"THE IDEAL OF SUSTAINABILITY IN PLANNING: A STUDY ON CONSUMPTION FACTOR RELATED TO THE GREEN ECONOMY"

Ayse Akbulut[1], Ozlem Ozcevik[2],

[1]PhD Student (Istanbul Technical University), ayseakbulut8801@gmail.com
[2]Assoc. Prof. Dr.,(Istanbul Technical University), ozceviko@itu.edu.tr

Abstract:

In this study,green economy subject is examined within the scope of rebound effect issue by consecutive questions in the light of the world's main goal of the sustainable development.The components of sustainable development known as 3E(economy-ecology-equity) has been studied since 1987.There are discussions on this subject about the significance,comprehensiveness and integration into countries of these components.The economy represents a significant role in these discussions.Economic and environmental attitudes that globally adopted; use-distribution of natural resources and waste shows that the world moves away from sustainability.It is stated that placing green economy approach to 3E supports sustainable development by the various disciplines.However the consumption creates the subject of debate in this situation. Sustainable development is affected negatively in all economies by the consumption-oriented lifestyle.Game theory approach could establish the link between the consumption with environmental issues. In this context, the main problem question that directs the study is: even if all technological developments and new economic regulations will be provided, can sustainable development be achieved in consumerist society?In conclusion; these evaluations can be carried out when trying to understand environmental issues by different game theory approaches from the perspective of urban planning: All the living thing on the earth wants to maximize their profits independently of each other.But human is tend to interfere with the systems of the other living or non-living thing.Unless there is no sense of near-term profits individually, sense of unconscious consumption doesn't disappear.At this cycle, planning is canalized to unsolvable questions.

Keywords (maximum 3): sustainable urban planning, green economy, consumption.

Introduction

More for the extension of the practice of urban sustainability, these practices are also supported by both public administrations and the private sector that will contribute to achieving the purpose of the provision of urban planning, it is believed of the city; the host offered by them in the residential area of population, housing area, work area, employment conditions etc. because of the features that can be increased in the way the city enters into a direct relationship with the system environment. Therefore, the individual and the community gradually working to meet the needs of the urban system, sustainable development is meeting at this point. The expression of sustainable cities, indicate the appropriate actions to be found in most of the city (Nijkamp,1998). The reasons for the creation of indicators that determine the suitability of this be listed as follows: II. Major breakthrough of industrialization after World War II was experienced, towards the end of the 1960s, air pollution, lack of infrastructure, population growth and mass deaths begin to occur because of hunger (Douglas,2012). Therefore, strengthening environmental sensitivity starting in the 1960s, and in the 1970s, the result of moving to the international platform today, the concept of sustainability (Yönet & Yirmibeşoğlu, 2005). Starting in the 1970s, urban planning agenda and increasingly after 1990 and therefore constitutes the main framework of the main goals of sustainability (Munda,2006). In the report Our Common Future (UN,1987) as noted, economic development, sustainable development,

ecological conservation and intergenerational equity considerations strives to provide a compromise in between. While doing this approach emphasized the necessity of the adoption by countries globally 3E. These economy-equity-ecology is defined.
The triple bottom components are in equilibrium with each other when in the area and by the nature of the components in approach, a resource conflict between economy and ecology, Ecology and development conflict between equity, there is ownership conflict between them. (Godchalk,2004). All end this conflict and urban planning approaches that are being developed in order to produce solutions (new urbanism, Smart City, green city, eco-city, etc.) it is known that one of the main purposes of sustainable development. However, the components that can be achieved for a sustainable balance between residential systems still are being put in the effort. Questionable relationship to the present day, while the components with each other since the year of 2010, the components themselves in the science of urban planning also has begun to be questioned (James, 2015). The adoption of a global economic system and process, the level of economic development between countries and the diversity of the diversity of the possessors of natural resources between countries, between countries and socio-cultural values in the difference, therefore, accepted the obligation to consider the diversity dynamics of urbanization among countries is a fact. If that is the situation common to all systems are "the economy" component on all components of domination and oppression. Therefore, by countries, global and national economic insights, for the purpose of a sustainable future, is born out of the necessity to be revised. The goals of sustainable development that is compatible with the other components of the economy more realistic, an approach that puts a floor when you enter a search for "green economy" is the only approach that can meet these expectations. The green economy approach; as a concept, especially focuses on generating alternative sources of energy and efficiency. Encountered as a researcher, "consumption efficiency that eliminates the element of "rebound effect" (Hahn,2013) has created some of the systematic study of the phenomenon.

