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1 Introduction

1.1 Activity background

In order to reduce prospective climate change related damages as well as current air and water pollution, the European Union and its member states adopted several pro-environmental policies such as ecological taxes, emission trading, or subsidies for investments in renewable energy. Moreover, these pro-environmental policies aim to reduce the dependence on oil and gas imports from political unstable countries such as Iraq, Iran, or Libya.

Some of these pro-environmental policies are coordinated at the European level. However, environmental regulation substantially differs from country to country given that there exist structural, cultural, and economical heterogeneities between different countries. In spite of these cross-country heterogeneities, Europe's scientific and political public has reached an important consensus during the last years: local municipalities are seen as the decisive factor to reduce European carbon dioxide emissions and to enhance sustainability (see Wilcken and Janssen 2006). Therefore, more and more research focuses on the specific motives, conditions, and capacities of European municipalities with respect to the promotion and implementation of sustainable energy investments.[1] The importance of local municipalities relies on several factors: first, municipal facilities (like hospitals, schools, or legislative buildings) are often responsible for a non-negligible part of the local energy consumption. Second, by investing in sustainable energy projects, municipalities serve as a role model for households and private companies. Third, municipalities know their citizens much better than national governments so that they can promote people's pro-environmental behavior more effectively. Fourth, municipalities often serve as an intermediator between national governments and citizens.

Why do municipalities invest in sustainable energy projects? First and foremost, they do so since these investments are to reduce the costs for the provision of energy. For example, core insulation measures at the municipal school building can be very profitable if they reduce the energy costs for heat. In that case, such a measure yields a high return on the initial investment. In order to assess the investment's profitability, most municipalities carry out various economic profitability analyses. Standard methodologies that are frequently used are, for instance, the *Net-Present-Value-Method*, the *Internal-Rate-of-Return-Method*, and the *Dynamic-Amortization-Method* (see Erdmann and Zweifel 2008).[2] The basic idea of all these methods is quite simple: the discounted prospective cash flows which

[1] In the following, sustainable energy investment (sustainable energy project respectively) refers to a policy measure that increases the sustainability of the energy system. This can be achieved by reducing carbon dioxide emissions, air pollution, and/or energy demand (for instance, core insulation, promotion of renewable energies, or environmental education of the population).

[2] The Net-Present-Value-Method and the Internal-Rate-of-Return-Method will be explained in more detail in section 3.

are generated by the sustainable energy project (e.g., saved energy expenditures) are summed up and compared to the initial investment costs. Only if the former exceed the latter by a certain amount, the specific sustainable energy project should be carried out.

In addition to this profit-orientated goal, municipalities often pursue other goals when investing in sustainable energy projects: more independency from energy imports, more local jobs, higher local economic growth, reduced environmental pollution, and other image-related factors. These goals are often neglected in the standard profitability analyses mentioned above. Yet, ignoring these effects certainly reduces the probability of realization of sustainable energy investments given that not all positive effects of such investments are revealed to the decision makers. That is, the non-integration of macroeconomic effects in standard profitability analyses seems to be a direct impediment for sustainable development.

1.2 Aim and structure of the activity

We seek to increase sustainability by creating a general economic-valuation-model that, in contrast to standard microeconomic profitability analyses, includes social effects. These social effects include mainly macroeconomic, ecological, energy-security-related, and image-related effects. By revealing, debating and – if possible – quantifying these effects, we hope to provide supplementary arguments in favor of sustainable energy investments. With regard to all these social aspects, we acknowledge that we will probably not be able to quantitatively include every single aspect in the economic-valuation-model given that the research on the monetization of energy-security-related- and image-related-effects has just begun (see Cohon et al. 2010). As a consequence, we will only quantify macroeconomic and ecological effects of sustainable energy investments, whereas energy-security-related and image-related aspects will rather be treated as additional qualitative factors.

Within the valuation-model, we take into account heterogeneities of the investor-specific objectives and incentives as well as heterogeneities of different regions within the North Sea SEP program.[3] Pertaining to the former, we acknowledge that different investors might have different objectives. For instance, some municipalities – as well as many households or firms – might solely be interested in the microeconomic profitability of the accordant sustainable energy investment. Yet, other municipalities might also be interested in the macroeconomic and environmental profitability of the investment. Therefore, our model will be designed in a flexible way that enables the respective investor to choose the profitability aspects that should be included in the valuation-model. Relating to the region-specific differences, we account for the fact that the economic, social, and environmental effects of sustainable energy projects are region-specific because environmental quality, environmental policies, as well as labor market conditions are not homogenous across regions. In fact, not every

[3] In this article, investor refers to the different actors that are interested in sustainable energy investments. The three most important investors on the regional dimension are: municipalities, enterprises, and households.

location provides the possibility and necessary requirements to realize, operate and maintain various sustainable energy projects.

The premises of our valuation-model are traceability, convenience, and practicability. The model is mainly designed for regional decision makers, not for scientists. As such, we deem it acceptable that our valuation-model will not be able to reflect every aspect of the capacious scientific debate. Rather, our model should serve as an exemplary guideline of how to include social effects in microeconomic profitability analyses.

In order to give a first overview of our research activity's structure, we present a short chronological outline:

1) Registering realizable sustainable energy investments
Realizable sustainable energy investments within each North Sea SEP region have to be registered. That is, we take into account that cultural, structural, or economical constraints might prevent the realization of certain sustainable energy investments in some regions. For instance, citizens might be opposed to the construction of windmill-powered plants. In order to preselect the realizable sustainable energy investments, we will utilize tools from the academic disciplines *GEO-Information*, *Construction Economics and Management* and *Public Economics*.

