?" countries emphasized that expert groups on the national level are needed. Politicians (ministers) are elected by the Government and put in the positions where they do not have enough expert knowledge. Even on the second or third administrative level people are not following the development of the technology. Moreover, because of the saving measures they are not allowed to attend conferences where current stages of the technologies are presented. Expert groups need to be formed out of the expert (and not with self-named experts) who can help develop national policies in certain field. Emphasis show that countries have such groups, Slovenia on the other

hand does not have it. This is another reason why implementation results are better in Germany, Denmark and Norway compared to Slovenia.

With the **question** “Do you think that long-term development priorities are needed in the form of a strategy confirmed by parliament?” countries emphasized steady development and smooth and effective implementation of new technologies requires long-term development priorities in the form of a larger strategy supported and ratified by parliament.

In Norway parliament is tasked with the responsibility for priorities through its confirmation of the long-term strategic priorities.

In Slovenia a common position recognises the urgent need for the country to set priorities in order to map out the directions the country would like to pursue.

In Germany the country recognises the needs for a balanced mix of long-term planning (back-casting by first defining and following a long-term goal) together with short-term roll-out/action (forecasting) – which constitutes a basic and well-established approach that provides for some degree of continuity in an otherwise particularly dynamic time.

When analysing existing system in the country with the target groups it is needed to check coherent answers between the target groups. Coherent answers among the each target group was already analysed in table 7. The following 4 sections show coherent answers among each country and 3 target groups. If the answers are coherent, the implementation system works and there is no misunderstanding in the process. If the answers are not coherent, there are problems in the process because one level (policy developers) does not know what implementation level (national agencies) is doing or vice versa.

6.2.4. Slovenia – Consistent answers among/between the target groups

Starting with target group A, experts provided answers on the recent status/stage of the technology and the measures necessary to support further research and development of the technology.

The combined response from group A indicates there are no active applications in Slovenia. A number of hydrogen production facilities Slovenia serve a certain industrial demand but these are not part of any larger strategic hydrogen implementation scheme, and serve the needs of industry alone. In Slovenia, we find only fragments of this technology present in research departments in universities and/or similar institutions. Some laboratories for testing hydrogen

technologies have been built in the past few years. And some fuel cell systems have been purchased for national demonstration projects (a 1.3 kW fuel cell system, a 30 kW Uninterruptable Power Supply system) and some systems have been upgraded with nationally developed and produced components (auxiliary 7kW power supply for a military vehicle, 7 kW PEM FC-based cogeneration system for an auxiliary power supply in heavy trucks). There is one Slovenian company that is a globally established producer of cathode blowers for FC systems, and another that deals with production of small PEM stack prototypes.

The focus in Slovenia is linked more to system development factors, such as the price of the technology, new skills, lack of promotion, public fear, and subsidies required for demonstration projects. Knowledge capacity in Slovenia is still in the “how to approach” phase compared to the other three countries, where the thinking is focused on those measures required to more easily implement the technology. This problem is closely connected to the complete absence of a national program and set of national priorities.

Slovenia has pointed out certain obstacles, such as widely disparate ideas and non-authoritative decision-making in the transport sector, the new skills that are needed, public fear, and subsidies required for demonstration projects.

Slovenian conclusions indicate that there is no national program for hydrogen and fuel cells, which results in no implemented technology.

Slovenian research institutes and industry see hydrogen technology as a reserve solution and do not invest great financial and personal capacities in the development of such. This is because there are no clear signals on the national level that such a technology would be a priority for Slovenia.

Slovenia emphasized that it needs a long-term energy strategy that will provide guidance and a framework for national priorities as well as social education, public awareness campaigns that address the safety and availability of the technology, and the inclusion of hydrogen in the development strategies of all relevant ministries (on transportation, infrastructure, research, etc.). On the political level, Slovenia also needs to practice faster decision-making.

In target group B, ministry employees involved in the horizontal coordination of priority policies in different ministries and in the inclusion of those priorities in the nation budget.

Slovenia does not have a system that would prevent new governments from changing strategic documents or repealing development priorities, regardless of the fact that such documents would be prepared and passed by a parliamentary process.

Responses for Slovenia show that the country needs a clear strategic development strategy with a broad political consensus and support for key issues.

Slovenia does not have an office for the horizontal coordination of policy. The ministry in charge of a specific measure, policy or initiative should ensure there are appropriate budgets in order that the required measures might be implemented.

In Slovenia there is no proper check of/on content, only the issue of technical administration. The General Secretariat follows those implementation processes related to government decisions but not the individual measures nor initiatives of each ministry. To some extent, the Court of Audit does check the efficiency of said measures. The problem of the Court of Audit is that they check past measures, and its conclusions come too late to be implemented.

From the responses we see that this often happens in Slovenia, that documents are confirmed only to appease the EU and to be used for marketing/public relations. Many times it has been acknowledged, in instances of outside/external review, that Slovenia should produce less yet more realistic documents instead of the many produced yet which are not executed. Government documents that are sent for government approval as a rule include sections called financial obligations or financial impact. Yet it often happens in Slovenia that government documents do not include information related to financial consequences, impacts or requirements, but only the measures and planned/forecasted results.

In target group C, leading employees involved in the preparation of national priorities provided answers on how to make priorities sufficiently concrete that they would not be changed with every change of government.

Slovenia, for its part, does not have a group of experts who formulate the country's development priorities. Some past governments have had one, but they were commonly more or less a simple expression and extension of political reach and influence. The council for science and technology manages the distribution of funds for research.

Slovenia does not have an expert group for the preparation of national priorities. No ad hoc expert groups have or observe any specific processes. As an example, the council for science and

technology follows a set procedure, wherein expert groups are typically assembled such that all of the relevant stakeholders are represented in the group. The work of expert groups is in general conducted in a way that first gathers all of the needs, lists all of the challenges, identifies the strengths and weaknesses in the area in question and then, through various rounds of debate (which is ideally complemented by consultation and feedback from the community of stakeholders between each round), arrive at a common agreement on priorities, or at least the main frameworks for broader issues that all agree have high priority. Setting priorities is a complex process, and typically the resulting priorities are more a reflection of compromise than they are relevant priorities.

Even though a science and technology council does exist in Slovenia and does have a process in place designed to identify priorities it more provides opinion on current policy proposals and in the larger scheme, works in line with those priorities as set by the government.

Slovenia does not have a group of experts that could identify priorities for development in Slovenia.

In Slovenia, a common position recognises the urgent need for the country to set priorities in order to map out the directions the country would like to pursue.

In conclusion, we can see that there is a coherent and consistent flow of answers among and between the target groups. Comments from the experts in group A show that Slovenia does not have specific technology strategies or wider sector strategies. The experts' responses indicate a wealth of knowledge on the current state/status of the technology, what activities other EU countries are implementing, and what kinds of measures are necessary for the efficient implementation of the technology on the national level. This corresponds to and is consistent with the responses of group C, which concludes that there expert group exists that could develop national strategic priorities or even a process to approach such priorities. All 3 groups are agreed in their response that Slovenia needs long-term priorities, an office for horizontal coordination, and a system that ensures priorities and strategies do not change with every election. Responses also show that there is real lack of cooperation between experts and policy developers. This situation occurred because group B is not responsive to the expert's suggestions from group A. There is a lack of communication and cooperation between groups A and B. If there is no personal commitment in group B activities will not be carried out. In addition, the system will not work if the person in group B does not have appropriate knowledge and it is named on the

position because of the political connections. The result of the existing approach is that Slovenia does not have an implemented application for hydrogen and fuel cells.

6.2.5. Germany – Consistent answers among/between the target groups

In target group A, experts provided answers on the recent stage/status of the technology and the measures necessary to support further research and development of the technology.

In Germany, there are research and demonstration projects involving hydrogen vehicles with a view towards commercialization. Daimler announced the introduction of hydrogen-powered cars to the market for 2017. Germany also has about 500 stationary devices that have been tested in field tests. In addition, Germany boasts demonstration projects for fuel cell heating systems (Callux), fuel-cell-powered back-up public safety digital radio service stations (BDBOS), and parts of the German armed forces are using direct methanol fuel cells (DMFC). German companies have sold about 30,000 such portable devices around the world.

Germany identifies obstacles such as financial support schemes for market introduction, public support, and synchronized introduction of filling stations and cars in selected hubs and larger areas in the country, and the cost and availability of hydrogen. These obstacles are directly linked to the implementation of the technology.

Germany emphasized that tax breaks/incentives similar to those for electric cars and subsidising hydrogen fuel are needed.

Germany emphasized that they have national programs in place for hydrogen and fuel cells, and mechanisms such as research councils, horizontal ministerial cooperation and government organizations that are in charge of hydrogen implementation on the national level.

Germany emphasized that they are carrying out the implementation of national programs where measures such as lower taxes, more demonstration projects, public programs for purchase and adoption etc. are planned.

In group B, ministry employees involved in the horizontal coordination of priority policies between different ministries and in the inclusion of those priorities in the nation budget recognise Germany has long-ranging commitments, a very high degree of continuity and only minor adjustments with changes of government.

Germany has long-term priorities, continuity and strategic development. Every new technology has an implementation rate that is linked to its complexity – the more complex a new technology the longer the implementation of such takes.

Germany emphasized that a system for implementing and assuring long-term government priorities that cannot simply be changed with the next election is indeed needed.

Germany emphasized that they do not have specific offices for horizontal coordination of national policies and related required inclusion in the national budget. However, they do have mechanisms for coordination.

In Germany, work is shared between the Federal Ministry of Finance and Parliament's Budget Committee. Employees sit down and discuss how a topic should be framed overall to ensure it is in line with all included ministries.

Checks are made at several stages in Germany: in advisory councils and ministerial divisions, in government, and the Ministry of Finance.

Germany emphasized that they do not have specific systems for assessment in place. However, case-by-case assessment of implemented measures is performed as required, and the country agrees that such a system is needed.

Germany emphasized that measures cannot be agreed on without the appropriate budget available. In Germany they are systematically aware that there are reasons for such a situation: projects like major infrastructure projects in particular tend to require an extensive development phase before they are ready to be carried out.

In group C, leading staff involved in the preparation of national priorities provided answers related to making priorities sufficiently concrete that they are not changed with every new election.

Germany has expert groups for specific subjects/fields. The Advisory Board is tasked with providing both content and technical consulting support to the management of the program partners for the implementation of the 'National Innovation Program for Hydrogen and Fuel Cell Technology'. The Federal Ministry of Transport and Digital Infrastructure has an advisory board of external experts for research.