This study of the components of sustainability accepted by querying the relationship with each other to discuss how to update the tools of Urban planning is made accordingly for the purpose of the think piece. The first hypothesis of the proposed study; the phenomenon of consumption in societies that exists for various reasons, internal and external, and the latter with a permanent tension between sustainability therefore is based on where it is located. Practice is as followed:

-How are the components of sustainable development and relationship between them interpreted in history?
-Are the components of sustainable development and "green economy" approach compatible?
-Changing the name of the economic approach and the concept of sustainable development can produce a solution to the goal?
-Why the green economy approach in the rebound-effect phenomenon is emerging?
-Why sustainable consumption is not done?
-Non-sustainable consumption, How does that affect the concept of urban planning?
-Urban planning tools in this context, How can be re-editable?

The literature on the questions in the interpretation of the results from a general result by associating them with each other shall be made. This thought in the following way conveyed graphically the relationship of the questions and content of the work (see fig1):

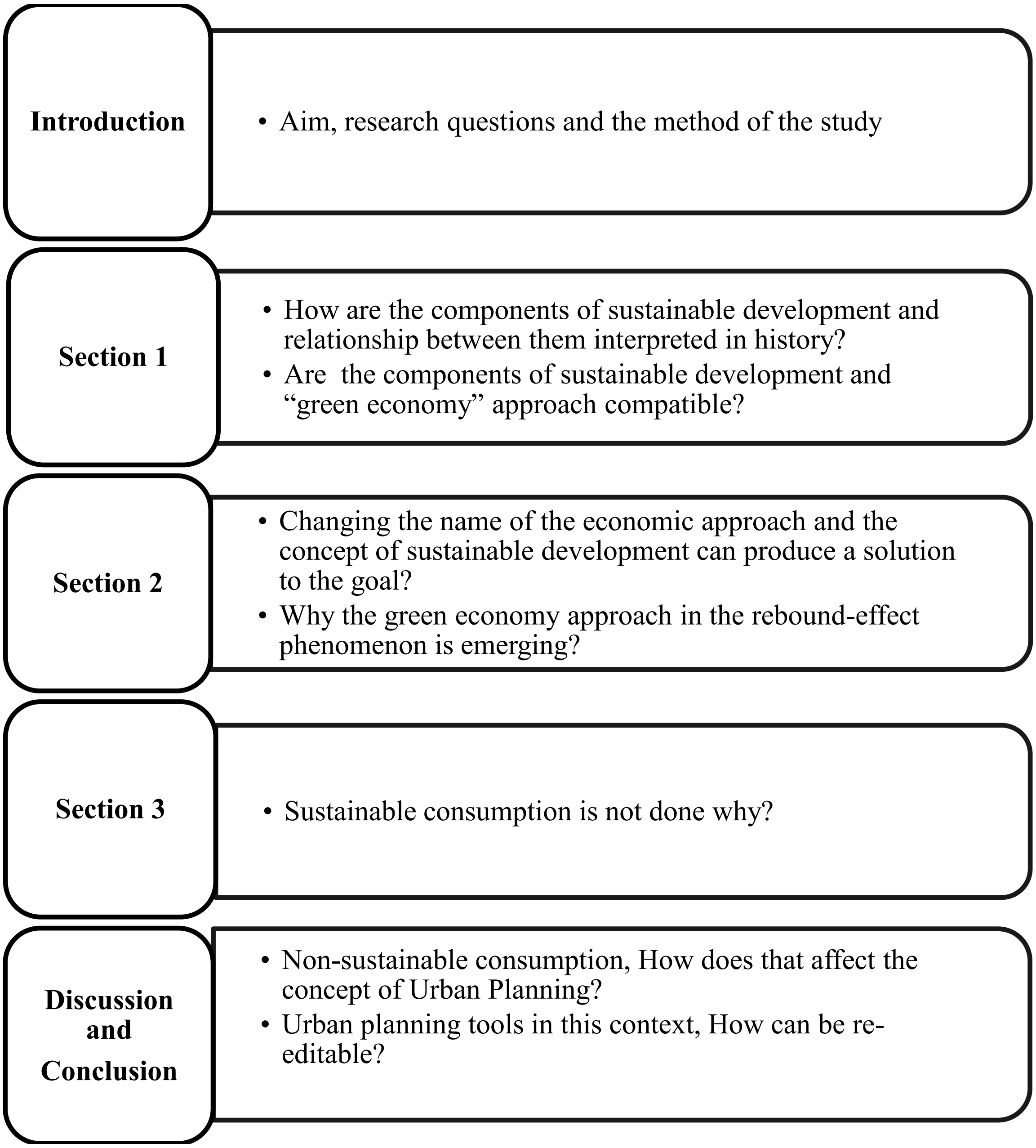
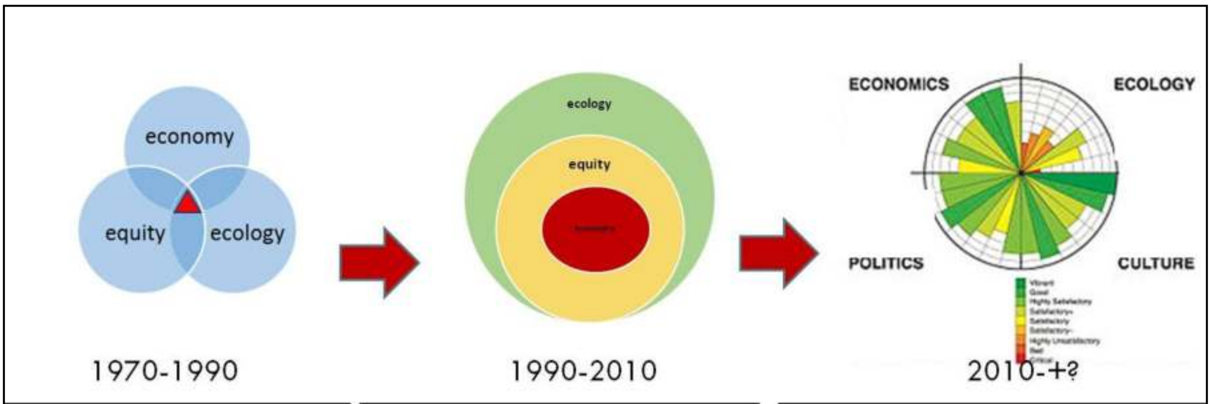