2) Microeconomic profitability analyses of the realizable projects
We will use a convenient economic-valuation-model that allows a quick calculation of the microeconomic profitability of each realizable sustainable energy investment in the different North Sea SEP regions. As mentioned above, we will – amongst others – use the widespread *Net-present-value-method* which is in spread with actual practice. Of course, we also consider the heterogeneous legislative conditions in different regions.

3) Integration of the macroeconomic perspective
First, those macroeconomic effects that can be monetized (macroeconomic and environmental effects) have to be included in the valuation model. In doing so, the cross-regional heterogeneities in environmental and economical conditions have to be taken into account. At the end of these calculations, we will have assessed the microeconomic, the macroeconomic, and the ecological profitability of the various sustainable energy investments. The results will be transformed into a regional grid that contains all sustainable energy projects evaluated according to these three profitability dimensions. Second, those macroeconomic effects that can hardly be monetized (energy-security-related and image-related aspects) have to be discussed and their potential benefits have to be addressed. They can be presented as qualitative factors within our valuation-model.

4) Using our results to promote sustainable energy investments
As a potential last step, we deem it extremely worthwhile to figure out the ideal way of combining the findings from bullets 2 and 3 in order to

promote the realization of sustainable energy investments. This means that we want to discuss if and how the knowledge of the social effects of sustainable energy investments can be used as an incentive for private and public investors to invest in these projects. Yet, it has to be discussed to what extent this step can really be realized within the present research activity.

The remainder of this draft is organized as follows: Section 2 reviews the conflicting goals of the different investors such as households, firms, or municipalities and emphasizes municipalities' important role in the process of sustainable energy planning. Further, important methodological premises of our valuation model are discussed. Section 3 presents the layout of our valuation model and describes how we will integrate social effects in the model. Section 4 offers an preliminary and exemplary profitability analysis for a cluster of sustainable energy investments in the region of Osterholz in North-West Germany. These calculations will illustrate the basic idea of our economic-valuation-model. Finally, section 5 describes the data and informations that have to be provided by our North-Sea SEP partner regions in order to run our valuation model in other regions. Also, possible extensions of our valuation model are presented.

2 Background and premises of the activity

2.1 Investor specific motives

Obviously, investors invest in sustainable energy projects for various reasons. In addition to profitability aspects, macroeconomic, environmental, energy-security-related, or image-related motives are important for different investors.

Municipalities invest in sustainable energy projects for several reasons: first and foremost, they wish that their investments yield a high rate of return. For instance, they generally decide to invest in energy-saving technologies if the monetary economies of these investments outweigh the initial expenditures. Second, municipal decision makers are interested in the macroeconomic effects of sustainable energy investments. They intend that their investments create more local jobs and generate a certain local value added, also due to a partial return flow of their investment costs. Further, policy makers certainly raise their re-election changes by privileging their own community. As such, many participants of the last year's *Workshop North Sea SEP Tynaarlo* from November 3rd to November 5th mentioned *local-value-added* and *benefits in other economic sectors* as two important criteria that investments in local energy projects should met. At the same workshop, economic growth and more jobs were pointed out as important regional benefits from a local energy project (see Milentijevic and Menz 2010).
Third, environmental motives are also important for municipalities. For instance, more than 1300 European municipalities and regions are organized within the European *Climate Alliance* (see Wilcken and Janssen 2006). They share environmental and technological knowledge and develop sustainability

strategies in order to reduce fossil fuel consumption. One motive for their joint activities is the will to improve environmental quality in order to increase their citizens' quality of life (see Wilcken and Janssen 2006). The importance of environmental aspects also became apparent at the aforementioned meeting in Tynaarlo. Confronted with the question regarding which criteria a local energy project should met, many participants mentioned an improvement of environmental quality (see Milentijevic and Menz 2010).
Fourth, energy-security-related aspects such as local energy autarky or lower energy price volatility might also be important for some municipalities (see also Milentijevic and Menz 2010). For instance, energy autarky is also one of the most important motives for investments in local energy projects for our partner region Osterholz.[4] Municipalities are interested in energy autarky in order to reduce the dependence from political unstable countries and monopolistic energy suppliers or/and to reduce the risk of future price volatility.
Fifth, image-related factors such as approval by the electorate, signaling-effects for households and companies, or recreational aspects, might influence the decisions on sustainable energy investments (see Milentijevic and Menz 2010).
In sum, municipalities are particularly interested in economic motives. They want that their investments have a high internal rate of return and that, additionally, some parts of the investment flow back to the local budget via higher tax earnings or lower unemployment compensations. Additionally, many municipalities are also interested in environmental effects of their investments. They also consider energy-security-related and image-related aspects.

Private households primarily invest in sustainable energy projects in order to save money (see Stieß et al. 2010). Many households, for instance, only install solar panels on their roofs because such an investment is very profitable for them. This becomes perspicuous by comparing Sweden to Germany: in Sweden, investments in solar panels are not subsidized by the government. Accordingly, only very few Swedish households install solar panels on their roofs. In contrast, the German government highly subsidizes investments in solar panels. As a consequence, German citizens are Europe's most enthusiastic solar-panel-investors.
However, even if investments in solar panels are not sufficiently subsidized in each European country (e.g., in Sweden), some households from these countries decide to install them on their roofs. They merely want to contribute to sustainable development. Solely the knowledge that their investment reduces fossil fuel consumption is a sufficient incentive for them to invest in the project. That is, these households are not interested in private profitability motives but rather in ecological effects of their investment. Finally, it seems highly implausible to assume that macroeconomic effects or an increased level of local energy autarky are relevant motives for households to invest in sustainable energy projects.
The same is probably true for private companies. They certainly do not care much about macroeconomic or energy-security-related effects. However, they are very interested in profitability aspects of their investments. Firms

[4] See section 4.

primarily invest in sustainable production facilities if such an investment yields a high rate of return. Admittedly, environmental aspects might also be relevant for private companies. In some cases, they use a more energy efficient machinery and emit fewer pollutants than requested by environmental regulation. By means of this o*vercompliance*, companies want to improve their image and attract pro-environmental customers.