For hydrogen in Germany, the NOW Advisory Council meets on a regular basis (3-4 times per year). Members include representatives from different industry sectors (automotive,

infrastructure, energy, stationary, suppliers), and each of these members report to the respective industry group to assure an independent, unbiased view. Priorities are discussed and prepared in these groups and include program managers from NOW.

Germany emphasized that they have a clear understanding of the process by which priorities are defined.

In Germany, the ministries and industry both agree on a National Implementation Plan (NIP) with specific subjects and goals, its total budget, and an annual subject-specific budget allocation, which is set out and followed by an ordinary planning process formulated by NOW, and supported by the national body Project Office Jülich (PtJ), which assists with the formal funding processes.

Germany emphasized that expert groups on the national level are needed. Politicians (ministers) are elected by the government and appointed to positions for which they do not have enough expert knowledge.

Germany emphasized the fact that steady development and smooth and effective implementation of new technologies requires long-term development priorities in the form of a larger strategy supported and ratified by parliament.

In Germany, the country recognises the need for a balanced mix of long-term planning (back-casting by first defining and following a long-term goal) together with short-term roll-out/action (forecasting), which constitutes a basic and well-established approach that provides for some degree of continuity in an otherwise particularly dynamic time.

From the German responses we can see that from the government level down the answers are consistent. The German government has expert groups who help to develop strategic priorities.

Government includes experts in the decision-making process so that strategies are efficient.

Working groups work closely with industry to create measures that are efficient and available for the industry to develop. This efficient approach results in many implemented applications for hydrogen and fuel cells technology.

6.2.6. Norway – Consistent answers among/between the target groups

In group A, experts provided answers on the recent status/stage of the technology and the measures necessary to support further research and development of the technology:

Norway answered that the country has 25 fuel cell-powered passenger vehicles, 5 fuel cell-powered buses and 7 fuelling stations for hydrogen. Norway has many tax and traffic incentives that make hydrogen vehicles commercially more competitive.

Norway identified certain obstacles such as financial support schemes for market introduction, public support, synchronized introduction of filling stations and cars in selected hubs and larger areas in the country, and the cost and availability of hydrogen. These obstacles are directly linked to the implementation of the technology.

Norway pointed to obstacles such as “tax breaks/incentives similar to those for electric cars and subsidies for hydrogen fuel.”

Norway emphasized that they have national programs for hydrogen and fuel cells in place, and mechanisms such as research councils, horizontal ministerial cooperation and government organizations that are in charge of hydrogen implementation on the national level.

Norway emphasized that they are carrying out implementation of national programs where measures such as lower taxes, more demonstration projects, public programs for purchase and adoption etc. are planned.

In group B, ministry staff are involved in horizontal coordination of priority policies between different ministries and in the inclusion of those priorities in the nation budget.

Norway pointed out that there is no formal system that ensures long-term government priorities cannot simply be changed or repealed by the next elected government. However, there are long-term strategies and action plans that will guide priorities independently of the elected government.

Norway emphasized that a system for implementing and assuring long-term government priorities that cannot simply be changed with the next election is indeed needed. Such a system is crucial to producing excellent results.

Norway emphasized that they do not have specific offices for the horizontal coordination of national policies and required inclusion in the national budget. However, they do have mechanisms for coordination.

Norway emphasized that this task of checking implemented measures is entrusted to the Research Council of Norway.

Norway emphasized that they do not have specific systems for assessment in place. However, case-by-case assessment of implemented measures is performed as required, and the country agrees that such a system is needed. Political agreements need to be implemented.

Norway emphasized that measures cannot be agreed on if there is not an appropriate budget available.

In group C, leading staff involved in the preparation of national priorities provided answers on how to make priorities sufficiently concrete that they do not change with every new government. Norway emphasized that for specific subjects such as hydrogen, road, rail, air, and sea transport there are groups of experts who create development priorities for the country. The preparation of national development priorities can be seen from two examples:

Hydrogen: The Hydrogen Council uses their own internal resources as well as external advisors to propose strategies and priorities on a national level. These are compiled into a report and presented to the government.

For the transport sector: Every four years expert groups conduct a strategic planning process that lasts roughly two years, consisting of a one-year analysis phase followed by a planning phase that also lasts roughly one year. The work is done on the basis of a detailed mission drawn up by the government.

Norway emphasized that they have a clear process for expert groups tasked with preparing development priorities for the country. For hydrogen, the Hydrogen Council uses their internal resources as well as external advisors to formulate and propose strategies and priorities on the national level. These are compiled into a report and presented to the government.

Norway emphasized that they have a clear understanding of the process by which priorities are chosen.

Norway observes agreements based on consensus in the group regarding what should be included in the documents prepared. Sometimes dissenting opinions are presented as the view of individual members or organizations. The process is concluded with a vote.

Norway emphasized that expert groups on the national level are needed. Politicians (ministers) are elected by the government and appointed to positions for which they do not have enough expert knowledge.

Norway emphasized the fact that steady development and smooth and effective implementation of new technologies requires long-term development priorities in the form of a larger strategy supported and ratified by parliament.

In Norway, parliament is responsible for priorities through its confirmation of long-term strategic priorities.

From the responses in Norway, we can see that the government has a system for the implementation of hydrogen and fuel cell technology. The responses are consistent and represent an efficient process. Government has a clear aim with long-term strategies. The government includes people expert in forming priorities and experts for specific sectors. Norway emphasized that they have a clear process for expert groups that prepare national development priorities. Norway clearly understands that clear, long-term strategies and collaboration with experts creates an efficient implementation system. Government activities result in implemented hydrogen and fuel cell applications.

6.2.7. Denmark – Consistent answers among/between the target groups

In group A, experts provided answers on the recent status/stage of the technology and the measures necessary to support further research and development of the technology.

In Denmark, several hydrogen vehicles are in operation, and a number of hydrogen tanking stations are in place. Denmark also has hundreds of UPS for telecoms back-up installed. Some companies are selling UPS systems in Canada and China.

Denmark points to obstacles such as financial support schemes for market introduction, public support, synchronized introduction of filling stations and cars in selected hubs and larger areas in the country, and the cost and availability of hydrogen. These obstacles are directly linked to the implementation of the technology. Denmark emphasised obstacles such as “tax breaks/incentives similar to those for electric cars and subsidies for hydrogen fuel.”

Denmark stressed that they have national programs for hydrogen and fuel cells in place, and mechanisms such as research councils, horizontal ministerial cooperation and government organizations that are in charge of hydrogen implementation on the national level.

Denmark emphasized that they are carrying out the implementation of national programs where measures such as lower taxes, more demonstration projects, public programs for purchase and adoption etc. are planned.

In group B, ministry staff is involved in the horizontal coordination of priority policies between different ministries and in the inclusion of those priorities in the nation budget.

In Denmark, parliament determines Danish priorities. The more political parties included in the agreement the better for the current government, since their political line will continue in some form after the next election.

Denmark emphasized that a system for implementing and assuring long-term government priorities that cannot simply be changed by the next elected government is indeed needed. Such a system is crucial to producing excellent results.

Denmark emphasized that they do not have specific offices for the horizontal coordination of national policies and required inclusion in the national budget. However, they do have mechanisms for coordination. Tasks involved in horizontal coordination are carried out by the Ministry of Finance.

In Denmark, there is an understanding among the ministries that agreed measures simply need to be implemented and that there is no other solution.

Denmark emphasized that specific systems for assessment are not in place. However, case-by-case assessment of implemented measures is performed as required, and the country agrees that such a system is needed. Political agreements need to be implemented.

Denmark emphasized that measures cannot be agreed on if there is not an appropriate budget available. Without the necessary budget, measures are not adopted.

In group C, leading staff involved in the preparation of national priorities provided answers related to the question of how to make priorities sufficiently concrete that they do not change with every new election.

No one special group of experts advises the Danish Government. However, in 2008 the Danish Government appointed a Commission on Climate Change, consisting of 10 experts with special knowledge in the fields of climate, agriculture, transportation and economics. The task of the Commission was to present proposals for new proactive instruments for an energy and climate change policy with global and market-based perspectives that contribute to cost-effective realisation of the long-term vision.

Denmark emphasized that they have a clear understanding of the process by which priorities are defined and set.

There is a long-standing tradition in Denmark of broad agreements related to energy in the country's parliament, which provides a solid and stable framework for private and public investments in the sector, regardless of changes in/to government.

Denmark emphasized that expert groups on the national level are needed. Politicians (ministers) are elected by the Government and appointed to positions for which they do not have enough expert knowledge.

Denmark emphasized the fact that steady development and smooth and effective implementation of new technologies requires long-term development priorities in the form of a larger strategy supported and ratified by parliament.

From the Danish responses we can see that the responses in all 3 selected groups are consistent.

The country has expert knowledge and specific measures are identified. Government works closely with experts and involves them in policy development. The government is aware that long-term strategies are needed to assure measures remain consistent and are continued. This approach has resulted in implemented hydrogen and fuel cell technologies.

6.2.8. Conclusion of consistent responses

We can conclude from the consistent responses that long-term priorities, continuity and strategic development separate these three other EU countries from Slovenia. Every new technology has an implementation rate that is linked to its complexity – the more complex a new technology the longer the implementation process.

Hydrogen and fuel cell technology has a very complex implementation profile. A country needs to have or put hydrogen production and distribution infrastructure in place. It needs to provide education and training in new skills and prepare the public in order that is accepted. All of these tasks require strategic planning, horizontal coordination among different ministries, and continuity. Continuity is very important. A new/changed government with different views and priorities can slow the rate of implementation to a minimum.

A system for monitoring implemented measures is required. That way a particular development can be monitored and any possible obstacles for which solutions can be identified and prepared

swiftly and efficiently. The checking of agreed measures leads back to budgetary planning and the strategic focus of the country. In order to identify goals for 2020, the country needs to track back to the current time and the steps that are now required, identify specific milestones and human capacity requirements, and finally, ensure the appropriate budget is allocated every year. On the question – “Is there a penalty for not implementing agreed measures?” and “If not, would you support implementing one?” – countries emphasized that specific systems for assessment are not in place. However, case-by-case assessment of implemented measures is performed as required, and countries agree that such a system is needed. Political agreements need to be implemented.

Accepting measures with the relevant constituent budgets is linked to high rates of successful implementation of measures. Insufficient budget efficiency rates tumble and implementation periods stretch well into the future. Nor is it financially/economically sound to initiate work/projects (construction of hydrogen production) and not assure sufficient funds/budgets to continue with distribution infrastructure. Each project should have clearly identified project steps, a timeline and the required budget.

