CHALMERS


# The Role of Environmental Assessments in Public Policy on Support and Regulation of Technology

A pre-study on the Swedish alternative fuels development in 1974-2004.

MAGNUS ANDERSSON

Department of Energy and Environment
*Division of Environmental Systems Analysis*
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012
Report No. 2012:9
ISSN: 1404-8167

REPORT NO. 2012:9
ISSN: 1404-8167

# The Role of Environmental Assessments in Public Policy on Support and Regulation of Technology

A pre-study on the Swedish alternative fuels development in 1974-2004.

MAGNUS ANDERSSON

Department of Energy and Environment
*Division of Environmental Systems Analysis*
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden, 2012

# The Role of Environmental Assessments in Public Policy on Support and Regulation of Technology

A pre-study on the Swedish alternative fuels development in 1974-2004.

MAGNUS ANDERSSON



Report No. 2012:9
ISSN: 1404-8167
Department of Energy and Environment
Division of Environmental Systems Analysis
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone +46 (0)31-772 1000

Chalmers Reproservice
Gothenburg, Sweden 2012

## Abstract

This pre-study is directed at the issue of how Environmental Assessment (EA) methods are used in public policy-making that targets support and regulation of technology development. It is specifically aimed at identifying research questions for future work, and does that by performing a case study on Swedish government support for alternative fuels in the time period of 1974-2004. The case study employs an explorative and technology oriented research approach resulting in a description of a generalised three stage decision process in which the Swedish government administration uses EA of technology to varying degrees in response to environmental issues, here called landscape forces, in support of technology. The three stage decision process is described below:

1. Interpretation and assignment of a landscape force to a government authority and a related decision process, based on organisational capabilities and rationality of the government administration.
2. Possible engagement in a structured inquiry process with input from internal or external EAs, to find a solution to the interpreted landscape force in combination with other contemporary political goals.
3. Utilisation of EA results combined with other input to form a decision on policy implementation.

The identification of the three stage process results in proposal of three themes of research with connected case study research questions, see Table I. The questions are generalised and accompanied with proposals of research methods, see Table II.

Table I: *Relevant research themes and case study questions related to the use of EA methods in public policy-making targeting support and regulation of technology development.*

| Research themes | Case study research questions |
|---|---|
| 1. Organisational issues of EA | • How are issues related to environment and technology assigned to specific authorities in government administration, and how does this affect the use of EA methods?<br>• How do differences in mandate, capability and logic between different authorities influence the type, scope and results of an EA?<br>• What types of political issues are treated with a structured inquiry process with input from EA methods, and which are not?<br>• How do differences in work organisation and knowledge within the government administration affect the ability to use EA methods? |
| 2. Implementation issues of EA | • Are specific EA methods more commonly used in some political decision processes than others?<br>• Which EA methods are used in relation to specific technologies and do they affect decision outcomes in different ways?<br>• How are EA parameters, such as geographical, temporal and environmental scopes, set in political decision processes and how does it affect decision outcomes?<br>• In what cases are EAs commissioned by government actors involved in a decision process, when are non-commissioned EAs used, and does the choice impact quality of decision outcomes?<br>• How are results from different assessment methods balanced in a political decision process, specifically how are quantitative and qualitative results balanced?<br>• How are EA methods implemented and combined in the different stages of political decisions, and how does it affect technology development and steering? |
| 3. Utilisation issues of EA | • How well do statements in official documents match preceding statements and EA results? Are there obvious mismatches in statements, data or scopes that hint at that the EA has been used in a deceptive way to support decisions based on other motives? |

Table II: *Pre-study proposal of future research themes with connected research questions and methods.*

| Research themes | Generalised research questions | Proposed research methods |
|---|---|---|
| 1. Organisational issues of EA | How can a government administration be organised to enable efficient and effective use of EA methods of technology? | Comparative studies |
| 2. Implementation issues of EA | How can EA methods of technology be implemented to enable fair assessments suitable for government administration? | Survey and interview studies |
| 3. Utilisation issues of EA | How can the use of EA methods of technology within government administration be effectively monitored? | Comparative studies |

## Acknowledgments

This pre-study has been initiated by, and performed in cooperation with, the Division of Environmental Systems Analysis at the Department of Energy and Environment at Chalmers University of Technology. It has been accomplished through the supervision, guidance, and input from a number of people at the division that the author wishes to thank:

For kindly enabling the pre-study to take place:

Anne-Marie Tillman,
Professor, Environmental Systems Analysis
Head of Division

For initiating the pre-study and for his trust, commitment, evaluable guidance, knowledge and time in supervising the study:

Björn Sandén,
Professor, Environmental Systems Analysis

For greatly valuable discussions, ideas and input:

Rickard Arvidsson,
Lic. Eng., Environmental Systems Analysis

Steven Sarasini,
Ph.D., Environmental Systems Analysis

## List of figures



## List of tables



## List of abbreviations

| | |
|---|---|
| CBA | Cost Benefit Analysis |
| EA | Environmental Assessment |
| EF | Ecological Footprint |
| EFA | Energy Flow Accounting |
| EFUD | The Committee on Energy Research, Development and Demonstration (Energiprogram för forskning, utveckling och demonstration, in Swedish) |
| EIA | Environmental Impact Assessment |
| En | Energy analysis |
| EPK | The Committee on Energy Programs (Energiprogramkomittén, in Swedish) |
| EPU | The Committee on Energy Prognosis (Energiprognosutredningnen, in Swedish) |
| ESA | Environmental Systems Analysis |
| IOA | Input-Output Analysis |

| | |
|---|---|
| IEA | International Energy Agency |
| KFB | The Swedish Transport and Communications Research Board (Kommunikationsforskningsberedningen, in Swedish) |
| LCA | Life Cycle Assessment |
| LCC | Life Cycle Costing |
| LIP | Local Investment Programme |
| MAK | The Motor Alcohol Committee (Motoralkoholkommittén, in Swedish) |
| MFA | Material Flow Accounting |
| MLP | Multi Layered Perspective |
| RA | Risk Assessment |
| SEA | Strategic Environmental Assessment |
| SEEA | Systems of Environmental and Economic Accounting |
| SSEU | Foundation for Swedish Ethanol Development (Stiftelsen Svensk Etanolutveckling, in Swedish) |
| Swedish EPA | Swedish Environmental Protection Agency |
| TIS | Technological Innovation Systems |

# Contents

# 1. Introduction

With increase in human population and use of energy and material resources over the last century, global environmental concerns such as climate change have become apparent. Technology plays a key role in this development, both as an aid in human evolution and as an instigator of environmental problems. The importance of social changes and technological innovations in order to change the course of development has long been stressed but yet to have any real impact on a range of global environmental issues. Regarding technological innovations, focus has been on how to enable growth of innovations in general to improve human conditions via economic growth, and less on how to enable growth of specific kinds of innovations or how to steer their development in a more sustainable direction. In connection, the need for public policy measures in order to diffuse innovations in society is often emphasised even though it is debated how different policy measures are best implemented. On a different note, Environmental Assessment (EA) is commonly used in the environmental field to assess how innovations may contribute to improving the environmental performance of society. Can technological innovation, public policy and EA be combined in ways so that technology serves the needs of humanity without giving rise to negative impacts on the sustainability of society? The question serves as the foundational seed of this pre-study, aimed at exploring how EA methods are used in public policy-making targeting support and regulation of technology development, and at identifying research questions for further work within the field. The study takes its starting point in literature on technical change, where development of technology is studied in a social context, and performs a case study on Swedish government support for alternative fuels in the time period of 1974-2004. The Background section will expand on the connections between environmental problems and technology, the role of government in technology development and importance of effective use of EA before subsequent chapters describe the pre-study purpose, scope, research questions and report outline.

## 1.1 Background

Environmental issues around technology have existed as long as the human use of technology itself. There are many historic examples of how technology has aided human evolution and at the same time given rise to severe environmental side effects. One example is the unsustainable water use of ancient Mesopotamian irrigation systems leading to soil salinization, another, coal burning in London during the industrialisation period leading to hazardous local air quality (Ponting, 1992; Grübler, 1998). The examples show that environmental impact from technology and society is not something occasional, rather it is immediately connected and grows in scale and complexity together with technology and society as they develop. This is not least evident when thinking about the current global and complex challenge of climate change.

Today there is a growing realisation that managing technology development is important to avoid environmental side effects like the ones described above. Specifically the topic of how to support innovations that solve existing environmental problems while actively steering them to avoid that new problems are created has gained increasing attention in the literature on technical change. This has been conceptualised in the ideas of 'reflexive innovation systems' and 'reflexive governance'. A reflexive innovation system not only has mechanisms that stimulate innovation, but also mechanisms for self-control to avoid development in unsustainable directions (Fogelberg & Sandén, 2008). Reflexive governance means actively using such mechanisms, and could involve the use of EA methods.

But where and how should EA methods be implemented in society to promote reflexive innovation systems and governance? When discussing this sort technology management on the societal scale, government authorities inevitably play a key role. Public policy is required not only to disfavour environmentally deleterious technologies, e.g. via environmental taxes, but also to foster new alternatives (Azar & Sandén, 2011). The use of EA in formation of policy for new alternatives is particularly problematic since the many uncertainties tied to new technologies make it less clear what aspects needs to be assessed. The uncertainties also enable actors connected to a policy decision to shape EA methods, or to use EA results, in selective or deceptive ways to serve their own political goals in what can be described as political power struggles (Bergek, et al., 2008a; Owens, 2005). Effective and efficient implementation of EA of technology in public policy processes is hence of great importance.

In summary technology, society and environmental problems are interconnected and evolve together. Without sufficient management of technological innovations there is a risk of technology becoming as much a threat as an asset to society. Government administration plays a key role in that management through its mandate to form policy for support and regulation of technology development, and through its way of using EA to form such policy.

## 1.2 Purpose of study

Having briefly touched upon the importance of using EA within government in relation to technological innovations, it is clearly a valuable field of study for reaching insights on societal sustainability. This pre-study aims to explore the field through a case study on how EA methods were used in public policy-making targeting support for alternative fuels in 1974-2004, and through discussing pathways for future work. By doing so the pre-study also aims to connect to understandings of reflexive innovation systems and reflexive governance.

## 1.3 Research questions

Through the completion of the pre-study the report aims to answer the following two questions:

- How were EA methods of technology used by the Swedish government administration when forming policy on support for alternative fuels in 1974-2004?
- What could be relevant topics for research on technological innovations, EA and government administration in future work?

## 1.4 Scope of study

The main components of the study are technological innovations, authorities within the Swedish government administration and EAs of technology. Regarding innovations the case study is focused on the development of alternative fuels and car technology in Sweden from 1974 to 2004. This period has been extensively studied from a technical change perspective by Sandén and Jonasson (2005), whose work will serve as the starting point for the case. Since the transport sector includes technology that is tightly connected to environmental problems as well as technological innovations that may solve some of those problems, the case is well suited for the pre-study purposes.

Regarding the choice of government administration, Sweden is rated as having a well-functioning government system as well as being committed to environmental issues in ranking surveys such as the 'Environmental Performance Index', by Yale Centre for Environmental Law and Policy, and the 'Worldwide Governance Indicators', by the World Bank (Yale Center for Environmental Law and Policy, 2012; The World Bank Group, 2011). As such Sweden has the potential for a high degree of steering and reflexivity which serves the study well. Regarding specific authorities within the government administration, the ones of relevance to the case are those with influence over Swedish technology development and environmental issues in the transport sector. There are three levels in the Swedish government administration; national, regional and local. Based on the actor analysis by the Swedish Environmental Protection Agency (Swedish EPA) of who has influence over Swedish environmental objectives, there are relevant authorities on each level (Swedish EPA, 2011). At the national level there are the Swedish parliament and government with appending committees, ministries and national agencies such as the Swedish EPA itself, the Energy Agency, the Transport Administration and the Chemicals Agency etc. At the regional level there are the counties with connected executive committees as well as the regional representation of the state through the administrative boards. At the local level there are the municipal councils and municipal executive boards together with municipal public companies.

