Integrating Economics with a Strategic Sustainable Planning Method-To enhance decision making processes

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Abstract: The complexity of environmental, social, economical, and technological objectives creates a challenge for decision makers when prioritizing the right measures that will move a project or organization toward sustainability at least cost. Currently there are methods or tools available to assist in this decision making and through a strategic approach potentially enhance the process. The focus of this thesis is to evaluate how the quantitative nature of economic detail as a tool which has been informed by a strategic sustainable framework can contribute to the complex decision making process for sustainable development when prioritizing measures. A two- step matrix format is used to represent the proposed approach. The complexity of sustainable development issues for decision makers within Sweden's energy sector provides a suitable case study to explain this approach. Karlskrona, Sweden district heat was chosen. The results revealed an enhanced decision making process utilizing the proposed approach in district heat thus ensuring organizational and social profitability as defined by, static and dynamic efficiency and equitable allocation. The thesis concludes that the suggested approach has the potential to enhance the decision making process for strategic sustainable development when prioritizing measures in district heat and may be universal in its application in many other sectors. However, further validation of the approach through testing in real life situations is recommended.

Keywords: District Heat; Economics; ABCD Analysis; Sustainability; Strategic Sustainable Development; Prioritization

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Executive Summary

Background

The complexity of environmental, social, economical, and technological objectives creates a challenge for decision makers when prioritizing the right measures that will move a project or organization toward sustainability at least cost. Currently there are methods or tools available to assist in this decision making process and through their collaboration potentially enhance the process. The focus of this thesis is to evaluate how the quantitative nature of economic detail as a tool which has been informed by a strategic sustainable framework can contribute to the complex decision making process for sustainable development when prioritizing measures. The complexity of sustainable development issues for decision makers within Sweden's energy sector provides a suitable case study to explain the approach. Karlskrona, Sweden district heat was chosen.

Method to Explain Proposed Approach

Data was collected regarding operational issues for sustainable development through personal interviews with key personnel of a district heat company and Sweden's Energy Authority. The objective was to discover the history and current state of operations (e.g. production, distribution, consumption) as well as future plans for the district heat company with regard to prioritizing sustainable measures to theoretically explain the approach of this thesis.

Government involvement with sustainable development initiatives in the energy sector was also investigated which could potentially influence the prioritizing of measures within the municipality district heat. The information received was limited in its depth due to time and economic constraints for those interviewed. However a literature search contributed to a better understanding of the district heat operations within the context of the Swedish and European energy sector as well as specific documents from the Swedish Energy Authority and the National Board of Housing Building and Planning.

Literature searches and interviews also provided the necessary understanding regarding the strategic sustainable framework [1] (specifically "Step D" of the ABCD analysis within the 5 level framework), as well as the economic approach when prioritizing measures for sustainable development.

The proposed approach of this thesis utilizes "Step D" of the ABCD analysis as the overarching strategic sustainable development model with further quantification by economic analysis to determine social, and organizational profitability as defined by static and dynamic efficiency and equitable allocation. This proposed approach for prioritizing measures in strategic sustainable development was then theoretically applied to the case study of Karlskrona, Sweden district heat. Four separate sustainable development issues in district heat operations were assessed utilizing the proposed approach.

- Supply Side: 1. Cogeneration 2. Renewable Fuels
- Demand Side Management: 3. Pricing Structures 4. Split Incentives.

Each district heat issue was challenged initially by "Step D" of the ABCD analysis and qualitatively presented in a matrix followed by the "economic analysis" to provide quantitative detail which is also presented in matrix format. The integration of economic detail with "Step D" of the ABCD

[1] The 5 level framework provides a strategic planning method for sustainable development referred to as the ABCD analysis for guiding the prioritizing of measures; Defined in the ABCD analysis as "Step D": 1) Does the measure move the organization towards sustainability, 2) Does the measure provide a flexible platform for further investments towards sustainability so that sub-optimisations and blind alleys can be avoided, and 3) Does the measure give an adequate return on investment to ensure an influx of resources for the continuation of the process? The quantitative solutions are left up to the decision maker to determine within the context of the 5 level framework. (Blekinge Institute of Technology, 2005)

analysis, as an overarching strategic planning method, in a two step matrix format is the proposed approach of this thesis.

Results

The proposed approach of this thesis utilized the qualitative design of "Step D" of the ABCD analysis, within the 5 level framework for strategic sustainable development, to initially inform the economic detail required to address the complexity of issues within the sustainable development process of Karlskrona district heat operations (i.e. Supply: Co-generation and Renewable Fuels and Demand side: Pricing Mechanisms and Split Incentive) and to optimize results. The informed economic detail contributed value by further prioritizing sustainable development measures defined by the "Step D" of the ABCD analysis by evaluating business profitability (financials) and social profitability (i.e. static and dynamic efficiency and equitable allocation) of each of these operational issues. The theoretical application of the proposed approach in district heat operations offered the decision maker a potential qualitative and quantitative tool for sustainable development decision making.

Discussion

Decision making may be enhanced with the use of tangible tools to quantify the details when prioritizing measures as defined by "Step D" of the ABCD analysis within the 5 level framework for strategic sustainable development. When multiple flexible platforms are revealed by "Step D" of the ABCD analysis that all appear to be smart, strategically sustainable options, then economic detail can provide additional clarification to assist in prioritizing these options. Natural Resource and Environmental economics can provide the necessary analysis for this process. This leads to, for instance, quantitative decision support which can be further enhanced by structuring a matrix to qualitatively present the "value" of the sustainable measure in terms of organizational and social profitability for an optimal sustainable choice. Several measures within Karlskrona district heat (supply and demand side management) fit into the matrix giving the organization a better picture of the impacts of its decisions. The value added by the economic analysis to quantitatively assess the details was apparent within the context of the Karlskrona District Heat case study.

Conclusion

The proposed approach of this thesis suggests an enhanced decision making process through the initial guidelines of the “Step D” of the ABCD analysis, within the 5 level framework for strategic sustainable development, followed with a quantitative valuation of the sustainable measures by economics to ensure organizational, social and environmentally profitable outcomes when explained in a case study of district heat operations (i.e. supply and demand side management). The relevance of pricing, information, incentives and tradeoffs were contributing aspects to the overall economic component. In addition to district heat, the proposed approach has the potential to be context-free and universally applied in other sectors to assist decision makers who are dealing with the current dilemma associated with the prioritizing of measures in sustainable development. However, actual testing and validation of the approach in real life situations is recommended.

Further Research

Due to the time constraints of this thesis, future research is recommended to provide additional information regarding the prioritizing of sustainable development measures. Research which would verify and test the approach suggested in this thesis as well as implement the proposed model in a current project is suggested as a viable “next step”.

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1 Introduction

1.1 The Concept of Sustainable Development

History

Ideas regarding sustainable development have been described by native tribes of North America as early as 1800's. ((Mitroff and Linstone 1993, 163)) and perpetuated through the industrial development during the 19th and 20th centuries.

Concern for the affects of this industrial development on the ecosystem and the interconnectedness of human activity to the biosphere lead to discussions that emerged as global forums. The first United Nations summit on the Human Environment in Stockholm, Sweden in 1972 set an agenda to address the environmental impacts of human behavior in a collaborative global effort thus heightening the awareness on a political level. (Kuisma, 2000)

As global environmental awareness grew, developing nations grew fearful of the threat to their economies and free access to natural resources. The World Commission on Environment and Development (WCED) was established by the United Nations to address the growing issues of concern. In 1987, as chair to the WCED, Norwegian Prime Minister Mrs. Gro Harlem Brundtland brought additional international attention to the concept of sustainable development by presenting "Our Common Future" (The Brundtland Commission Report). The report described seven strategies for sustainable development: 1) revive growth, 2) change the quality of growth 3) meet essential needs for jobs, food, energy, water and sanitation 4) ensure a sustainable population 5) conserve and enhance the natural resource base 6) reorienting technology and managing risk 7) merging environment and economics in decision making. Emphasis was placed on the inadequacies of our technology and social organization to meet human needs now and in the future. (National Centre for Sustainability)The Rio Earth Summit in 1992 strongly endorsed these goals with the development of Agenda 21 and thus promoted the international acceptance of the Brundtland definition of sustainable development listed here. (World

Energy Assessment, 2000)

"Development that meets the needs of the present without compromising the ability of the future generations to meet their own needs."(WCED, 1987)

By 2002, world energy concerns became an inherent part of the definition as improvements in the quality of life were directly related to the continued improvements in the sustainable production, distribution and consumption of energy. (World Energy Assessment, 2000)

Multiple Definitions

In 1995 more than 70 definitions of sustainable development were reported by Trsyna (Trsyna, 1995). The social, economic, environmental and technological aspects in sustainable development are presented in Trsyna 1995 as inter-related to meet the goals of well being for now and in the future. However success in achieving one aspect might actually undermine the capacity to achieve success in another. (e.g. environmentally necessary, however economically not possible)(Kuisma, 2000) Additionally, how to prioritize current and future needs is not sufficiently addressed if at all. These kinds of contradictions without direction illustrate the complexity of issues that sustainable development measures present to decision makers despite the historical attempt to define and describe.

1.2 Prioritizing Measures for Sustainable Development: Energy Sector

Complex issues create challenges for decision makers when prioritizing measures towards a sustainable goal. More specifically the energy sector on a global, national and local level is faced with this very challenge to evaluate complex issues surrounding the decisions to reach a sustainable energy future at least cost. Local decision makers contend with the influences of government sustainable development directives which add to the complexity of achieving sustainable development goals.

"Everywhere energy policy is more or less the same. Energy supplies are required to be reliable, available at reasonable prices and have as little environmental impact as possible. These objectives can complement each other or be mutually opposed, which explains the complexity of energy policy. Improving the efficiency of energy use and concentrating on the use of renewable energy sources can contribute to these objectives." (Energy of Sweden, 2005)

Most energy systems that exist today are not addressing the basic needs of all people and the current business practices may undermine future generations to meet theirs. Energy production and consumption that can support human development over the long term with all of its social, economic, and environmental aspects would be in line with the Brundtland definition. (World Energy Assessment, 2000)

1.3 Prioritizing Measures

When a decision maker is prioritizing measures in sustainable development an overarching framework is desirable as well as quantitative tools to provide fact based evidence to support the decision. In this thesis "Step D" of the ABCD analysis within the 5 level framework provides the overarching strategic sustainable development model which can highlight multiple sustainable measures. Economic analysis provides the quantitative detail to assist in further prioritizing of these measures.

The 5 level framework's ABCD analysis was designed as a sustainable development compass to guide for strategic direction rather than a prescription for detailed actions. The ABCD analysis within the 5 level framework consists of a strategic planning method or "backcasting" process for sustainable development. It is based on four basic sustainability principles (system conditions) for socio-ecological sustainability as well as provides guidelines for systematic transitions to comply with the principles. Through the description of these socio-ecological principles or system conditions for sustainability provided by the framework, decision makers of private and public organizations are able to discuss how their current situation may violate these conditions currently. They are challenged to envision the sustainable society in which violations due not occur, and then propose strategic actions that will take them from today's reality to the future vision. (Broman, Holmberg, Robert, 2000, 13-25)

The Economic approach is varied among economists, however for purposes of this thesis the perspective of Environmental and Natural Resource economics is presented due to its Brundtland perspective on sustainable development. Economics utilizes models to deal with complex issues and to assess the interrelationships such as the economy, environment, and technology in a quantifiable manner. Economic models explicitly specify objectives, relationships involved, and assumptions made providing full disclosure of how conclusions were derived. (Tietenberg, 2006) The primary goal of economic detail is to serve the interests of society as well as the individual organization's long-term competitiveness by improving on resource efficiency, fairly allocating scarce resources (e.g. the environment), avoiding investments that are high-risk in the long-term, and improve on innovation and design in order to lay a better ground for future business that respects the needs of current and future generations. The economic approach can ensure to the decision maker (i.e. political or organization) that the social costs and benefits of proposed measures are well balanced through a cost benefit analysis. However, it can be difficult to estimate costs and benefits in the environmental context, since complete information regarding the benefits may be lacking. Economics can then utilize a cost effectiveness approach which can assist in achieving the environmental goal more efficiently and at least cost as well as meet the sustainability criterion through a spectrum of quantitative choices.

It is the strategic perspective of the 5 level framework's ABCD analysis "Step D" and the integration of economic detail as a tangible approach to assist decision makers when prioritizing measures in sustainable development that is the focus of this thesis. Theses approaches are addressed in more detail in Chapter 3.0

1.4 Conceptual Framework for the Thesis

How could economic detail be integrated with the strategic sustainable potential that exists in the 5 level framework's strategic planning method (i.e. ABCD analysis " Step D"), when evaluating and prioritizing complex measures whether it is in the energy sector or other sectors? Although this approach has the potential to be universally applied to any sector (e.g. energy policy, healthcare, natural resource management, etc) a specific case study is presented to explain the approach on a local energy sector level in the municipality of Karlskrona Sweden –District Heat.

1.5 Research Questions

Following the conceptual framework, the Master's thesis will try to answer the following question:

1. Is there value added when integrating economic analysis to the Strategic Planning Method ("Step D" of the ABCD analysis) of the 5 level framework in strategic sustainable development in the proposed thesis approach when prioritizing measures?

CASE STUDY: Karlskrona District Heat

The following secondary questions are addressed in order to optimize the potential for the suggested approach.

1. Can sustainability be optimized when prioritizing sustainable development measures from an organizational and social profitability perspective as defined by static and dynamic efficiency and equitable allocation?

2. How does government policy and economic factors influence decision makers when prioritizing of measures for the introduction of sustainable projects into society? i.e.

- Prices and information
- Incentives and trade-offs

1.6 Research Partners

This thesis work was conducted with cooperation from several municipalities and national governance bodies in Sweden regarding District Heat. District Heat Municipalities: Affarsverken–Karlskrona, Vaxjo and Kristianstad, National Board of Housing, Building, and Planning and The Swedish Energy Authority, and Anders Carlsson Licenceate Economist Blekinge Institute of Technology (BTH) Karlskrona, Sweden and former consultant to National Board of Housing, Building, and Planning for

District Heat

The thesis work has been supervised by the sustainability program at Blekinge Institute of Technology (BTH) in Karlskrona, Sweden for the purpose of completing the final part of the Master of Specialization in Strategic Leadership towards Global Sustainability

2 Research Methods

This chapter describes the research methodology used as well as its limitations to present a case study of district heat issues in sustainable development to explain the proposed approach. Research information was acquired from municipality district heat interviews, and literature review regarding the "Step D" of the ABCD analysis of the 5 level framework and economic detail for prioritizing measures in strategic sustainable decision making. A matrix system is used to model the potential of economics as the quantitative component to the "Step D" of the ABCD analysis of the 5 level framework when prioritizing measures to enhance the decision making process.