Table 1: Relevance of investor-specific motives

	Municipalities	Companies	Households
Private Profitabiliy	+++	+++	+++
Environmental effects	++	+	+
Macroeconomic effects	+++		
Energy-security-related effects	+		
Image-related effects	+		

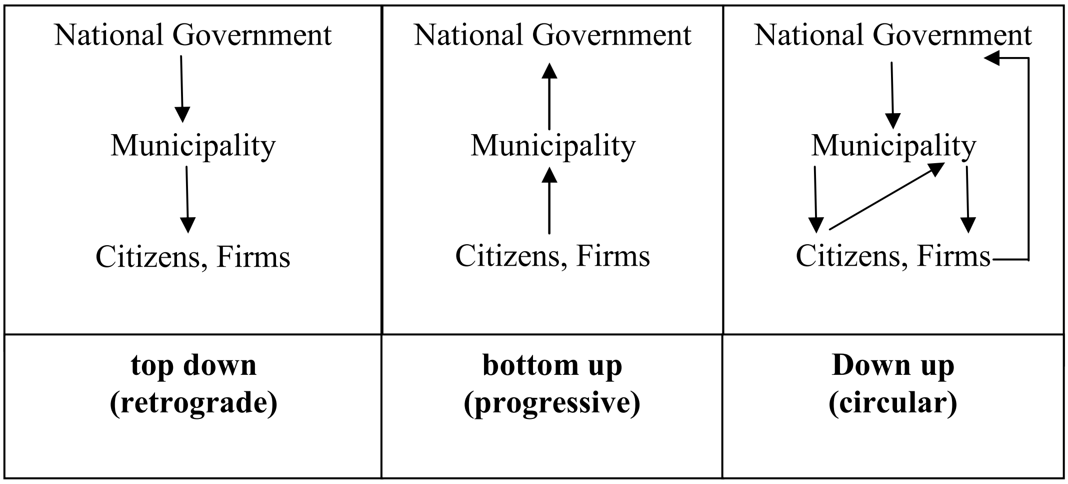
+++ = very important, ++ = important, + = somewhat important

Table 1 summarizes the relevance of the investor-specific motives for investments in sustainable energy projects. We believe that the different motives of private and public investors are crucial with respect to the promotion of sustainable development. The discrepancy between the private and public investors' motives are liable to the "classic" coordination problem of the corporate planning. That is, there exist different stakeholders, on different levels, with different conditions. Taking into account these differences is essential to coordinate and attain the goal of sustainability.

2.2 The role of municipalities

As mentioned in the introduction, the importance of local municipalities relies on several factors: first, municipal facilities (like hospitals, schools, or legislative buildings) are often responsible for a non-negligible part of the local energy consumption. Second, by investing in sustainable energy projects, municipalities serve as a role model for households and private companies. Third, municipalities know their citizens much better than national governments so that they can promote people's pro-environmental behavior more effectively. Fourth, municipalities often serve as an intermediator between national governments and citizens. Municipalities' role as an intermediator between national governments and citizens becomes visible in figure 1 which is based on the so called Dottlet-Line-Principal known from the strategic planning (see e.g., Jung 2003).

Figure 1: Municipality's role in the process of sustainable energy planning



Within the retrograde approach, environmental regulation and sustainable energy investments are administered by the national governments. In this case, municipalities should mainly execute the national governments' policies and control their citizens' compliance. Such a top down approach might be quite effective. However, it neglects local heterogeneities, municipalities' as well as citizens' motives and is less democratic than the other approaches.
Within the progressive approach, environmental regulation and sustainable energy investments are formulated by citizens and municipalities. In this case, the national government only monitors the regional approaches and guarantees some kind of minimum environmental quality. This bottom up approach is very democratic and flexible with respect to differing local conditions. However, it might not be very effective and lead to lower environmental standards.
The circular approach is a mixed-form between the retrograde and the progressive approach. The national governments administer environmental regulation but the citizens and the municipalities have many possibilities to give a feedback and to impact environmental regulation and sustainable energy projects. As such, this approach is quite effective, regional-based, and democratic. Overall, the circular approach is the most realistic and widespread approach in environmental regulation.
Against this background, it becomes obvious, to what extent municipalities are important within the process of sustainable energy planning and environmental regulation. They know their citizens' and companies' needs and motives much better than the national governments. Additionally, they have a higher bargaining power than their citizens and companies and can therefore negotiate more effectively with the national government.

2.3 Premises of our valuation model

We want to integrate social effects of sustainable energy investments in a standard economic valuation model. With respect to this goal, Maibach et al. (2007) formulated important requirements such a model must meet:

- Pertaining to environmental effects, it is absolutely necessary to use reliable cost estimates given that the overall acceptance of the model is positively related to the accuracy of these estimates. Therefore, we will use recent cost estimates calculated by a pan-European research network called the *NEEDS* (see section 3.2.2 for further information).

- Politician's desire to make use of different cost estimates (e.g., low, medium, and high estimates) and economical scenarios is not very pronounced. They prefer ready-made figures that are easy to interpret. In the light of this, our basic model version only relies on medium cost estimates and standard economic scenarios.
- Researchers must recognize that microeconomic, macroeconomic, and environmental profitability aspects are only one possible criterion to value different investments. Policy makers might also be interested in their reelection, the promotion of sponsors and friends, or the image of their municipality.
- The inclusion of environmental and macroeconomic effects can be used as a marketing tool to promote the probability of realization of sustainable energy investments. By unfolding and monetizing these effects, the public acceptance of pro-environmental investments probably increases. We will further discuss this point in section 5.