Regarding EA methods of technology, the case is concerned with frameworks, models and standardised assessment methods that serve as input for political decisions related to environmental impacts from technology. Of particular interest are established methods for Environmental Systems Analysis (ESA), which are commonly used as such input. The case does not primarily focus on the design of EA methods themselves. The focus is on the use and output of the EA methods, and the implications of that use.

The case takes into account that the shape and form of these three components are subject to change over time by being part of a never-ending chain of evolution. The ESA methods that are of particular interest to the case were however shaped to a great extent during the 1970's, which was also the decade that saw a rapidly growing interest for alternatives to petroleum based fuels. For these reasons the case therefore also serves as a good temporal starting point.

## 1.5 Report outline

The next chapter starts by describing fundamental frameworks related to technological innovation, transitions and governance as well as theory related to the Swedish government administration and relevant EA methods. The subsequent Chapter 3 will adopt the theory in a discussion on possible methodology for studying the area. Chapter 4 will engage in the actual case study of alternative fuels by employing the developed method. Results will then be analysed in Chapter 5, where questions will be raised around the case study findings to formalise a suggestion for research themes relevant for future work. The questions and analysis will then be discussed in relation to scope and method in Chapter 6, where also the final conclusions and suggestions for future research are given.

# 2. Theoretical foundations

The theory and theoretical frameworks used in this pre-study are reviewed below. The sections go through relevant aspects of the main components of the report; technology, government administration, and EA methods of technology. Frameworks for studying technological innovations, transitions and governance are introduced. A brief description is given to the design of the Swedish government administration as well as of the Swedish public policy process. Common EA methods of technology are finally introduced.

## 2.1 Technological innovations, transitions and governance

The importance of technological innovations was stressed in the introduction chapter. The mechanisms for stimulating innovation have been the topic of extensive research. One theoretical framework that has been developed over the last two decades is the Technological Innovation Systems (TIS) framework. The foundation of innovation studies originate from economics of innovation, which is focused on economic growth related to technology. At the core of the subject is the notion that technology is tightly connected to social aspects of society in so-called 'socio-technical systems'. The Technological Innovation System (TIS) is comprised of the socio-technical system around a technical innovation that makes it develop and diffuse in society. The TIS consists of structural components that are influenced by internal functions and external forces, see Figure 2.1

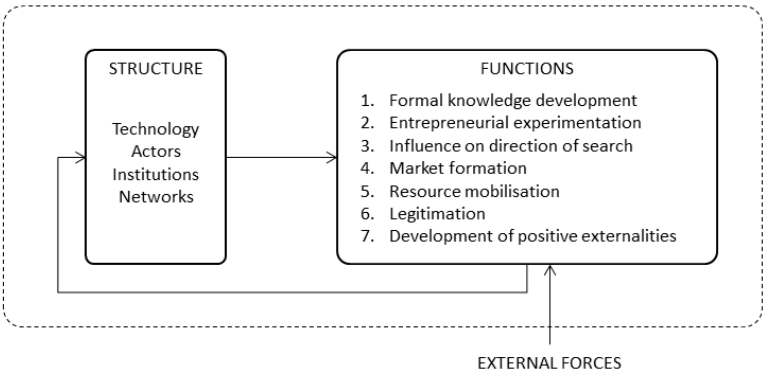


Fig. 2.1: *The structural components of a TIS, its internal functions and external forces. Adapted from Bergek et al. (2008)*

The structural components of the system consist of technology, actors, networks and institutions. Technology is thought of as either material objects or as knowledge in different forms. Actors may be private companies, government authorities, NGOs, individuals or other stakeholders connected to the development of the technology. Institutions are regarded as the juridical laws and normative rules that regulate interaction between actors. A network is comprised of bonds between actors, and is the glue that forms a system out of what would otherwise be unrelated structural elements. Networks are formed because of

shared values or habit based contacts between actors, or as a natural progression of shared interaction with technology in the system. Once structural components have been put together they may influence the innovation process in a number of ways. In order to analytically treat that influence a set of processes, called functions, exist in the framework. The framework is used to identify functions that need to be strengthened or weakened in order for an innovation to grow. As functions grow in strength in a TIS, the influence on it by external forces decrease and the system becomes increasingly independent. External forces drive the development in the early phase of a TIS, when components and functions are underdeveloped (Bergek, et al., 2008a; Bergek, et al., 2008b).

External forces are part of the wider socio-technical system in which the TIS resides. How an emergent system develops over time, and in comparison to other technologies, is described in the technology transition literature. The Multi-Level Perspective (MLP) framework describes how well established technological systems, called regimes, relate to the less established TISs, here called niche technologies, and how both are situated in a grander societal evolutionary landscape where they are affected by external forces, so-called landscape forces, such as culture, religion, normative values, politics, economics, or environmental problems (Geels, 2002; Geels and Schot, 2007). The idea can be schematically represented in a hierarchy were landscape forces put pressure on regime technologies to change, as well as enabling niche technologies to grow and challenge regimes, in a system of development processes evolving in parallel over time. See Figure 2.2 below.

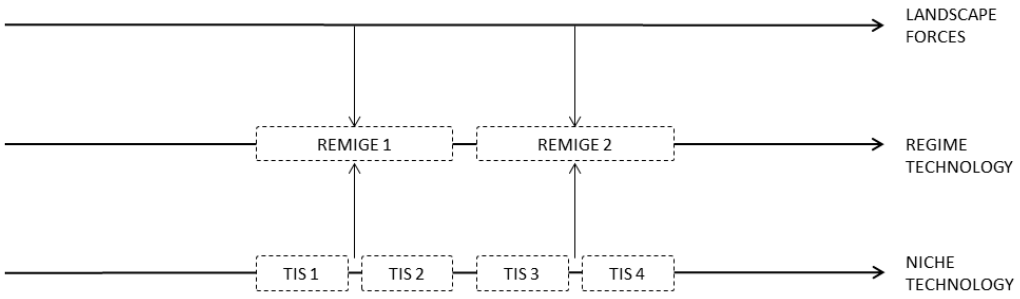


Fig. 2.2: *The MLP of technology transition. Arrows represent influence of change.*

As management of technology has become an increasingly important aspect of innovation studies, growing attention have been put on how to influence TIS functions in ways so that the innovation process can be steered in a favourable direction. In recent attempts the TIS framework has been extended to incorporate how government administration and public policy affect TIS functionality (Hillman, et al., 2011). In this expanded framework structures related to government administration are partly isolated from the rest of the TIS in order to identify their specific influence on functions. Governing structures are seen both as parts of TISs through shared structural components, such as shared institutions,

actors or networks, but also something of an own entity imposed on one or several TISs, controlling them through the same shared components, see Figure 2.3.

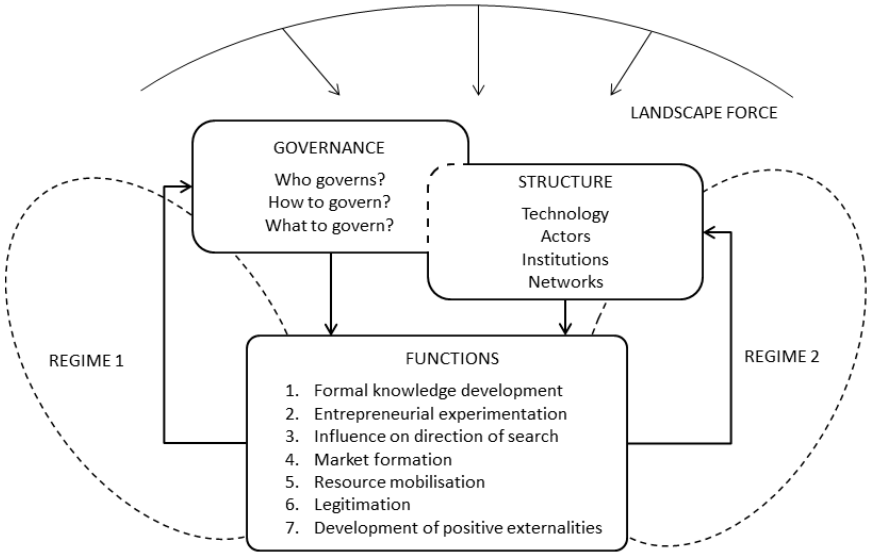


Fig. 2.3: *TIS governance arrangements. Adapted from* (Hillman, et al., 2011)

Governance is specified through six components referred to as 'governance arrangements', which are grouped two by two in three 'dimensions'. The three dimensions are formulated as questions that need to be answered to identify how governance is arranged, see Table 2.1. The first dimension, 'Who governs?', defines the actor component in identifying where in the government administration governing actors are situated, and whether or not they are involved with private actors. The second dimension, 'How to govern?', defines which type of policy measures, or mechanisms, are used to influence a TIS, and whether they are directed at the supply or demand side of the TIS through either 'push' or 'pull' type policy respectively. The third dimension, 'What to govern?', defines the object that the policy is directed at in terms of TIS functions and technology specificity. Technology specificity is used to identify the scale and number of technologies that the policy is directed at. If car fuel technology is used as an example, sector based policy would be directed at the entire road transport system, system based policy could be directed at fossil fuel cars, and sub-system policy at diesel cars. Finally, the framework also positions itself inside the MLP framework and acknowledges that both TIS and governance arrangements are affected by landscape forces and regimes.

Table 2.1: *The three dimensions of governance arrangements. Adapted from* (Hillman, et al., 2011)

| Dimension | Governance arrangement |
|---|---|
| Who governs? | • Governance level: Local/regional, national, EU, global<br>• Private involvement: No/little, moderate, high |
| How to govern? | • Mechanism: Regulative , market-based, normative, cognitive<br>• Push/pull: Push, pull, both |
| What to govern? | • Key process(es): 1-7<br>• Technology specificity: Sector, system, sub-system |

## 2.2 Swedish government administration and policy process

This section introduces the design of the Swedish government administration and the decision processes around public policy in order to lay grounds for analysing EA use within them. A natural starting point is to outline the main structure of the administration, and to chart the typography of government authorities that are relevant for decisions around technology, innovation and environment.

Firstly, the basic design of the administration is divided into three political levels; national, regional and local. All levels have publicly elected assemblies in charge of making decisions and of appointing a governing authority to implement those decisions. The legislative power resides at the national level. The regional and local levels are equal in their hierarchical position but treat separate policy issues and operate in different geographical territories. The regional and local levels are self-governing but work within the boundaries of the laws and directives set at the national level. A representation of the three political levels is seen in Figure 2.4.

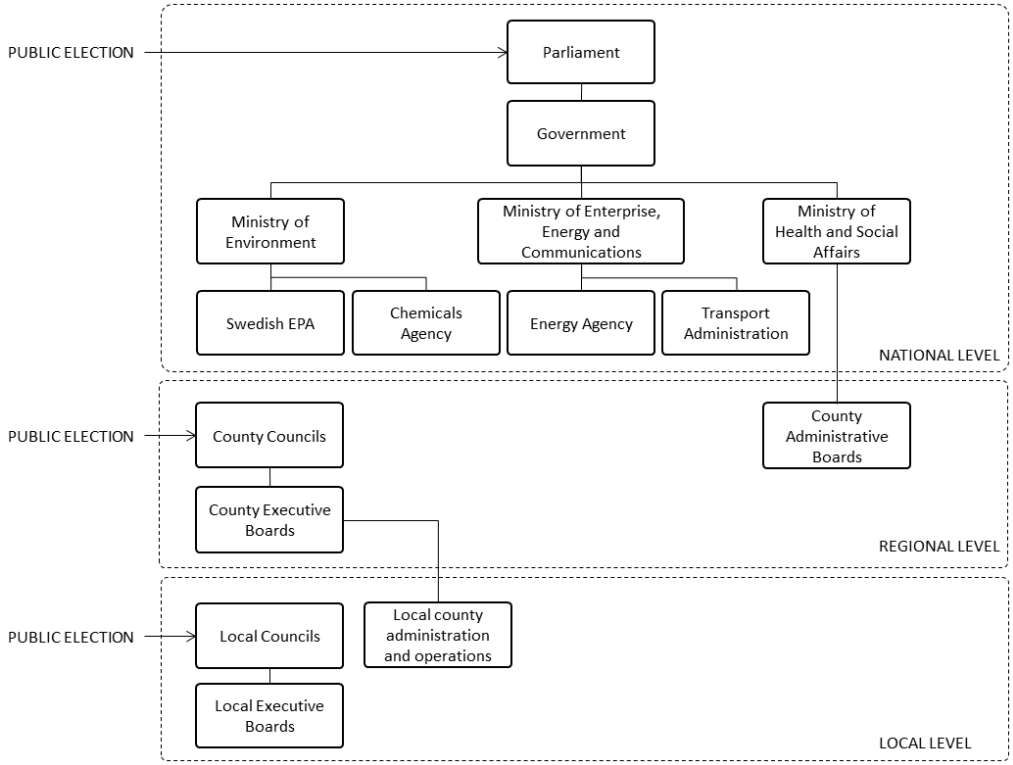


Fig. 2.4: *The design of the Swedish government administration in simplified form.*

The national level consists of the parliament with connected committees and parliamentary agencies, as well as of the government with connected ministries and government agencies. The parliament is the head assembly of the Swedish regulatory system, it decides on regulation which the government is in charge of implementing. Much of the parliamentary work is done through committees, each of them treats a dedicated policy area and is comprised of a parliamentary representation of 17 politicians as well as policy relevant expert officials. The purpose of the committees is to screen and treat bills and motions in order to prepare for decisions in parliament (Swedish Parliament, 2012). The government work is structured in a similar fashion. It is largely performed through the ministries which are divided into policy areas, under the head of the cabinet office. Each ministry is comprised of a minister appointed by the government, as well as a number of expert officials assigned to the ministry by the cabinet to prepare for government decisions, usually through public official inquiries. Connected to the ministries are the government agencies, which are in charge of executing decisions by the government through directives from the ministries (Swedish Government, 2012).