2.1 Analysis of Municipality Perspectives

The primary data was collected through personal interviews that included a comprehensive list of questions given to the key personnel of the district heat company and Swedish Energy Authority prior to the meeting or discussion. The objective was to discover the history and current state of operations (e.g. heat supply: production, distribution, heat demand: consumption) as well as future plans for the district heat company with regard to prioritizing sustainable measures to be used as a case study for explaining the proposed approach. The influence of government policy with these sustainable development initiatives was also investigated.

2.2 Application of the ABCD Analysis "Step D" and Economic detail

The initial application of the ABCD Analysis "Step D" followed by economic detail to prioritizing sustainable measures within current district heat operations (e.g. heat supply, distribution, heat demand) as well as planned operations was conducted by analysis of key issues within each area. After analysis, a matrix was developed to demonstrate results of applying economic detail which was informed by the "Step D" of the ABCD analysis within the 5 level framework in the sustainable development process for prioritizing measures. Did the sustainable measure result in a profitable solution for both the company's and society perspectives? The specific measures chosen for evaluation included; 1) Supply 2) Distribution: 3) Demand.

2.3 Scope and Limitations

The method used for this study has several limitations. The application of the research data was dependent on the response time from the various municipalities and their willingness to provide operational accounting data. When the municipality-specific operational data was not acquired, national data statistics were utilized. If national data statistics were limited, then principle-based evaluations were presented. The interpretation of whether the proposed sustainable measure is the optimized solution from both the company's and society's perspective is presented. What is necessary for a sustainable measure to become optimized is discussed without quantitative analysis due to the time constraints for this thesis. Measurement of the progress and shortcomings of prioritized measures (sustainability metrics) that are implemented are not in the scope of this thesis.

3 Prioritizing Measures in Sustainable Development

This chapter introduces the concept of prioritizing measures in sustainable development, the 5 level framework, and the ABCD analysis as the strategic sustainable planning method within the framework (specifically "Step D") as the overarching model when prioritizing measures in sustainable development. Economic analysis contributes the quantitative detail (Natural Resource and Environmental Economics) to further prioritize the sustainable measures highlighted by "Step D".

3.1 Concept of prioritizing sustainable measures

Sustainable development according to the Brundtland definition is the development process needed to ensure an outcome where the needs of all people today and of future generations are not compromised. As an overarching definition, it qualitatively describes what is needed on the operational level to prioritize sustainable measures in that direction.

In an organization, multiple sustainable strategies emerge as part of this sustainable development process which requires prioritization that integrates technological, environmental, social, and economical perspectives. Historically the agreement between these different perspectives has been less than optimal, however their convergence appears eminent. (Global Reporting Initiative, 2000). The integration of these aspects has been demonstrated in the qualitative design of "Step D" of the ABCD analysis within the 5 level framework for the prioritizing process of sustainable measures. The "Step D" is then quantified with economic analysis which is described in detail for purposes of this thesis.

3.2 The 5 level framework

The 5 level framework for strategic sustainable development as described and discussed in Robert et.al. 2002 was developed to guide an organization's development toward sustainability. This framework for sustainability provides a 5-level systems model that addresses the complexity of the sustainable development process. (Robert et.al. 2002) The 5-level model represents an organization's incremental progression from understanding its current role within a much larger context (i.e. the ecosphere) to the necessary actions it needs to take to ensure its future existence within the constraints of the socio-ecological principles provided in the model. The model provides an overarching strategic approach to sustainable development allowing each organization to determine the details that may be required to further their own sustainable development within the constraints of the framework. (Broman, Holmberg, Robèrt 2000, 13-25)

3.2.1 The 5 Level Framework – for strategic sustainable development

The strategic 5 level framework defines "Sustainable Development" through a five level process. (Byggeth, Hochschorner, 2005)

Level 1 The System Level:

The system level is a description of the overarching system in which planning and problem solving takes place.

Level 2 Success Level:

The success level describes the overall principles that are fulfilled in the system when the goal is reach such as social and ecological sustainability. Defining the goal allows the process to be strategic. Social and ecological sustainability is defined through a set of basic complementary principles that are able to address upstream issues in cause-effect relationships that are concrete enough to guide thought processes and asking of relevant questions. In a sustainable society, nature is not subjected to systematic increases in:

1. Concentrations of substances extracted from the Earth's crust;

2. Concentrations of substances produced by society;

3. Degradation by physical means; and

4. In such a society people are not subjected to conditions that systematically undermine their capacity to meet their needs.

The four sustainability principles (Success Level) of the strategic 5 level framework are essential conditions for the sustainable development process. When applied to the energy sector the system principles would be exemplified as:

1. Decrease extraction and use of fossil fuels;

2. Decrease emission of pollutants such as NOx, CO_2 and SOx, and Particulates from energy production;

3. Minimal disruption of natural ecosystems from energy infrastructures;

4. From the same unit of fuel obtain more electricity or heat, due to minimization of losses in the production process. Social and organizational welfare is maximized ensuring current and long term success.

Level 3 Strategy Level: ABCD analysis

This level describes the strategic guidelines for planning towards the goal in the system (Success Level). The overriding strategic guideline is to launch investments step-by step that (a) are possible to further develop in line with the basic principles of sustainability while (b) being sound from an economic perspective so that the process does not come to an end due to lack of economic resource.

Level 4 Action Level:

Actions are informed by the strategy level to achieve the goal (success level) in the system (system level). An example: energy efficiency in production to enable economic savings that justify switching to renewable energy).

Level 5: Tools Level:

The tool's level describes the tools used to measure, manage and monitor the (Action level) activities so that those are chosen in a (Strategy level) strategic way to arrive at a (Success level) success in the (System level) system. Example: Environmental Management tools.

Level 2 and 3 are key areas of the framework which define "sustainability" and the prioritizing of measures through a set of socio-ecological principles or system conditions and addressed further in this thesis.

3.2.2 The ABCD Analysis and Backcasting

Overview

Level 2 of the five level framework includes a set of socio-ecological principles or system conditions that help to define a sustainable society to assist Level 3 (ABCD analysis) "backcasting method" to develop strategies to achieve that defined goal.

ABCD Analysis and Backcasting

The 5 level framework for sustainable development utilizes a "funnel" metaphor to illustrate the potential risk of continued nonsustainable anthropogenic activities (e.g. accumulating wastes, diminishing resources, increasing population, decreasing potential for health and economy). As these activities systematically increase, organizations which are economically dependent on contributing to the violations of the system principles will eventually face the "walls of the funnel" and become economically insolvent. The "strategic organization" will develop measures to lessen and eliminate their dependence on nonsustainable activities thus opening the funnel walls for an economically successful existence in a sustainable society, thus guided by the system principles. (Broman, Holmberg, Robèrt 2000, 13-25) A step by step approach (ABCD) facilitates and directs this process. (Blekinge Institute of Technology, 2005)

Step A: Awareness

1. The framework – including the system principles, the step-by-step approach to comply with them, and the business motivation for doing so in a strategic manner –is shared as a mental model for community building amongst the planning participants.

Step B: Baseline

2. An assessment of "today" is conducted by listing all current flows and practices that are problematic from a sustainability perspective, as well as considering all the assets that are in place to deal with the problems. Assessing "now" from an imagined principle of sustainable success in the future defined as "backcasting".

Step C: Visioning

3. Solutions and visions for "tomorrow" (i.e. opening of the funnel) are created and listed by applying the constraints of the system principles or conditions to trigger creativity and scrutinizing the suggested solutions.

Step D: Setting and Managing Priorities

5. Prioritize measures from the C list above based on a set of questions.[2] Smart early moves and concrete programs for change, i.e. action planning, are launched.

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[2] The 5 level framework provides a strategic planning method for sustainable development referred to as the ABCD analysis for guiding the prioritizing of measures; Defined in the ABCD analysis as the "D" Step: 1) Does the measure move the organization towards sustainability, 2) Does the measure provide a flexible platform for further investments towards sustainability so that sub-optimisations and blind alleys can be avoided, and 3) Does the measure give an adequate return on investment to ensure an influx of resources for the continuation of the process? The quantitative conclusions and solutions are left up to the decision maker to determine.

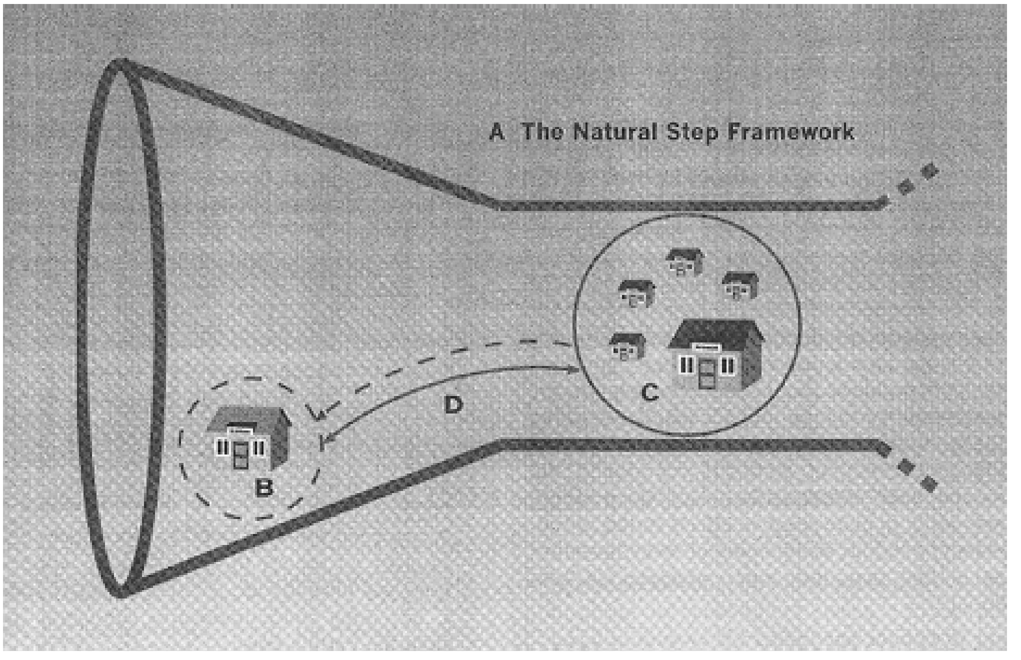

Figure 3.1: The ABCD Analysis. (Source: Robèrt, 2000)

Note in figure 3.1 the ABCD method is exemplified. Step A description of the system boundaries as guided by the 5 level framework, system principles for sustainability as a shared mental model among participants followed by Step B description of the current reality, assets to deal with the problems of "today", and assessing "today" from an envisioned sustainable future perspective (i.e. "backcasting"). Step C Solutions and visions for "tomorrow" Step D which are the prioritized measures from Step C to achieve the envisioned sustainable future.

3.2.3 The "D" Step: Prioritizing Measures

The "D" step of the ABCD analysis of the 5 level framework for sustainable development is considered the "prioritizing" phase for sustainable organizational measures that will carry the organization from their current reality to the future sustainable goal. Measures are proposed that do not violate the system principles or conditions for sustainability. The measures are prioritized based on:

1. Is the measure a step towards the vision?

(i.e. in compliance with the sustainability principles, which measure moves toward sustainability the fastest?)

2. Can the measure be a platform for further development towards the vision?

(i.e. Does the measure act as a stepping stone for other measures, or does it lead to a blind alley? Are investments technically and ecologically flexible platforms for further investments? If technical and economic conditions change will the measure be flexible enough to adapt to the fluctuations?) (Holmberg, J. and Robèrt, K-H, 2000).

3. Does the measure provide the organization an adequate financial return?

The measure should give good enough return on investment to fund the next level of sustainable measures. If it does not have an early and/or good enough "payoff" then alternative investment measures might be a better choice.

(i.e. Will it bring good enough social, political, and financial return on investment in the short and long term? Does the measure align the long term path towards sustainability with the short-term reality for economic profitability? Does the measure lead to reduced costs, time, material, and other resources? Does the measure lead to improved revenue streams? Does the measure create lower levels of ecological, social, economic risk? Is there risk if no action is taken? Does the measure develop the operation in terms of product, service, capacity, and lessen dependence on resources? What resources are needed to implement the measure...economic, technical, labor? Do stakeholders have requirements and views regarding the measure such as customers, employees, owners, etc? (K.H. Robèrt 2005, 242) (Holmberg, J. and Robèrt, K-H, 2000).

Additional Principles for Level 3

Precautionary Principle:

The precautionary principle of using caution to avoid mistakes is applied in ABCD analysis of the 5 level framework as a method to address uncertainty of economic and ecological consequences in prioritizing measures. If knowledge regarding the measure's compliance of the system conditions is unknown then precaution is necessary.

Additional risk reduction in decision making is addressed through the "backcasting" approach of defining the successful sustainable future in order to make appropriate decisions today. Decisions to take action or no action are weighed equally in terms of the potential consequences each type of decision has to bear.

The "D" step of the method is based on a general analysis of low, medium and high evaluation of costs and revenues, and timeliness of returns associated with implementation of strategic sustainable measures. It is a generalized framework for the assessment of financial return to be used as a directional tool to guide the organization in the prioritization of measures. It is not intended to provide details but to inform the search for such. (Robert, KH et.al, 2002)

Social Principles:

Additional principles included in Level 3 of the framework for sustainable development include:

Dialogue and Encouragement: Balancing the moral conflicts involved with benefiting the "few" at the expense of a secure future for all through the backcasting approach of a defined future.

Transparency: Cooperation and trust with all industry participants to correct mistakes.

Political means

Economic means: the development of which is the theme of this thesis.

3.3 Economic detail

The economic component utilized in this thesis as a tool to quantify the "Step D" of the ABCD analysis within the 5 level framework when prioritizing measures, comes from the specialized fields of Environmental and Natural Resources economics.

The interface between economics and the earth as the life support system, including geological and biological resources is addressed in these fields. (Sterner, 2003, 5) Positive and Normative economic analysis is utilized to enhance the understanding of this relationship. Positive economics evaluates impacts from an empirical stance based on fact and withholds value judgment such as the impacts of trading resources. Natural stock resources flow across the interface of the environment into society and back again (or recycled within the society).