3 The economic-investment-valuation-model

3.1 Model overview

The model encapsulates different variants of sustainable energy projects in the field of energy generation (e.g., solar energy, wind energy, biogas) and constructional and technical operations that reduce energy consumption (e.g., core insulation, usage of energy efficient appliances). In the first stage of our activity, different methods are used (geological information and others) in order to generate preliminary clusters of feasible investment projects for every considered region. This analysis takes into account the region-specific territorial, natural, legislative, and technological background. At the end of this stage, there will be preliminary information about the overall feasibility of different sustainable energy investments in the respective regions. This stage is visualized in figure 2:

Figure 2: Stage 1 of the Basic Concept (Selection and Clustering)

Background:
Region specific territorial, economic, cultural, and legislative conditions

Goal of stage 1:
Selection of adequate sites and projects

Starting point:
The complete set of all technical feasible sustainable energy investments:

New onshore wind parks, repowering of existent wind parks, solar heat, solar modules on public buildings, large solar parks, biogas plants, biomass facilities, usage of geothermal energy, usage of hydropower, core insulation of public buildings, environmental education of the citizens, diverse energy saving measures, …

Tools applied to reach the goal:

- Geo-informational tools (cluster-analysis)
- Consideration of the legislative and economic background
- Elementary analysis of social benefits
- Interconnection analysis of the different projects

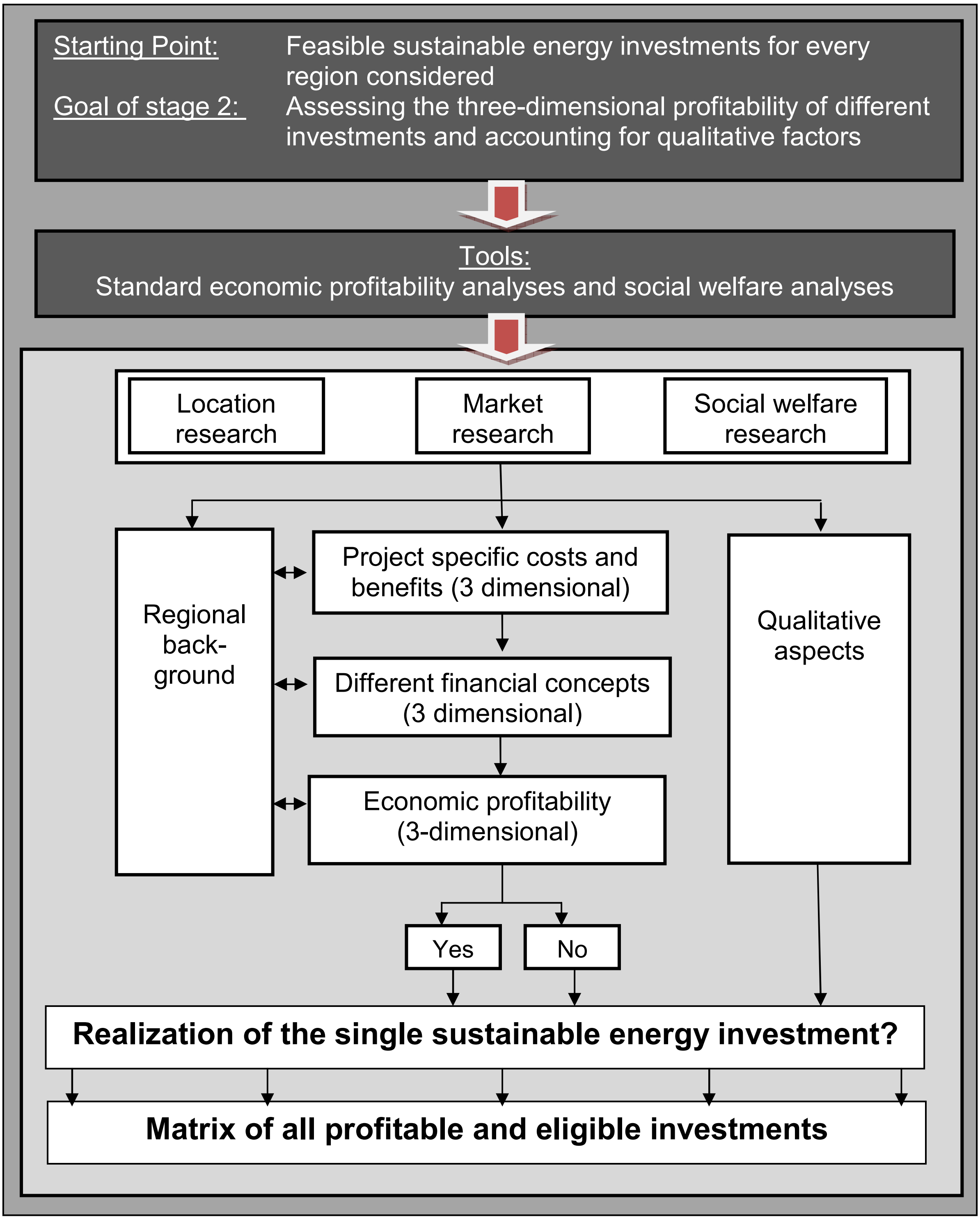
End point:

	Region A	Region B	…	Region M
Alternative 1	Feasible	Maybe Feasible	…	Feasible
Alternative 2	Feasible	Not Feasible	…	Feasible
…	…	…	…	…
Alternative n	Not Feasible	Feasible	…	Maybe Feasible

As seen in figure 2, the outcome is a matrix in which every cell reflects the project- and location-specific feasibility of the respective sustainable energy investment. Additionally, we will discuss to what extent the feasible sustainable energy projects are interconnected in every region. At the end of this stage, we will be able to present clusters of feasible sustainable energy projects for every region. However, the matrix does not yet reflect the exact profitability of the single sustainable energy projects. According to the project development theory, this calculation is postponed to the next stage.