The regional level is comprised of counties, executive committees and connected county committees. It also includes the county administrative boards. The counties are the regional equivalent of the parliament where county members are appointed through public elections. The county appoints the executive committee which is the equivalent to a regional government. The counties and executive committees are generally responsible for health care issues but may also engage in

other regional matters. Corresponding to the national level, much of the regional work is performed in county committees divided into specific policy areas. The regional level also has administration and operations offices on the local level to synchronise regional and local work. The county administrative boards are separate entities from the counties and are the regional representation of national authorities, functioning as links between the national and regional level. The boards are in charge of organising and implementing certain national level affairs, such as law enforcement, environment and social care (Löfgren, 2010).

The local level is similar in structure to the regional level. Its publicly elected council appoints a municipal executive board in charge of implementing decisions. Municipalities are self-governing to a great extent in matters bound by their geographic area such as education, social services, city planning, water and sanitation etc., but may also be in charge of energy and environmental issues depending on the size on the municipality. The local work is performed in municipal committees and then implemented by municipal authorities (SKL, 2012).

Moving on to how decisions are made in the government administration, there exists a formalized procedure that can be exemplified by describing the national level. The first step is that an initiative is taken, in most cases by government, but an initiative may be taken by anyone in parliament. If taken by a parliament member a motion is written which is then treated by a relevant parliament committee. If the motion is deemed legitimate it is further treated before a parliament vote is performed. If the initiative comes from government it is treated by a relevant ministry, usually through committees of inquiry or by single officials in the ministry. The conclusions of the ministry are published as a public official inquiry report. The report is sent out for referral to relevant authorities or special interest groups in order for the ministry to get feedback. The report and feedback may then be used as basis for a government bill. The bill is sent to a relevant parliament committee, which treats it before it is subjected to a parliament vote (Swedish Government, 2009; Swedish Government, 2011). The equivalent processes exist at regional and local levels in simplified forms.

## 2.3 Environmental assessment methods

The need to quantify environmental impact from human activities has created the field of environmental assessment. The term assessment is broad and includes using more or less defined frameworks, models, or standardised methods. Frameworks can be described as a way of formalising and structuring ideas, concepts or work procedures. Models simplify reality into more easily understood forms. A standardised method is a more formalised working procedure than a framework. A range of standardised methods can be placed under the common heading of Environmental Systems Analysis (ESA). Table 2.2 gives an overview of ESA methods divided into assessment objects and impacts, i.e. what the object

of an assessment is and what type of environmental impacts that are included. Energy analysis (En), Ecological Footprint (EF) and Material Flow Accounting (MFA), define environmental impacts in terms of energy, geographical area and material use, respectively. Energy Flow Accounting (EFA) is a form of En which is similar to MFA, but focuses on energy flows and energy transformations instead of material flows. Energy systems modelling is a further development of the EFA method more oriented towards simulation and economic optimisation. Risk Assessment (RA) determines the risk of undesirable outcomes occurring in relation to environment or human health. Strategic Environmental Assessment (SEA) is a set of work procedures for decision making regarding policies or projects etc., often combined with Environmental Impact Assessment (EIA) which is aimed towards impact on geographical areas. Input-Output Analysis (IOA) together with Systems of Environmental and Economic Accounting (SEEA) is geared towards demands of goods or services between nations or regions and attaching environmental impacts to them. Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) connect environmental impacts and costs of producing, using and decommissioning products or services. Cost Benefit Analysis (CBA) puts monetary value on environmental and social issues.

Table 2.2: *Overview of commonly used ESA methods. Adapted from Finnveden and Moberg (2005).*

| Impacts / Objects | Use of natural resources | Environment | Use of natural resources, Environment | Use of natural resources, Environment, Economy |
|---|---|---|---|---|
| Policies, plans, programmes, projects | En, EF, MFA | RA | SEA, EIA | CBA |
| Nations, regions | En, EF, MFA | | SEEA , IOA | SEEA, IOA |
| Products, services | En, EF, MFA | | LCA | LCC |
| Substances | En, EF, MFA | RA, MFA | | |

# 3. Research methodology

This pre-study aims to perform a case study on how EA methods were used in public policy-making targeting support for alternative fuels in 1974-2004, and to discuss pathways for future work based on its result. To do that the frameworks from Section 2.1 will be used to contextualise the development of the alternative fuels and the connected policy decisions taken by the Swedish government administration during that time. The frameworks emphasise that technology is one of several connected components in a socio-technical system. Choosing to study one component hence also means indirectly making a choice of the connected components. For instance, choosing to study a certain technology would automatically mean choosing actors, institutions and networks etc. Translated to the research field where the pre-study is situated, a selection of technology means an indirect selection of a range of connected EA methods and authorities or actors within government administration.

From a methodological point of view there is hence a choice of object and scope of study to be made that will impose restrictions on the case study. Putting a specific technology as the object of study and following it over time gives insights to how and when specific authorities and EA methods enter the evolution of that technology. Choosing instead to follow one or a range of actors and analysing how they use EA methods in policy decisions related to many technologies, gives insight on similarities and differences in how separate parts of the government administration deals with technology and environmental issues. Putting a specific EA method in focus provides understanding of how the design of that method is suited to different political levels, authorities and policy processes, and if there are any connected possibilities or barriers for its use. Any study will have to be delineated with regards to technologies, actors and assessment methodologies, and the appropriate choice of scope will depend on the questions asked.

As the case study is connected to the work by Sandén and Jonasson (2005), it combines a selection of technology and actors by examining alternative fuel support within the Swedish government administration. The methodical procedure follows the above discussion by attempting to put technology into context. Contextualisation is done by defining landscape forces, regimes and niches using the MLP framework, as well as defining structural elements and influential internal functions using the TIS framework in order to structure the technological development events of the studied era. The extended TIS governance framework by Hillman, et al. (2011) is then employed in order to identify how the Swedish policy support was arranged and how it influenced the events. Since the study is especially interested in examining the use of EA methods in those arrangements, which lacks a specific framework, four questions inspired by the governance framework and the typology of ESA methods from Table 2.2 will be used: ‘What type of EA is used?’, ‘What is the object of study connected to the EA?’, ‘Who supplies, performs and receives the EA?’, and ‘How are EA results used in the

decision process?'. The execution of this contextualisation can be seen as performing blocks of operations with described frameworks, see the summary below.

i. Define landscape forces, regimes and niche technologies (MLP framework).
ii. Define relevant TISs in terms of structural elements and influential internal functions (TIS framework).
iii. Position different TISs in relation to the MLP (combination of TIS and MLP framework).
iv. Define governance arrangements related to the different TISs (Governance framework).
v. Examine the use of EA methods within the relevant governance arrangements (four questions).

As mentioned the method will be applied to the case of alternative fuels development in Sweden in the years between 1974 and 2004. The case has been extensively studied by Sandén and Jonasson (2005) in terms of MLP and TIS theory which effectively lays the ground for blocks i-iii, leaving blocks iv and v to be complemented.

Since the study positions itself within Swedish government administration the overarching empirical input for the blocks is official documentation on proceedings from the three political levels of authority; national, regional and local. Examples of such documentation are public official inquiries, government bills, parliamentary motions, and regional and local council documents. The starting point for the documentation reading will be government bills. It will then branch out into deeper levels of documentation by following the most frequently occurring references, creating a tree like structure of data processing.

# 4. Case study exploration: The alternative fuels development in Sweden in 1974-2004

The modern development of alternative fuels between 1974 and 2004 has been extensively studied by Sandén and Jonasson (2005). Section 4.1 starts with a description of their use of MLP and TIS theories to account for events of the era in order to put technology development into context. Section 4.2 extracts and builds on their description of events using governance theories developed by Hillman et al. (2011), this in order to identify government actors and policy measures influential on the development. Sections 4.3-4.5 explore the use of EA methods in the formation of those policy measures in terms of the "what, who and how" questions described in Chapter 3.

## 4.1 Description of events using MLP and TIS frameworks

Sandén and Jonasson (2005) explore and sections the era according to environmental landscape forces, which they define by analysing number of related articles in Swedish newspapers. The studied era starts in the early 1970s with the international oil crisis, continues through increased attention to local environment, and ends with raised awareness of climate change. The regime is naturally defined as the socio-technical system around petrol and diesel fuels and cars, for which they provide statistics of increase in both fuel use and number of cars, showing the unrivalled position of the technology during the era. The authors then examine the effects of shifting landscape forces on the development of niche technologies by studying documents from public and private sector, as well as performing interviews with relevant parties. Doing so enables them to follow the discourse, action and support directed at niche technologies by government and private actors. They conclude that even though the regime technology was not greatly affected by any of the niche technologies, each period left important trails of structural elements connected to alternative fuels which might constitute important parts of future development. The MLP of the era is represented in Figure 4.1, where dotted boxes represent relevant socio-technical systems of the time.

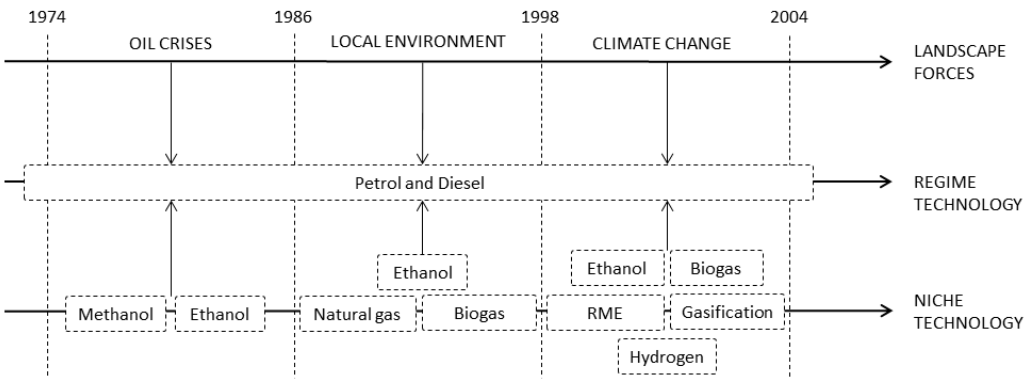


Fig. 4.1: *The MLP on transport fuels and car technology during 1974-2004.*

In the 1971 roughly 70% of the Swedish energy system was based on oil. When oil prices increased dramatically after the OAPEC embargo in 1973 the Swedish government initiated extensive strategies to increase national energy efficiency and to shift the energy system away from oil. The strategies came to involve all energy consuming sectors, at first mainly the housing sector but soon also the transport sector. Decreasing amount of transport or increasing energy efficiency in the transport system was not seen as politically viable or technically achievable at the time. Instead a large scale introduction of non-oil based methanol fuel was planned. Later as a consequence of controversies around a sugar plant shutdown in the southern city of Karpalund and a related government inquiry, ethanol became a competing option. The political interest in both fuels dropped dramatically however as oil prices fell rapidly around 1985 combined with increased debate on nuclear power safety after the Tjernobyl accident in 1986.