The normative economic approach for sustainability attempts to provide a "valuation" of those flows and to tackle the basic problem of scarcity regarding all resources involved including natural, capital and labor. (Pearce 1996, 310). Static and dynamic efficiency and fair allocation (i.e. intragenerational and intergenerational equity as the sustainable criterion) of scarce resources is addressed in this type of economic analysis as it applies to sustainable development.

3.3.1 Prioritizing Measures through efficient and sustainable allocation

The Efficient Allocation

The success of how well society allocates scarce resources is determined by efficiency which can be static (i.e. certain point in time) or dynamic (i.e.

over a period of time). The goal of efficiency is to maximize social welfare.

Static: Efficient allocation at a certain point in time is achieved when there is a market equilibrium or balance in the marginal costs for producing with the marginal benefits of consuming. It is at this strategic point in the market economy that total social welfare is maximized. (i.e. consumer + producer surplus) The efficient allocation where "net benefits" are maximized for societal well being is illustrated below:

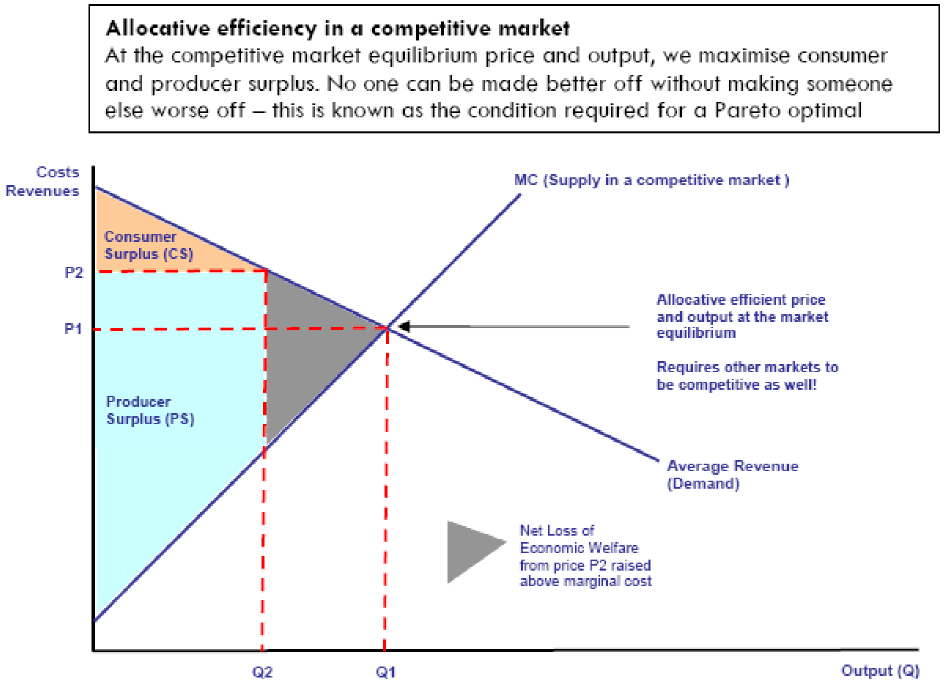

Figure 3.2: Economic Efficiency Preserving Social Welfare (Source: www.tutor2u.net; Author G Riley, 2005)

Figure 3.2 reveals Economic Efficiency preserving social welfare: "At the market equilibrium, consumer and producer surplus[3] combined is maximized. If the producer were to artificially control supply to less than Q1 (e.g. Q2) and charge a higher price, then consumer surplus would fall at the expense of an increase in producer surplus. But in net terms, the total amount of economic welfare would decline, in other words there would be a deadweight loss of welfare." (Economic Revision Focus, 2004)

Dynamic: A dynamically efficient economy produces "a stream of maximized total welfare functions that is non-declining over time". (Stavins, Wagner, Wager, 2002) The development of technology, investments in labour, and sharing of ideas between countries enhances the dynamic efficiency. (Parkin, Powell, Matthews, 1998) This is aligned with the system principles or conditions in strategic sustainable development.

This preservation of static and dynamic efficiency through competitive markets which is quantified for the decision maker supports the 5 level framework for strategic sustainable development. However, the efficiency equilibrium can be challenged when there are imperfections in the market.

Losing Efficiency through Market Imperfections

Resource use is optimally efficient when marginal benefits equal marginal costs both statically and dynamically. However, optimal market efficiency is lost with subsequent losses in social welfare when imperfections occur in the market as in market externalities (i.e. pollution), natural monopoly (i.e. district heat), split incentives (i.e. heat demand), or when the market lacks full information calling for government intervention. Two of these imperfections are addressed here to provide economic detail with further analysis developed later in the case study of Karlskrona District Heat.

The value of pollution abatement measures (i.e. externality) is established through an emission rights trading market. The emission trading market gives the emitters, (i.e. district heat) complete information of the cost of

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[3] Consumer surplus = net consumer benefits or the difference between what the consumer is willing to pay and what the consumer actually pays. Producer Surplus = net producer benefits or the difference between producer revenues and cost of production.

abatement of all emitters in the market. This information assists the emitters to determine whether to combat emissions in their own facilities or to purchase the right from others. The external social costs can then be internalized to maximize social welfare in alignment with the system principles or conditions for strategic sustainable development. Figure 3.3 demonstrates how full cost accounting revealed in the pricing structure of emitters internalizes market externalities thus preserving the social welfare.

A natural monopoly emerges when the infrastructure costs to society are too great to have multiple producers and therefore only one or a few firms exist in the market. (Parkin, Powell, Matthews 1998, 296) The producer and consumer are dependent on a network infrastructure for distribution of service as in a municipality owned district heat, electricity, or natural gas. Profit maximizing in natural monopolies undermines the social welfare and thus the capacity for society to meet its needs as stated in system principle three, unless it is regulated as in cost based pricing mechanisms with double tariffs addressed in the case study of this thesis. See Figure 3.3.

Market imperfections as mentioned here are usually corrected through government intervention with policies that regulate them to preserve the social welfare equilibrium. These issues are addressed further in the thesis in the case study of Karlskrona District Heat.

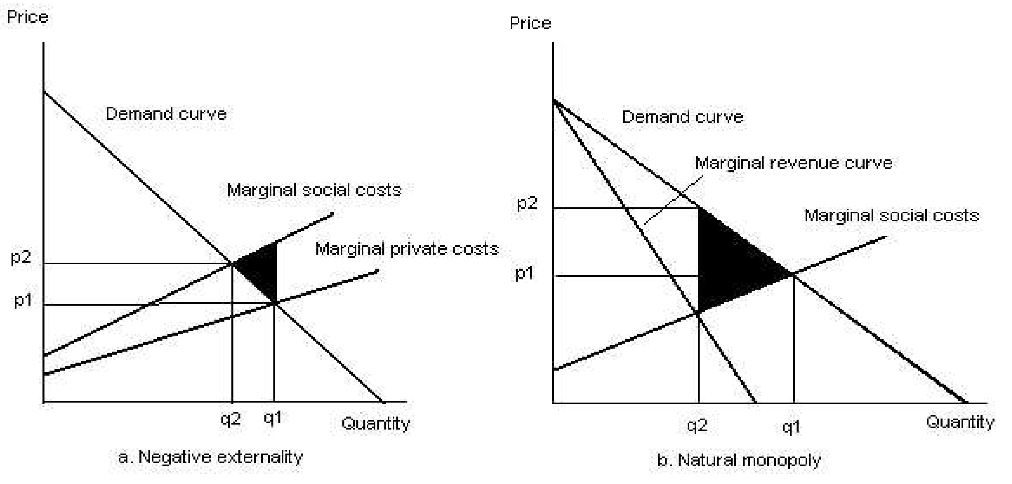


Figure 3.3: Diminished Social Welfare with Market Imperfections: Externality and Natural Monopoly

Note in figure 3.3: In the first figure "a" "externality" of pollution abatement as a market imperfection is demonstrated. Too much quantity is produced since the intersection between the demand curve and the marginal private costs curve is at p1, q1. However seen from society's point of view, intersection ought to be at p2, q2 where the external costs have been included in the producer's pricing decision (through environmental taxes, or emission trading). That's where the social surplus is maximized. If such intervention is not made, society will loose the dark triangle.

In the natural monopoly figure "b" the perfect competition solution would be at p1, q1. But since it is a natural monopoly, the single firm could use its monopoly power to increase the price and thus resulting in a decrease in quantity demanded. The natural monopoly will find the solution where the marginal revenue curve is equal to marginal social costs. The price charged will be p2 and quantity will be q2. But from society's point of view, the solution that would maximize social surplus is p1, q1. If some sort of price regulation is not implemented (the planner set price = p1), then society will loose the dark triangle. Economic efficiency is taken a step further when informed by the 5 level framework when substitutions for scarce resources are valued by the same market forces.

Sustainable Allocation: equitable distribution

In a sustainable allocation, the current generation's resource use for well being should not exceed a level that prevents future generations from achieving the same level of well being. A spectrum of efficient allocations is possible in this economic approach that still meets the requirements for sustainability. The equation is:

Total Value = Aggregate Value "Price" x Flow "Quantity"

1. Weak Sustainable Allocation: As long as the total "aggregate" value of the stock of natural and physical (e.g. buildings and $) resources does not change, the value of individual aggregates can vary.

Total Value = Natural Capital Value + Physical Capital Value Total

Value= (Resource value x Flows) + (Technology or $ value x Flows)

Total value = (price of oil x quantity of oil) + (price of infrastructure x quantity of infrastructure)

Example: Total Value =
Does not decrease

(Extremely high price of oil x"0"or scarce supply) +

(price of roads x number of roads)

In this weak, although possible sustainable economic allocation some of the natural resource could be depleted as long as the future generation was compensated with physical capital ($ or technology.) This does meet the condition for sustainability at the bare minimum especially if it is the only choice; however it is not always sufficient and substitutions for scarce resources as defined in the 5 level framework could address the allocation issue.

2. Strong Sustainable Allocation: The total value of natural capital stocks should not decrease as opposed to "total capital" above. It supports the perspective that natural capital cannot be substituted with physical capital. The quantity of the natural stock must never reach zero, but the price

"value" can sky rocket to provide for the future generation a lessened quantity of natural resource that has a greater value than present day.

Total Value = Natural Capital Value + Physical Capital Value

Total Value = (Resource value x flows) + (Technology or $ value x flows)

Example:

$$\underbrace{\text{Total value}}_{\text{Does not Decrease}} = \underbrace{(\text{price of oil} \uparrow \text{x quantity of oil} \downarrow)}_{\text{Does not decrease}}$$

+

(price of roads x number of roads)

The 5 level framework for sustainable development provides for substitution of scarce resources as an optimal choice for allocation.

3. <u>Environmental Allocation</u>: The flows of individual resources should be maintained in addition to preserving the component value of the natural and physical resources.

Total Value = Natural Capital Value + Physical Capital Value

Total Value = (Resource value x flows) + (Technology or $ value x flows)

$$\underbrace{\text{Total Value}}_{\text{Does not decrease}} = (\text{price of oil x } \underbrace{\text{quantity of oil}}_{\text{Does not decrease}})$$

+

(price of roads x number of roads)

The quantity of oil for future generations should not be less than quantity of oil available today. (Tietenberg, 2006, 100) The scarce resources will be preserved through efficient use and substitutions that meet the system principles or conditions in the 5 level framework for strategic sustainable development.

Efficiency and Sustainability

Whether the allocation is efficient (static and dynamic) from a societal welfare perspective and meets the sustainability criterion of the Brundtland definition (i.e. meeting the needs of current and future generations) is the challenge for this approach.

The proposed allocation is challenged by whether it is:

1. Inefficient yet Sustainable;
2. Inefficient and Unsustainable;
3. Efficient yet Unsustainable;
4. Efficient and Sustainable –Optimal "win/win" solution

Efficient allocations or measures can be occurring at the same point in time "static" or over a time period "dynamic". Efficiency in resource utilization, production, distribution and consumption can create profit maximizing which can be taken advantage of in the current generation thus compromising the future. Efficient allocation by compensating future generations puts society in a position of guessing what the future generation might or might not value. The economic approach is "to preserve the options of future generations rather than guess their preferences". (Tietenberg, 2006) Thus the sustainability criterion (i.e.Brundtland) is the overarching constraint in the current economic detail. This criterion is then furthered by the ABCD analysis "Step D" for prioritizing measures that meet the sustainability system principles. Here the dynamic efficiency of allocation provided by economic detail can then provide the necessary quantification to prioritize these sustainable measures by maximizing net benefits to society derived from sustainable allocations. (Parkin, Powell, Matthews, 1998).

The criterion for efficient allocation and the criterion for sustainable development are potentially incompatible due to diminishing resources and increasing global externalities when not considering the substitutions necessary to replace scarce resource utilization as described in the 5 level framework. However, the "win/win" solution includes resource substitutions, implementation of economic incentives, creative strategies to harness the power of market forces as well as utilizing government intervention to correct market imperfections. This will assist in moving a sustainable measure forward or holding it in reserve if necessary until future technologies are commercially available thus preserving resources and internalizing the externalities.

3.3.2 The Economic detail -Optimizing solutions

The economic analysis that is proposed in this thesis to quantify the detail defined in the "Step D" of the ABCD analysis for prioritizing measures in strategic sustainable development begins with a Benefit/Cost analysis. When demand side information is not available or is not reliable a Cost Effectiveness analysis is performed to achieve the sustainable goal at least cost. These analyses attempt to quantitatively reveal the relationships between the environment and the economic and political systems by identifying circumstances that lead to environmental problems and discovering potential solutions thus aiding the decision making process. Further descriptions are provided here.

Identifying Optimal "Efficient" Sustainable Outcomes: Economic Analysis

A. Benefit/Cost Analysis:

The benefit/cost analysis identifies the desirability of specific sustainable measures. The analysis quantifies the gains (benefits) and the losses (costs) of a measure. It provides a "framework" for the accounting of the potential for or the effects of the measures being assessed. The structure of a benefit/cost analysis includes several steps described in steps a through h.

a.) Define the system to be analyzed by determining the resources to be reallocated or substituted.

b.) Determine the population over which the costs and benefits are distributed.

c.) Determine which impacts maximize social welfare "benefits" and those that decrease it "costs". Some impacts having no price value are referred to as “externalities”.

d.) Quantifying the costs and benefits and over what time period.

e.) Valuation of the effects in monetary terms: Pricing is set by the markets, and if not available through the market then through predictive values, relative values, or market price correcting.