Figure 1: Thinkpiece Questions in the Content of the Study

1. The Components of Sustainable Development and Green Economy Approach

All three components of sustainable development in the 1970s and 80s (community-nature-economy) began to appear on the public agenda and in the planning at the same rate. In the 1990s, environmental problems all over the world has become visibly noticeable (see Fig2). In response to this effect to the work of civil society organizations, in particular, sustainable development of the components of the "environmental" more focus on the phenomenon was born of necessity.



Components: -Economy -Ecology -Equity **Position :**Balanced **Belief:** effective for all of the world.	**Components:** -Economy -Ecology -Equity **Position :** Unbalanced Ecology > Equity > Economy **Belief:** It is too late to find a balance position for the components. People destroyed many parts of the World's natural resources and environmental problems increase day by day.	**Components:** -Economics -Ecology -Politics -Culture **Position :** Unbalanced **Belief:** sustainability goal was failed by the unrealistic beliefs. Its components and applications can/should be differ from country to country. Since all of them has different urban dynamics.

Figure 2: Components of Sustainability and their relations between each of them in history

But the global neo-liberal economic approach in the system, most of the economy is dominated by the left behind the sustainability approach, in theory, even a bona fide destination, can be applied in practice to the present day to get away from the semantic losses and is noted as the source.