In the second period of 1986-1998 public awareness was growing about local environmental issues. At the national level, alternative fuels were not of main concern, but a tax change favouring ethanol was enforced. In the larger cities, poor air quality became the main driver for several municipalities to take their own initiatives to engage in alternative fuels for buses. Malmö had been connected to natural gas pipelines and invested in natural gas buses which later spread to Gothenburg. Linköping invested in biogas after failed hopes of it too being reached by the pipelines. Stockholm invested in ethanol buses after joining up with private ethanol producing actors in the region. The enthusiasm for bus projects died out at the end of the period because of a declining economy, privatisations of bus companies and a gradual shift of the landscape force towards climate change.

Climate change stood as the single biggest driver for alternative fuels in the third period of 1998-2004. After the Brundtland Commission in 1987 and the Rio conference in 1992 with the Agenda 21 action plan for sustainability, the Swedish government was fully committed to acting on climate change in the mid-90s. The EU of which Sweden became a member in 1995 was also committed. This multilevel commitment combined with alternative fuel stakeholders from the previous periods enabled a multitude of fuels to grow in use during this period.

Continuing the description using TIS methodology, Sandén and Jonasson identifies actors, institutions, networks and functions of each period that enabled niche technologies to grow. During the first period the government and the car manufacturer Volvo became important actors when joining up to create the methanol research company SMAB, which later resulted in demonstration projects for methanol cars. The company would become an important institution and network hub in making methanol the main alcoholic fuel. The actor constellation affected the influence on the direction of search, formal knowledge development and legitimacy in favour of methanol. In the aftermath of the Karpalund sugar plant debate the Federation of Swedish Farmers got funding for

an ethanol plant in Lidköping which would start a small network with agricultural actors around ethanol, legitimising it as a viable option.

During the second period municipal politicians and companies joined up with private actors. In Malmö the local energy company contacted the local transit authority to find uses for the natural gas pipelines. Together with transit authorities in Stockholm, Oslo, Copenhagen and Helsinki the Co-Nordic Natural Gas Bus Project consortium was initiated. The consortium contacted Volvo and Scania to produce initial engine trials that later influenced Gothenburg municipality to buy 20 natural gas buses. In Linköping the municipality adapted five buses for natural gas. When the extension of the natural gas pipeline was stopped the municipal waste, sewage and energy companies joined up to produce biogas instead. In Stockholm the local transit authority, SL, contacted the Foundation for Swedish Ethanol Development (Stiftelsen Svensk etanolutveckling, SSEU, in Swedish) which earlier had been formed in the area as a cooperation between municipalities, the county, the Federation of Swedish Farmers and local ethanol and chemical producing companies. Together they contacted Scania to produce 32 ethanol buses to be tested in Stockholm. All of the projects got different amount of funding from state level through the Swedish Transport and Communications Research Board (Kommunikations-forskningsberedningen, KFB, in Swedish). The actors and networks formed in these cities combined with state support led to entrepreneurial experimentation and increased legitimacy for each respective fuel.

In the third period the use of ethanol and biogas started to increase rapidly because of government tax exemptions on ethanol and funding programs that benefitted biogas. Both fuels still had support from actors and networks developed during the second period. Ethanol also benefitted from low cost Brazilian imports and growing support by actors in the car industry. The increased attention to climate change and sustainability also enabled RME, hydrogen and gasification routes to be explored to some extent. RME had been used in the agricultural industry in the second period but got extended support in the third because of favourable production costs compared to ethanol. Hydrogen research got support by EU funding programmes as well as by strong international actors in the coal industry when carbon sequestration and hydrogen production became an option. Different forms of biomass gasification technologies also got scattered support. The wide support for alternative fuels during this period strengthened mainly market formations of ethanol, biogas and RME. The scattered gasification support led to resource mobilisation in the form of pilot production plants around Sweden. Finally, the European and international interest for hydrogen legitimised it as being the fuel of the future.

Based on this description there are a number of policy decisions that stand out as crossroads for the alternative fuels development. The first period is characterised by the formation of SMAB which would later lead to demonstration projects and

tax changes in favour of methanol, and also by the initial government inquiry after the Karpalund debate which would turn the tide in favour of ethanol. The second period is characterised by decisions at the local level to start demonstration projects, and by the tax change in favour of ethanol and the decision to initiate the KFB funding programme at the national level. The third period is characterised by the government support for ethanol and biogas as well as the increased attention to alternative fuels in general from several different directions, both public and private. The governance arrangements and decisions related to the Swedish government administration in these cases will be further explored in coming sections.

## 4.2 Identification of governance arrangements

The previous description will be interpreted by identifying governance arrangements related to the supported technologies of each period using the framework by Hillman et al. (2011). In applying the framework it is relevant to structure how technologies relate to each other in terms of systems and sub-systems (see Section 2.1). For the purpose of this section it is sufficient to define ’the sector’ as the road transport system, ’the system’ as the regime opposing technologies of non-petrol or non-diesel fuels, and ’the sub-systems’ as the niche technologies from Figure 4.1. It is also relevant to define what policy measures are used and whether they are of push or pull type. During the era there are mainly two types of actions taken by government; tax exemptions and demonstration projects. Tax exemptions are economic market based instruments designed to affect market formations through a pull type mechanism. Demonstration projects are designed to mobilise resources and develop knowledge and can as such be defined as cognitive push mechanisms.

Applying the framework to the first period, the governance level for both methanol and ethanol was national in that it was characterised by an ambition by government to explore new fuel options. The methanol strategy of creating SMAB to push development had a high involvement from the private sector in the form of Volvo. Early on the strategy was directed towards demonstration projects of methanol cars to investigate technical functionality, which from a policy perspective is a cognitive push mechanism influencing resource mobilisation and knowledge development on the sub-system of methanol. The ethanol track instead had little private involvement as it was initiated by an inquiry by the Department of Agriculture and later supported by the Centre Party. The resulting governing mechanism was a tax change in favour of ethanol, i.e. a market based pull mechanism directed at the market formation of the sub-system of ethanol.

The governance level of the second period shifted and became parallel for all fuels in the period in that both national and local levels were involved. The local bus projects were however mainly driven by municipal actors in moderate to high degree of cooperation with private actors.

Regarding ethanol technology it got support at the national level in terms of the favourable tax change. It also got national support together with biogas in the form of funding for demonstration projects from KFB. At the local level, SL and the joint public and private foundation of SSEU were in charge of the local demonstration projects. From a governance perspective the sub-system of ethanol hence got multilevel governance support; at national level in the form of both market based pull mechanisms (favourable taxes) and cognitive push mechanisms (funding of demonstration projects) with relatively little private involvement, and on local level more cognitive push mechanisms through the realisation of said demonstration projects with moderate private involvement. The governance arrangement for biogas was similar, at national level it too got funding set aside by KFB for demonstrations projects, and at local level it was primarily the municipal public traffic organisation around Linköping, LITA, with little private involvement that performed the demonstration projects. The natural gas project got less amount of support from KFB and was primarily performed on local level by the municipalities included in the Co-Nordic Natural Gas Bus Project with high involvement by private actors in the form of Scania and Volvo who co-developed the technical details of the project (Ekelund, et al., 1993).

The third period continued to get more parallel and diversified with respect to governance. The period not only included a new governance level in the form of the EU but also a bigger variety of fuels with both private and public backing. From the government side there was a substantial commitment to tax exemptions for demonstration projects. The reason for the devotion was an EU regulation that prevented individual tax rates on fuels. Tax exemptions were however allowed for fuels used in connection to demonstration projects. The implication was that even though tax measures were favoured by government during this period, they were implemented in connection to demonstration projects, resulting in a combination of two types of governing mechanisms. Ethanol got a great deal of funding from the national level through the demonstration project of an ethanol plant in Örnsköldsvik run by the Energy Agency. In governance terms this was a mixed cognitive and market based push and pull mechanism from the national level with little private involvement, directed at the sub-system of ethanol and thereby affecting its market formation, resource mobilisation and knowledge development. The other major commitment to alternative fuels by government at the time was directed towards biogas, in the form of the Local Investment Programme (LIP). LIP was an investment fund for which municipals could apply for funding of local projects aimed at sustainability. The programme was not primarily geared towards alternative fuels but greatly benefited municipalities who had the opportunity of synchronising municipal waste, energy and transport companies in demonstration projects of waste based biogas. At the national level, the program can be described as a cognitive push mechanism with little private involvement. Since it was not directed primarily at alternative fuels it can be seen as wider support for the entire sector of road transports with the aim of affecting

resource mobilisation and knowledge development. At the local level it can be described in the corresponding way but as a mechanism directed at the sub-system of biogas because of the favouring conditions of the programme to build on existing structural elements.

The development of the other fuels of the period was the result of complex networks including private and government actors. The nature of these networks will not be covered in this brief report. It can be noted however that the political support system for fuels became increasingly complex, multileveled and international during this period; the Energy Agency, the Swedish EPA, the Innovation Agency and the Transport Administration were all running their own research programs related to different fuels (Utredningen om förnybara fordonsbränslen, 2004). In addition, EU was financing Swedish research and demonstration projects related to hydrogen and fuel cells (Jönsson, 2006). In Europe, several countries had invested in RME which made it more readily available also in Sweden. Scattered investments in gasification of biomass throughout Sweden also affected the resource mobilisation and legitimacy of gaseous fuels (Utredningen om förnybara fordonsbränslen, 2004; Sandén & Jonasson, 2005)

In summary, two different policy measures were used at the national level to favour the two different sub-system fuels of methanol and ethanol in the first period. In the second period, the national level favoured three sub-system fuels with both market-based and cognitive policy without much private influence. At the local level private involvement was moderate to high and demonstration project policy was used on the same sub-systems. In the third period, the national level employed tax-based policy in connection to demonstration projects on the sub-system of ethanol, and used cognitive policy directed at the wider sector through LIP. Both of which had little private involvement. At the local level, the demonstration policy of LIP was implemented with little to moderate private involvement. The use of EA methods in the decisions leading up to the implementation of these policy measures are studied in coming sections.

## 4.3 Use of EA in 1974-1985: Oil scarcity and methanol development

The initiation of the methanol track can be said to start in 1974 with the government bill on measures for energy savings. It describes the Swedish dilemma of being heavily dependent on oil in the on-going oil crisis and suggests that a national energy programme should be implemented directed at energy savings in the housing sector (Swedish Government, 1974). The bill describes how two committees of inquiry, the Committee on Energy Prognosis (Energiprognosutredningnen, EPU, in Swedish) and the Committee on Energy Programs (Energiprogramkomittén, EPK, in Swedish), have been initiated to suggest future options for an extended programme covering other sectors as well.

The results of the committee inquiries are presented in the follow-up bill on energy in 1975. The extensive bill, written to a large extent by the Ministry of Industry, heavily relies on the results by both inquiries when proposing actions for how Sweden was to decrease oil dependency in the coming ten years, as well as in preparation for the distant future of year 2000 (Swedish Government, 1975). The bill sets the tone for the period in that it focuses on reduction of energy use, increased energy efficiency and employs a resource perspective by emphasising a migration of the Swedish energy system away from oil by utilising other natural resources. In order to avoid future situations of limited resource supply the bill suggests an increased national use of natural gas and coal. It can be noted that many environmental issues of today are explored and reflected upon in the introduction to the bill. It explores the dilemmas of the energy sector and emphasises the need for a joint economic, social and environmental development, i.e. what we today call sustainable development. In connection several issues related to sustainability and socio-technical development are described; resource scarcity, acidification and climate change because of fossil resource use, the need for equity between generations and nations with growing populations, as well as path dependency and inertia of technological development and change. Specifically with regards to transport, methanol is suggested as an alternative to oil, based on the conclusions by EPK and EPU. The bill follows the recommendations of EPK and states that research funds should be set aside to develop engines capable of running on methanol. It is also positive to the joint venture of SMAB between the state owned Berol Kemi AB and Volvo AB because of the possibilities to reach quick results. The follow-up bill on energy in 1979 gives further support to the methanol track and proposes a more favourable tax for methanol based on the annual report of 1978 by SMAB. It also states that the proposed research programs by the Committee on Energy Research, Development and Demonstration (Energiprogram för forskning, utveckling och demonstration, EFUD, in Swedish) should be supported (Swedish Government, 1979).