The basic calculation to value the effects:

Present monetary social benefits – Present monetary social costs = Net social benefits

Social Benefits are defined as “The willingness to pay.” The benefits or “value” that is received from a proposed measure is equal to the amount that the beneficiary is willing to pay for it. As the perceived value increases, so does the benefit of having more available. However, having full information regarding the measure as well as the ability to pay for it is also affects the perception of value. Thus the notion of what is valued and how great it is valued is important in an analysis of sustainable development measures for the decision maker. Primary and secondary effects are calculated as well as tangible and intangible benefits through sensitivity analysis which are aligned with the system principles for strategic sustainable development. (Field, 2002, 52-53)

Social Costs are defined as “The opportunity cost for the benefit that is foregone.” Information regarding estimated costs vs. actual costs is calculated from known data (e.g. averaging all technology costs), or surveying the specific industry. (e.g. as in asking the polluter for abatement costs) In either case the information may be difficult to acquire or may be unreliable but can serve as the baseline of information.

f.) Discounting: Discounting benefits and costs is the method of choice for summarizing the social benefits and cost aspects that accumulate over a time period which is a necessary component in strategic sustainable decision making. Essentially, social discounting is based on the fact that present consumption is “valued” differently than future consumption. The costs and benefits that take place during different time periods are then compared and presented in today’s terms (i.e. Net Present Value). Discounting benefits and discounting costs can be intra-generational and inter-generational.

The basic calculation is:

(Net Social Benefits of each year x time dependent weight) + (Net Social Benefits of the next year x time dependent weight) etc. = Net Present Value.

$NPV = NB0 + d1NB1 + d2NB2 + ... dnBn$

NB = (Benefits – Costs) in period 1 or 2 or ending period “n”

Time dependent weight: $d = 1/(1 + r)^t$

r = interest rate selected, t = time period, d = final discount rate used

As a component of the “time dependent weight” in the above equation, the discount rate “d” selected is crucial for appropriate calculations of current and future consumption in order to provide accurate analysis for the sustainable criterion. There has been great controversy and discrepancies in the selection of an appropriate discount rate for “social discounting” as compared to “private discounting.” Discount rates have been manipulated in the past to mislead decision makers to select one sustainable measure over another. (Tietenberg, 2006) Standardization has recently been implemented to inhibit bias of decisions thus introducing equality in decision making that is in alignment with the system principles of the 5 level framework. (Environmental Protection Agency, 2000) (Hanley, 1993, 17- 18)

g.) Apply the Net Present Value Test: To assess if resources (capital, labor and natural) are being utilized most efficiently the Net Present Value Test is performed. If the sum of the discounted benefits exceeds the sum of the discounted costs then the sustainable development measure potentially represents an efficient shift in resource allocation given the benefit/cost data. (Hanley 1993, 17)

h.) Sensitivity Analysis: The sensitivity analysis involves changing the parameters of the proposed sustainable development measure and studies how this affects the outcome. In the benefit/cost analysis, the most common parameter that is varied is the discount rate as described previously. (Pearce 1996, 389) The sensitivity analysis identifies assumptions that the benefit/cost analysis was based which could potentially change the outcome. In prioritizing sustainable development measures, a sensitivity analysis might provide alternative options to the proposed measure that would achieve the same goal at a lesser cost.

The previously described benefit/cost analysis is a step by step quantitative valuation to determine both static and dynamic efficiency. However it does not provide a "precise" numerical result since effects can be unquantifiable, moderately certain or even speculative. It does provide a quantitative baseline that can contribute to other analysis such as equitable allocation in strategic sustainable decision making. (Hanley 1993, 8-25)

B. Cost Effective Analysis:

The cost effective analysis attempts to achieve the sustainability and efficient allocation criterion previously described in section 3.3.1 at the "lowest possible cost." When benefits cannot be monetized as in the benefit/cost analysis and demand side information is difficult to acquire or unreliable and yet a specific goal is defined, (e.g. sustainability) then the cost effectiveness calculation is appropriate for prioritizing measures. It allows for sustainable goals to be reached at lower costs particularly in situations where a collaborative effort is the approach for collective impacts. (e.g. Electricity certificates for renewable production of electricity...improving technology and balancing the costs across producers). (Tietenberg, 2006, 56)

The cost effective analysis is calculated by:

Annualized cost of the measure ÷ non-monetary benefit measures

(e.g. Abatement costs ÷ emissions in metric tons)

Although other considerations (e.g. technological feasibility) may interfere with choosing the "least cost" sustainable option, the cost effective analysis can point out which measures would be less than adequate thus assisting in the prioritizing process. (Environmental Protection Agency, 2000)

4 District Heat

This chapter begins with developing an understanding of the technical operations of a Swedish district heat company and its historical role in the evolution of a complex national and global energy sector. Next, the interplay of stakeholders, politics, energy directives and vested interests are woven into the complexity of its sustainable development goals. The chapter then describes the sustainable development process (i.e. current and future) of the operations of a local municipality owned utility of Karlskrona, Sweden district heat. Sustainable measures in the company's operational phases of heat supply (production), distribution, and heat demand (consumption) are then presented for later evaluation by "Step D" of the ABCD analysis for prioritizing measures with quantifying economic detail.

Sweden: A brief overview

Swedish municipalities in the late 1940's needed to increase electricity production and looked at district heat as a "heat sink" for Combined Heat and Power plants. District heat in Sweden supplies residential buildings, commercial premises and industries with heat for space heating and domestic hot water production. Its use spread during the 1950s and 1960s, due to large investments in new housing and the need for upgrading and replacement of boilers in the country's existing buildings through the Swedish government's "Miljonprogram" initiative. ("To build one million homes in a decade.) Group heating systems were gradually linked up to form larger systems, which were then in turn connected to district heating systems. District heating continued to expand from 1975 to 1985, partly due to its ability to replace oil (i.e. oil crisis) and through its flexibility of fuel use. Currently district heat supplies heat and hot water for about 47% of total residential and commercial buildings and is most common in apartments. Production in district heat accounts for 54 TWh of Sweden's total 2004 energy supply of 647 TWh. Biofuels waste, and peat fuel sources supply 61% of the total energy for district heat (i.e. 33 TWh/54TWh). (Energy of Sweden, 2005) (Persson, 2005) See figure 4.1

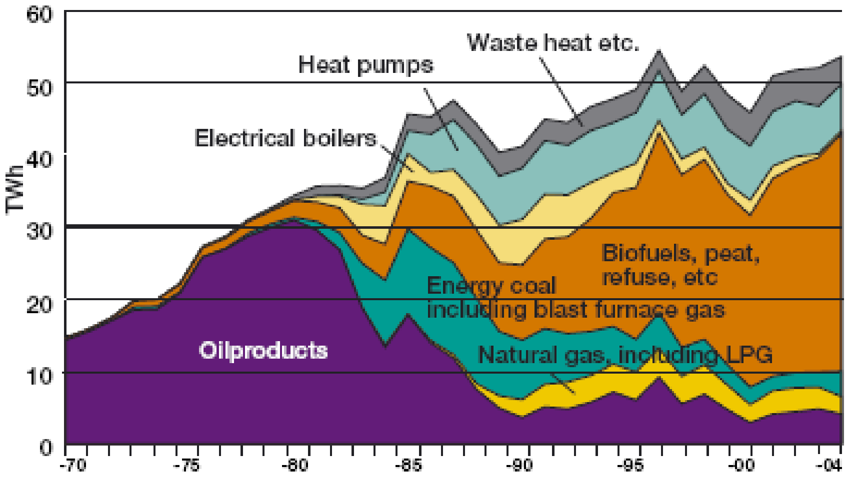


Figure 4.1: Energy Input for District Heating 1970 – 2004 (Source: Swedish Energy Authority, 2005)

Note in Figure 4.1 the steady progression away from fossil fuel use in Sweden's district heat sector to multiple biofuel sources today. Heat pumps and waste heat sources provide additional non-fossil fuel alternatives to the current energy input mix.

4.1 District Heat Defined –Technical Terms

District heating can be defined in technical terms as the centralized production and supply of hot water, distributed through a piping system and used for the space heating of buildings. Figure 4.2 shows an example of a simplified district heating system with only one production unit.

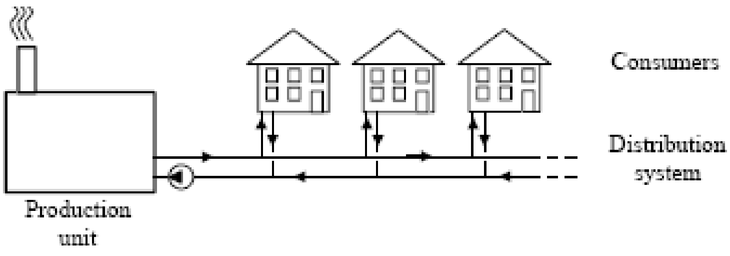


Figure 4.2: Example of a Simple District Heating System (Source: Persson, 2005)

Note in figure 4.2 the centralized heat supply fuelled by renewables and the necessity of a network grid for delivery of the heat commodity to consumers in populated areas.

4.1.1 The Supply of Heat: Production

The district heat plant is a centralized facility that uses boilers, chillers, heat pumps and other equipment to produce chilled water (district cooling) and hot water (district heat), which are used as energy source to heat and cool the entire district. Controlling the production of heat in such a centralized manner allows thermal energy to be utilized at a high degree of efficiency. The facility can achieve greater energy efficiency and energy savings by combining the operations of heat with power production in the same plant referred to as Cogeneration or Combined Heat and Power (CHP).

Flexibility of Fuels

The large-scale heat production units in municipalities make it feasible to use different fuel sources. Historically, oil, natural gas, and coal were the predominant sources, however in the last few decades the use of renewable fuels (biofuels) such as wood chips, pellets, peat, biogas, and landfill waste, waste heat, heat pumps and "green" electricity is dramatically increasing.

Renewables are considered carbon neutral due to their recent assimilation of $C0_2$ from the atmosphere and when combusted do not emit a net increase of $C0_2$ which reduces green house gas emissions that are having global climate impacts. Each of the fuel sources; oil, biofuel, biogas and electricity with differing energy densities (stored energy) upon combustion produce different qualities of energy "exergy" for the same input, require different types of boilers with varying boiler efficiency rates, producing various emissions and subsequent costs to the district heat company. However, multiple fuel sources combined with multiple boiler systems and capacities allows for greater operational flexibility when there are fluctuations in market prices, supply availability, network expansion, and state directed energy initiatives. [4]

Distribution Network

In a district heating system, heat is distributed to the consumer via a piping system with a heat carrier that is water. Water is the heat carrier of choice due to the supply availability, non toxicity, inexpensive and relatively high heat capacity. Historically, steam was circulated, but circulation pumps today circulate the water. The pipes are insulated in order to reduce heat losses and can be configured with one to four pipes (e.g. 2 exit and 2 return). As the number of pipes in the network increase, costs of implementation increase but also provide flexibility in terms of providing heat and hot water supply with different temperatures. The pipe diameters and the line heat density (# of customers on service) and efficiency in the distribution network design (pipe length and spatial plan) are critical for profitability. The distribution network transports the heat to the consumer's buildings where it is transferred through a heat exchanger to heat the buildings and to supply hot water to the tap.

[4] Compared to renewables however, fossil fuels higher energy content and boiler efficiencies have made them the desired fuel source although environmentally compromising.

Network Markets

Electricity markets for heat have the advantage that the network grid is already used to provide electricity. District heat has higher costs for network construction, distribution as well as dependence on high heat density areas than electricity and gas grids. These aspects for district heat networks directly relate to their profitability and competitiveness in the heating markets. (Kristianstad, 2006)(Persson, 2005) (Swedish Energy Authority, 2006)

Network Industries as "Natural Monopolies"

Network industries like electricity, natural gas, and district heat are dependent on a network to be able to deliver their commodities to the consumers. The dependence of the district heat producer to deliver heat and the consumer to receive it through the network grid creates the situation of a "natural or local" monopoly. Natural monopolies arise when it is cheaper for society to have only one producer in the market due to infrastructure costs. However, this can create social inefficiency or a market imperfection if pricing of the commodity is not regulated. (Parkin, Powell, Matthews 1998, 296) Government intervention is required to correct the market imperfection through pricing regulation.

Energy and Economic Balance

In establishing a district heat or co-generation facility, costs are incurred throughout the flow of operations. See figure 4.3. These include capital costs of investment, installation, supply source, production (pumping) and distribution (heat and hot water) losses, maintenance and sales/marketing costs. (Kristianstad, 2006) The challenge for district heat facilities is to achieve economic gains from the production of heat that are greater than the costs incurred from distributing it. This requires connecting as many customers to the district heat network as possible in heat density areas. Proposed new construction sites, replacement of old systems, customer preference changes, incentives, taxes, and grants etc. all affect the expansion potential of the network (Swedish Energy Authority, 2006) (Persson, 2005)

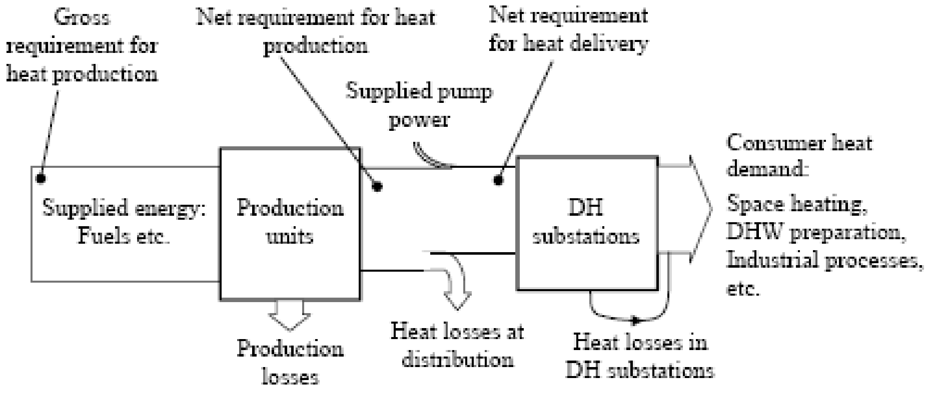


Figure 4.3: District Heat Energy Balance: Production and Distribution Losses (Source: Persson, 2005)

Note in figure 4.3 losses that can occur throughout the entire district heat process (i.e. inputs of fuel sources, production, distribution and consumption.). Thus an efficient operation through minimizing system losses is critical for profitability.