In order to give a short overview of the next stage of our model, we present figure 3 which visualizes the second stage of our economic-valuation-model. Note that our valuation-model is region specific so that the analysis presented in figure 3 has to be carried out for every single North-Sea-SEP-region.

Figure 3: Stage 2 of the Basic Concept



As mentioned, the selection and clustering of region-specific sustainable energy projects serves as a starting point for the second stage of our model. The goal of the second stage is the calculation of the three dimensional profitability of all feasible projects in the considered region as well as the consideration of rather qualitative aspects. In this context, three dimensional refers to the three different aspects: microeconomic, macroeconomic, and environmental profitability. The tools that will be used in order to assess the profitability figures are standard economic valuation tools such as the *Net-Present-Value-method* (*NPV*), the *Internal-rate-of-return-method* (*IRR*), and

the *Dynamic Amortization* (*DA*). In addition, social welfare analyses are used to calculate the value of macroeconomic and environmental effects. During the calculation of these values, we take into account the region-specific economic, legislative, cultural, and structural background. In the end, depending on the financial concept used (*NPV*, *IRR*, *DA*), we can say whether a specific sustainable energy investment is profitable (from the microeconomic, macroeconomic, and environmental perspective) in the considered region. The answer to that question, as well as the qualitative factors that are not incorporated in our economic-valuation-model will indicate whether the single project should be realized or not. The selection of profitable projects as well as projects that should rather be carried out for qualitative aspects (called *eligible investment* in figure 3) results in a matrix of feasible, profitable, and eligible projects that should definitely be realized in the considered region.
Obviously, the inclusion of qualitative factors makes our economic-valuation-model quite flexible with respect to the policy maker's desire to account for different aspects of sustainable energy investments. If, for instance, a politician places a high weight on his re-election probabilities, this factor can easily be included and highly weighted within the qualitative factors.

3.2 Methodology

3.2.1 Private Perspective

The first goal of the second stage is to calculate the profitability of every feasible sustainable energy project from the microeconomic perspective. In order to calculate these values, we will conduct cost-benefit analyses which will partly be executed in co-operation with the respective partner regions. To what extent this goal is accomplishable with only one model relies mainly on the specific conditions of every country itself and has to be analyzed within the research program. The calculations will be based on different methods (*Net Present Value* (*NPV*), *Internal Rate of Return* (*IRR*), and *Dynamic Amortization*.
For introductory purposes, formula (1) shows the *NPV* which is certainly the most frequently used valuation method in operational practice:

Equation 1

$$NPV = \sum_{t=0}^{T} \frac{Cash\ Flow_t}{(1+i)^t} - Initial\ Investment\ Costs$$

In the formula, *t* stands for the considered year and ranges today (*t*=0) up to *T* (*t*=*T*). That is, *T* is the overall project life span. The investor-specific refinancing interest rate is given by *i*. Equation (1) shows that the *NPV* is simply the difference of the sum of the prospective cash flows which are discounted with the interest rate (*i*) and the initial investment costs. The discounting implies that future cash flows have a lower weight in the calculation than current cash flows. A positive *NPV* indicates that the discounted future benefits outweigh the investment costs and that the investment should be carried out.

Which informations are needed to calculate the *NPV*? First, the initial investments costs have to be known. Initial investments costs include all costs that are necessary get the respective facility (e.g., biogas plant, solar park, or insulated building) ready for operation. Second, the term *Cash Flow* refers to the yearly cash flows that are generated by the project. The yearly cash flows are calculated by subtracting yearly maintenance costs (materials, labor costs, reparation costs, etc.) from the yearly project-specific earnings. The consistence of the earnings is project-specific: a solar park, for instance, generates earnings since its electricity can be sold to households or has to be purchased at a guaranteed feed-in tariff by the regional energy supplier. In contrast, the earnings generated by an insulated building are lower energy expenditures.
The crucial step in this calculation is certainly the adequate assessment of the cash flows for every period. Pertaining to this, the prospective development of several factors has to been taken into account: maintenance costs, legislation, market structure, resource prices, or consumer preferences. Ignoring these factors might lead to biased calculations.

Finally, note that the internal rate of return (*IRR)* can easily be derived from the *NPV*. To calculate the *IRR* of a specific project, one has to set its *NPV* equal to zero and to solve equation (1) for *i*. That is, the internal rate of return is the interest rate for which the net present value of the project is zero. If the *IRR* is higher than the refinancing interest rate of the investor, the project should be carried out.

3.2.2 Public Perspective

A first extension of the standard microeconomic valuation model from the last section integrates macroeconomic effects of sustainable energy investments. According to Hirschl et al. (2010), three aspects have to be considered as macroeconomic effects: net-earnings of involved local companies and craftsmen, net-income of (new) personnel employed in these companies, and local taxes that are based on the specific supply chain. At this point, we acknowledge that the exact calculation of the region-specific macroeconomic effects associated with different sustainable energy projects is extremely difficult and it's exact identification beyond the scope of the present research activity. Yet, given that the research in this area progresses continuously, it might be possible to integrate adequate region-specific values for the local value added in several years. Currently, we will only be able to use rather approximate values for this figure based on the research from Hirschl et al. (2010).
Synonymously to the microeconomic cash flows presented in equation (1), one can calculate a kind of *macroeconomic net present value* (*MENPV*) of the specific sustainable energy investment. The accordant calculation is shown in the following equation:

Equation 2

$$MENPV = \sum_{t=0}^{T} \frac{Macroeconomic\ Cash\ Flow_t}{(1+i)^t} - Initial\ Investment\ Costs$$

That is, the initial investment costs (the same figure as in equation 1) have to be subtracted from the discounted macroeconomic cash flows. The outcome is the present value of all macroeconomic effects which can be attributed to the specific investment. Obviously, we can also calculate the *macroeconomic rate of return* (*MRR*) based on equation (2).