The committee inquiry by EPK was commissioned by the Ministry of Industry in 1973. Its directive states that it should map Swedish energy research in order to suggest research programs for the coming ten years. The specific aim of the suggested programmes was to secure and increase the access to energy resources, decrease the need for energy and to lower the costs of producing it (EPK, 1974a). The report takes an international stance on the issue of increasing access to energy by performing MFAs and EFAs starting with global availability of material and energy resources and relating them to the energy consuming sectors of Sweden. It also performs a number of scenario based forecasts on future availability of materials and energy resources, as well as their market demands, based on input from EPU, in order to deduce suitable pathways for the Swedish programme. Related to the transport sector it is stated that that no improvements of energy efficiency or reduction of the amount of transport is likely within the ten years. In

the appendix with detailed material for the transport programmes, it is stated that based on the analyses the only viable alternatives to the world oil resources in the transport sector is coal and natural gas, from which methanol can be produced. Ethanol and hydrogen technology is mentioned but disregarded as being too far off into the future. As a result, demonstration projects related to methanol cars and future projects related to domestic methanol production are suggested, nothing is mentioned about the environmental consequences of using a coal based supply system (EPK, 1974b).

The committee inquiry by EPU was commissioned by the Ministry of Industry in 1972. Its directive states that its aim is to develop forecasts of energy resource demand and technology supply capabilities of Sweden for 1985, and to a lesser extent also for the period 1995-2000. The report states that it worked under the pre-conditions that energy supply in the period 1984-1987 could only be met with existing technology and that the increase rate of energy demand would be lower than that of the past. Environmental issues related to the forecasts are treated through a qualitative discussion based on comments on the report by the Swedish EPA. It is however stated that the comments had no effect on the forecast themselves, but that they should be considered when later investing in technology. It is also stated that the comments received could not be fully reflected upon because of the narrow time frame available to the inquiry. Regarding transport forecasts, unwanted effects of eutrophication and acidification are mentioned briefly in the discussion but not treated in detail (EPU, 1974a). More details are given in an appendix report which states that the increase rate of energy use is expected to slow down because of decreased population growth, and that no increased energy efficiency can be expected in the sector in the coming ten year period. Based on that, it proposes an introduction of alternative technologies and suggests methanol blends, electric and hydrogen vehicles. The latter two technologies are deemed not to be technically viable within the ten year time frame. In the appendix introduction it is stated that the transport section was due to unfortunate events handled by only one investigator (EPU, 1974b).

The SMAB report is commission by the government with the purpose of informing it on the current work status of the company since its initiation in 1975. The report states that work is well on its way and writes recommendations heavily in favour of methanol technology by suggesting future methanol vehicle specification regulation, pilot plans for domestic production plants and reduced methanol fuel tax. The report mainly discusses technical, economic and resource aspects of introducing methanol. It suggests a future strategy where methanol is produced from imported natural gas or coal. Environmental aspects of the strategy are qualitatively discussed with focus on toxicity and vehicle exhaust emissions in terms of CO, HCs and $NO_X$ but not studied in detail (SMAB, 1978).

The report by EFUD was commissioned by the Ministry of Industry in 1975 and published in 1977. Its directive was to develop project plans for research and

development in the energy sector in a long term perspective (EFUD, 1977). Similar to the report of EPK, the perspective of the report is put on global energy resources and the connected technological opportunities for the Swedish energy system. MFA and EFA are used in this respect as input to determine which resources are enough to meet Swedish demand at the time. With regards to fuel technology, transportation demand forecasts from EPU are used as input to suggest a methanol project plan stretching up to and beyond 1995 when it is envisioned that a pure domestic methanol production and transport system is in place. By doing this it affectively uses results developed for a 10 year scope and applies them to a 20 year scope. As a part of the project plan the work by SMAB is suggested to continue. Environmental effects of the plans are briefly covered in a qualitative discussion in terms of how fuel properties relate to exhaust emissions of CO, HCs, $NO_X$ and lead. The effects are somewhat disregarded by claiming that emission regulation would unify emissions independent of future fuel choices.

Around 1980 the international oil prices began to drop dramatically. The energy bill of 1980 emphasises the need for domestic production and favours the idea of a methanol production plant, but also notes that ethanol has potential for domestic fuel production based on initial results from the upcoming inquiry on ethanol by the Ministry of Agriculture launched after the Karpalund sugar debate (Swedish Government, 1980). The energy bill of 1981 stresses the importance of domestic fuel production even further because of national security reasons. It mainly supports methanol, but also opens up for demonstration projects of ethanol production based on the now completed inquiry (Swedish Government, 1981).

The ethanol inquiry was commissioned by the Ministry of Agriculture in 1979 and published in 1980. Its aim was to investigate technical and economic conditions for ethanol production (Etanolutredningen, 1980). The report suggests increased funds to establish an ethanol production plant and a lowered tax rate for fuels produced with domestic resources. The conclusion is drawn from collecting and evaluating various EFA reports on ethanol from sugar and starch products available in Sweden. The EFA reports employ a system perspective including the stages from cultivation through the use phase to calculate net energy outputs. The environmental effects of embracing ethanol are limited to a discussion on waste water pollution from ethanol production plants, with the conclusion that only marginal effects are expected.

Swedish oil prices reached a plateau in the mid-1980s. The energy bill of 1985 describes how future oil prices are likely to decrease and that oil dependency of the Swedish energy system has decreased to roughly 50%. The need for alternative fuels is confirmed but mainly for future national security reasons, their potential to improve exhaust emissions and the possibilities to avoid lead by using low blends. To investigate these matters further a new committee of inquiry, the Motor Alcohol Committee (Motoralkoholkommittén, MAK, in Swedish) is

suggested by the Ministry of Energy. Its result would later impact the events of the second period. In 1986 Swedish oil prices collapsed, and in combination with the Tjernobyl accident alternative fuels where no longer a main issue at the national level. In the coming energy bills of the period, alternative fuels are not given much attention.

In summary, the government bills of the period are heavily influenced by the oil crisis with subsequent decisions by ministries, mainly the Ministry of Industry, to initiate several inquiries related to alternative fuels. The ministries set the scope for the committee reports in terms of content and time limit of delivery, with heavy focus on natural energy resources, technology and investment costs. The committee reports employed MFAs and EFAs to analyse global natural energy resources and related implications for the Swedish energy system, but raised little or no attention to other environmental perspectives. Results of committee reports were sometimes interlinked and misused, but still affected the outcome of political decisions and the creation of the policy measures of the period. In addition to using EA results, the recommendations by committee inquiries were based on qualitative discussions on technology and investment costs.

## 4.4 Use of EA in 1986-1997: Fuel choices for improved local environment

During this period local air pollution was becoming the major landscape force affecting the development of alternative fuels. The oil price shocks of the 1970s were gone, removing the need at the national level to migrate the Swedish energy system away from oil. The national energy agenda was now instead filled with issues around nuclear power safety after the Tjernobyl accident. The energy bill in 1986 states that the investments in oil reducing effort of the past have been successful, and that future effort should be directed at reducing the commitment to nuclear power. Nothing is said about alternative fuels other than that the results of MAK should be awaited (Swedish Government, 1986). The following energy bills do not treat alternative fuels until 1991, when it is suggested that KFB should dispose of funds for demonstrations projects of alcohol fuel technology in cities (Swedish Government, 1991a). The suggestion is based on a brief discussion on the environmental performance of alcohols, as well as the importance on national self-sufficiency, but is not anchored in any detailed analysis. In general, alternative fuels during this period were separated from the energy domain and instead became related to traffic, local environment and health. Energy bills do not treat alternative fuels again until the end of the period when climate change and sustainability started to fuse different political domains together. In the meantime references to alternative fuels are found in government bills on traffic and health. The 1988 bill on traffic issues discusses a wide range of subjects such as accessibility, economics, efficiency, safety and environmental effects of the national transport system. The 1991 bill on health and environment deals with future regulation and public policy related to these issues. They both discuss

vehicle exhaust emissions from fossil fuels in terms of CO, $NO_X$, and HCs, and conclude that stricter regulations are needed (Ministry of Communications, 1988; Swedish Government, 1991b). They both briefly also suggest alternative fuels as means for improving air quality in cities referring to the results of MAK and the KFB program. The two bills would later serve as input for the Communications Committee which would have great effect on events in the third period. For this period however the development of alternative fuel technology can generally be attributed to the municipal bus projects.

The report by MAK was commissioned by the Ministry of Energy and Environment in 1985, and published on behalf of the Ministry of Industry in 1986. Its purpose was to examine possibilities of using low blends of alcohols in petrol and diesel and to investigate the overall potential of alternative fuels. The introduction to the report states that the precondition for the committee was to investigate alternative fuels that could be produced from domestic resources and compete economically with fossil fuels (MAK, 1986). In spite of statements favouring methanol by the former equivalent to the Energy Agency (Statens Energiverk, 1986), the report concludes that no choice of either ethanol or methanol should be made at that time. However, it also suggests that future demonstration projects should focus on ethanol, that ethanol has the advantage of contributing to resource self-sufficiency because of its domestic resource base and that production can be small scale and therefore inexpensive. It also suggests a halving of the fuel tax for alcohols based on volume, which favoured the higher energy density of ethanol over methanol. The report bases its arguments on a qualitative discussion around several perspectives of political concern such as national security, economic growth and employment. It mainly compares domestic resources with public fuel demand and investment costs for ethanol and methanol vehicle and production technology. No deeper analysis is done on environmental or health effects of the two fuels.

The KFB demonstration project was initiated because of the 1991 energy bill. It was initially called ‘The Motor Alcohol Programme’, but was later renamed to ‘The Biofuels Programme’ as a result of the 1993 bill on climate change where it was suggested that KFB should widen its scope and also support biogas with the goal of reducing $CO_2$ (Swedish Government, 1993). The 1993 bill is extensive and does not treat the KFB programme in detail but states that demonstration projects are an important part of reducing national $CO_2$. The KFB programme was to be run for four years but was later extended to six, and came to fund a great deal of coming ethanol and biogas projects. In 1997 the results of the programme was evaluated by KFB itself. The evaluation report describes that the programme was initiated based on a political agreement between the Centre Party, the Liberal Party and the Social Democratic Party. It states that the rationale for starting it was based on political assumptions around the qualities of ethanol and biogas, and

that the grander picture of why the two fuels were to be trialled was not questioned or analysed sufficiently (Arnold & Thuriaux, 1997).

At the local level the largest of the bus projects was the one demonstrating 32 ethanol busses in Stockholm as a cooperation between SL and SSEU. The project was finished and reviewed in 1995 in a report by SL to inform the municipality of results. The report describes technical characteristics of the busses and the capabilities of the vehicle exhaust measurement system that was used within the project. It also goes through details on the fuel properties of ethanol and summarises the project investments costs. In addition, it provides extensive measurements results of CO, $NO_X$ and HCs and concludes that the measurements showed positive results in comparison to diesel. The resource perspective on ethanol is briefly discussed but said to be out of scope of the report, as fuel supply is handled by contractors. After three years of running the project it is concluded that no problems were encountered other than the possibility of an acetic acid odour from buses in heavy acceleration (Rydén, 1995). Results with similar characteristics are found in the evaluation reports of the bus projects in Malmö and Linköping. The Malmö project that resulted in the Co-Nordic Natural Gas Bus Project and in the trial of 20 natural gas buses in Gothenburg published their report in 1993. It describes events leading up to the trial and discusses technical and safety issues of using gas bus technology and fuelling stations, as well as accounting for emissions measurements of CO, $NO_X$ and HCs. The report briefly mentions that the fossil origin of natural gas has been criticised but somewhat dismisses the topic by suggesting an increased effort at the national level to increase the share of biogas in the natural gas supply as a solution (Ekelund, et al., 1993). The evaluation of the Linköping project was published in 1993 by LITA. It too discusses technical functionality and economic aspects of gas buses. Environmental aspects are treated through a discussion of mainly exhaust emissions of same type as the other projects. The limitations of the resource base of biogas is briefly discussed but not treated or analysed in detail.