4.1.2 Heat Demand: Consumption

District heat companies participate in a heating market which includes competitor companies that market heat pumps, individual boilers (oil, electric, biofuel, natural gas) and solar systems. However, district heat facilities tend to dominate their market as a "local monopoly" since their profitable existence depends on marketing network expansion in densely populated areas with a high number of connections. (Persson, 2005)

The consumer's choice between independent heat systems vs. district heat lies in the investment and maintenance costs as well as their speculation of future energy pricing. They are "locked in" with all choices for an extended period of time (i.e. 10 -15 years life time of heat exchanger for district heat, heat pumps, and boilers) as well as dependency on pricing structures in electricity and gas markets or district heat. Consumer investment for an individual heat pump plus 100 meter hole drilling is approximately 120,000 SEK. The district heat –heat exchanger investment is approximately 50,000 SEK. Natural gas requires the expense of a chimney. (Swedish Energy Authority, 2005)

Demand -pricing structures

A. Profit based natural monopolies:

The district heating facilities were operated by local authorities prior to the 1980's. Since then, limited liability companies have been established with ownership by the local authorities. Deregulation of the electricity market has created consolidation among owners. Some of the local authority energy companies in Sweden, including their district heat facilities were purchased by the larger electrical utility companies thus creating a mix of 40% private and state, and 60% local authority owned district heating. The district heating companies are free to set their own pricing structures. (Swedish Energy Authority, 2005)

The Public Service Fee Group and the Swedish Energy Authority of Sweden annually survey municipalities for pricing comparisons since district heat is not "price regulated" yet is a natural monopoly. The District Heat Commission also provides more in depth review of the district heating activities and has established legislation for separate accounting methods from electricity, performance indicators, and arbitration issues. Currently there is a large pricing spread among district heat companies however, to be competitive in their local markets their prices are "as cheap as or cheaper" than the alternatives mentioned previously. (Swedish Energy Authority, 2005) Current pricing is set slightly below the alternative for the consumer. Estimates of future district heating prices are based on price trends for the fuels used and on production costs for competing methods of heating. (Swedish Energy Authority, 2005)

B. Cost based natural monopolies:

Cost-based pricing is a method of pricing utilized in natural monopolies where the number of market players is few and it is cheaper for society if only one firm supplies the market demand. (e.g. district heat).The firm may use its market power to maximize profits; therefore price regulation through government intervention might be necessary to achieve a socially efficient outcome and correct the market imperfection. (Carlsson, 2006) See figure 3.2 and 3.3.

Cost based pricing is based on variable and fixed costs plus a "scarcity rent" during peak loads and nothing more. This is to ensure the commodity exists for future producers and consumers thus making the natural monopoly "socially efficient".

There are many variations of cost based pricing mechanisms. "Two Part Tariffs" cost based pricing is what is referenced here. This refers to volume pricing with a monthly fee that doesn't vary with the amount of heat used. The monthly fee is designed to help cover the cost of capital in fixed costs. (Tietenberg 2006, 625) Variable or "short run marginal costs" should cover scarcity, if needed. As an example the district heat consumer pays one tariff to access the heat network and a second tariff for their actual consumption.

Split Incentives: Self Monitoring

The ability of the consumer to monitor their own heat energy consumption is generally available to commercial, industrial and residential home owners on the district heat network. However, high heat density areas such as attached housing/apartments are not metered separately in many municipalities inhibiting these consumers from managing their own energy usage. There is little incentive to save energy for the apartment dweller since he/she receives little benefit from reducing consumption. The incentive to conserve energy is on the apartment owner however he/she has little control over the apartment dweller's consumption creating issues of "split incentives" addressed later. (Plepys, 2001) (Carlsson, 2006) (Affarsverken, 2006)

4.2 Sweden's Initiatives

Sweden's energy policy 1997, now under the jurisdiction of the Ministry of Sustainable Development, has set priorities to restructure its energy market through economic policies, political awareness for the surveillance, control and safeguarding its energy markets and reducing vulnerabilities through preparedness. The policy states: "Sweden's energy policy...is intended to create the right conditions for efficient use of energy and a cost efficient

Swedish supply of energy, with minimum effect on health, the environment or climate, and assisting the move towards an ecologically sustainable society." (Swedish Energy Authority, 2005) In November of 2005, Goran Persson, Prime Minister of Sweden, declared a primary political initiative to break Sweden's dependency on oil by the year 2020.

Sweden's 1997 Energy Policy initiatives; carbon dioxide taxation, changes in the taxation policy for co-generation, electricity trading certificate scheme, directives for sustainable municipalities, and Baltic Sea Rio Conference on Agenda 21, to name a few have added greater incentive to move towards the sustainable energy goal.

The electricity certificate incentive indirectly enhances the prospects of district heat expansion through its provision of certificates to producers of electricity from renewable sources. It is an additional source of revenue to the energy producer when re-sold in the certificate market. Electricity produced from the renewable fuel sources of district heat, along with government funds to expand district heat networks, has motivated local authorities to move towards co-generation quicker. Reduced taxation for co-generation and tax-free biofuels has added further incentive. (e.g. fossil fuels tax rate is 50% of cost). Sustainable Municipality programs designed by the Energy Authority advise municipalities to become "fossil fuel free" and act as exemplary models such as Vaxjo and Kristianstad. Thus, district heat in Sweden has received more recent attention due to the potential for greater energy efficiency, energy savings and reduced emissions by combining the operations of heat with power production in the same plant referred to as Co-generation or Combined Heat and Power (CHP). (Swedish Energy Authority, 2005)

4.3 European Union Directives

"Everywhere energy policy is more or less the same. Energy supplies are required to be reliable, available at reasonable prices and have as little environmental impact as possible. These objectives can complement each other or be mutually opposed, which explains the complexity of energy policy. Improving the efficiency of energy use and concentrating on the use of renewable energy sources can contribute to these objectives." (Swedish Energy Authority, 2005).

The complexity of these objectives, local, regional, national and global creates a challenge for decision makers when prioritizing the right measures that will move a project or organization toward sustainability at least cost

In November 2000, the European Commission published a Green Paper for the energy sector. It suggested a long term energy strategy for the expected 20% increase in the import energy needs of the EU over the next 20 to 30 years. Several new directives have been implemented, one of which supports the expansion of district heat to co-generation.

"The Cogeneration Directive (2004/8/EC) was adopted in February 2004. Its purpose is to support and facilitate investment in, and use of, cogeneration plant. The starting point for the directive is not that additional cogeneration capacity is an objective as such, but that cogeneration can provide an efficient means of achieving energy savings and reducing carbon dioxide emissions. Sweden's cogeneration plants easily meet all the criteria in the directive." (Europa, 2006)

In addition, the Kyoto Protocol document was agreed upon in 1997 and ratified in 2004 by those countries responsible for 61% of industrialized counties emissions. The protocol calls for reduction of carbon dioxide and 5 other green house gas emissions to levels of at least 5% of 1990 levels during the first commitment period. Since the European Union negotiates as a single entity, the commitment level is 8%. Due to Sweden's progressive sustainable energy initiatives prior to 1990, base level emissions were substantially lower than other countries. Thus, Sweden's Kyoto commitment is to "not increase emissions" by more than 4%. The protocol is implemented through emission trading and project-based mechanisms. Thus, the reduced emissions of combined heat and power plants can contribute significantly to reaching the goals of the Kyoto protocol and economic success in the energy trading markets. (Swedish Energy Authority, 2005) (Europa, 2006)(Swedish Statistics, 2006)

4.4 Affarsverken: Brief Business Overview

Affarsverken is a local municipality owned utility company located in the city of Karlskrona in the Blekinge region of Sweden. It has several distinctly separate profit centers including; electricity, heat, garbage, boat/traffic, Information Technology (IT) and Sales. Although only 10% of

Affarsverken 155 employees are in employed in District Heat, this sector provides 25% of total revenues for the company. Despite being owned by the municipality, it is a private legal entity (i.e. Limited Liability Corporation -LLC) whose financial operations are profit driven. (Affarsverken, 2006)

4.5 Karlskrona District Heat

Energy production is located at two main sites in Karlskrona; Gullberna Park and Centrum Vasterudd, and an additional site in Lallerstedt. Original fossil fuel boiler operations have transitioned to the current biofuel mix (e.g. wood chips, saw dust pellets, land fill gas) with oil and electricity (in sub-networks only) as backup reserve fuel. Smaller facilities are located in Rodeby, Jamjo, and Sturko.

The district heating facility which began its biofuel distribution phase to homes in 1990 is currently, in the "mid-phase" of sustainable project development where new measures toward increased sustainability are being proposed.

Cogeneration of power and heat (CHP) utilizing primarily renewable fuels is the primary proposed measure to meet the needs of the political and economic energy directives as mentioned previously. As an adjunct measure, expansion of the current district heating network to include more residences, industry and commercial buildings in strategic locations is required to ensure cost effectiveness of co-generation.

4.6 Description of Current Operations

Current operations of Karlskrona district heat is described within the context of the supply of heat (i.e. production,) the distribution of heat, and the demand of heat (i.e. consumption).

4.6.1 Supply of Heat: Production

The Swedish national energy policy is directed towards saving energy and reducing carbon dioxide emissions at least cost. Therefore, efficiency in production to reduce production costs is necessary for profitability in district heat within the constraints of the national energy policy.

Fuel Choice and Boiler Capacity

In order to satisfy the heat demand in its networks, Karlskrona district heat uses different kinds of fuels which include biofuels (i.e. wood chips, pellets, and biogas) oil and electricity. The total energy content of the inputs used equals 200 GWh. The profitable choice for fuel stock is market price driven. The combined effect of high taxes on fossil fuels and tax free biofuels makes biofuels the optimal fuel stock.

The current biofuel stock of choice for the base load is biogas from Affarsverken landfill site “Bubbetorp” which can produce 13,140 MWh of heat demand.

Therefore, the biogas boiler runs at full capacity year round. However, with a limited capacity of only 1.5 MW other biofuels’ (i.e. wood chips and pellet) boilers must provide the additional heat capacity to meet demand at the next cheapest price. Oil and electricity as fuel stocks are utilized during peak loads such as in winter and at a very high cost

The boiler efficiencies are 85% or greater with electricity at 99%. For the greatest efficiency these boilers should operate at or near peak output all of the time. Due to off peak loads and fuel conversion and distribution losses, overall efficiency can be compromised. However, Karlskrona district heat system still operates at 90% efficiency. (Affarsverken, 2006) See Figure 4.6.1.

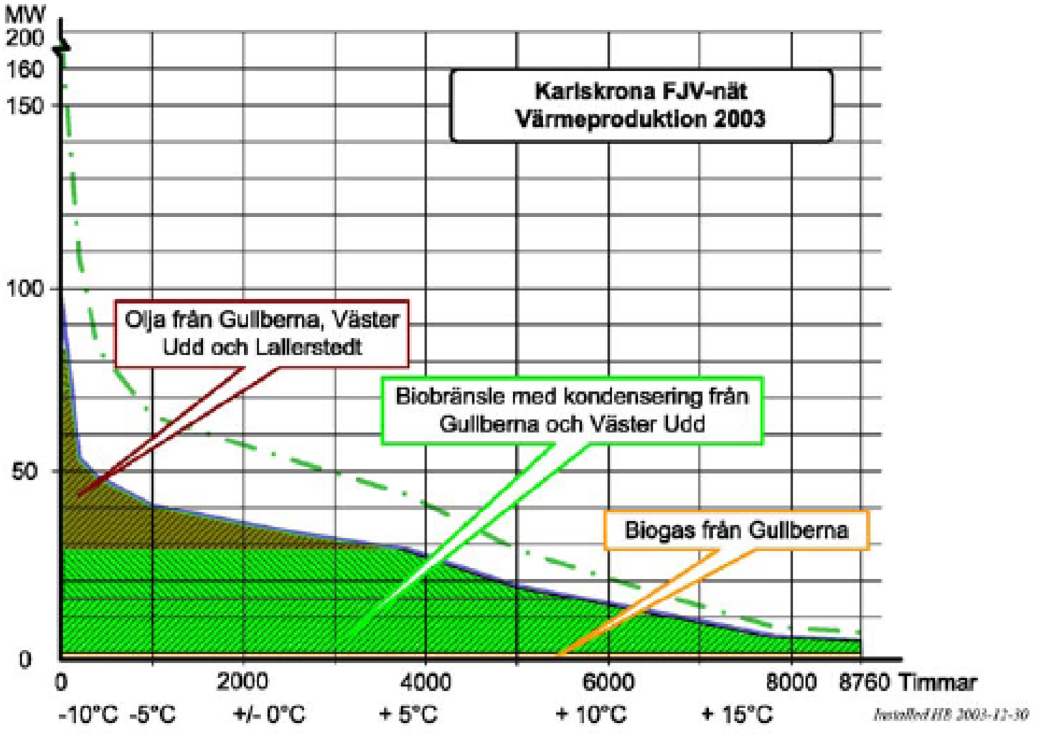


Figure 4.4: Heat Production in Karlskrona District Heat 2003 (Source: Affarsverken, 2006)

Note in Figure 4.4 that biogas operates as the base load running at full capacity 24 hours a day year round. (1.5 MW). Biofuels as the next cheapest fuel source provides 35.2 MW additional capacity year round. Oil is the back up fuel at 69 MW capacity at multiple facilities for peak loads during the winter months. Electrical boilers not shown in the figure provides 3.7 MW capacity which is utilized only at the substations previously listed. Thus the total installed capacity is 109.4 MW to meet the 200 MWh fuel input demand.