A second extension of the standard microeconomic valuation model from the last section integrates ecological effects of sustainable energy investments. These ecological effects primarily include improved air- and water quality as well as reduced prospective climate change related damages. Likewise equation (2), equation (3) presents how the *environmental net present value* (*ENPV*) can be calculated:

Equation 3

$$ENPV = \sum_{t=0}^{T} \frac{Environmental\ Cash\ Flow_t}{(1+i)^t} - Initial\ Investment\ Costs$$

Again, the *environmental rate of return* (*ERR*) can easily be derived by setting *ENPV* equal to zero and solving for *i*. We now turn to the important question how the ecological benefits of sustainable energy projects can be valued? In the last decades economists developed several methods in order to assign a monetary value to the public good *environmental quality*. In Europe, many valuable research has recently been carried out under the so called *NEEDS* project (see Bickel and Friedrich 2005) which was funded within the European Commission 6th Framework Program (*NEEDS* = *New Energy Externalities Development for Sustainability*). The primary objective of this research program has been to develop innovative research and generate original scientific knowledge. In addition, the NEEDS project is intended to provide direct usable inputs to the evaluation of sustainable energy projects (see Ricci 2006). The data from the NEEDS project are quite detailed. For instance, the researchers calculated country-specific ecological costs for each energy source. The benefit of the NEEDS results within our own research activity is obvious: the data show, for instance, that the ecological costs of a kilowatt-hour electricity generated by means of coal amount to 3.5 Eurocents in the Netherlands, whereas a kilowatt-hour of electricity generated by means of wind is only associated with ecological costs of 0.1 Eurocents in the same region (due to the production and the transport of the windmill-powered plant). Given that these values are country-specific and given that the national energy mix is country-specific as well, we are able to calculate country-specific average values for the ecological costs of the national electricity consumption. Table 2 shows these values for the six North Sea SEP countries:

Table 2: Region Specific environmental costs of electricity production

	Environmental Costs associated with the average national electricity production in Eurocents per kWh
Belgium	1.71
Denmark	3.64
Germany	2.68
Netherlands	2.03
Sweden	0.42
United Kingdom	2.68

Source: Own calculations based on the NEEDS results.

Table 2 demonstrates that from the environmental perspective, general energy savings are particularly welfare improving in Denmark, Germany, and the United Kingdom, whereas the Swedish public should not care much about energy savings for ecological reasons.
Following the same calculations, the NEEDS data enable us to calculate the external costs of the energy used for heating purposes. Obviously, the results can also be used if one region substitutes a specific energy source against another (e.g., by installing a large wind park and shutting down a gas-fired power plant). This means that we are able to calculate the environmental benefits of every sustainable energy investment that is technological feasible. In other words, the complete set of projects from figure 2 can be evaluated from the environmental perspective.

Besides the macroeconomic and environmental effects of sustainable energy investments, our economic-valuation-model will also consider rather qualitative factors which can hardly be monetized. Examples for such factors are: energy autarky, energy security, acceptance by the electorate, advancement of the legal process, and possible signaling effects of the investment (see Cohon et al. 2010 or Schirrmeister 2010).[5]
Our idea with respect to the inclusion of these qualitative aspects is the following: the decision with respect to the relevance of these qualitative factors is left to the different regions' policy makers. They have to decide on the relevance of each single qualitative aspect and the overall relevance of the qualitative aspects in comparison with the profitability aspects. As a consequence, our economic-valuation-model will be sufficiently flexible to be adopted by policy makers from different regions.

[5] Please refer to Cohon et al. (2010) for a detailed overview of the difficulties to monetize such effects.

4 Exemplary calculations for the region of Osterholz-Scharmbeck

4.1 *Background of the model region*

In order to demonstrate the basic idea of our economic-valuation-model, we will show some rudimentary exemplary calculations for the county of Osterholz. Osterholz is located in North-West Germany closed to Bremen. This county hosts 112.000 inhabitants. In total, its' administrations, citizens, and firms spend approximately 82 Million Euro per year for electricity and 64 Million Euro for heating purposes. Note that roughly 92 percent of electricity is imported from outside the region and that approximately 99 percent of heating energy is produced by means of imported oil and gas (see Müller et al. 2010).

In the light of this, the county's policy-makers goals are to increase energy-autarky, renewable energy use, and sustainability by contributing to a reduction of fossil fuel use. In doing so, the county wants to keep a larger part of the energy related expenditures within the region in order to foster the local economy. According to calculations from the *REON-AG* (see Schirrmeister 2010), the county could be able to cover 100 % of electricity consumption and 80 % of heating demand on its own in 2030. This could be achieved by means of energy savings, installation of twenty to thirty windmill-powered plants, biogas plants, and the usage of solar electricity and heat.