In summary the technology choices of this period was shaped by political uncertainty at the national level resulting in a funding program based on a political agreement with little analytical input. The municipal projects focused heavily on technology, usability, costs and exhaust emissions of regulated emissions. The government bills, committee inquiry reports and project reports show little or no references to EA methods or structured analyses of environmental issues beyond measurements of, and discussions on, regulated exhaust emissions. The policy measures of the period hence contributed to the growth of sub-system fuel technologies and the overall alternative fuels development without clear references to EA methods.

## 4.5 Use of EA in 1998-2004: Actions against climate change

Already in the previous period the issue of climate change had started to grow and influence political decisions, but in this period the discussion was intensified and became the main driver of the alternative fuels development. As a result, several political domains were fusing in the mid-90s. The climate change agenda can be traced to the UN Conference on Environment and Development in 1992, where Sweden signed the Framework Convention on Climate Change and the Agenda 21 action plan. The Swedish commitment was accepted by parliament in the bills on climate change and sustainability in 1993 and 1994 (Swedish Government, 1993; Swedish Government, 1994). The bills describe that a new structure and unity is needed within government administration, and that environmental issues needs to be put in the forefront of decision making. Fuels and their emissions are stated to be crucial issues to battle climate change. This marks a substantial turn in argumentative character compared to the bills from a few years earlier. In 1996 the newly instated government declared that Sweden should be in the lead among the countries taking action to reach societal sustainability. One year later the Kyoto protocol was signed and in the coming years a number of bills related to energy, transport, climate change and sustainability were submitted. This new national ambition is described in the government letter to parliament in 1997 where it is written that a joint commitment by all sectors of society is needed. In relation to alternative fuels, a national introduction of bio-based fuels is suggested (Swedish Government, 1997a). The letter continues to describe how the upcoming Communications Committee inquiry is to be the base for a new national traffic policy. One year earlier, in relation to energy policy, an agreement was made between the Social Democrats, the Centre Party and the Left Party where it was decided that the future energy system of Sweden should be based on renewable and domestic resources, and that it should contribute to national economic growth and employment. The agreement is declared in the bill on energy in 1997, where also 210 million SEK are set aside for a cellulose-based ethanol production plant as part of the upcoming bill on national traffic policy (Swedish Government, 1997b). The traffic policy is presented the next year with the goal of levelling $CO_2$ emissions from transports in 2010 at the level of year 1990. It also confirms the ethanol strategy based on results by the Communications Committee (Swedish Government, 1998a).

The Communications Committee inquiry was commissioned already in 1994 by the Ministry of Communications as a response to the increased attention to climate change and sustainability of the time. Its purpose was to establish a national scheme for Swedish communications that would improve environmental performance and contribute to economic growth and employment. Its report was published in 1997 where an extensive plan for all modes of transport is presented. Regarding road transport it suggests that a future fossil free transport system will primarily use alcohol and electric vehicles. Alcohols are favoured however since

it is reasoned that they have the advantage of being capable to be readily used in conventional cars, as well as functioning as bridging technology to future fuel-electric hybrid vehicles. Based on the Swedish cellulose resources, a strategy to reach 10-15% cellulose ethanol in the transport system until 2010-2020 is suggested. Introduction cost is seen as the biggest concern and therefore an ethanol demonstration plant is suggested to improve cost efficiency of production.

The arguments and of the inquiry were based on two underlying reports by KFB and two other agencies called NUTEK and SIKA. Their first report deals with the issue of choosing vehicle technology. It states that a number of technologies are of interest based on a qualitative discussion on natural resources and costs of introduction. It further states that if Swedish resources are to be used, cellulose ethanol has the largest potential. Electric and hydrogen vehicles are said to be too expensive and in a too early stage of development. Their second report deals with how to introduce ethanol. It performs a national CBA on differently paced investment scenarios with the $CO_2$ tax of the time as the valuation of environmental costs. $CO_2$ emissions are calculated based on an LCA on ethanol performed by the IEA. The most favourable option is the suggested ethanol plant.

Going back to the inquiry report by the Communications Committee, its combined suggestions for the entire transport plan is finally assessed with an SEA where environmental issues are treated through estimated reductions of $CO_2$, $NO_X$, $SO_X$ and VOC compared to business as usual forecasts. It is concluded that the plans indeed would lead to reductions and that they therefore are motivated.

The coming bills on energy and environment are geared toward climate issues. The 2002 bill on climate strategy emphasises the importance of continued introduction of alternative fuels but states that any new decisions regarding the matter should not be made since they are heavily dependent on coming EU regulation (Swedish Government, 2002a). In the budget bill of the same year the strategy of tax exemptions for demonstration projects is suggested to continue in the meantime (Swedish Government, 2002b). In the coming years the tax exemptions also favoured imports of Brazilian ethanol, and together with increased ethanol attention by private market, and municipal decisions to aid alternative fuel technology with measures such as free parking, ethanol use grew rapidly (Sandén & Jonasson, 2005).

The third period also showed a large increase in biogas use, which can be substantially attributed to the LIP programme. The four year programme started as part of the government initiative against climate change in 1997 and is commented on in the previously mentioned government letter to parliament. A five member delegation from the Social Democratic Party was initiated by the prime minister of the time to suggest a future action plan in accordance with Agenda 21. The conclusions of the delegation resulted in a new government letter on Ecological Sustainability and the proposal of the LIP programme, which was

later specified in the coming budget bills (Swedish Government, 1997c; Swedish Government, 1998b; Swedish Government, 1998c). The aim of the programme was to shift society towards sustainability and create employment opportunities. The 1998 budget bill specifies the requirements for project approvals. They consist of several topics described in a wide manner but primarily states that applications should treat how a project contributes to long term sustainability, employment, development of new technology and how much it is expected to cost. It further states that the selected applications should decrease environmental load by contributing to increased efficiency of material and energy use, contribute to increased use of renewable resources and improvement of biodiversity.

As described by Sandén and Jonasson (2005) the design of the programme came to favour the municipalities with the ability to coordinate municipal waste, energy and transport companies in demonstration projects on biogas. The programme was evaluated by Swedish EPA in a number of reports starting in 2002. The projects that got funding related to alternative fuels were evaluated in a report from 2004. Roughly 150 million SEK was put on primarily biogas vehicles in 32 municipalities to transform the transport sector and abate $CO_2$ emissions. The report concludes that since there was no directive on how to environmentally assess projects in the approval requirements, the environmental gains from supported projects were not possible to compile because of large variations in municipal reporting. One part of the report evaluates a couple of projects in more detail. It specifically notes that large discrepancies are found between suggested and achieved projects results because of methodological differences and errors (Rehnlund, et al., 2004). The results in other reports by Swedish EPA aimed at evaluating the LIP programme as a whole, state that large differences were found in environmental goals, knowledge and systems thinking between municipalities. They also state that the organisation of work and use of EA methods between the national and local level differed considerably (Sköllerhorn & Hanberger, 2004; Eckerberg, et al., 2005; Wandén, 2005).

In summary, a new political will at the national level led to a reorganisation of efforts related to combatting climate change, which put alternative fuels firmly on the agenda. The Communications Committee inquiry was heavily involved in decisions on policy measures for ethanol. The inquiry used several EA methods to deliver their report, which was commissioned by the Ministry of Communications. In a parallel development, the LIP funding programme was designed by a number of political actors to address both climate change and employment issues. The wide scope of the programme, as well as differences in goals, knowledge and organisation between horizontally and vertically positioned actors in government administration meant that results were hard to evaluate.

# 5. Analysis

From the description in the previous chapters of how EA methods were used in public policy on alternative fuels, it is clear that such use is far from straight forward. It is rather part of a dynamic decision process which shifts in relation to changing contextual events such as landscape forces and governance arrangements. In this dynamic process EA methods serve as one of many inputs that influence technology policy. The performed methodological blocks of operations have enabled a description of the development of alternative fuels during 1974-2004, of how technology policy influenced that development and of how EA methods were used in the formation of the policy. The description started with a wide scope using the MLP framework, and was stepwise narrowed through the TIS and governance arrangements frameworks. Finally focus was put on EA methods themselves with the four questions; 'What type of EA is used?', 'What is the object of study connected to the EA?', 'Who supplies, performs and receives the EA?', and 'How are EA results used in the decision process?'. A first observation from this methodological procedure is that not only does EA influence policy, but the contextual events previously mentioned also influences which and how EA methods are used. Hence there is an interplay in the use of EA methods in technology policy which will be analysed below.

This chapter starts by analysing how EA influence policy by moving backwards through the performed methodological blocks. It starts from the narrowest scope by using the four questions, to stepwise widening the circle around EAs and increasing the scope by investigating the influence of EA on connected governance arrangements and TISs. The opposite direction is then investigated to analyse how landscape forces of the MLP framework and governance arrangements influence the use of EA methods. The aim of each step is to identify relevant questions for further research. At the end, all issues will be categorised into themes to define future areas of research.

Starting with the what, who and how questions related to EA, some rudimentary observations can be made. First, there are decision processes where EA methods come into play, and processes where they do not. In the material that has been studied they enter through the work of public official inquiries, mainly in the form of committee inquiries. This is natural from the perspective that committee inquiries collect information from the outside world in order to facilitate informed political decisions. Then there are decision processes which have great impact on technology development but where EA methods do not come into play; the political three party agreements at national level and the technology investments made by municipalities in both the second and third period show little references to EA methods or other analytical treatment of environmental issues.

Turning to the public official inquiries where EA methods clearly are used and studying them through the four questions, several observations can be made.

Starting with the question 'What type of EA method is used?', the most frequently occurring types are ESA methods. In the first period MFA and EFA were used, in the third LCA, CBA and SEA. Other methods are not clearly identified. Based on this the following questions can be raised:

- *Are specific EA methods more commonly used in some political decision processes than others?*
- *Which EA methods are used in relation to specific technologies and do they affect decision outcomes in different ways?*

Continuing to the question 'What is the object of study connected to the EA?', in relation to methanol MFA and EFA were used in the first period to examine global to national material and energy flows, and to connect them with national demands. During the same period, EFA was used to examine energy efficiency of ethanol production from domestic agriculture products. In the third period, in relation to domestic ethanol, LCA was used to study $CO_2$ emissions throughout a production plant life cycle, CBA was used to calculate social-economic and environmental costs of investment plans, and SEA was used to study connected reductions of $CO_2$, $NO_X$, $SO_X$ and VOC. A first observation is that regardless of the differences between methods, the object of study was connected to different geographical scopes within and between periods. In the first period the global scope was used in relation to methanol, resulting in that coal and natural gas was favoured because of their presumed larger resource bases. In the same period, energy efficiency was calculated with a national perspective which instead made Swedish agriculture products a favoured resource. In the third period, the national scope was again chosen resulting in cellulose to be the largest resource, when in reality Brazilian sugar resources were much larger, at least in the short run. There are also some noticeable differences in environmental scopes and how that affected compatibility between methods. In the third period $CO_2$ was analysed in the LCA by IEA and in the CBA by KFB, NUTEK and SIKA. Their reports were used as input for the SEIA by the Communications Committee where not only $CO_2$ but also $NO_X$, $SO_X$ and VOC were evaluated, creating an obvious mismatch. Regardless of why the specific methods and scopes were chosen, this shows how such choices impact the base for decisions in terms of what information is made available. The following question can be raised:

- *How are EA parameters, such as geographical, temporal and environmental scopes, set in political decision processes and how does it affect decision outcomes?*