In order to achieve the efficient implementation of new technology a country needs to have an agreed procedure by which development priorities for the country are decided. If this process is subject to a political competition the end result is typically a mere wish list, as many politicians simply do not have the knowledge or the capacity to effect and manage such implementation. Including stakeholders in developing priorities, together with broad consensus among political parties, can be key in identifying the best and most viable priorities on the national level. Once priorities are set, the government works with industry to plot a path forward for national implementation. Based on well-formulated priorities, industry is well equipped to form a policy and plan for investment in research and development. If the government does not set clear national priorities or changes them every four years, industry cannot manage investments effectively, which in turn means their chances of becoming leaders or important players in certain fields are indeed poor.

7. Proposal for Program preparation process

Chapter 7 sets out the core foundation on which the preparation of a methodology for practical process can be built. The practical process proposal is built on results and discussion provide an understanding of the issues and the current stage of development for hydrogen and fuel cell technology laid out in chapter 6 and before.

All of the above information, together with examples from national strategies for hydrogen and fuel cell technology in the selected comparison countries, along with the author's personal knowledge and observations will be combined and refined in the proposed preparation of a practical program process.

Here is presented a preparation process for a national program for hydrogen and fuel cells that will support the development of infrastructure and a systemic environment for the implementation of hydrogen fuel cell-powered vehicles and stationary applications in Slovenia. The preparation process will focus on vehicles and stationary applications – two of the most important applications from the standpoint of achieving the EU's GHG abatement goals in Slovenia. The implementation of hydrogen and fuel cell vehicles is the next stage or step forward from battery-powered electric vehicles, and is particularly important in the process of developing a sustainable transportation scheme. In addition, stationary applications are an important part of the smart energy grid and smart cities, which is very promising for the Slovenian energy sector and its future development. Stationary applications can be used as both backup power systems and as main power supply/sources.

Slovenian needs to prepare a National Development Strategy with precise goals as soon as possible, together with scenarios outlining how to achieve these goals, what measures to employ, monitor the effects of particular measures and link them to the relevant EU requirements. Only in this way can a National Program for hydrogen and fuel cell realise its full potential and see effective, continuous development. Only investments in specific goals or technologies can produce results – widely dispersed investments are not efficient and cannot achieve the required results.

7.1. Practical process for preparation

The practical process will draw on research material accumulated during the preparation of this thesis, knowledge gathered over the years of following the development of hydrogen and fuel cells, and the experiences the author gathered during the preparation of:

- Information on implementation trends for battery-powered electric vehicles, supporting infrastructure, systematic environment and demonstration project (SVPS, 2010)
- Slovenian national program for battery-powered electric vehicles and charging infrastructure (SVPS, 2010)
- Project Evaluation of the Impact (extended impact assessment) of the introduction of hydrogen as a fuel to power motor vehicles in terms of safety and environmental impact, for the European Commission (TRL, 2006)
- Slovenian national representative in the Joint Technology Initiative (JTI) working group for hydrogen and fuel cell
- Head of Slovenian Government group for hydrogen and fuel cells
- Comparing the fleet of 100 diesel buses to the fleet of 100 hydrogen buses; benefits for the local air quality and the Environment, published paper at World Hydrogen Energy Conference, Brisbane, Australia (Leben, 2008)
- Correlation between national development indicators and implementation of hydrogen economy in Slovenia, published paper in International Journal of Hydrogen Energy (Leben, 2011)
- Correlation between national development indicators and implementation of hydrogen economy in Slovenia, published paper at FC Expo, Tokyo, Japan (Leben, 2012)
- Correlation between national development indicators and implementation of hydrogen economy in Slovenia, published paper at World Hydrogen Energy Conference, Toronto, Canada (Leben, 2012)
- Implementation of Hydrogen Technologies in Slovenia: Identification of Resistance to Change Factors by a Comparative Study, published presentation at World Hydrogen Technology Conference, Prague 2017

The practical preparation process should be straightforward, with an explanation of the content for every step. It is instrumentally optimal to have the whole preparation process in a single place, thus a flowchart was prepared as shown in chapter 8.1.1 outlining all of the steps. It is more effective in the case of a new or improved implementation process to present it graphically rather than to describe it in words. (Dias, 2004) The flowchart below consists only of the main, named steps of the process. The flowchart below consists of steps relevant to the ministry based on the author's (SVPS, 2010) experience working in public administration. It is noted that each of the compared countries has its own preparation process, its own specific actors involved (industry, research organizations) and ministries. The practical process, with the tasks related to each step, is formulated based on the content of the work in Ministry of Economic Development and Technology, the Ministry of Infrastructure, the Ministry of the Environment and Spatial Planning, and the Ministry of Education, Science and Sport in Slovenia. Each of these ministries has mechanisms by which to intake relevant input information for the preparation of such a program from organizations that answer to the ministry (e.g. Eco Fund, Slovenian Research Agency, Energy Agency, etc.). From practical comparison of 4 countries the author maintains that the Ministry in charge of the implementation process should do the coordination among the ministries. Each ministry involved needs to supply relevant information to the process. Thus, it would not be helpful to list all of the relevant organizations in the flow chart. It is essential to list the relevant ministries who will include the necessary stakeholders (NGOs, professional associations, academies, etc.) in the process. At this point, the flowchart has steps marked in different colours. The different colours correspond to different fields of the preparation process (objectives, status, drivers, policy, and stakeholder involvement.) Colours correspond to paragraphs in section 8.2. and identify the following fields. Policy makers should be aware what subject each steps covers. Table 20 below shows steps in the practical process divided between specific subjects. Policy makers should know when specific step covers objectives, policy development or when stakeholder involvement should be assured.

Table 20: Steps in the practical process divided between specific subjects

Objectives	Status	Drivers	Policy	Stakeholder involvement
7.2.1.	7.2.2., 7.2.5.	7.2.3., 7.2.4., 7.2.6.	7.4.3., 7.4.4., 7.4.5., 7.4.6.	7.2.7., 7.2.7.1., 7.2.7.2., 7.3., 7.4.,

				7.4.1., 7.4.2.
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Colour key for the corresponding colours:

Red: Objectives

Green: Status

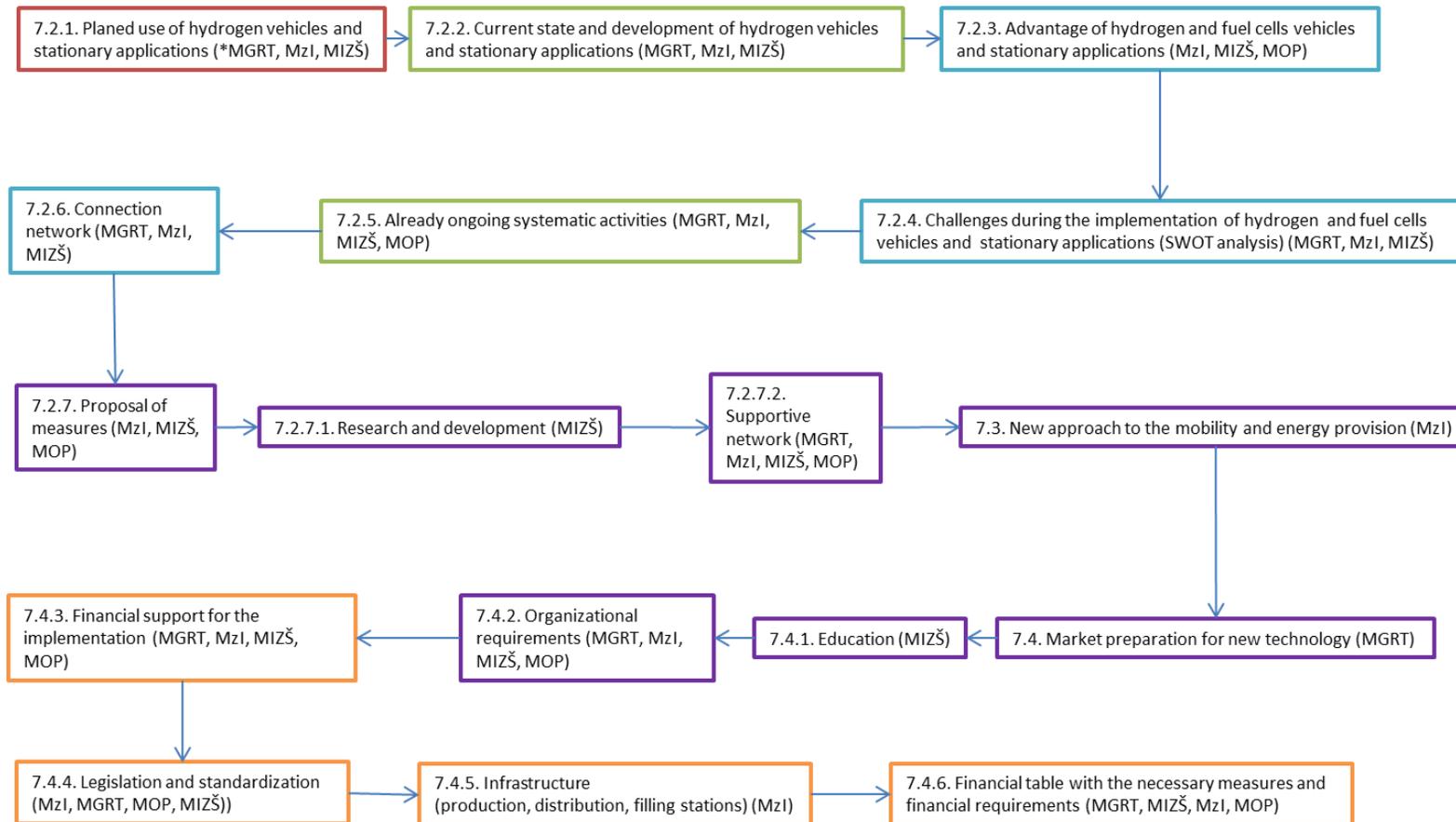
Blue: Drivers

Purple: Policy

Orange: Stakeholder Involvement

The flowchart could, however, be augmented with more specific tasks, responsible persons for execution and a timeline with milestones and deliverables.

7.1.1. Flow chart of the practical preparation process



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¹⁵ *Abbreviations in brackets are linked to the government structure of Slovenia on page 97.

7.2. Content of the national program

7.2.1. Planed use of hydrogen vehicles and stationary applications

With the implementation of hydrogen vehicles the aim is not the immediate replacement of (the county's) entire vehicle stock. This would not be rational from the economic (amortization cycle) and environmental (emissions during new vehicle production) point of view.

The same understanding needs to be applied to the consideration of stationary applications for the production of heat and electricity as backup or main source/supply. This application can be easier implemented in our daily business and lives because they can be fitted to the existing gas-related infrastructure in our homes and businesses.