In this context, the influence of modernism and the quest for the middle way approaches have changed in the scientific world, advanced, and "Environmental Economics" emerging stronger from the science academic with a workspace "ecological economy" kept on the agenda of the phenomenon (Stop& Başol,2007). "Ecological Economics" in general "sustainable development" as the main goal of classical economic theories set off with "environmental issues" with the title is moving. According to Sengupta (2014);ecological economics are considered interdisciplinary scientific field of study and in this workspace: Ecology, physical resource theory, institutional economics, neoclassical economics, the environment, politics, and sociology, psychology and business organizations, human ecology and sustainable development is all about research fields. In this branch, environmental problems one-on-one is interested in theory, “the theory of externalities” (Stop& Başol,2007). This theory; Ecology and economy among the public is described as an approach to seeking solutions. Externality; Economics field, an asset for production and consumption goods to third parties other than vendors and buyers to install or to provide a benefit at a cost is called (Sengupta, 2014). In the opinion of the Mishan (1993) is another feature of the external behavior of an individual's impact on other individuals was a legitimate activity, and is not intended or earlier is that it is an extraordinary byproduct. According to the economist who created the first theory of externality Marshall(1920) reflected positive externalities to third parties to be questioned, while negative emphasis areas occured. Here is the next sub-research question can be mainstreamed into these externalities? Shaped. So, as a result of substances that are used in production and consumption activities, is it possible to leave no waste processes. At this point, the responses give clues to sustainable development are obtained. Today's manufacturing technologies and recycling efforts significantly advances over the last century to show that although waste-free production and consumption is still not possible (Sengupta,2014). This course of studies after the response given to people to reduce harm and tertiary media evolving. In this loss mitigation, environmental and personal losses in order to resolve different types of taxation and subsidies with persons, institutions or organizations, there are 2 different options on it. This chart outlining all systematic thought (see Fig3) is located below:

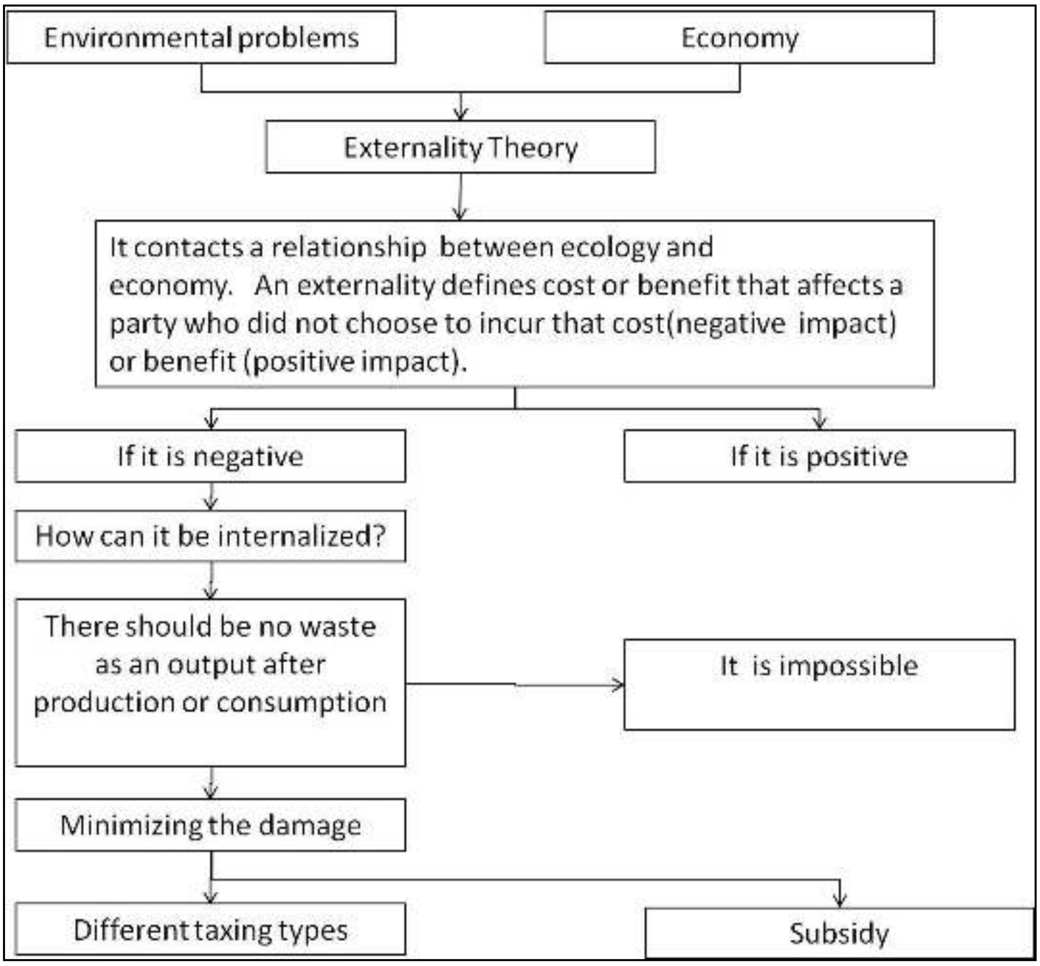


Figure 3: Summary of the relationship between environmental issues and the economy

Summary of the relationship between environmental issues and as a result of the economy, in order to be a new concept for sustainable development approach is the necessity arises. At this point, the "green economy" approach comes up. "Green economy" as found in the literature the term: The United Nations Environment program (UNEP, 2010) Although the concept of a framework proposed; production and consumption as the world's natural boundaries of thresholds can be expressed as an economic approach. Under the theme of ecological economy are separated from each other with the expression as one of several approaches to "green economy" approach among the ecological oriented economies (Hahn, 2013).. Sustainable development, green economy is the first to make the connection between the capital approach in the public interest that creates economic study, published in 1989 by Pearce (1993), Green has been named the blue book for the economy works. In this book, is failing because of sustainable development in today's economies tend to consume natural capital to sustain growth was suggested. 20 years later, in 2009, the UN General Assembly first Rio Earth Summit for 20.To celebrate the year 2012 (Rio + 20) in a Summit in Rio de Janeiro it was agreed to. Two of his agenda for Rio + 20; "The fight against poverty and sustainable development in the context of green economy" and "sustainable development" has been specified as the International Framework for the first time and "green economy" goal, global and officially adopted at this event. UNEP's definition of "green economy"; mankind's environmental risks and the likelihood of ecological scarcity, improve the quality of life and social justice wants to ensure he was born with. The green economy is simply low-carbon, resource efficiency and the thought of social inclusion can be expressed as. The main purpose here; sustainable development and quality of life and the economy is thought to be as a tool for it. "Green economy" of components and objectives with today's global world, the prevailing economic system on the path to sustainability, there are significant differences between (Hahn, 2013). These are conveyed in the following table (see: table1):

Table1: Today's global economy and "green economy", the differences between the approaches are, (adapted from Hahn,2013)

Today's Global Economy	**Green Economy**
To maximize production (To increase GSMH), close to the targeted to maximize profits	Increasing the benefits of low consumption, long term increase in targeted income
quantitatively increasing economic growth	Both the quantitative and qualitative increase economic prosperity
By exploiting natural resources abuse	Planning and efficient use of natural resources
Investors will be focusing on their earnings; -increase the external costs -reduce workforce costs -linear production model -product selling	Focusing on the shareholders ' gains; -external costs reduction -versatile viral production reduction -circular economy model -services for selling
Efficiency is defined as the factor that reduces the consumption	Providing capacity to reach their goals of sustainability efficiency being defined as
Technology and innovation are accelerating the use of energy and natural resources, reduces the efficiency of work force	Energy-work force and natural resources in order to establish a balance between innovation, energy efficiency is the most important target
Based on your personal interests: saving status to persons of consumption Contest	Based on the interests of a broad audience: the use of natural capital incentives for public goods Business Association

It is seen that the green economy approach, in theory, creating strategies that will serve the main goals of economic sustainability; at the same time, provides a positive contribution to the social and environmental components.

2.Rebound Effect in Green Economy: As a Result of Consumption Factor

The economic component of sustainable development in this part of the study with others is to be able to adapt more easily discusses whether there will be enough of the green economy approach. In this context questions also asked: to change the name and concept of the economic approach to sustainable development goal can produce a solution for it? Why rebound effect phenomenon is emerging? Quality of life based on purpose, mostly; low carbon, resource use efficiency, efficiency in energy consumption, focusing on the green economy approach in the rebound-effect phenomenon are encountered (Lin&Liu,2015), (Hahn,2013). Why rebound-effect phenomenon is emerging? The question proposed to call this phenomenon is clearly described and the establishment of relationship with sustainability is required. The term "Rebound effect"; which is one of the most important goals of sustainability energy efficiency and reducing consumption phenomenon is noted as the consumed with (Aydın, 2014), (Lin & Liu, 2015). "A case of repeated consumption described over includes 2 different types of rebound effect (Aydın, 2014).