Emissions

The oil backup boilers utilized during peak loads in winter months generate CO_2 emissions of 7 ktons per year. (Affarsverken, 2006) Emission rights currently granted to Karlskrona district heat based on a historical baseline of emissions is 11,584 metric tons. The value of Karlskrona district heat emission rights (i.e.11, 584 metric tons) reveals the marginal cost of abatement in the emissions trading market. Biofuels are considered carbon neutral as previously described and therefore generate zero CO_2 emissions. In the current production, the boilers produce other emissions such as NOx, SO_2, Particulates, CO, NH_3, and N_20 which are addressed further in planned operations section 4.8

4.6.2 Distribution

Karlskrona district heat currently provides service to 25% of Karlskrona total population and 50% of the city population. Due to large industrial customers, district heat supplies approximately 70% of the total community energy demand economically viewed as the previously described "natural monopoly". (Affarsverken, 2006)

Reduction in the losses of heat and hot water in the distribution phase are also important to the profitability of district heat. Different energy carriers have different conversion losses and different distribution losses. Prior to 1970 when oil was the primary fuel source for heat, the greatest losses were in the distribution rather than the conversion (i.e. production) phase. However, the transition away from oil to electricity and district heat has created a shift in the losses being primarily in the production phase. The effect is reduced energy consumption by the consumer. (Swedish Energy Authority 2005, 26)

Distribution losses for Karlskrona district heat network average 8-10% on a yearly basis which is slightly lower than the Swedish municipality average of 11%.(Swedish Energy Authority, 2005) Measures contributing to efficiency of the network besides the transition from oil include upgrading windows, increasing insulation in the homes and pipes, improving the efficiency of the consumer's sub-central unit and addressing heat and hot waters leaks. (Affarsverken, 2006) (Swedish Energy Authority, 2006)

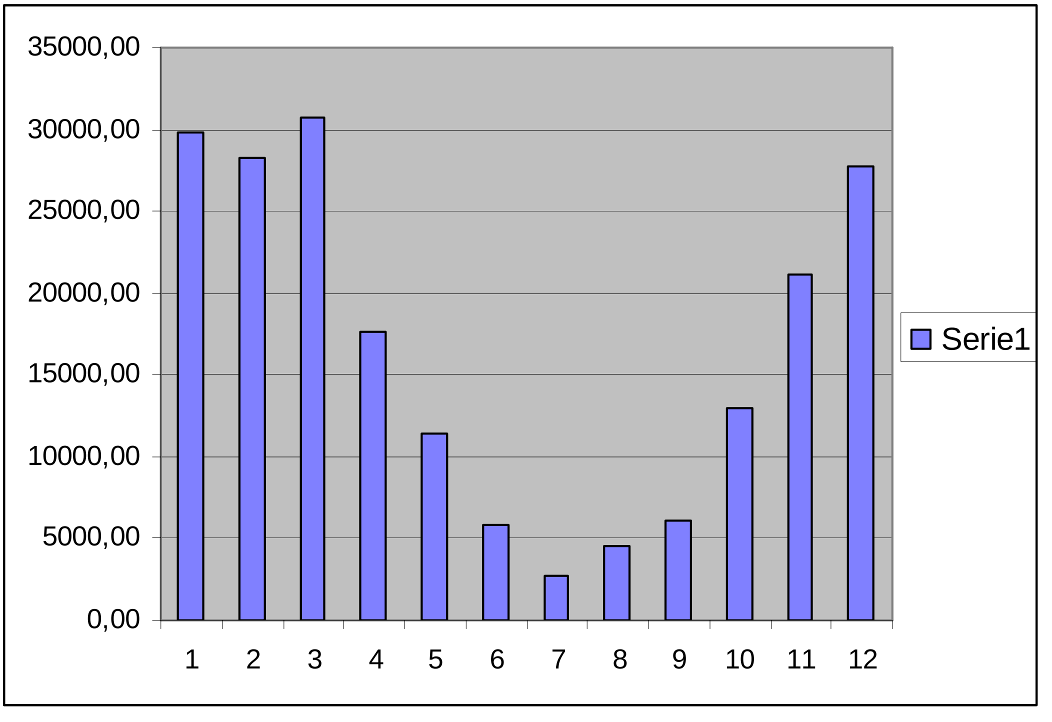
The current network investment for the municipality in Karlskrona is 200 million kronor. This investment includes factors such as efficiency of the network (i.e. pipe layout) and quality (i.e. types, number, diameter, length, insulation). Capital investment costs decrease with wider pipes and higher heat density areas. Therefore, far reaching low heat density customers should be avoided if not eliminated from the network. (Swedish Energy Authority, 2006) Karlskrona has several outlying customers on their network served by smaller facilities which may compromise their network efficiency. (Affarsverken, 2006)

4.6.3 Heat Demand: Consumption

Current Heat Demand

In order to satisfy the total heat demand in the current network 200 GWh of fuel input is required; however the demand distribution varies between different months as seen in Table 4.2

Table 4.1: Karlskrona District Heat Monthly Sales MW hours for 2005 (Source: Affarsverken, 2006)



Note in Table 4.1 that October through April (i.e. 10 to 4) are peak heat demand months with higher sales associated with the additional production coming from a more expensive fuel source (i.e. oil). The heat demand from May through September is provided by primarily by biogas and biofuels which are cheaper fuel sources.

Tariffs

In Karlskrona the consumer is billed for their consumption based on the temperature difference from the water entering their building to when it is cycled out. (Affarsverken, 2006) The pricing structure offered to the current customers of Karlskrona district heat is based on 3 different alternatives A, B and C which are divided on fixed cost/MW hours and variable cost/MW hours. (Current price is 73 ore/kWh for householders varying with length of contract.)

Alternative A: 60% fixed and 40% variable

Alternative B: 30% fixed and 70% variable

Alternative C: 100% Variable

Addition: Peak load-price 1st October – 30th April, 2.50 SEK/m3

As a network industry, district heat is a "natural monopoly" however the pricing for district heat and co-generation is not regulated in Sweden. Therefore, municipalities like Karlskrona district heat have the freedom to set their own market based pricing. District heat companies are in the business to produce energy for consumption and to maximize their profits.

District heat prices are established based on the cost of the fuel stock (2004 biofuels 13.8 ore/kWh and oil 30 ore/kWh + 50%tax) and the cost of production for the alternatives (i.e. cheap as or cheaper than electricity, heat pumps etc.). Currently, oil is taxed and biofuels are not making the transition to renewables economically attractive to the consumer and producer. As the dependency on fossil fuels continues to decrease, fossil fuel-based tax revenues will also decrease. Eventually biofuels would most likely be taxed as well, bringing the biofuel price back to what the consumer was paying previously for oil-based heat. However, renewables would be used and still be the cheapest alternative as the taxes on oil would be higher. (Swedish Energy Authority, 2006)

Split Incentives

Consumption is metered on an individual (e.g. residential homes) and collective basis (apartments) in Karlskrona. Due to the nature of their high heat density, apartments are the largest consumer market for Karlskrona district heat. However since metering is on a collective basis (e.g. included in the rent) the apartment dweller has no incentive to proactively reduce his/her own heat consumption and would receive no benefit from it if they did. The burden of cost for providing individual meters is on the apartment building owner who chooses not to do so at this time. (Affarsverken, 2006). Implementation of individual metering, through subsidy support, is currently under investigation in Sweden. The main issue is whether the social benefits of eliminating split incentives are higher than the social costs.

4.7 Description of Proposed Business Operations

As previously described many district heat companies in Sweden are moving towards cogeneration as their next phase of sustainable development. The major advantage of cogeneration is the optimized fuel efficiency (up to 90 percent) and reliability. CHP reduces pollution by using the fuel's energy several times, producing up to 50% less than the emissions from separate applications. Cogeneration also adds more producers to the market that are independent of the larger players creating additional competition. It also provides back up production sources independent of the larger players for greater control and security in the Swedish energy sector. (US Combined Heat and Power Association, 2006) (Swedish Energy Authority) See figure 4.5.

Currently, district heat and co-generation plants in Sweden are not subsidized. However the Swedish government does provide support for network expansions (i.e. KLIMP program) and cogeneration plants are taxed at lower rates than heat-only plants. (Swedish Energy Authority, 2006)

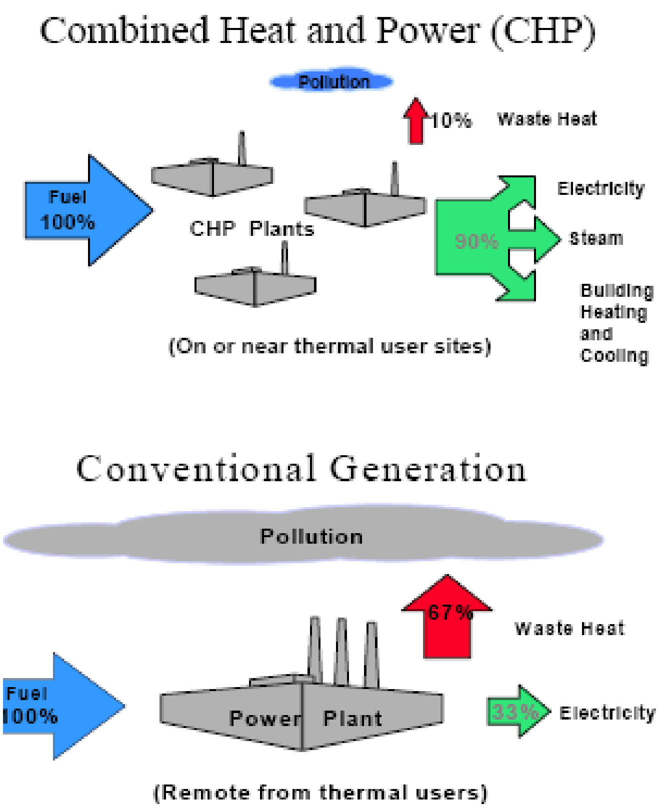


Figure 4.5: Efficiency of Combined Heat and Power
(Source: US Combined Heat and Power Association, 2006)

Note in figure 4.5 the increased energy efficiency (90% compared to 33% of a conventional generation), reduced waste heat losses (10% compared to 67%), and emission reductions that a combined heat and power plant provides over conventional power plants.

4.7.1 Cogeneration and Expansion

Karlskrona district heat is proposing to build a cogeneration plant and the subsequent network expansion that is required to facilitate the cost-effectiveness of the project. Permits and political approval are pending.

Current vs. Proposed

In the present system. Approximately 200 GWh of fuel input to meet the current heat demand is produced in the district heating system by biofuels, biogas, and oil.

For individual houses not connected to the district heating system, 150 GWh is produced. (75 GWh is fuelled by oil and 75 GWh) by electricity in these detached homes. Furthermore, 20 000 metric tonnes of sorted combustible waste are transported to Västervik, a city some 200 kilometres to the north of Karlskrona with a cost to Affarsverken –Waste. Also, 85 GWh of electricity is "imported" from coal-fired plants in Denmark, Germany, and Poland creating 68 ktons of CO_2 emissions. CO_2 emissions from the oil boilers are 7 ktons for which 11, 584 emission rights are granted. The boilers also produce other emissions such as N0x, SO_2, Particulates, CO, and N_20. (Affarsverken, 2006)

In the proposed system with combined heat and power (CHP) all individual houses are proposed as being connected to the district heating system through an expansion of the network at an additional cost of 100 million kronor. The proposed 350GWh of total heat demand would be produced by biowaste "avfall", biofuels and oil "olija" boilers with 85-90% efficiency. The additional cost to district heat for this equipment is 800 million kronor. 85 GWh of electricity would be produced in the new system from renewables instead of importing it from fossil fuel plants. (Affarsverken, 2006) Refer to Appendix A.

In the new cogeneration plant 70 000 metric tons of combustible waste would be used as an additional fuel source. Karlskrona municipality would generate 20 000 metric tons of this combustible waste and the additional 50 000 metric tons would be "imported" as a projected source of revenue. See appendix A and B for proposed network locations and proposed plan. (Affarsverken, 2006)

The expansion of the district heat operations now includes those homes which were creating emissions independent of the district heat and less electricity that is produced by coal is imported. Thus, the total CO_2 emission reduction in Karlskrona changes from 164 ktons to 23 kton for a net change of -141 ktons. However, due to the introduction of waste heat as a fuel source (emitting an additional 17 ktons of CO_2) the district heat facility will have to purchase emission rights rather than save or sell them as in the current situation. Total CO_2 emissions in the new cogeneration plant would equal 22 kton with only 11,584 rights. (Swedish Environmental Protection Agency, 2004) (Affarsverken, 2006)

Boiler emissions of N0x, $S0_2$, Particulates and CO are also substantially reduced in the proposed system producing an overall improvement from the existing system. However, additional NH_3 emissions from waste heat and biofuels exist in the new system that didn't exist previously. N_20 emissions increase in the new system as well, due to increased biofuel production to meet the increased network demand.

The proposed cogeneration measure meets the goal of reducing CO_2 and other climate changing emissions as well as increased energy efficiency and savings to meet the Swedish Energy policy guidelines.

5 Method used to explain proposed approach in district heat

The proposed approach for integrating economics into the "Step D" of the ABCD analysis of the 5 level framework for strategic sustainable development is explained through the complexity of operational issues and economic factors (i.e. pricing, information, incentives, tradeoffs) in district heat as well as the influence of government policy and initiatives for sustainable development.

The process utilized to demonstrate the proposed approach is:

1. Sustainable development issues within current district heat operations (e.g. heat supply, distribution, heat demand) as well as planned operations was conducted by analysis of key operational measures within each area. The four specific and independent issues chosen for evaluation include:

- Supply Side: Cogeneration and Renewable Fuels
- Demand Side Management: Pricing Structures and Split Incentives.

2. After the district heat operational analysis, a two-Step matrix approach was utilized to present the initial results from the "Step D" analysis followed by further quantifying with the economic analysis.

- 1st Matrix: The initial analysis of "Step D" of the ABCD analysis within the 5 level framework for strategic sustainable development for each of the selected independent Supply Side issues (Cogeneration and Renewable Fuel) and the Demand Side Management issues (Pricing Structures and Split Incentives) was performed by answering:

  1) Right Direction: Does the measure move the organization towards sustainability within the constraints of the sustainability principles I-IV of the 5 level framework? If the answer is potentially "Yes", an "X" is placed in the appropriate box for Right Direction in the matrix. The strategic question is asked for each independent issue.

2) Flexible Platform: Does the measure provide a flexible platform for further investments towards sustainability so that sub-optimisations and blind alleys can be avoided? If the answer is potentially "Yes", an "X" is placed in the appropriate box for Flexible Platform in the matrix. The strategic question is asked for each independent issue.

3) Does the measure give an adequate return on investment to ensure an influx of resources for the continuation of the process? This question is also applied to each independent district heat issue. The question is answered by addressing three specific areas of adequate return on investment:

1) How quick is the return on investment? (i.e. The notation used in the matrix to answer this question is: Short Term "S" for immediate – 1year return, Medium Term "M" for 2-5 years return, and Long Term "L" for 5+ years return time.)

2) What are the costs involved with the investment? (i.e. The notation used in the matrix to answer this question is: Low "L" for low or minimal costs without budget allocation; Medium "M" for medium costs which need budget allocation; and High "H" for high costs that need financing and approval.

3) What are the revenues involved with the investment? (i.e. The notation used in the matrix to answer this question is: Low "L" for low amount of expected revenue both now and in the future; Medium "M" for minimal or higher revenues currently with potential for future returns to be even greater; High "H" for high amount of expected revenues both current and future.