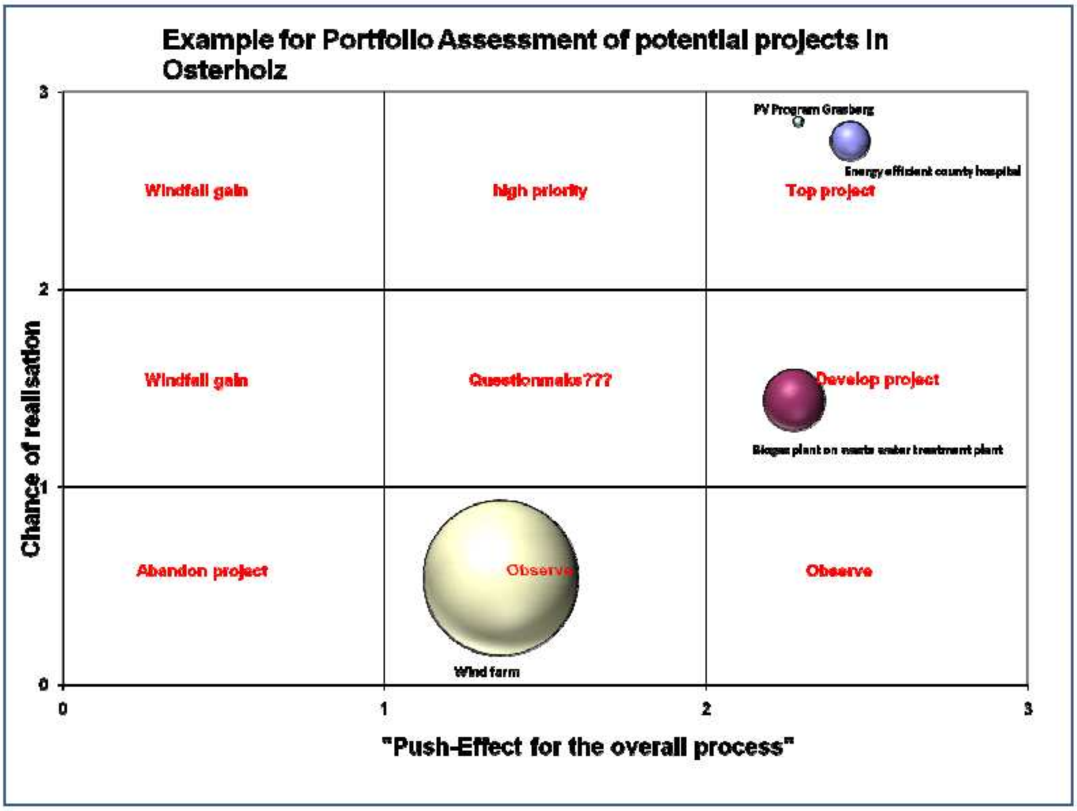
4.2 *Preliminary results for Osterholz*

The first step of our valuation model is the selection and clustering of different sustainable energy investments. We first consider the national settings in Germany that might be relevant for the selection of feasible alternatives. Given the German energy mix and high energy prices in Germany, investments in energy-saving-measures are profitable from the microeconomic and the environmental perspective. Due to high subsidies paid by the German government, investments in solar energy, wind energy, and biogas plants are very profitable from the microeconomic perspective. That is, given the general German background, we could not eliminate certain sustainable energy investments.

We next turn to the regional background in Osterholz. In fact, two county-specific factors limit the set of realizable investments. First, the citizens of Osterholz are generally opposed to the creation of further wind farms. For that reason, this investment is probably not politically enforceable and therewith not realizable in Osterholz. Second, given that Osterholz lies in a region with sparse sunlight, it seems not to be well suited for large solar parks. As a consequence, these two alternatives were excluded from the set of feasible investments.

In order to keep this section short, we further pretend that only three sustainable energy projects are realizable in Osterholz: increasing the energy efficiency of the county hospital (*Hospital*), a new biogas plant on the existing waste water treatment plant (*Biogas*), and a small photovoltaic roof register program in Grasberg (*PV-program*).[6] Figure 4 (from Schirrmeister 2010) presents a matrix of these projects classified according to their chance of realization and their environmental and technological signalling effect (*Push-Effect*). As seen, the chance of realization of a potential wind farm is low due to the public opposition. Therefore, we will only present estimates of the *IRR* (Internal rate of return) figures for the three investments with a high chance of realization.

Figure 4: Potential projects in Osterholz



Source: Schirrmeister (2010)

The second step of our valuation model is the calculation of the microeconomic, macroeconomic, and environmental profitability of all feasible investments by means of different methods (e.g., *NPV, IRR*, and *DA*). In the final version of our model, we will execute in-depth calculations by considering initial investments costs, projected cash flows, and legislative circumstances. These calculations are not yet finalized so that we will only present estimated values based on Müller et al. (2010) and Schirrmeister (2010) in this draft.

The starting point is the microeconomic profitability of the investments. That is, the relevant question is if the (discounted) projected cash flows that are generated by the investments pay off the initial investment costs. Based on

[6] This program necessites further explanation: The municipality of Grasberg is a part of Osterholz. The idea is that the county invests money in order to create a register that classifies each roof of all buildings in that municipality according to their potential for the accommodation of photovoltaic facilities. The aim is to increase private investments in solar energy.

preliminary informations (see Müller et al. 2010, Schirrmeister et al. 2010), we estimate the following *IRR*-figures for the three projects:

Project 1: Hospital: *IRR* = 9.5 %
Project 2: Biogas: *IRR* = 8.0 %
Project 3: PV-program: *IRR* = - 0.5 %

From the perspective of the investor who is only interested in the private return of his investment, projects 1 and 2 are very attractive, since their rates of return exceed the general interest rate. The investment *Hospital* has a high rate of return because the projected energy savings are quite pronounced. The investment Biogas is also very profitable given the high feed-in tariff for the energy produced in this facility. From the microeconomic perspective, an investment in the PV-program is not at all profitable for the county and yields a negative rate of return. The reason is that the county pays for the preparation of the roof register but that governmental subsidies for the installed solar modules are received by the house owners.