In both cases the following goals should be achieved:

- Implementation of new technology, which is in the long term competitive, but more costly in the implementation phase compared to mature technologies
- Providing choices to customers that, with the replacement of old vehicles have the possibility of replacing it with a new, more efficient vehicle with lower emissions

At this stage, the government shall consider analysing the potential of hydrogen and fuel cell vehicles and stationary applications, the rate of introduction and sectors (postal services, delivery vehicles, telecommunications and personal use) that will be among the first in the uptake stage of the technology.

This first step also includes developed understanding amongst governmental decision-makers that the government shall consider establishing a supportive environment to enable research, development and deployment of hydrogen and fuel cell technology.

This step will help improve political management, as seen in the diagram on page 88, for the preparation of such a program. The government needs to decide what it wants, when, and how it will do it. The minister in charge of implementation of new technologies needs to be a change agent for implementation of new technology. The minister is the one that can initiate change on the subject (changing laws or decrees) or in the organizational management.

This approach will help to improve communication among the ministers and build a consensus that this technology has real potential in the country and that it should be supported. The analysis

shows that consensus on these subjects and schemes are needed in Slovenia to be able to enjoy long-term support. As shown with the other three comparison countries, governments systematically draw up priorities and determine when the measures need to be in place. This and the next step are the only two in which political management should be involved. Once goals and financing is agreed, it is the lower levels of administration that need to prepare the implementation program. One should have in mind that if the plan and system is set up now it should be implemented. Even 2 years delay of implementation will result in the need to reshape the plan because of the new developments on the Slovenian, EU or world markets.

7.2.2. Current state and development of hydrogen vehicles and stationary applications

At this stage, the government shall consider assessing the current state of hydrogen and fuel cell vehicles in Slovenia and the supportive environment – from the automotive cluster and companies working together for the production of components for green drives to the National Research Agency (ARRS) who finances research projects. It is very important to know what already exists in the country and to continue building measures from the current, existing point onward. The worst-case scenario would be for the government to start work from point zero. This step in the development process will help to improve work and actions on the political management level as seen in the diagram on page 99. Political management level needs to have all the relevant information regarding the current state of specific technology to be able to make a decision for policy or other measure development which will support technology implementation. Political management level in Slovenia is in general named based on the political party connotation and not based on the expert knowledge. Thus so much more important to have adequate information for the decision making. The Prime Minister, Minister and MPs will have available data on the technology and what potential the technology has in the country. There would be no room for excuses that claim no other country is implementing the technology and that Slovenian industry does not have the potential for implementation. As seen in the outcome of the analysis government shall consider connecting existing activities in order to assure the positive cumulative effects of the measures taken. Experts should be properly consulted and employed on the current activities and the measures needed to achieve the government's goals.

Activities in this step may well encounter resistance to change. Once all of the data on the potential of a certain technology is available, different interests can be identified among the possible responsible “players” in the decision-making process. One side would like the new technology with all of the benefits and new business opportunities. The other side would like to stay with the business-as-usual scenario where “roles” are set, business is running and no written “power” is in place.

7.2.3. Advantage of hydrogen and fuel cells vehicles and stationary applications

At this stage it is vital for the government to understand what advantages hydrogen and fuel cell vehicles and stationary applications bring in connection with CO₂ emissions in the transport and domestic sector. It is vital to have life cycle analysis (well to wheel) and life cycle impact analysis (LCIA) for both technologies based on use of the energy and production of the energy source. Life cycle analysis will also demonstrate the benefits of using both technologies in terms of our dependence on fossil fuels and the benefits of using renewable energy sources. In addition, it is important to know the benefits both technologies bring to urban areas as regards NO_x and PM₁₀ particles. Furthermore, the government also needs to know how to connect the smart use of hydrogen and fuel cell vehicles and stationary applications to the energy grid, because this approach can bring benefits to the grid with a more efficient supply of electricity for the tuning of peak production.

Government shall consider gaining a better understanding of the way hydrogen and fuel cell vehicles and stationary applications will help increase activity in the existing Slovenian industry¹⁶, which is working on programs for green vehicles and smart cities.

This step in the development process will help improve activities on the political/organizational management level as seen in the diagram on page 98. State Secretaries need to play the role of implementation managers and carry out inter-ministerial coordination. As evidenced in the analysis of responses, ministerial coordination is vital for measures to be in line with all governmental structures. Only this way can implementation of new technology be carried out effectively and efficiently.

¹⁶ ACS

This step will require overcoming resistance to change among the ministry staff. The structure of the Ministry staff sees employees that are and have been there for decades, alongside younger generation staff. The older employees are used to the business-as-usual scenario and have expertise in the existing technologies of the day. Implementation of new technology will require new education related to the technology and the preparation of implementation scenarios. Younger employees however, are eager to learn and are full of energy for new tasks. With the tasks and measures outlined above, resistance to change can be overcome and implementation activities can be easily implemented.

7.2.4. Challenges during the implementation of hydrogen and fuel cell vehicles and stationary applications (SWOT analysis)

The government shall consider analysing the challenges these two technologies present for sectoral measures, the inclusion of new players on the market and new forms of cooperation among companies.

The government needs to assess what fields of research and development need to be supported, what connecting networks need to focus on and what measures are needed to prepare market uptake of these technology.

In this step a SWOT analysis would be particularly instrumental, and would give policymakers some answers related to the advantages, weaknesses, opportunities and risks associated with these two technologies in Slovenia.

This step in the development process will help improve activities on the organizational management level as seen in the diagram on page 99. The organizational management level in government administration plays a vital role in implementation. At this stage, ministry staff prepares a list of measures that will help create a supportive environment. At this stage, people need to determine whether they have the knowledge required for the preparation of such measures. As evidenced in the response analysis, the comparison countries understand the importance of cooperation between ministry staff and experts working in/on the specific technology. The worst-case scenario would see ministry staff working on subjects about which they do not know enough (and are reluctant to ask for help).

In addition, people in organizational management need to prepare measures aimed at working with the public and securing their acceptance of the new technology. Based on the preparation steps, staff will have enough information that they can demonstrate the benefits of the new technology and how to use it.

7.2.5. Already ongoing systematic activities

A systemic environment needs to connect already ongoing activities and upgrade them in a way such that they support the implementation of hydrogen fuel cell vehicles and stationary applications. Activities need to support research, development and deployment work of the active research organizations and companies on the market. Some of the fields and factors that need to be linked are:

- Research and development
- Safe, efficient and accessible system of fuel cells stacks
- New concepts for vehicles and stationary applications and their components
- Integration of hydrogen and fuel cell vehicles in transport and stationary applications in the electrical and heating systems

This step in the development process will help to improve activities on the political/organizational management level as seen in the diagram on page 88. Activities at this stage need the support of horizontal cooperation between the ministers and ministries. State Secretaries need to coordinate activities among the ministries. Based on the prepared measures from each ministry, the state secretaries need to communicate among their peers what activities already exist and what body of measures would serve to build on them. As the analysis evidences, the country needs to enjoy a high degree of continuity during the implementation of new technologies. Every new technology has an implementation rate that is linked to its complexity. The more complex the new technology is, the longer it takes for its implementation. If the continuity component of a certain technology is interrupted or disturbed the implementation process will be longer and more costly.

7.2.6. Connection network

The challenges related to improving energy efficiency and lowering CO₂ emissions require a coordinated supporting environment for the implementation of required measures. A supportive environment provides a long-term strategy that will present the possibilities and financial resources required to support the development of new technologies.

Slovenia already has knowledge relevant for the implementation of both technologies. This knowledge comes out of research institutions and companies that already have their products on the market. It is important to create connection networks of knowledge and direct these toward the common goals. In addition, the implementation of both technologies requires new planning approaches on both the regional level and in urban centres.

The education sector plays an important role by providing new educational programs that enable the creation of new human resources with knowledge capital, which will help produce new concepts central to the implementation of the new technology.

This step in the development process will help improve activities on the organizational management level as seen in the diagram on page 88. Government staff needs to build on existing activities and add/create new ones for the implementation environment to be efficient.

7.2.7. Proposal of measures

A more active implementation scenario for hydrogen fuel cell vehicles and stationary applications requires an initial linking of all existing activities in addition to financial investments in research, the development and deployment of hydrogen and fuel cells vehicle and refuelling infrastructure (subsidies for vehicles and refuelling stations, tax breaks and incentives, etc.) and stationary applications (subsidies for installation).

Different measures need to be carried out efficiently at different stages of the implementation process timeline.

This step represents the sum of all prior activities. Once the political decision has been made and the wheels in the ministry administration have started to turn, a document outlining the proposed measures should be prepared and synchronized among all of the relevant ministries. The following section presents the fields that require particular government attention in the

implementing of new technology. The section constitutes an aggregate of the topics and content that needs to be included.

7.2.7.1. Research and development

The most important factor is to create target priorities in the education sector with the aim of assuring knowledge capacity for new employment seekers in the field of both technologies. At the same time it is important to start encouraging research and development in smart energy grids, linking the grid with the vehicles and stationary applications, and creating new decentralized network grids.

This way, the Government will assure efficient, reliable and economically viable applications for these two technologies.

Toward the lowering of transport emissions and dependence on fossil fuels it is essential to create and adopt a transport program for research on mobility and transport technology. The program would dictate certain guidelines for development in mobility and transport technology in Slovenia and include new vehicles concepts, powertrains and components.

7.2.7.2. Supportive network

In order to assure an adequately supportive environment for hydrogen and fuel cell vehicles and stationary applications, the government shall consider setting out goals, timelines, responsible ministries and budgets. In addition, the infrastructure should be easy to use and cost-effective. Activities need to run concurrently, together, with and between energy companies, schools, car companies and the general public. New technology will be interesting for the market if it is economically accessible and brings with it benefits compared to the current technology.

Moreover, because of the agreements in place to lower CO₂ emissions, the use of renewable energy should be a focus in all steps and stages of implementation; on one side with hydrogen production and on the other, with stationary applications for heating and power.

It would also be expedient to use existing networks in order to identify potential young human resources, support them through educational channels and assure them employment after

graduation. The government shall not enable knowledge-drain abroad owing to the current conditions surrounding training in (these) new technologies.

7.3. New approach to the mobility and energy provision

At this stage, policymakers need to understand the current state of the mobility sector and energy consumption in the country. One needs to be familiar with vehicles, driver behaviour and driver needs. Moreover, one needs to know about current energy demands in the country, specifics related to the energy grid and specifics related to corporate and household energy demand.

In order to convince the general public and assure policymakers it is vital to establish demonstration projects in which the new technology will be shown in real life conditions. This way the technology will be user-approximated and represented as easy-to-transition to use.