Regarding the question 'Who supplies, performs and receives the EA?', there are many possibilities. The performer is either an individual or organisation commissioned by the inquiry directly, as seen with the MFA from the methanol case, or the EA is performed in unrelated contexts and later picked up by the inquiry as seen with the EFAs and LCA in the ethanol cases. The implication of

this seems to be two-fold. If an EA is commissioned it might be better suited for decisions, but also scoped too close to these decisions so that peripheral but important environmental issues are overlooked. On the other hand if external EA reports are used they might not suit decisions at all. The latter is evident in the ethanol inquiry in the first period where several external EFA reports are compared, and since some of them did not match the purpose of the investigation the investigator adapted results using own assumptions. Regarding receivers of EA results, they are part of what can be described as a tier based system. The first tier is the committee of inquiry itself, the EA results then become part of the inquiry report which is received by second tier actors such as the ministry in charge of the inquiry, any remittance groups or any parallel inquiries working with connected issues at the time. The report is then published and might become part of a bill submitted to a third tier of parliament committees where it is prepared before a vote. The finished bill might in turn be used as reference in up-coming bills. The bills and inquiry reports are then publicly available to a fourth tier where anyone who is interested may use them for many years to come. From this perspective the receivers of one tier also become the suppliers of EA results to the next tier. In each step there is considerable risk of data aggregation or misuse of results. This is evident in the first period when EFUD used results from EPU that had been developed for a different temporal scope. It is also evident in the case from the previous paragraph where sub-reports were combined in a main report in spite of the fact that many assumptions and analyses did not match. The topics addressed here of how EA results are distributed also relate to the theories by Owens (2005), about how they may be used selectively as part of power tainted processes. With Owens power perspective in mind the following questions may be raised:

- *In what cases are EAs commissioned by government actors involved in a decision process, when are non-commissioned EAs used, and does the choice impact quality of decision outcomes?*
- *How well do statements in official documents match preceding statements and EA results? Are there obvious mismatches in statements, data or scopes that hint at that the EA has been used in a deceptive way to support decisions based on other motives?*

The question ‘How are EA results used in the decision process?’, opens up for a range of topics, and to the broader question of how EA use relates to governance arrangements and TISs. The question has been somewhat explored in previous paragraphs where EA references mainly were found in public official inquiry reports or connected sub-reports, and later in aggregated form in government bills. In the inquiry reports, EA results are often joined by investment and demand forecast assessments in quantitative form, as well as with qualitative assessments in discussion form around technological maturity and national employment, security and self-sufficiency. This is evident in almost all the studied material. The results from the assessments are aggregated into a written recommendation

that meets the requirement of the report directive. The aggregation is rarely done in a structured way, creating an obvious risk that one assessment becomes more influential than others. This is evident in many of the larger reports that include many topics, where final results may have dropped issues raised in some of the assessments. Based on this the question below can be raised:

- *How are results from different assessment methods balanced in a political decision process, specifically how are quantitative and qualitative results balanced?*

The analysis now continues to explore how EA results relate to governance arrangements and TISs. As described in Section 2.1, governance arrangements basically consists of six components. In the studied material there is no clear evidence that EA affects any of them, with one exception. This is interesting from a reflexive governance point of view since the impact on TIS functionality differs between policy measures. It is natural that EA does not impact the level and degree of private involvement in decisions, it is rather the other way around, which will be explored in later paragraphs. One could however expect that EA could affect the type of policy measure employed, and thereby also which key processes and what technology specificity the policy is targeting. The extent of EA use shifted extensively between periods of the era. In period two very little references were found and still the same type of policy was implemented as in the cases where EA was extensively used. Hence the material rather points to that the role of actor constellations and that the degree of technological maturity are influential factors on the choice of policy measure. The exception to this is the use of CBA and SEA in the third period to assess the demonstration plant policy related to ethanol. This is natural since those methods are geared toward planning, but it also raises questions around how, when and in what combination different methods should be implemented to be able to steer technological development:

- *How are EA methods implemented and combined in the different stages of political decisions, and how does it affect technology development and steering?*

The analysis now shifts focus to raise issues around how landscape forces of the MLP framework and governance arrangements influence the use of EA methods, of which there are many examples in the material. This is of equal importance for technology development and also opens up for analysing decisions where little reference to EA methods were found. The work by Sandén and Jonasson (2005) already describes how landscape forces put pressure on the regime and how several TISs emerged during the era. The studied material suggests that also the governance arrangements, which partly share structures with the TISs, are heavily influenced by landscape forces in line with theories by Hillman, et al. (2011). A first step is to observe that the public official inquiries previously discussed are part of a bigger treatment process of political issues, which are surrounded by pre-

and after-processes. The pre-process is the upstream process that decides what question is treated as well as how and by whom it should be treated, the treatment process itself may or may not include an inquiry depending of the outcome of the pre-process, and the after-process is the downstream process leading to a decision and possible implementation of a policy.

Starting with the pre-processes, in each period the landscape forces were interpreted by the governmental administration and picked up by a specific authority or network of actors. In the first period, the oil crisis was mainly interpreted as an energy and national self-sufficiency issue as is evident from the political discourse from related bills. It could have been treated differently, as the introduction to the 1975 bill clearly also connects it with environmental issues, but it was not. The main parts of the bill were written by the Ministry of Industry. The same ministry also ordered the initial inquiry committees treating the issue. The directives to those inquiries were strongly connected to the policy area of the ministry itself, mainly technology, costs and resource supply from an industry security perspective. The inquiries then naturally used MFA and EFA to analyse the resource supply issue. Swedish EPA was the agency with the main responsibilities for environmental issues at the time, but it had little input which is strikingly obvious in the case of the EPU report, where it came in after the report was already done leaving no time to implement their comments. Similar aspects are found in relation to the investigation on ethanol in the first period. The issue was picked up by the Ministry of Agriculture because it rose out of an agricultural debate on an ethanol production plant. The report then analyses production efficiency through several EFA reports and favours ethanol from Swedish agriculture products. It did not analyse implications of resource limitations because it was not part of its directive, even though previous inquiries had disregarded domestic ethanol as too expensive and short of resources. Corresponding tendencies can be found in the second period. The landscape factor of that time was the local environment. At the national level alternative fuels were interpreted as an issue related to traffic, health and environment, not energy. Since the landscape force was about local environment, local authorities acted on the issue and invested in new technology. From what can be deduced by their project reports almost no analytical methods were used, which is notable from the perspective that their demonstration projects were as much a part of the alternative fuel development as any support from the national level. In the third period, climate change related alternative fuels to $CO_2$ and domestic employment opportunities. The related Communications Committee inquiry focused heavily on the same issues by using LCA, CBA and SEA. This description points to two things; that landscape forces are interpreted by the government administration and can be combined with other political issues to drive development, and when interpretation is done it is picked up by a relevant authority and acted on with the mandate, capability and logic of that authority. With that as a background the following questions can be raised:

- *How are issues related to environment and technology assigned to specific authorities in government administration, and how does it affect the use of EA methods?*
- *How do differences in mandate, capability and logic between different authorities influence the type, scope and results of an EA?*

Continuing by comparing treatment and after-processes occurring at national level with ones occurring at local level, some further observations can be made. Regarding treatment processes at national level, both methanol and ethanol support were treated through inquiries with high degree of EA references in the first period. The decision to start the KFB program in the second period was treated through a political agreement. Support for ethanol was treated through an investigation with high EA content in the third period, while the LIP program was treated through a wide political consensus around sustainability. Treatment processes at the local level instead had few references to EA methods in the second period, some but vague, or according to the investigation reports by Swedish EPA, incorrectly used references in the third period. This points to that the national level may treat issues through inquiries with the input from EA methods, or through pure political agreements depending on circumstance. It also raises questions about how the local level is organised and what knowledge exists about EA methodology. Regarding after-processes, the material highlights the richer capabilities of national level actors to engage in policy measures. This in turn raises the question of how decisions should be distributed in the government administration to reach effective steering. In summary the following questions can be raised:

- *What types of political issues are treated with a structured inquiry process with input from EA methods, and which are not?*
- *How do differences in work organisation and knowledge within the government administration affect the ability for using EA methods?*

From a process perspective the collection of questions above may be viewed as part of a three stage decisions chain occurring in the government administration when affected by a landscape force:

1. Interpretation and assignment of the landscape force to a government authority and a related decision process, based on organisational capabilities and rationality of the government administration.
2. Possible engagement in a structured inquiry process with input from internal or external EAs, to find a solution to the interpreted landscape force in combination with other contemporary political goals.
3. Utilisation of EA results combined with other input to form a decision on policy implementation.

The process can also be viewed as a decision funnel where decisions from early stages put constraints on later stages. Summarising the questions above and grouping them into themes of future research related to the three process stages, Table 5.1 can be compiled, see next page.

Table 5.1: *Relevant research themes and case study questions related to the use of EA methods in public policy-making targeting support and regulation of technology development.*

| Research themes | Case study research questions |
|---|---|
| 1. Organisational issues of EA | • How are issues related to environment and technology assigned to specific authorities in government administration, and how does this affect the use of EA methods?<br>• How do differences in mandate, capability and logic between different authorities influence the type, scope and results of an EA?<br>• What types of political issues are treated with a structured inquiry process with input from EA methods, and which are not?<br>• How do differences in work organisation and knowledge within the government administration affect the ability to use EA methods? |
| 2. Implementation issues of EA | • Are specific EA methods more commonly used in some political decision processes than others?<br>• Which EA methods are used in relation to specific technologies and do they affect decision outcomes in different ways?<br>• How are EA parameters, such as geographical, temporal and environmental scopes, set in political decision processes and how does it affect decision outcomes?<br>• In what cases are EAs commissioned by government actors involved in a decision process, when are non-commissioned EAs used, and does the choice impact quality of decision outcomes?<br>• How are results from different assessment methods balanced in a political decision process, specifically how are quantitative and qualitative results balanced?<br>• How are EA methods implemented and combined in the different stages of political decisions, and how does it affect technology development and steering? |
| 3. Utilisation issues of EA | • How well do statements in official documents match preceding statements and EA results? Are there obvious mismatches in statements, data or scopes that hint at that the EA has been used in a deceptive way to support decisions based on other motives? |

# 6. Discussion and conclusions for future research

The analysis of the previous chapter revealed issues related to both how EA influence technology policy as well as how landscape forces of the MLP framework and governance arrangements influence the use of EA methods. This chapter expands the analysis by discussing how the scope and method of the case study fits into a larger picture, as well as giving examples of research pathways for future work.

Regarding scope, the case makes a distinct selection of technology. As described in Chapter 3, this means also making a selection of government authorities and EA methods. Since the technology in question is alternative fuels and cars, it is natural that energy, communications and transport actors came to be involved to a great extent. Also, because the issue throughout the era was about replacing oil for different reasons, it is natural that material and energy oriented EA methods were used. Regarding the extent to which the results of the pre-study can be generalised, much of the government system remains unexplored, such as other ministries with connected agencies, the regional level, as well as much of the local level. The same is true for EA methods. Several of the readily available methods were not uncovered even though they are well known to be used (Pilli-Sihvola, et al., 2010). For further studies it hence becomes interesting to investigate other parts of the government administration, to explore how EA is used in other processes with different prerequisites than that of committee inquiries. Regarding method, the frameworks that have been used are heavily geared towards technological innovation systems theory. The frameworks are relevant for the case study since it follows technological innovations over time, but the wider area where the case study is situated lies in the cross-section between technical change, political science and EA. The frameworks are not entirely suited for detailed analysis of the second two areas which should be addressed in further studies.