Subsequently, the next stage is the calculation of the macroeconomic effects of the three different investments. To be concrete, based on the information by Müller et al. (2010) and Schirrmeister et al. (2010), we estimate the *macroeconomic rate of return* (*MRR*) for the three different projects:

Project 1: Hospital: *MRR* = 0.5 %
Project 2: Biogas: *MRR* = 3.0 %
Project 3: PV-program: *MRR* = 1.0 %

The alternative *Biogas* ranks highest. This is due to the fact that prospective energy imports can be reduced significantly and that a large part of the prospective energy expenditures stays within the region. The alternative *PV-program* ranks second. The positive macroeconomic effects of this investment rely on the fact that the PV-program induces investments in solar energy by households and firms. As a consequence, local companies and craftsmen can easily benefit by acquiring the correspondent contracts. This means also that a part of the initial investments flows back to the county via taxes paid by these companies and craftsmen. However, the macroeconomic profitability of the PV-program is significantly lower than that from the alternative *Biogas*. From the macroeconomic perspective, the alternative *Hospital* is the least attractive. Local craftsmen are needed to modernize the hospital but after these initial expenditures, no local cash flows are generated.

The next step is the calculation of the ecological effects of the three investments. Projects 1 and 2 are very attractive from this point of view since they both substantially reduce fossil fuel consumption. In doing so, they contribute to the reduction of air pollution and climate change related damages. Even if solar energy is carbon free, the PV-program is not very attractive given that the total amount of energy that is produced with the solar modules is rather small. The following figures for the *environmental rate of return* (*ERR*) reflect this situation:

Project 1: Hospital: *ERR* = 1.5 %
Project 2: Biogas: *ERR* = 2.0 %
Project 3: PV-program: *ERR* = 0.2 %

Finally, we can combine the three different profitability aspects in order to get an overview of the overall profitability of the three sustainable energy investments. To this end, we calculate the *overall rate of return* (*ORR*), that is, the sum of the three components *IRR*, *MRR*, and *ERR*. For the three alternatives, the accordant figures are:

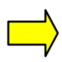
Project 1: Hospital: *ORR* = 11.5 %
Project 2: Biogas: *ORR* = 13.0 %
Project 3: PV-program: *ORR* = 0.7 %

If these figures were the only decision criteria, projects 1 and 2 should be realized. Even if the rate of return from project 3 is positive, it should not be realized. Why? Simply because 0.7 % is lower than the refinancing interest rate of the county Osterholz. In this case, the county should better use the investment costs to pay off its public debt – such an “investment” would definitely generate a higher rate of return.

As mentioned in chapters 2 and 3, there might be other decision criteria that could be relevant for the decision.[7] One aspect is certainly the acceptance by the public which is very high for the alternatives *Hospital* and *PV-program* and only moderate for the *Biogas* investment. Another is the advancement of the legal approval process that is high for the alternatives *Hospital* and *PV-program* and only moderate for *Biogas*. A third aspect might be a signal effect for the public. Such an effect mainly exists for the *PV-program* and the investment *Hospital.* These measures could induce citizens and firms to install solar panels on their roofs or to increase the energy efficiency of their homes.
Overall, with respect to the qualitative effects, the PV-program is the most attractive alternative. The investment *Hospital* is also very attractive, whereas the investment *Biogas* is only moderately attractive.

The outcome of the all these considerations is a matrix that shows the three dimensional profitability, the overall profitability, and the qualitative aspects of the three sustainable energy investments. This matrix is shown in table 3:

Table 3: Project valuation matrix

	IRR	MRR	ERR	ORR	Qualitative aspects
Hospital	9.5 %	0.5 %	1.5 %	11.5 %	
Biogas	8.0 %	3.0 %	2.0 %	13.0 %	
PV-program	-0.5 %	1.0 %	0.2 %	0.7 %	

[7] These qualitative factors are already partially integrated in the matrix from figure 4.

Based on these informations, policy makers should decide in which project they invest. As seen, the alternative Hospital is profitable from the microeconomic and the social perspective (high *ORR*) and is eligible with respect to its qualitative aspects. Therefore, this project should definitely be realized. The alternative Biogas is very profitable but only moderately eligible with regard to its qualitative aspects. That is, whether the project should be realized mainly depends on the weights policy makers attribute to quantitative or qualitative aspects. The same applies to the PV-program. Yet, in contrast to *Biogas*, this investment is not profitable (very low *ORR*) but is very attractive with respect to the qualitative aspects.

5 Data requirements and possible extensions of our activity

5.1 Data requirements

In order to use the valuation model in other North Sea Sep regions, one depends on the provision of data from the different regions. First, the user needs some introductory information concerning the legislative, economical, and political background of the considered regions. This includes informations on possible feed-in tariffs, subsidies, environmental taxes. Further, one depends on informations regarding the local economic background. This means that the counties should declare to what extent different investments can be carried out by local firms. Finally, this also includes information on the policy makers' preferences with respect to the weighting of the qualitative aspects. Second and foremost, the user necessitates financial data for each sustainable energy project that is envisaged. That is, the different counties should provide information on the initial investment costs, the projected maintenance costs, the generated cash flows, and the specific refinancing costs of the county.

If these informations are not delivered by the respective regions, one can only use our valuation model in a very rudimentary way. In this case, one needs to use estimated average values for the investment costs and the projected cash flows of different sustainable energy projects. Further, the region-specific background cannot be included effectively in the model if no information by the municipality is provided.

5.2 Extensions of our research activity

Subsequent to our research activity, we deem it worthwhile to analyze to what extent our model can be used to promote sustainable development in the different North Sea SEP regions. To be concrete, it would be very interesting to investigate if and how the knowledge about the macroeconomic and the ecological profitability rate of sustainable energy projects can be used to increase the probability that private and public investors actually carry out these projects. The question regarding what marketing measures can be used in this context might also be discussed.

The Interreg IVB North Sea Region Programme

European Community
European Regional
Development Fund

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