Demonstration projects should address the following issues:

- Present functionality, reliability, accessibility and suitability for everyday use
- Information gathering for future planning of mobility plans, energy use and smart energy grids
- Information gathering related to technology use, hydrogen needs, stable refuelling, and communication among all of the players in new business models
- To show prices: per km driven or kWh produced, price of production and refuelling infrastructure, taxes, and vehicle and stationary application prices.

Demonstration projects should not only include closed vehicle fleets in companies or public transportation, or stationary applications as backup power supplies in companies – they should also include private individuals using passenger vehicles and private houses for stationary applications. Demonstration projects should serve as a bridge towards broader technology utilisation, and all gathered data should be used for future planning of the implementation.

7.4. Market preparation for new technology

7.4.1. Education

Hydrogen and fuel cell vehicles and stationary applications will bring changes for many people who are now included in various aspects and activities related to vehicles (production and sales of components, service) and backup or main supply power systems (construction, use, servicing). After the demonstration projects, policymakers need to analyse gathered data to assess which sectors the implementation of new technology will impact.

In order to assure the development of new technology, policymakers need to plan for the preparation of new (educational) courses for engineers, the automotive industry, power, smart energy distribution, etc. from higher education up to the doctoral level. In addition, new courses related to the servicing of these new technologies and systems for recycling decommissioned technology will be required.

Similarly, it will be necessary to develop processes and train people on roadside assistance, emergency services and firefighting to deal with specific and acute situations and deal with the new technology.

7.4.2. Organizational requirements

In order to assure the most efficient implementation of the new technology, political management needs to agree on the ministry responsible for the implementation. When the decision is made, the ministry needs to start with the preparation of the outlined activities and with horizontal coordination. Other ministries should understand who is in charge and devote resources and capacity.

Government working groups that consist of representatives from political/organizational management, together with State Secretaries from each ministry involved need to be created. When working groups meet to discuss specific measures, staff from organizational management is invited to the meetings, or outside experts if the subject so requires. It would be beneficial to employ the two-stage participation of experts in the preparation of the national program. Once the program outline is set and once the analysis is produced a draft of measures is put in place. This way ministry people have the possibility to discuss open issues and ensure that in the end

the program will be realistic, efficient, and easy to implement in the real environment. Ministry people should prepare actual documents to be ultimately implemented so the government can minimize implementation deficits in prepared programs and action plans.

7.4.3. Financial support for the implementation

Every new technology needs time to mature. Economy of scale plays an important role in implementation. Good demand on the market drives production costs down and the technology becomes increasingly available to the general populace.

Policymakers need to determine when best to introduce financial incentives to support faster implementation and how long should they remain in place. The government can introduce lower taxes, subsidies for new purchases, etc. and horizontal ministerial cooperation for demonstration projects. At this stage, analysis should be made on the applications that can be expected to come to market, what market requirements will be and how long the uptake will last.

7.4.4. Legislation and standardization

At the moment there is no requirement to bind the country to implement such technology. Signed agreements are linked to lower CO₂ emissions, clean air, quotas for renewable energy and alternative fuels in the transport system.

At this stage, policymakers need to know what legislation needs to be updated on the national level to support the inclusion of new technology on the market and in use. Policymakers need to think about the homologation of vehicles and other technical requirements, emergency procedures, construction guidelines, planning permits and similar.

7.4.5. Infrastructure (production, distribution, filling stations)

At this stage, policymakers need to establish conditions to support the construction of production facilities for hydrogen, distribution processes and refuelling stations. In addition, similar activities will be required in the energy sector to support the inclusion of backup power systems

and electricity and heat generation units in industry and households. Moreover, stationary applications need to be included in the planning of future smart energy grids.

7.4.6. Financial table with the necessary measures and financial requirements

The national program should include a financial table consisting of the name of the measure, the funds needed for at least the current year plus two, and the institution responsible for implementation, and the institution responsible for monitoring the impact of the measure through time.

7.5. The plan is set

At this point, the government has prepared an accepted National Plan for hydrogen and fuel cells. The proposed methodology will help to overcome resistance to change, political involvement, and set the stage for efficient implementation of the program without allowing the program to be accepted and then forgotten in a drawer somewhere.

8. Conclusions

The aim of this thesis, through the literature review, questionnaire-based research and typical case study, was to develop and improve our understanding of new technology implementation processes in compared countries. As a result of the thesis is to propose a new practical process for the easier adoption of a new technology that the Slovenian Government shall seriously consider.

We can conclude, based on the development indicators and HDI, that Slovenia can be compared to other developed countries. There is no longer any excuse for adopting an inactive role in the implementation of new technologies. Based on the results of the questionnaires and Slovenia's ranking among other EU and non-EU countries, it could be expected that Slovenia has already implemented hydrogen stations and hydrogen fuel cell vehicles. These conclusions could be drawn from the responses to the questionnaires among Slovenian experts on hydrogen and fuel cells. Unfortunately, this is not the case.

After analysing all of the responses in the questionnaires, the research and discussions point to the fact that changing the attitude and thinking of politicians and administrative staff is the most crucial factor in the process of moving to a new technology.

The government is seen as a “push” subject for the smoother introduction of a new technology through their understanding of the development the technology currently enjoys in the surrounding countries, and through the introduction of policies and taxation measures.

Furthermore, responses in Slovenia show that the Government is weak in determining national priorities, that Slovenia produces too many unrealistic policy documents, and that cooperation between experts, ministries and government agencies is poor and inefficient.

From the literature review and responses to the questionnaires we can conclude that cooperation between experts and policy developers is crucial for the efficient implementation of new technology. This kind of cooperation can clearly show the opportunities afforded by a hydrogen economy and which extends across all government sectors.

Ultimately, it is very important for a master plan that all of the steps related to implementation are coordinated. A broad and rapid realisation of an efficient implementation process can only be

achieved if its complex technological potential is properly coordinated among the nation's institutions and their activities in specific specialist fields. It is vital to think about the quality and not the quantity of work performed during the implementation process.

As seen from the results of the questionnaires, "It was many times acknowledged in the process of external review, that Slovenia should have fewer realistic documents instead of the many that are not executed". Written documents are neither sufficiently harmonized on a hierarchical level, nor harmonized among the different ministries' activities and/nor the national budget.

At the outset, it is vital to put in place evaluation measures to follow the efficient execution of national strategies and action plans. As shown from the responses, evaluating the execution of different programs is vital for the Prime Minister and ministers, vital for them to best determine what measures can be expected to produce the right/best results and what measures need to be updated.

In order to be able to implement new technology, Slovenia needs to establish the organisational and economic conditions for its implementation. Investment activities in certain technologies from different national ministries in Slovenia should be better coordinated in order to achieve more efficient implementation. Coordinated work is very important, to link together all of the sectors and resources such that the technology is actually implemented. Furthermore, a well-coordinated spending of financial resources can have a greater impact, with targeted cumulative investment, than the dispersing of smaller amounts across numerous different fields.

When new technology is implemented, all of the national ministries need to carry out their respective activities with a view to following a single unified strategy, where an implementation plan is clearly formulated and laid out. Work among the ministries needs to be cooperative and directed at the same goal (the growth of a country) rather than competitive and influenced and motivated by the political environment and political power. As seen from the responses, political posturing and manoeuvring should not unduly influence the development of a country.

The first step in the implementation of hydrogen and fuel cells in Slovenia is to create a national program. This should not be a short-term project, not the project of a single government mandate of four years. Rather it should extend over two entire mandates, which would provide steady, continuous implementation over a span eight years and more. Over such a period, hydrogen and fuel cell technology might well come to enjoy self-sustaining development.

The scope of implementation of the hydrogen economy requires using sound economics to work through and present all of the issues associated with implementation. A hard economic approach, presented with realistic numbers, can be a very powerful tool and very and helpful in the decision- making related to finalizing policies.

Implementation of hydrogen economy needs to be a government project, not the work of a singular ministry. It is vital that the government accept responsibility for the national implementation of a hydrogen economy toward a better environment, human health and wellbeing, new business opportunities and, especially, energy independence. As seen from the responses, new technologies overarch many sectors and only strongly unified inter-ministerial cooperation can bring efficient implementation.

The Government shall show the distinct will to support implementation, and words on paper are only the first step toward implementation. Naturally any governmental policy first needs the approval of Parliament. In the course of this procedure it is worth making a strong effort to inform the wider general public properly and process feedback effectively. Without a broad consensus within and across society it will be impossible to implement any development strategy further.

The Slovenian environment needs more specialization, new ideas and more complex thinking in policy development – all in line with the Smart Specialization Strategy¹⁷. In order to achieve this it is important to create an environment that will support growth among the best educated in Slovenian industry. Consequently, such an approach will support the development of new hydrogen applications. To create an environment that supports high PhD rates will require study subjects related to hydrogen and fuel cell technologies at the post-graduate level. More attractive pay rates for newly-created jobs may draw those in higher education to that particular (technology) field. The broader community will also benefit considerably from higher wages. “Each highly-skilled employee at a high-tech company supports the jobs of four American workers.” (Sherk, 2008)

Alongside the economic impact, higher wages for skilled workers will make Slovenia’s national industrial profile more competitive, besides the economic impact. Such impact is discussed in

¹⁷ National and regional authorities across Europe shall design smart specialization strategies in entrepreneurial discovery process, so that the European Structural Investment Funds (ESIF) can be used more efficiently and synergies between different EU, national and regional policies, as well as public and private investments can be increased

work by Shapira, a professor at Georgia Tech's School of Public Policy and co-author of an analysis that was reported in the Georgia Tech newsletter High Tech Vital Signs. "Positions that require high levels of knowledge and skill, defined as high tech occupations, are important to maintaining the state's overall competitiveness," says Shapira. "Not all jobs in industries defined as high tech actually require higher education or higher skills, while many jobs that do require those are in other sectors. That's why it's important to look beyond the traditional 'high tech' industries."

This approach is of particular importance to new hydrogen technology, where high-skill knowledge from the "traditional" automotive industry does not support the implementation of a new industry standard.

The real pioneers in hydrogen energy production are new, private owners and newcomers on the energy market, not existing energy corporations. (Scheer, 2007) Slovenia needs to establish a new market in energy production and supply, one focused on available energy that is widely dispersed and independent (smart grids) and not concentrated on the national energy grid.

Moreover, Slovenia needs to start encouraging autonomous investment in energy production, instead of relying on government investment planning and the existing energy business.

As regards further work, the following topics can be taken up for future research. They are identified based on the work done on this thesis and professional experiences in the past years.