In relation to future research it is of interest to see how the case study research questions from Table 5.1 can be generalised further to serve as more useful input. The three stage decision process occurring in government administration when affected by a landscape force described in the Analysis chapter, is applicable to any form of decision since decisions are by nature surrounded by pre- and after-processes. However, it would be of interest for future research to examine how these stages shift in nature between different types of government administrations. From the introduction to the Swedish government administration in Chapter 2, the repeating nature of the administration should enable the questions to be applicable to the entirety of the structure. The questions of the first theme relate to how differences in organisation of a government administration affect the use of EA methods, and can be generalised to the question: ‘How can a government administration be organised to enable efficient and effective use of EA methods of technology?'. The questions of the second theme relate to how EA methods are technically implemented within a government administration and can be

generalised to the question: ‘How can EA methods of technology be implemented to enable fair assessments suitable for government administration?’. The question of the third theme relates to how EA results are utilised within a government administration, and if they are done so in an appropriate manner. The question hence relates to the power issues in public policy-making where EA results might be used in deceptive manners to support specific motives as described by Owens (2005). From a reflexive innovations systems perspective, if EA results are deceptively used their capability to function as reflexive mechanisms might be threatened, and ultimately so also the goal of reaching a sustainable society. With that perspective it is of relevance to reformulate and generalise the theme question as: ‘How can the use of EA methods of technology within government administration be effectively monitored?’. Subsequent to generalising the questions would be to assign methods to each of them. To give examples, the first question could be investigated through comparative studies between political levels or government administrations of different countries. The second questions could be investigated through surveys and interviews, to compare requirements on decision support material in a government administration with the design requirements of EA methods themselves. The third theme could also be investigated with comparative studies focusing on how well EA results and political decisions match in different policy processes, or on the functionality of auditing authorities within different types of government administrations. The generalisation of the case study research questions and the proposed accompanied research methods are summarised in Table 6.1.

Table 6.1: *Pre-study proposal of future research themes with connected research questions and methods.*

| Research themes | Generalised research questions | Proposed research methods |
|---|---|---|
| 1. Organisational issues of EA | How can a government administration be organised to enable efficient and effective use of EA methods of technology? | Comparative studies |
| 2. Implementation issues of EA | How can EA methods of technology be implemented to enable fair assessments suitable for government administration? | Survey and interview studies |
| 3. Utilisation issues of EA | How can the use of EA methods of technology within government administration be effectively monitored? | Comparative studies |

Finally the research questions under Section 1.3 can now be answered. Regarding the first one, 'How were EA methods of technology used by the Swedish government administration when forming policy on support for alternative fuels in 1974-2004?', the answer can be summarised with the three stage decision process formulated in the Analysis section. More formally put, the Swedish government administration used EA methods of technology to varying degrees, in response to contemporary environmental issues, when forming policy support around alternative fuels in 1974-2004 through a three stage decision process described in general below:

1. Interpretation and assignment of a landscape force to a government authority and a related decision process, based on organisational capabilities and rationality of the government administration.
2. Possible engagement in a structured inquiry process with input from internal or external EAs, to find a solution to the interpreted landscape force in combination with other contemporary political goals.
3. Utilisation of EA results combined with other input to form a decision on policy implementation.

Regarding the second question, 'What could be relevant topics for research on technological innovations, EA and government administration in future work?', the answer can be summarised with Table 5.1 and Table 6.1.

In summary this pre-study has investigated a limited section of the Swedish government administration using an explorative and technology oriented research approach, and found a number of questions that are of interest for further studies (Table 5.1). Given the large amount of government administration that is still unexplored there is an urgent need for future research. Three themes of research with connected research topics and suggestions of possible methodology have been proposed (Table 6.1). Finally, it can be concluded that the use of EA methods in formation of public policy on technology development, and the connected implications for reflexive governance, is a complex and multidimensional field of research, but one that needs to be better understood in order to move towards a more sustainable society.

# 7. References


Arnold, E. & Thuriaux, B., 1997. *The Biofuels Programme at KFB, 1991-1997,* Stockholm: KFB.

Azar, C. & Sandén, B., 2011. The elusive quest for technology-neutral policies. *Environmental Innovation and Societal Transitions,* 1(1), pp. 135-139.

Bergek, A. et al., 2008b. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy,* 37(3), pp. 407-429.

Bergek, A., Jacobsson, S. & Sandén, B. A., 2008a. 'Legitimation' and 'development of positive externalities': two key processes in the formation phase of technological innovation systems. *Technology Analysis & Strategic Management,* 20(5), pp. 575-592.

Eckerberg, K. et al., 2005. *Understanding LIP in Context,* Stockholm: Swedish Environmental Protection Agency.

EFUD, 1977. *SOU 1977:56 Energi - program för forskning, utveckling, demonstration,* Stockholm.

Ekelund, M. et al., 1993. *Nordiska GasBuss Projektet, Projekt II, Slutrapport mm,* Stockholm:KFB.

EPK, 1974a. *SOU 1974:72 Energiforskning, program för forskning och utveckling,* Stockholm.

EPK, 1974b. *SOU 1974:75 Energiforskning, expermaterial avdelning C, energianvändning för transporter och samfärdsel,* Stockholm.

EPU, 1974a. *SOU 1974:64 Energi 1985 2000,* Stockholm.

EPU, 1974b. *SOU 1974:65 Energi 1985 2000, bilaga,* Stockholm.

Etanolutredningen, 1980. *Ds Jo 1980:7 Etanol ur jordbruksprodukter,* Stockholm: Ministry of Agriculture.

Finnveden, G. & Moberg, Å., 2005. Environmental systems analysis tools - an overview. *Journal of Cleaner Production,* Volume 13, pp. 1165-1173.

Fogelberg, H. & Sandén, B. A., 2008. Understanding reflexive systems of innovation: An analysis of Swedish nanotechnology discourse and organization. *Technology Analysis & Strategic Management,* 20(1), pp. 65 - 81.

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

Geels, F. W. & Schot, J., 2007. Typology of sociotechnical transition pathways. *Research Policy*, 36(3), p. 399–417.

Grübler, A., 1998. *Technology and global change.* Cambridge: Cambridge Univ. Press.

Hillman, K., Nilsson, M., Rickne, A. & Magnusson, T., 2011. Fostering sustainable technologies: a framework for analysing the governance of innovation systems. *Science and Public Policy,* 38(5), pp. 403-415.

Jönsson, H., 2006. *Vätgasens historia i Sverige: aktörer och aktiviteter inom vätgas- och bränslecellsområdet mellan 1960 och 2005,* Gothenburg: Chalmers University of Technology.

KFB, 1995. *Flottförsök med 32 etanolbussar vid AB Stockholms Lokaltrafik,* Stockholm: KFB.

Löfgren, I., 2010. *Så styrs landstingen.* [Online]
Available at:
http://www.skl.se/kommuner_och_landsting/om_landsting_och_regioner/sa_styrs_landstingen
[Accessed 10 May 2012].

MAK, 1986. *SOU 1986:51 Alkoholer som motorbränsle,* Stockholm.

Ministry of Communications, 1988. *Prop. 1987/88:50 Om trafikpolitiken inför 1990-talet,* Stockholm.

Ministry of Communications, 1994. *Dir. 1994:140 Uppdrag att utarbeta en nationell plan för kommunikationerna i Sverige,* Stockholm.

Owens, S., 2005. Making a difference? Some perspectives on environmental research and policy. *Transactions of the Institute of British Geographers,* 30(3), pp. 287-292.

Pilli-Sihvola, K. et al., 2010. *Survey on the use of climate scenarios and climate change research information in decision making in Finland, Sweden, and Norway.* [Online]
Available at: http://www.naturvardsverket.se/sv/Start/Forskning/Forskning-for-miljomalen/EU--och-internationell-forskning/CIRCLE/
[Accessed 11 April 2012].

Ponting, C., 1992. *A green history of the world : The environment and the collapse of great civilizations.* London: Penguin books.

Rehnlund, B. et al., 2004. *Framtida möjligheter med nya drivmedel - en utvärdering av LIP-finansierade åtgärder inom alternativa drivmedel ,* Stockholm: Swedish EPA.

Rydén, C., 1995. *Flottförsök med 32 etanolbussar vid AB Stockholms Lokaltrafik,* Stockholm: KFB.

Sandén, B. A. & Jonasson, K. M., 2005. *Variety Creation, Growth and Selection Dynamics in the Early Phases of a Technological Transition: The Development of Alternative Transport Fuels in Sweden 1974-2004.* Gothenburg: Chalmers University of Technology.

SKL, 2012. *Om kommuner.* [Online]
Available at: http://www.skl.se/kommuner_och_landsting/om_kommuner
[Accessed 10 May 2012].

Sköllerhorn, E. & Hanberger, A., 2004. *LIP och lokalt miljöarbete,* Stockholm: Swedish EPA.

SMAB, 1978. *Methanol as motor fuel,* Stockholm: Svensk Metanolutveckling AB.

Statens Energiverk, 1986. *Motoralkoholer i Sverige: Tekniska och ekonomiska förutsättningar,* Stockholm: Statens Energiverk (former equivalent to the Energy Agency).

Swedish EPA, 2011. *Vem gör vad?.* [Online]
Available at: http://miljomal.nu/Undre-meny/Vem-gor-vad/
[Accessed 23 February 2011].

Swedish Government, 1974. *Prop. 1974:69 Angående vissa energibesparande åtgärder,* Stockholm.

Swedish Government, 1975. *Prop. 1975:30 Regeringens proposition om enerighushållningen m.m.,* Stockholm.

Swedish Government, 1979. *Prop. 1978/79:115 Om riktlinjer för energipolitiken,* Stockholm.

Swedish Government, 1980. *Prop. 1979/80:170 Om vissa energifrågor,* Stockholm.

Swedish Government, 1981. *Prop. 1980/81:90 Om riktlinjer för energipolitiken,* Stockholm.

Swedish Government, 1986. *Prop 1985/86:102 Om vissa åtgärder för omställning av energisystemet,* Stockholm.

Swedish Government, 1991a. *Prop. 1990/91:88 Om energipolitiken,* Stockholm.

Swedish Government, 1991b. *Prop. 1990/91:90 En god livsmiljö,* Stockholm.

Swedish Government, 1993. *Prop. 1992/93:179 Om åtgärder mot klimatpåverkan m.m.,* Stockholm.

Swedish Government, 1994. *Prop. 1993/94:111 Med sikte på hållbar utveckling; Genomförande av besluten vid FN:s konferens om miljö och utveckling - UNCED,* Stockholm.

Swedish Government, 1997a. *Skr. 1996/97:50 På väg mot ett ekologiskt hållbart samhälle,* Stockholm.

Swedish Government, 1997b. *Prop. 1996/97:84 En uthållig energiförsörjning,* Stockholm.

Swedish Government, 1997c. *Prop. 1996/97:150 1997 års ekonomiska vårproposition,* Stockholm.

Swedish Government, 1998a. *Prop. 1997/98:56 Transportpolitik för en hållbar utveckling,* Stockholm.

Swedish Government, 1998b. *Skr. 1997/98:13 Ekologisk hållbarhet,* Stockholm.

Swedish Government, 1998c. *Prop. 1997/98:1 Budgetpropositionen för 1998,* Stockholm.

Swedish Government, 2002a. *Prop. 2001/02:55 Sveriges klimatstrategi,* Stockholm.

Swedish Government, 2002b. *Prop. 2001/02:1 Budgetpropositionen för 2002,* Stockholm.

Swedish Government, 2009. *How laws are made.* [Online]
Available at: http://www.sweden.gov.se/sb/d/2854/a/19197
[Accessed 10 May 2012].

Swedish Government, 2011. *Lagstiftningsprocessen, från initiativ till beslut.* [Online]
Available at: http://www.regeringen.se/sb/d/1522
[Accessed 10 May 2012].

Swedish Government, 2012. *Så styrs Sverige.* [Online]
Available at: http://www.regeringen.se
[Accessed 10 May 2012].

Swedish Parliament, 2012. *Så funkar riksdagen.* [Online]
Available at: http://www.riksdagen.se
[Accessed 10 May 2012].

The World Bank Group, 2011. *The Worldwide Governance Indicators (WGI) project.* [Online]
Available at: http://info.worldbank.org/governance/wgi/sc_country.asp
[Accessed 24 February 2012].

Utredningen om förnybara fordonsbränslen, 2004. *SOU 2004:133 Introduktion av förnybara fordonsbränslen,* Stockholm.

Wandén, S., 2005. *Vad vi kan lära av LIP,* Stockholm: Swedish EPA.

Yale Center for Environmental Law and Policy, 2012. *2012 Environmental Performance Index and Pilot Trend Environmental Performance Index.* [Online]
Available at: http://epi.yale.edu/epi2012/rankings
[Accessed 24 February 2012].