2nd Matrix: The application of quantitative economic analysis of each of the independent Supply Side (Cogeneration and Renewable Fuel) and Demand Side Management issues (Pricing Structures and Split Incentives) are qualitatively presented in a matrix. The result chapter of this thesis does not include the actual economic analysis and modelling presented in detail previously, however a qualitative representation through a matrix is presented in terms of social and organizational profitability using the notation of a question mark, (As determined by static and dynamic efficiency and equitable allocation.)

The questions below are used to guide the explanation of the proposed approach through the district heat case study:

Did the sustainable measure from the "D Step" of the ABCD analysis of the 5 level framework result in a profitable solution for both the company's and society perspectives when applying economic detail? Did the two step matrix approach present an enhanced decision making process when prioritizing measures in strategic sustainable development? Did the integration of economic detail with the strategic planning method ("Step D" of the ABCD analysis) provide added value by revealing through the two step matrix approach issues of compromise or "tradeoffs", complexity of issues or "grey areas" with pricing, and policy/information incentives, influences from vested interests in sustainable development?

6 Results

Overview

Karlskrona district heat's current operations and proposed business plan presents an interesting case study to evaluate an organization that is in the mid-phase of sustainable development to explain the proposed approach of this thesis. At the time of this thesis sustainable measures are already implemented or proposed to meet the supply, distribution or demand for heat within its municipality. The selected independent district heat operational issues (i.e. Supply: Cogeneration and Renewable Fuels and Demand side: Pricing Mechanisms and Split Incentives) are evaluated from the strategic sustainable development context of the "Step D" of the ABCD analysis within the 5 level framework and then elaborated further with quantitative economic detail and presented in the proposed approach of a 2 step matrix.

District heating and cogeneration is a movement towards a sustainable society as defined by the 5 level framework for sustainable development as it addresses pollution control, energy efficiency, and energy savings. It is flexible in its operations with multiple renewable fuel sources to transition to emerging sustainable technologies (i.e. cogeneration) while meeting today's needs, and has a profitable return on investment as a profit based corporation for the municipality. The ABCD analysis "Step D" utilizes this basic model for prioritizing measures within the district heat operations; 1) Movement towards a sustainable future based on the four sustainability principles or conditions for sustainability 2) Flexible platform for emerging sustainable technologies and 3) Adequate Return on Investment. Economic detail then further quantifies through analysis of business profitability (financials) and social profitability (i.e. efficiency and equitable distribution) of Karlskrona district heat through modelling (i.e. sensitivity analysis) to further prioritize "Step D" measures. A qualitative representation of this evaluation is presented here.

Measures that might be chosen for implementation by an organization in the sustainable development process may actually be economically unsustainable for the firm and socially undesirable (i.e. violating system principles) as determined by economic detail which is informed by the "Step D of the ABCD analysis of the 5 level framework. Thus potentially undesirable outcomes may be prevented. Economic detail can also quantitatively validate appropriate strategic sustainable development choices through its quantitative modelling of social and organizational welfare.

6.1 Proposed approach explained through district heat issues.

Karlskrona district heat issues in sustainable development (i.e. pricing structure, split incentives, cogeneration, and renewable fuels) are qualitatively and independently evaluated as separate issues from the ABCD analysis "Step D" perspective. However the district heat issues are presented here for the reader in a combined format in one matrix in Table 6.1.

Each of the separate district heat issues are then quantified through economic detail independently of each other and evaluated from an organizational and social profitability perspective. However, again the district heat issues are presented for the reader in a combined format in a second qualitative matrix represented in Table 6.2

Table 6.1: District Heat Measures independently evaluated with "Step D" of the ABCD Analysis

Measure	Right Direction (I - IV principles)	Flexible Platform	Return on Investment S M L	Cost L M H	Revenue L M H
PRICING Profit Based	X	X	**S**	**L**	**H**
SPLIT INCENTIVES OWNER VIEW	X	X	S	H	H
COGENERATION	X	X	M	H	H
RENEWABLE FUELS	X	X	S	L	H

Note in Table 6.1 four district heat issues are assessed independently of each other by the ABCD Analysis “Step D” methodology. Also note in Table 6.1 the prioritization of measures is dependent on;

1) Right Direction: Does the measure assist the organization towards the strategic sustainability goals as defined by the 5 level framework and sustainability principles I-IV?

2) Flexible Platform: Does the measure have flexibility for movement towards greater sustainable development?

3) Adequate “Return on Investment” which is determined qualitatively by the rate of return in terms of short, medium or long term and costs and revenues in terms of low, medium and high defined previously in the method chapter.

Step “D” for prioritizing measures in the ABCD analysis of the 5 level framework can be elaborated further through quantitative economic analysis of profitability and unprofitability required for organizational and social sustainability. This detailed analysis can quantitatively address the “grey areas” of uncertainty that emerge when prioritizing decisions which are complicated by additional perspectives such as social welfare. (e.g. government, politicians etc.)

Table 6.2: District Heat Measures independently evaluated with Economic Detail

Economic Approach	Organization Welfare	Social Welfare	
Measure		Profitable	Unprofitable
District Heat Pricing Structure-Profit Based	Profitable	?	?
	Unprofitable		
Split Incentives Individual Meters Owner vs Society	Profitable	Sensitivity Model ?	?
	Unprofitable		
Proposed Cogeneration	Profitable	?	Sensitivity Model ?
	Unprofitable		
Renewables	Profitable	Sensitivity Model ?	?
	Unprofitable		

Note in Table 6.2 district heat issues (independent of each other) are analyzed by quantitative economic detail which is informed by the 5 level framework. Through the use of sensitivity models economic detail can determine organizational and social profitability. The economic detail consists of an analysis of profitability which includes; static and dynamic efficiency and equitable sustainable distribution described in Section 3.3.

Due to time constraints, the actual economic sensitivity analysis is not within the scope of this thesis. However the potential results are qualitatively presented in Table 6.2 with further discussion of the proposed process for sustainable development decision making. The proposed approach for integration of economic detail with "Step D" of the ABCD analysis in this thesis:

The "Step D" of the ABCD analysis qualitatively prioritizes and discovers the sustainable development "hotspots" with results presented in a matrix. These issues are evaluated further through quantitative economic analysis and modelled (illustrated in a matrix), to enhance the decision making process in sustainable development.

6.1.1 Discussion of results of district heat issues when applying the proposed approach

Profit Based Pricing

Note Table 6.1 for the "Step D" of the ABCD analysis and Table 6.2 for economic analysis.

Current pricing structures in the district heat energy sector of Sweden are market based although it is a network dependent industry and "natural monopoly". The prices in district heat are determined by the cost of the fuel sources (renewables are not currently taxed) and the cost of production of the alternative. The price is "as cheap or cheaper" than the alternative for the consumer thus making it desirable to switch to district heat.

In the "Step D" of the ABCD analysis (i.e. Table 6.1) the profit based pricing mechanism could be assessed by the district heat company as a sustainable measure that is moving towards greater sustainability by encouraging reduced energy consumption by the consumer; a flexible platform since profits are maximized allowing for more revenues to be used for emerging sustainable developments, and a high return on investment in a short period of time. The economic detail quantifies this (Table 6.2) through its efficiency and equitable distribution analysis providing a profitability perspective for the district heat and society. It is financially profitable for the district heat to maximize profits through market based pricing as seen in Figure 3.2. As a natural monopoly, district heat can further maximize profits by increasing its operational efficiency. If a "natural monopoly" company becomes complacent in terms of efficiency, profit based pricing may not keep them economically sustainable for the future. (Parkin, Powell, Matthews 1998, 296-313) However, from a social perspective as seen in Figure 3.3 total social welfare is not maximized as a loss occurs in the total consumer and producer surplus aggregate. Thus social welfare for future generations is not protected either which violates the principles or conditions for sustainability as defined by the 5 level framework. Note in Table 6.2 the matrix reveals organizational profitability with social unprofitability.

Profit based pricing does not provide for total organizational and social profitability. This might be addressed by further economic evaluation of a "cost based" pricing mechanism for natural monopolies modelled in an economic sensitivity analysis. Cost based pricing as seen in Figure 3.3. could reinstate the equilibrium of maximizing social welfare. Consumer tariffs that are cost based for district heat would include variable and fixed costs, scarcity rent and nothing more. As stated previously in section 4.1.3., there are many variations of cost based pricing mechanisms. "Two Part Tariffs" cost based pricing is what is referenced here. This refers to volume pricing with a monthly fee that doesn't vary with the amount of heat used. The monthly fee is designed to help cover fixed costs. (Tietenberg 2006, 625) The consumer would pay the first tariff to access the network and another tariff for their consumption. However the total social surplus would not be compromised in this pricing mechanism which is then in agreement with system principle 4.

This presents an interesting discussion of why Sweden's district heat pricing is profit based and not cost based. The reason may lie in the fact that energy savings and reduced emissions is a national directive. A higher consumer tariff with profit based pricing motivates the consumers to save energy (i.e. less resource use but at a lesser cost than the alternative fossil fuels which are taxed higher) Producers are profitable in providing non taxed renewables and the national directives are also met. Thus it becomes a win/win/win situation potentially at the expense of current and future social welfare ultimately undermining system principle 4. The result could be economically modelled to reveal the most socially desirable pricing mechanism in Table 6.2.

Split Incentives

Individual meters rather than the current collective metering situation (i.e. part of the rent) in Karlskrona apartments are a sustainable measure if viewed from the real estate owner perspective. (Oldmark, J, 2005) The measure moves towards greater sustainability and flexibility due to increased energy savings with consumption monitored by the user instead of the owner. The investment by the owner however would be costly up front, but the rate of return would be quick and revenues high due to the energy savings. The measure might be postponed if other alternative measures had a lower cost of investment. Note Table 6.1 regarding Split Incentive measure.

Economic detail might (owner perspective) demonstrate the energy savings to be very profitable for the owner, yet unprofitable from a societal perspective. Due to the costs of implementation of the meters, the burden of those costs may eventually fall on the individual consumer potentially compromising social welfare. From an emission reduction perspective due to energy savings, the social welfare may actually benefit. This is where an economic analytical modelling of the measure could produce quantifiable information that would ensure the greatest sustainable social welfare from all the options at the least cost. (i.e. system principle 4) Note Table 6.2 regarding Split Incentive measure.

Cogeneration

The proposed cogeneration measure for Karlskrona district heat as stated previously is considered a sustainable measure that is moving toward sustainability with the use of renewable fuel sources, a flexible platform with fuel flexibility (i.e. multiple biofuel sources) and for emerging sustainable technologies, and profitable for the municipality with profit based pricing, high operational efficiency and reduced emissions. See Table 6.1 cogeneration measure. Although the cost of investment is high, projected revenues are high with a quick return on investment due to lower short term marginal costs as compared to the alternative.(e.g. coal fired imported electricity) (Swedish Energy Authority, 2006)

The further quantification with economic analysis potentially places cogeneration as the “optimal” measure as it meets the criteria for district heat to be financially profitable and socially desirable. The goal of cogeneration as part of Sweden’s national directive is to reduce emissions through efficient production and reduced energy consumption. Economic modelling of the cogeneration measure may reveal other options that achieve the same goal at a lesser cost (i.e. system principles 1-4). A sensitivity model would set an “objective function” or goal to minimize the losses in total social surplus within the constraints of emissions not to exceed the proposed levels in Karlskrona district heat stated in Table 4.3. The model would utilize any combination of boilers, fuels, network designs and expansion, pricing mechanisms, and policy solutions etc. to provide the most sustainable solution at least cost (i.e. static and dynamic efficiency and equitable allocation.). Note in Table 6.2 that cogeneration could be the “optimal” choice due to organizational and social profitability. However, through the sensitivity model it might be shown to be socially undesirable with another alternative achieving the same emission reduction and energy efficiency at a lesser cost making cogeneration a less than optimal choice.

As Kyoto Protocol drives the cap on the emissions down over the next commitment period, the costs of further abatement will go up. This could place the economic evaluation to be unprofitable for the organization and profitable for society due to even further emission reduction or unprofitable due to increased financial losses. (i.e. system principles 1- 4) The economic analysis and modelling could reveal the potential outcomes and alternative solutions initially revealed by The Natural Step framework at least cost.

Renewable Fuel Sources

Renewable fuel sources are addressed in Table 6.1 for evaluation by “Step D” of the ABCD analysis Renewables are viewed as a step in the right direction towards greater sustainability due to their neutral carbon dioxide effect on global climate (i.e. system principle 1). The flexibility of multiple biofuel choices such as biogas, wood chips, and wood pellets at Karlskrona district heat provides options for market and resource fluctuations as well as emerging technologies. In addition to being renewable, biofuels are not currently taxed as compared to fossil fuels making them the fuel of choice where fuel input selection is based on market price. Biofuel production is low cost, high revenue, and a quick return on investment due to efficient production and low short term marginal costs. It is the cheapest alternative for the consumer who is also required by Swedish law to purchase a certain percentage of renewable energy. (Swedish Energy Authority, 2006)

Table 6.2 can reveal the financial profitability of utilizing biofuels by determining the cost of fuel sources and production as compared to the alternatives. In Karlskrona district heat, biogas and biofuels are the primary fuels of choice in a price based market as seen in Figure 4.4. A detailed economic analysis may reveal the current and long term social consequences quantitatively of forest degradation, loss of biodiversity and desertification from unsustainable biofuel sources (i.e. violating system principle 3) thus undermining sustainable social profitability (i.e. violating system principle 4). Economic sustainable policies based on a property right principle could ensure sustainable forestry optimizing the measure for organizational and social profitability realigning the measure with all four sustainability principles of the 5 level framework for strategic sustainable development.

7 Discussion

The “Step D” of the ABCD analysis within the 5 level framework is based on a set of sustainability principles for a sustainable society which guides sustainable development for an organization such as a municipality owned district heat. When prioritizing sustainable measures, “Step D” of the ABCD analysis utilizes three steps to assist in the decision making process:

Does the measure guide the organization or project further along in the sustainable development process?

Does the measure provide flexibility to meet current sustainable needs as well as allow ease of transition to emerging sustainable technologies?

Does the measure provide an adequate return on investment such that it is currently achievable and paves the way for future sustainable investments?

These strategic prioritizing steps provide the overarching guidelines for organizations that are involved in a sustainable development process with complex technological, social, environmental, and economic issues that are often engulfed in a political medium (i.e. municipality owned district heat). In order to deal with different flexible platforms that are considered “smart choices” as identified initially by the “Step D” of the ABCD analysis a quantitative tool has the potential to further prioritize and optimize the choice thus supporting the decision making process.