Doing additional research will help with smoother implementation of hydrogen and fuel cells in the future. The topics are:

- Broaden Expand research to include newcomers and bigger countries
- Fine-tuning of methodology and cooperation among countries
- Improving approaches to executing policies based on real conditions
- Broaden Expanded research on measuring success in public policy
- Methodology of preparation and research;
- should ministers be appointed based on political experience or on their expertise in a certain field

9. References

- Aaron, C. T., et al. (2011). *Philosophies of organizational change*. Edward Elgar publishing limited: Cheltenham
- Achterberg, P., et al. (2010). "Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands." *International Journal of Hydrogen Energy* 35: 6075-6083.
- Achtnicht, M., et al (2008) 'Impact of service station networks on purchase decisions of alternative-fuel vehicles', Discussion Paper no. 08-088, Zentrum für Europäische Wirtschaftsforschung
- Afuah, A. (2003) *Innovation management: Strategies, implementation and profits*, Oxford University Press. New York
- Allen, R. W., et al. (1979). "Organizational politics: tactics and characteristics of its actors." *California Management Review* 22 (1), pp. 77-83.
- Aline L. (2008). *Hydrogen Technology. Mobile and Portable Applications*. Springer Series in Green Energy and Technology, Springer Verlag Berlin Heidelberg, pp. 1-7.
- Altheide, D. et al (1998). Criteria for assessing interpretive validity in qualitative research. In N.K. Denzin & Y.S. Lincoln (Eds.), *Collecting and interpreting qualitative materials*, pp. 283-312. Thousand Oaks, CA:Sage.
- Ambert, A. M., et al. (1995). "Understanding and evaluating qualitative research." *Journal of Marriage and the Family* 57, pp. 879-893.
- Andre, H., et al (2005) *Hydrogen infrastructure strategic planning using multi-objective optimization*. *International Journal of Hydrogen Energy* 30 (15), pp. 1523-1534.
- Ansoff, I. (1988). *The new corporate strategy*. Wiley
- Appelbaum, S., et al (2008). The role of leadership during large scale organizational transition: lessons from six empirical studies. *Journal of american academy of business* 13 (1), pp. 16-24.
- Bacharach, S.B., et al (1980). *Power and politics in organizations*. San Francisco: Jossey-Bass.
- Badham, D. B., et al (1999). "Politics and Organizational Change: The Lived Experience." *Human Relations* 52(5).
- Badwal S.P., et al (2006). "Hydrogen and oxygen generation with polymer electrolyte membrane (PEM)-based electrolytic technology." *Ionics* 12: 7-14.
- Baker, L. (2001). "Managed care and technology adoption in health care: evidence from magnetic resonance imaging." *Journal of health economics* 20 (3): 395-421.
- Ball, M. et al (2009). "The future of hydrogen – opportunities and challenges." *International Journal of Hydrogen Energy* (34), pp. 615-627.
- Bank, T. W. (2015). "Energy use ", from <http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE>.
- Bloomfield, B.P. (1995). The role of management consultants in the development of information technology: the indissoluble nature of socio-political and technical skills. *Journal of management studies* 32 (1).
- Bonhoff, K. (2014). *Overview of Fuel Cell and Hydrogen Developments in Germany*. 5th IPHE H2igher Educational Rounds, Rome.
- Boulding, K. (1963). *Conflict and Defense*. New York:Harper & Row.

- Braverman, H. (1974). *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*. New York and London, Monthly Review Press.
- Bronwyn H. H, et al (2003). Adoption of new technology. Working paper series, Bureau of economic research
- Brown, J. (1981). *The social Psychology of Industry*. Aylesbury: Pelican
- Bruegel Institute (2012) 'The great transformation: decarbonising Europe's energy and transport systems', Bruegel Blueprint Series, Volume XVI, available at <http://www.bruegel.org/publications/publication-detail/publication/691-the-great-transformation-decarbonising-europes-energy-and-transport-systems/>
- Bryman, A. (2001). The Debate about Quantitative and Qualitative Research: A Question of Method or Epistemology? *The British Journal of Sociology* 35, pp. 75-92
- Buchanan, B. (2013). *Power, Politics, and Organizational Change*. London, SAGE Publications.
- Buchanan, D. A. (1999). "The logic of political action: An experiment with the epistemology of the particular." *British journal of Management* 10: 73-88.
- Burns, T. (1961). "Micropolitics: mechanisms of institutional change." *Administrative Science Quarterly* 55: 257-281.
- Bush, B. (2012). NREL, retrieved in April 2012, http://www.hydrogen.energy.gov/pdfs/progress11/xi_3_bush_2011.pdf
- Carter, S. M., et al. (2007). Justifying Knowledge, Justifying Method, Taking Action: Epistemologies, Methodologies, and Methods in Qualitative Research. *Qualitative Health Research* 17 (10), pp. 1316-1328
- Carnall, C., (1995). *Managing change in organizations*. 2nd edition, London: Prentice Hall
- Caulfield, B., et al. (2010). Examining individuals' preferences for hybrid electric and alternatively fuelled vehicles. *Transport Policy* 17 (6), pp. 381-387.
- Clean Vehicle Europe, Info per Member State, Norway, <http://www.cleanvehicle.eu/info-per-country-and-eu-policy/member-states/norway/national-level/>
- Cline, K.D. (2000) Defining the Implementation Problem: Organizational Management versus Cooperation. *Journal of Public Administration Research and Theory* 10 (3), pp. 551-571.
- Coch L. , et al (1948) Overcoming resistance to change, *Human Relations*, 1, 512-532.
- Colella, W.G., et al. (2005). Switching to a US hydrogen fuel cell vehicle fleet: the resultant change in emissions, energy use, and greenhouse gases. *Journal of Power Sources*, pp. 150-181.
- Corlett, J. (2000). *Systems Theory Applied to Organizations*, unpublished paper.
- Cox, K. et al (1979). *Hydrogen: Its technology and implications, utilization of hydrogen*. Volume IV, CRC press inc. Boca Raton, FL
- Crabtree, G. W., et al. (2004). *The hydrogen economy*. Physics today.
- DaimlerChrysler (2006). *A zero emissions future – vehicles with hydrogen and fuel cell technology*, brochure.
- Danish Energy Authority (2003). *A general strategy for the development of fuel cell technology in Denmark*, Elkraft System and Eltra.
- David, C. (1998). *Organizational change- sociological perspectives*, Routledge.
- David. M., et al. (2003). *Social Research Theory*, London: SAGE Publications.
- Davis, W., et al. (2004). Perceptions of Politics and Organizational Cynicism: An Attributional and Leader-Member exchange Perspective. *Leadership Quarterly* 15, pp. 439-465.
- Dias, S., et al. (2004). Use Basic Quality Tools To Manage Your Processes. *Quality Progress*, 37(8), pp. 47-53.

- Demarco, T . (1978). *Structured Analysis and System Specification*. New York: Yourdon Press
- Drory, A. (1993). Perceived political climate and job attitudes. *Organization Studies* 14 (1), pp. 59-71
- Dunphy D. (1996). Organizational change in corporate setting. *Hum. Relat.* 49 (5), pp. 541-52
- Eberle, U., at al (2012). Fuel cell electric vehicles and hydrogen infrastructure: status 2012. *Energy and Environmental Science* 5 (10), pp. 8780-8798.
- Eberle, U., at al (2011). Auf dem Weg zur Kommerzialisierung, *Automobil Industrie*, December 2011, also available in html-format, retrieved in December 2011, <http://www.e-auto-industrie.de/energie/articles/295843/>;
- Ectos, (2007). Assessment and evaluation of socio-economic factors. □Online□. Retrieved in August 2014 from http://newenergy.is/en/projects/research_and_demonstration_projects/ectos/
- EG&G Technical Services (2004). *Fuel Cell Handbook*. Morgantown, West Virginia
- Egbue, O., et al. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy* 48, pp. 717-729.
- Ernst U., at al (1997). *Factor vier: Doppelter Wohlstand – halbiertes Verbrauch*. Droemersch Verlagsanstalt. Th. Knaur Nachf., München
- Ettlie, J. E. (2000). *Managing Technological Innovation*, New York: John Wiley and Sons, p. 72
- Federal Ministry of Transport, Building and Urban Development, (2013) *The Mobility and Fuels Strategy of the German Government (MFS)*
- FCH, (2015). *Advancing Europe energy system: Stationary fuel cell in distributed generation*
- Ferris, G. R. (1991). Politics in human resources decisions: a walk on the dark side. *Organizational Dynamics* 20 (2), pp. 59-71
- Fetterman, D. (1989). *Ethnography step by step*, Sage.
- Fischer M.D. et al (2015) "Knowledge leadership: Mobilizing management research by becoming the knowledge object" *Human Relations*, doi:10.1177/0018726715619686
- Fooddy, W. (1993). *Constructing questions for interviews and questionnaires: Theory and practice in social research*. Cambridge: Cambridge university press.
- Foley, J. (2001). *Hydrogen: Driving the Future*, Institute for Public Policy Research, <http://www.ippr.org.uk/research/files/team20/project12/hydrogenreport.pdf>
- Foresight, (2003). *Foresight Futures 2003: Revised Scenarios and Guidance*, London: Department of Trade and Industry, January 2003
- Frost, P. I., at al. (1977). An exploration in two cultures of political behavior in organizations. Paper presented at Cross cultural studies in organizational functioning, Hawaii.
- Fuel cell Today, (2013). *Fuel Cells and Hydrogen in Norway*
- Fuel cell standards, (2015). □Online□. Hydrogen fuel cell codes and standards, retrieved on 8.7.2015 from <http://fuelcellstandards.com/home.html>
- Gandz, J., at al. (1980). The Experience of Workplace Politics. *Academy of Management Journal* 23 (2), pp. 237-251.
- Ganzeboom, H. (1989). *Cultuurdeelname in Nederland. Een empirisch.theoretisch onderzoek naar determinanten van deelname aan culturele activiteiten*. Assen/Maastricht: Van Gorcum
- GermanHy, (2012) *Hydrogen infrastructure study conducted by a consortium under German Federal Government Funding*. Summary presentation by U. Bunger, June 2008, and final report, August 2009, www.germanhy.de, in German, retrieved in February 2012.