Economic detail is the quantitative “tool of choice” in this thesis when informed by “Step D” of the ABCD analysis within the 5 level framework to prioritize sustainable measures. It does so by providing “added value” through a detailed sensitivity analysis including total efficiency (static and dynamic) and equitable allocation (i.e. sustainable criterion). This quantitative approach is further enhanced by structuring a matrix to qualitatively present the “value” of the sustainable measure in terms of organizational and social profitability thus optimizing sustainable choices. Without a strategic sustainable vision, government policy and economic factors such as pricing mechanisms, information, incentives, and tradeoffs influence decision makers that often create sub-optimal, tradeoffs, and compromised solutions which may create a crisis management situation in the future.

In addition, economic analysis can then suggest creative sustainable policies based on the strategic sustainable principles for implementation of the prioritized measures.

The overarching ”Step D” of the ABCD analysis within the 5 level framework that also utilizes the strength of a quantitative element such as economic detail can give the decision maker greater fact based evidence to prioritize measures in sustainable development. At the time of this thesis, Karlskrona District Heat was further along in the sustainable development process in which the proposed strategic sustainable decision making approach could not be utilized or actually tested. However, it is exemplified in the context of Karlskrona District Heat issues of pricing, split incentives, cogeneration and renewable fuels from a theoretical perspective. The strategic sustainable economic aspect contributed with a fuller perspective of organizational and social profitability thus "optimizing" sustainable development decision making in district heat when different flexible platforms were identified in the "Step D" of the ABCD analysis. This thesis approach is believed to be context free with the potential to be universally applied in any sector to enhance sustainable decision making. Thus it is recommended that the approach be tested further in actual decision making when prioritizing measures in sustainable development.

7.1 Summary of findings

Sustainable measures(e.g. potentially Combined Heat and Power plants) that fully meet the "Step D" of the ABCD analysis and 5 level framework criterion and defined quantitatively by economic detail are considered "optimal" (i.e. social and organizational profitability) and are implemented first. Sustainable measures that minimally meet the strategic sustainable development criterion for economic social and organization profitability are currently set aside. No decision or procrastination may actually alter a measure's viability as time and circumstances change.

The sustainability measures that meet one profitability criterion but not the other offer opportunities for creative initiatives that may move the sustainable measure towards implementation. Measures that are profitable for society but unprofitable for the organization may actually become optimal choices with sustainable principle based policy intervention (e.g. subsidies). Unprofitable sustainable measures for society, which are profitable for an organization, pose another dilemma that violates system principles of the 5 level framework. (e.g. potentially natural monopoly pricing mechanisms in district heat.) The organization might implement this measure with adverse impacts without the detailed knowledge that a strategic sustainable economic analysis could provide which would reveal quantitatively the social undesirability. Again, undesired outcomes could be prevented and desired measures additionally supported through the fact based evidence of economic analysis that is aligned with the initial evaluation of the "Step D" of the ABCD analysis within the 5 level framework. Creative policies through government intervention could allow the sustainable measure to be implemented with certain constraints (e.g. time, taxes, etc.) to encourage development of other measures first.

A note of reflection

In the matrix, the assumption is made that the efficiency of the economic analysis is both static and dynamically optimal. It is also assumed that the allocation is optimally equitable as in the sustainable allocation described in section 3.3.1. In reality as we transition to greater sustainability it may be necessary to balance the tradeoffs with less than optimal measures that minimally meet the sustainability principles and the 5 level framework for economic efficiency and equitable allocation as a baseline that supports future sustainability. However, we compromise sufficiency. Substitutions of scarce resources also need to be taken into account in addition to utilizing scarce resources efficiently as defined by the sustainability principles of the 5 level framework. As we move further towards sustainability, greater optimization will be required and our spectrum of sustainable choices will become fewer. (i.e. sky rocketing oil prices and pollution costs referred to in the 5 level framework funnel metaphor previously described). Since we lack the information to fully foresee the demand side, what will be the additional costs that society must face in order to achieve higher levels of sustainability?

An example of this is in regards to pollution abatement for the district heat facility. At some point the cap on emissions will be set low enough to necessitate high cost abatement measures that may even compromise the economic sustainability of the organization and society which is described further here:

The proposed cogeneration measure for Karlskrona district heat is a step taken to move to a more sustainable situation. Through that, the emissions of CO_2 will be reduced by 141 000 tonnes, NOx emissions will be reduced by 48 tonnes and SO2 will be reduced by 81 tonnes. But it must be emphasized that emissions will still be generated in the Karlskrona District Heating system after the cogeneration plan has been implemented. For instance, oil will still be used during peak periods, generating 5 000 tonnes of CO_2 emissions. The question raised is whether Karlskrona District Heating ought to go even further in its pursuit of sustainability?

In general terms, the costs to society will increase when additional sustainability measures are implemented. If we confine the discussion only to the emissions of $CO_{2;}$ the marginal costs to society of reducing the emissions beyond 141 000 tonnes will be high, probably much higher that the marginal reduction costs of the first tonnes. Maybe a point has been reached with the proposed cogeneration measure, where further sustainability measures are too costly?

A strategic sustainable economic analysis (i.e. informed by the 5 level framework) could provide the decision maker with information of the total costs to society in terms of losses in consumer and producer surplus to reduce the emissions of CO_2 by 141 000 tonnes. Furthermore, such a model will generate an estimate of the costs to society of reducing yet another tonne, measured in SEK/tonne or EURO/tonne. This cost estimate can then be compared with the market price of emissions permits in the European Emission Trading System. If the costs of reducing CO_2 emissions in the Karlskrona District Heating are lower than the market price, then it is profitable for Karlskrona to reduce its emissions even further. If the costs in Karlskrona are higher, then the reverse holds true. That is then an indication that the measures taken in Karlskrona are not cost efficient.

As described in the previous example: How much sustainability is enough for one organization or nation until other actors with lesser costs “catch up” thus protecting social and organizational welfare? It is evident here that the timing for reacting to unsustainability as well as implementation of cost efficient sustainable measures is difficult to determine with environmental, social, and market fluctuations. How much sustainability will be enough until emerging sustainable technologies can become commercially available?

These questions reinforce the "funnel" metaphor of The 5 level framework previously described in section 3.2. "Unsustainable development can be visualized as society entering deeper and deeper into a funnel in which the space for deciding on options is becoming narrower and narrower per capita." (BTH text 2005, xxi). To avoid "hitting the walls of the funnel" (i.e avoiding increasing risks), organizations must stay on the cutting edge of solutions toward sustainability thus ensuring their long term economic, social and environmental survival. The organization's ability to balance their position within the current market, environment, and government influences along with mid and long term strategic sustainable development is crucial. When informed by the 5 level framework, economic detail as a quantitative tool for strategic sustainable development can add value by supporting decisions made under these conditions. Without a strategic sustainable planning method, vision and quantification, tradeoffs may occur in sustainable decision making due to vested interests and influences which may resolve today's issues but place the organization in a survival mode in the future as options and resources become fewer. Even more tools may be necessary in the future to additionally support strategic sustainable development decisions.

7.2 Proposed approach in context of previous work

Different methods to prioritizing sustainable measures have been proposed in the literature such as backcasting from scenarios, forecasting utilizing economics and the use of modelling. (Kuisma, 2000) Inferred relationships and assumptions in these methods can sometimes be made that interfere or produce flawed outcomes for decision makers. (Tietenberg, 2006) The "Step D" of the ABCD analysis within the 5 level framework for strategic development presented in matrix format coupled with the detailed component of explicit economic analysis in a qualitative matrix of social and organizational profitability perspectives demonstrated in this thesis can provide a broad and deep set of criteria for evaluating measures that may enhance the sustainable development decision making process.

8 Conclusions

The complexity of multiple sustainable objectives within the context of technological, environmental, social, and economical constraints creates a challenge for decision makers. When prioritizing sustainable measures that will move a project or organization toward further sustainable development, what are the choices that will lead to optimal least cost outcomes?

Currently there are methods or tools available to assist in this decision making and through a complementary approach, potentially enhance the process. This thesis specifically looked at the potential for economic detail to further quantify "Step D" of the ABCD analysis within the 5 level framework for prioritizing measures in strategic sustainable development.

As explained in the complex Swedish energy sector of Karlskrona district heat, the results of the proposed approach revealed an enhanced decision making process in the heat demand, distribution, and heat supply phases of their operations. Specifically pricing mechanisms, split incentives, cogeneration, and renewables were measures independently assessed for tradeoffs to test the thesis approach theoretically. Initial guidelines for prioritizing measures in sustainable development were provided by "Step D" of the ABCD analysis within the 5 level framework. Analytical valuation of the sustainable measure by economics was then utilized as the tool to ensure organizational and social profitability as defined by static and dynamic efficiency and equitable allocation. After modelling this economic analysis theoretically, the results were presented in a 2 step qualitative matrix approach demonstrating strategic sustainable development planning of "Step D" of the ABCD analysis as well as the quantified economic social and organizational profitability of selected measures. The relevance of pricing, information, incentives and resulting tradeoffs were contributing aspects to the overall economic complement. The results of explaining the thesis approach in the district heat case study theoretically revealed an enhanced decision making process. Economic detail provided added value with fact based evidence to quantify "Step D" of the ABCD analysis within the 5 level overarching framework for prioritizing measures in strategic sustainable development. The potential for the approach to be context free and thus universal in its application suggests that it might be utilized in other sectors.

Future research could provide greater analysis with the inclusion of the actual sensitivity analysis of prioritized measures of a case study in district heat through economic modelling software to reveal socially desirable sustainable outcomes at least cost. Other research might include further testing in other sectors, in real life situations, to validate the proposed approach.

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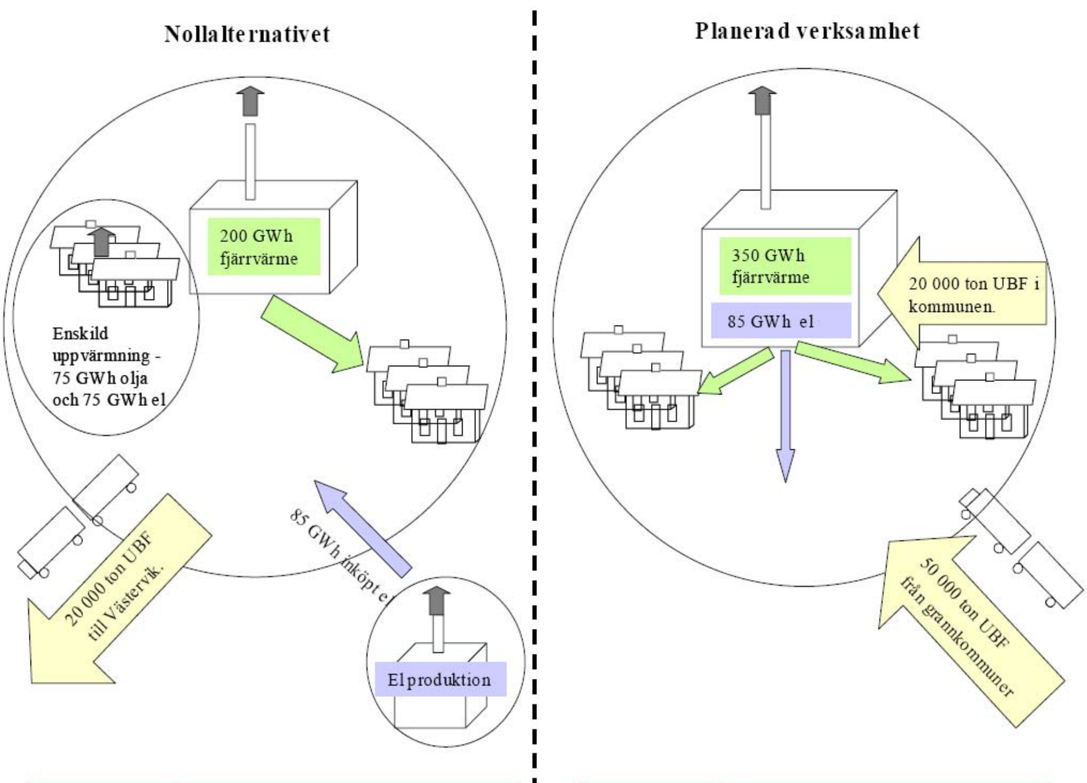
9 Appendices

A. Karlskrona District Heat Current and Proposed Business Plan (2006)

Miljokonsekvensbeskrivning, December 2004 www.affv.se accessed 03/01/06

Miljökonsekvensbeskrivning för kraftvärmeverk i Karlskrona



Fjärrvärme produktion	200 GWh med bef. anläggningar
Övrig uppv.	75 GWh olja och 75 GWh el
El	85 GWh inköpt el
Bränsle och transporter	Utsläpp från transporter av: • 20 kton UBF bränsle 20 mil • 60 kton biobränsle 10 mil • 11 kton olja 2 mil.

Fjärrvärme produktion	350 GWh med tillkommande anläggningar inkl bef anläggningar
Övrig uppv.	0 GWh
El	85 GWh egen producerad el
Bränsle och transporter	Utsläpp från transporter av: • 70 kton UBF bränsle 10 mil • 100 kton biobränsle 10 mil • 1,5 kton olja 2 mil.

Figur 1.3 Systemgränser

Appendix A: Karlskrona District Heat Current and Proposed Business Plan (Source: www. affv.se)

Note in Appendix A:

Nollalternativet: The Alternative or Business as Usual

Nollalternativet is the referenced alternative or “business as usual”. It is the present system. 200 GWh is produced in the district heating system. For individual houses not connected to the district heating system, 150 GWh is produced (= Enskild uppvärmning 75 GWh olja och 75 GWh el). 75 GWh is fuelled by oil and 75 GWh by electricity.

Furthermore, 20 000 metric tonnes of sorted combustible waste are transported to Västervik, a city some 200 kilometres to the north of Karlskrona with a cost to Affarsverken –Waste. Also, 85 GWh of electricity is “imported”.

Planned expansion:

Proposed system with combined power and heat (CHP). All individual houses are proposed as being connected to the district heating system through an expansion of the network. 350 GWh of heat is produced, as well as 85 GWh of electricity.

70 000 metric tonnes of combustible waste is used in the CHP. 20 000 metric tonnes come from the municipality, whereas 50 000 metric tonnes have to be “imported” which is a source of revenue.