- German Government, (2009). □Online□. German Federal Government's National Electromobility Development Plan, Retrieved on 5.8.2015 from http://www.bmub.bund.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/nep_09_bmu_en_bf.pdf
- Giddens, CF. (1985). Circumscribed areas within which administrative power can be generated.
- Gillham, B. (2005). Research interviewing: The range of techniques, Open university press.
- Gilmore, T., et al. (1986). Action Based Modes of Inquiry and the Host-Researcher Relationship. Consultation: An International Journal 5, pp. 160-176..
- Government of Slovenia Communication Office (2011) Facts about Slovenia. □Online□. Retrieved in 2011 from: <http://www.ukom.gov.si/fileadmin/ukom.gov.si/pageuploads/dokumenti/Publikacije/2011/FACTS2011W.pdf>
- Gross, B. K., at all (2012). Hydrogen fuelling infrastructure assessment, GM/Shell study, 2007, retrieved in April 2012, <http://www.h2andyou.org/pdf/GM-SH%20HYDROGEN%20INFRA%20PAPER.pdf>
- Gray, W. a. R. S. (1998). "Environmental regulation, investment timing and technology choices." Journal of industrial economics 46 (2), pp. 235-256.
- Grusky, O., at al. (1970). The sociology of organisations. The Free Press
- Halley, P. (?) Understanding organizational resistance surrounding technology change, SAS Institute Inc., Cary, NC.
- HyWays, (2006). Assumptions,visions and robust conclusions from project PhaseI
- Hardy, C. (1996). Understanding power: bringing about strategic change. British journal of Management 7 (special conference issue), pp. 3-16.
- Hočevar S., S. W., Ed. (2008). Hydrogen production. Hydrogen technology, Springer, Verlag Berlin Heidelberg.
- Harden, I., at al (1986). The Noble Lie: The British constitution and the rule of law. London, Hutchinson.
- Harding, J. (2013). Qualitative data analysis from start to finish, SAGE Publications, London.
- Harris, K.J., at al (2007). The Impact of Political Skill on Impression Management Effectiveness, Journal of applied psychology 92 (1), pp. 278-285.
- HFP, (2006). HFP – IP_ Draft Implementation Plan
- HFP, (2004). Deployment Strategy, European Hydrogen and Fuel Cell Technology Platform, Steering Panel, Draft Report to the Advisory Council, 6.12.2004. https://www.hfpeurope.org/uploads/677/687/HFP_DS_Report__second_draft_v8_061204.pdf
- Hočevar, S. (2008). Hydrogen in building applications, PPT presentation and COVEVO workshop.
- HyWays (2008) 'The European hydrogen energy roadmap', available at <http://www.hyways.de/>
- IEA. (2007). Hydrogen Production and Distribution. Paris: International Energy Agency
- Irenanewsroom (2015). The Reliability of Renewable Energy Systems: Why the Conventional Wisdom Is Wrong, accessed on 20.1.2016 from <http://irenanewsroom.org/tag/renewable-energy/>
- Jakobsen, T. G. (2013) Norway's Political Institutions – An Overview. □Online□ Retrieved on 6 May from: <http://www.popularsocialscience.com/2013/05/06/norways-political-institutions-an-overview/>
- Jamie, H. (2013). Qualitative data analysis from start to finish, Sage Publications Ltd.

- Jayasinghe, A. M. (2012). "The work of the Government." Retrieved 9.11, 2014, from http://www.thedanishparliament.dk/Democracy/The_separation_of_powers/The_Government/The_work_of_the_Government.aspx.
- Jermier, J., et al. (1994). *Resistance and Power in Organizations: Agency, Subjectivity and the Labor Process*. London:Routledge.
- Johnson, M. (1999). Observations on positivism and pseudoscience in qualitative nursing research. *Journal of Advanced Nursing* 30, pp. 67-73
- Judson, A. (1966). *A Managers Guide to Making Changes*. pp. 19.
- Kotter, J., et al. (1986). *Organization: Text, cases and readings on the management of organizational design and change*. 3rd ed. Homewood, Illinois: Richard D
- Kakabadse, A., et al. (1984). *Power, Politics and Organizations: A Behavioral Science View*. Wiley.
- Kenneth S. (2006). *Beyond Oil. The View from Hubbert's Peak*. Hill and Wang. A division of Farrar, Starus and Giroux, New York
- Kipnis, D., et al. (1988). "Upward-Influence Styles: Relationship with Performance Evaluations, Salary and Stress." *Administrative Science Quarterly* 33(4): 528-542.
- Kovač, M. Š., (2006) *Uspešnost uvajanja sprememb na področje vrednotenja nepremičnin v obdobju tranzicije. Država, državljani, stanovanja. Poslovanje z nepremičninami*.
- Kipnis, D., et al (1980). Intraorganizational influence tactics: Explorations in getting one's way. *Journal of Applied Psychology* 65, pp. 440-452.
- Kumar, K., et al. (1990). Organizational politics and planned organizational change. *Group and organizational studies* 15 (4), pp. 357-365
- Kvale, S. (1996). *Interviews:An introduction to qualitative research interviewing*. SAGE Publications.
- Kvale, S., et al. (2009). *Interviews: learning the craft of qualitative research interviewing*, SAGE publications
- Laboratory, E. S. R. (2015). "Recent Global CO₂." from <http://www.esrl.noaa.gov/gmd/ccgg/trends/global.html>.
- Latour, B. (1986). *The powers of association*
- Latour, B. (1987). *Science in Action*, Milton Keynes, Open University Press
- Lawrence, P. (1954). How to deal with resistance to change. *Harvard Business Review*.
- lazarsfeld, P.F. (1944). The controversy over detailed interviews- an offer for negotiation. *Public Opinion Quarterly*, 8, pp. 38-60.
- Lindeburgh, M. R. (2006). *Mechanical engineering reference manual for the PE Exam*. Professional Publications.
- Leben, J. et al (2008). Comparing the fleet of 100 diesel buses to the fleet of 100 hydrogen buses; benefits for the local air quality and the environment'' published paper on the World Hydrogen Energy Conference (WHEC 2008) Brisbane, Australia
- Leben, J. (2010). *Correlation between national development indicators and implementation of hydrogen economy in Slovenia*, Lambert Academic Publishing, ISBN-10: 3843392404, ISBN-13: 978-3843392402
- Leben, J. et al (2011). Correlation between national development indicators and implementation of hydrogen economy in Slovenia, *International Journal of Hydrogen Energy*, pp. 5468-5480, 2012, DOI: 10.1016/j.ijhydene.2011.11.099
- Leben, J. et al (2012). Correlation between national development indicators and implementation of hydrogen economy in Slovenia, published paper on FC Expo (2012) Tokyo, Japan

- Leben, J. et al (2012). Correlation between national development indicators and implementation of hydrogen economy in Slovenia, published paper on the World Hydrogen Energy Conference (WHEC 2012) Toronto, Canada
- Leininger, M. (1994). Evaluation criteria and critique of qualitative research studies. in J.M. Morse (Ed.), *Critical Issues in Qualitative Research Methods*. Newbury park, CA:Sage.
- Lewin, K. (1920) *Die Sozialisierung des Taylorsystems*, *Praktischer Sozialismus*, Heft 4, Berlin.
- Lincoln, Y.S., et al (1985). *Naturalistic inquiry*. Beverly Hills, CA:Sage.
- Markus, M. L. (1983). Power, Politics, and MIS Implementataion. *Communications of the ACM* 26 (6), pp. 430-444.
- Markus, M. L., et al. (2000). Multisite ERP implementations. *Association for computing Machinery, Communication of the ACM* 43 (4), pp. 42
- Martin, E. W. et al. (2009). Behavioral Response to Hydrogen Fuel Cell Vehicles and Refuelling: Results of California Drive Clinics. UC Berkeley Previously Published Works.
- Mack, N., et al. (2005). Qualitative research methods: A data collector's field guide. *Family health international*.
- Malterud, K. (2012). Systematic text condensation: A strategy for qualitative analysis. *Scandinavian journal of public health* 40, pp. 795-805.
- McKinsey & Company (2010) 'A portfolio of power-trains for Europe: a fact-based analysis. The role of battery electric vehicles, plug-in hybrids and fuel cell electric vehicles, available at http://www.iphe.net/docs/Resources/Power_trains_for_Europe.pdf
- McMurry, R. (1973). The problem of resistance to change in industry. *Journal of applied psychology* 47 (6), pp 589
- Melaina, M., et al (2008). Refuelling availability for alternative fuel vehicle markets: sufficient urban station coverage, *Energy Policy*, 2008, DOI: 10.1016/j.enpol.2008.04.025
- Ministry for economic development, M. (2009). *Green book for National energy Program*.
- Milton, C. (1982). Communicative Strategies in Organizational Conflict: Reliability and Validity of a Measurement Scale. *Communication Yearbook*, pp. 629-652.
- Miller, P., et al (1990). Governing economic life, *Economy and society*.
- Mintzberg, H., et al (1992). Cycles of organizational change. *Strategy Management Journal* 13, pp. 39-59.
- Mora, C. (2013). The projected timing of climate departure from recent variability. *Nature* 502, pp. 183–187.
- Moore, R. B. (1998). Hydrogen infrastructure for fuel cell transportation. *International Journal of Hydrogen Energy* 23 (7), pp. 617-620
- Morgan, G. (1997). *Images of organization*. Newbury park, CA: Sage
- Mori, H. K. (2009). Recent challenges of hydrogen storage technologies for fuel cell vehicles. *International Journal of Hydrogen Energy*, pp. 4569-4574.
- National Academy of Sciences, (2013) *Transition to alternative vehicles and fuels, USA*
- Norbeck, J. et al (1996). *Hydrogen fuel for surface transportation*. Automotive engineers inc. Warrendale, PA
- 'Norway – a Global Leader in Hydrogen: Action Plan 2012-2015', Norwegian Hydrogen Council, May 2012, English translation published November 2012: <http://www.hydrogen.no/hydrogencouncil/action-plan>
- Norwegian Government, Office of the Prime Minister, Press Release 53/2012, 'Ambitious Norwegian white paper on climate efforts', 26 April 2012:

- <http://www.regjeringen.no/en/dep/smk/press-center/Press-releases/2012/ambitiousnorwegian-white-paper-on-clima.html?id=679419>
- Norwegian Ministry of Petroleum and Energy, NOU 2004: 11, 'Hydrogen som fremtidens energibærer', 1 June 2004: <http://www.regjeringen.no/nb/dep/oed/dok/NOU-er/2004/NOU-2004-11.html?id=149967> English summary: http://www.iphe.net/docs/Norway/Hydrogen_as_the_Energy_Carrier_of_Other_Future-Summary_in_English.pdf
- Novelli, L., et al. (1994). Perceptions of Organizational Policies in an Autonomous Work Team Organization. *International Journal of Management* 6 (3), pp. 75-84.
- OECD (2015). OECD Economic Surveys Slovenia.
- OECD (2015). Gross domestic product. Retrieved 9.11.2014 from <http://stats.oecd.org/glossary/detail.asp?ID=1163>
- Palmer, B. (2003) *Making Change Work: practical tools for overcoming human resistance to change*. American Society for Quality, Quality Press, Milwaukee, pp. 8.
- Peled, A. (1999). Politicking for success: The missing skill." *Leadership and Organizational Change* 21 (1), pp. 20-29.
- Pettigrew, A. (1973). *The politics of organizational decision making*. London: Tavistock.
- Pfeffer, J. (1992). Understanding power in organizations. *California Management Review* 34 (2), pp. 29-50.
- Porras, J.I, et al. (1992). *Organizational development: theory, practice, research*. Handbook of Organizational Psychology, CA: Consult. Psychol. Press. 2nd ed.
- Porter, L.W., et al (1981). The politics of upward influence in organizations. In B.M. Staw & L.L. Cummings (Eds.), *Research in organizational behavior* 3, pp. 109-149. Greenwich, CT: JAI Press.
- Prochaska, J. O., et al (1983). Stages and Processes of Self-Change of Smoking: Toward An Integrative Model of Change, *Journal of Consulting and Clinical psychology* 51 (3), pp. 390-395.
- Ralston, D. A., et al. (1994). Ethical perceptions of organizational politics: A comparative evaluation of American and Hong Kong managers. *Journal of Business Ethics* 13 (12), pp. 989-999.
- Raman, V. (2004). Hydrogen production and supply infrastructure for transportation— Discussion paper. In *The 10-50 Solution: Technologies and Policies for a Low-Carbon Future*. Washington, D.C.: Pew Center on Global Climate Change and the National Commission on Energy Policy.
- Ricardo Consulting Engineers. (2002). Carbon to hydrogen "Roadmaps for passenger cars: a study for the Department for transport and the Department of trade and industry.
- Ritchie, J., et al. (2003). Designing and selecting samples. *Qualitative research practice*, pp. 77-108.
- Robey D., et al (2002). Learning to implement enterprise systems: An exploratory study of the dialectics of change. *Journal of Management Information Systems* 19 (1), pp. 17.
- Rogers, E. M. (1962). *Diffusion of Innovations*. New York, Free Press
- Rogers, E. M. (2003). *Diffusion of Innovations*. 5th Edition. New York, Free Press
- Rose, N., et al (1992). Political Power beyond the State: Problematics of Government. *The British Journal of Sociology*, Vol. 43 (2), pp. 173-205.
- Rosenberg, N. (1972). Factors affecting the diffusion of technology. *Explorations in economic history* 10 (1), pp. 3-33.

- Rosenfeld, P. R., et al (1995). *Impression management in organizations: Theory, measurement, and practice*. New York: Routledge
- Robbins, S. P. (1974). *Managing Organizational Conflict*. NJ: Prentice Hall, Engelwood Cliffs
- Rubin, H.J., et al (1995). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA:Sage.
- Sandelowski, M. (1986). The problem of rigor in qualitative research. *Advances in Nursing Science* 8, pp. 27-37.
- Sayles, L., et al. (1960). *Human behaviour in Organizations*. University of California: Prentice-Hall
- Scheberle, D. (1997). *Federalism and Environmental Policy: Trust and the Politics of Implementation*. Georgetown University Press: Washington, D.C.
- Scheufele, D. A., et al (2005). The public and nanotechnology. how how citizens make sense of emerging technologies. *Journal of Nanoparticle Research* 7, pp. 659-667.
- Schiebwohl, E., et al. (2009). Experimental investigation of parameters influencing the freeze start ability of a fuel cell system. *Journal of power sources*, pp. 107-115.
- Schmitter, P. C., et al (1974). Still the centiry of corporatism. *Reviwe of Politics* 36, pp. 85-131.
- Schon D. (1963). Champions for Radical New Inventions. *Harvard Business Review* 41 (2), pp.77-86
- Schwandt, T. A. (2000). *Three epistemological stances for qualitative inquiry*. Thousand oaks: Sage.
- Schulte, I., et al. (2004). Issues affecting the acceptance of hydrogen fuel. *International Journal of Hidrogen Energy* 29 (7), pp. 677-685.
- Sherk, J. (2008). *H-1B Workers: Highly Skilled, Highly Needed*. WebMemo No. 1916, The Heritage Foundation
- Scheer M. (2007). *Energy autonomy: the economic, social and technological case for renewable energy*. Earthscan in UK and USA
- Sicherl P. (2007). The inter-temporal aspect of well-being and societal progress. *Soc.Indic.Res.* 84: 231247
- Sicherl P et al. (2003). Time Distance as a Dynamic Measure of Disparities in Social and Economic Development. *International Journal of Forecasting* 19, pp. 199–215
- Sicherl P (2008). *Time Distance Comparisons of Macro Indicators of Wellbeing*. Paper Prepared for the 30th General Conference of The International Association for Research in Income and Wealth, Portorož, Slovenia, 24th-30th August
- SIHFC (2008). *SPEV – Slovenija in prehod na ekonomijo vodika, Ciljni raziskovalni program »Konkurenčnost slovenije 2006 – 2013«*. Slovenia, S. O. o. t. R. o. (3.11.2011). 3.11.2011, from http://www.stat.si/eng/novica_prikazi.aspx?id=807.
- Slovenian Environmental Agency (2011) *Environmental Indicators in Slovenia*. □ Online □. Retrieved on 3.11.2011 from: http://kazalci.arso.gov.si/?data=indicator&ind_id=272&lang_id=94
- Slovenian Development Strategy. (2005), *Urad Republike Slovenije za makroekonomske analize in razvoj*, Ljubljana,
- Smith, D. (2006) *Exploring innovation*, McGraw-Hill, Berkshire
- Spath, P.L. (2001). *Determination of the delivered cost of hydrogen*, NREL, Golden, Colorado, Midwest research institute, Battelle, Bechtel.
- Stimson, J. A., et al. (1995). Dynamic representation. *American political science reeviw* 89 (3), pp. 543-565.

- Schuckert, M. (2006). Progress in hydrogen fuel cell powered vehicles in action, Melbourne
- Stoker, R.P. (1983). Interorganizational Conflict and the Implementation Problem. Ph.D. dissertation, University of Maryland
- Sussman, L., et al. (2002). Organizational politics: Tactics, channels and hierarchical roles. *Journal of Business Ethics* 40 (4), pp. 313-329..
- SVPS (2010). Informacija o trendih uveljavljanja baterijskih električnih vozil s predlogom ukrepa zagotavljanja infrastrukture, systemskega okolja in vzpostavitve demonstracijskega projekta, accessible at http://www.vlada.si/fileadmin/dokumenti/Slikce/fotoarhiv/2010/SPS/_Informacija_o_trendih_uveljavljanja_baterijskih_elektri_350nih_vozil_.pdf
- SVPS (2010). Program ukrepov za zagotavljanje infrastrukture in systemskega okolja za vstop baterijskih električnih vozil na slovenski trg, accessible at <http://www.arhiv.svps.gov.si/fileadmin/svps.gov.si/pageuploads/EV/EV.doc.pdf>
- SVRK (2015). Slovenska strategija pametne specializacije, accessible at http://www.svrk.gov.si/fileadmin/svrk.gov.si/pageuploads/Dokumenti_za_objavo_na_vstropni_strani/S4_dokument_potrjeno_na_VRS_150920.pdf
- Tatsachen. (2014). "Facts about Germany." Retrieved 5.11.2014, 2014, from <http://www.tatsachen-ueber-deutschland.de/en/head-navi/home.html>.
- Tichy, N.M., (1986) *The transformational Leader*, Wiley and Sons, New York
- The Norwegian Electric Vehicle Association, in English: <http://elbil.no/om-elbilforeningen/english-please>
- Thomas, C.E. (2009). Fuel cell and battery electric vehicles compared. *International Journal of Hydrogen Energy*, pp. 6005-6020
- Thomas, C. E. S. (2009). Transportation options in a carbon-constrained world: Hybrids, plug-in hybrids, biofuels, fuel cell electric vehicles, and battery electric vehicles. *International Journal of Hydrogen Energy* 23, pp. 9279
- Timm M. (2000). Hydrogen and the electric utility industry. *Proceedings- HYFORUM*. Munich
- Tushman, M. (1977). A political approach to organizations: A review and rationale. *Academy of Management Review*, pp. 206-216.
- Tyndall Centre for climate change research, (2002). The role of hydrogen in powering road transport. □Online□. Retrieved on 20.8.2014 from <http://www.tyndall.ac.uk/node/192>
- Tyndall Centre for climate change research, (2004). UK Hydrogen Futures to 2050
- UNDP (2014). "Human Development Report 2014 – "Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience, HDRO (Human Development Report Office) United Nations Development Programme. Retrieved 25 July 2014.
- Veziroglu, A., et al. (2010). Fuel cell vehicles: State of the art with economic and environmental concerns. *International Journal of Hydrogen Energy* 36 (2011), pp. 25-43.
- Veziroglu N. (2000). Solar hydrogen energy system: A permanent answer to energy and environmental problems. *Proceedings- Forum on converting to a hydrogen economy*. Fort Collins, CO
- Views and News from Norway. (2011), 'Norwegians' most-hated taxes', 14 July 2011: www.newsenglish.no/2011/07/14/norwegians-most-hated-taxes/
- Von Hippel, E. (1988) *The source of innovation*, Oxford University Press, New York
- Voyer, J.J. (1994). Coercive organizational politics and organizational outcomes: an interpretive study. *Organization Science* 5 (1), pp. 72-85.

- Waddell, D., et al. (1998). Resistance: a constructive tool for change management. *Management Decision* 36 (8), pp. 543-548.
- Weick, K., et al (1999). Organizational change and development. *Annual Review Psychology* 50, pp. 361-86.
- Whittemore, R., et al. (2001). Validity in Qualitative Research. *Qualitative Health Research* 11 (4), pp. 522-537..
- William, L. (2000). Energy in the twenty first century. Proceedings- Forum on converting to a hydrogen economy. Fort Collins, CO
- Willson, Q. (2002) Public Opinion: Will Motorist's Really Go Green Presentation to The Centre for Transport Policy: Powering Future Vehicles Conference 20th February London
- Winter, J. (2000). On energies of change: The hydrogen Solution. Gerling, Munich
- Wurster, R. (2004). Hydrogen Regulations, Codes and Standards for Road Vehicles and their Refuelling Infrastructure in Europe, CUTE- Bringing a fuel cell bus fleet on the road in European cities event in London, June 2004
- Yin, R. K. (2003). Case study research, Sage.
- Zanzi, A., et al. (2001). Sanctioned Versus Non-sanctioned Political Tactics. *Journal of Managerial Issues* 13 (2), pp. 245-262.

11. Appendices

11.1. Appendix 1: Combined interviews with coding

11.2. Appendix 2: Flow chart Group A

11.3. Appendix 3 Flow chart Group B

11.4. Appendix 4 Flow chart Group C