Direct Way Rebound Effect: To describe the phenomenon of the consumption is deirectly destroyed or where it reduces efficiency.
If there is to be transferred via a simple example of the general; Governments, corporations, etc. organizations by energy-efficient tools to produce a high budget diverged. The idea here; less energy consumption to reduce carbon dioxide emissions, provide as follows. Fuel savings of up to 50% of new vehicles developed provided the person making the 50 km per week with the old tool, this new vehicle less fuel consumption when the 200 km a week, thinking he was doing the main objective is deviated from. In this way gives rise to a further increase in energy consumption and emissions.

Indirect Rebound Effect: Income effect terms in the literature as the energy efficiency obtained with additional income to other energy sources consumption refers to the focus. Very often, to be expressed with a simple example, more for the extension of the practice of urban sustainability, these practices are also supported by both public administrations and the private sector that will contribute to achieving the purpose of the provision of Urban planning, it is believed.
With these facts in the literature as direct and indirect rebound effect, asked at the beginning of this chapter: “the economic approach can produce a solution for change the concept of sustainable development? Generally the answer to the question can be given. Changing methods and approaches do not produce a solution. The system as a whole should be viewed, in part, the problems faced, both within itself and in its entirety should be evaluated.
The rebound effect and negative effects on the sustainability brings forth the issue of “consumerism” in this context also the element of the next section is a phenomenon that needs to be addressed and re-produces the research question.

3.Understanding the non-sustainable consumption behavior with a game theory approach

In the previous chapter with an element of sustainable economic approach could not serve the purpose of consumption have been identified. Why, sustainable consumption is not done in this part of the study? The main question with "renewable energy, energy efficiency, and all technological

developments, political support, even if these components to consumer society enough?" an answer to sub-question is being sought.
While you're at it "dealing with the economic behavior of consumption, researching game theory" (Hanley&Former,1998) over a general review will be made. City planners perspective, game theory approach with only; city planning since the 1990s are concentrated in "sustainability", why can not reach the purpose, general idea, located under the economic behaviors, therefore the validity of the impact on society and the nature of the world being studied.

Game theory, which explains the uncertain situation that many decision makers are in, will affect planning discipline in a positive way. Nijkamp (1980) proposed negotiations between agents for solving externalities in environmental problems and he added that game-theoretic strategies could be used for negotiations. He indicates min-max models that the compromise solution for conflicting objectives is based on conflicting strategies from game theory.

Game theory approach to urban planning discipline it wants to achieve with the actual result; More for the extension of the practice of urban sustainability, these practices are also supported by both public administrations and the private sector that will contribute to achieving the purpose of the provision of Urban planning, it is believed.

Game theory, an individual's success is based on the selection of other choices covering strategic situations do mathematically behaviors has been working to catch up. While modeling environmental problems since the 1960s as the sole strategy of the country uses to produce theories accepted (Stevens, 1961). According to Hanley, friends and Folmer (1998) international environmental problems addressed to the main static game theory concepts: Pareto efficiency, market equilibrium and Nash equilibrium can be listed. Briefly the content of this concept is to be transferred (if Hanley, Folmer&et al.1998):

Pareto Efficiency: Society producer, consumer and factor the status of one of the owners, without sacrificing one of them for improving the situation of someone else where it is not possible resource allocation status with the approach of this theory is expressed(Folmer&Musu,1992).. So, without reducing the welfare of at least one other of the individual in society the possibility of improving the welfare of society or the welfare of the opinion that it is defended optimum.

Market Equilibrium: The amount of a certain price level in the market the quantity of presentations with the prompt is equal to each other, in other words an excess of involuntary or presentation and can be described as the absence of (Hanley, Former & Mibfeldt, 1998). Win-win situations that accept a system that works, in theory, the supply with the demand for both producer and consumer in the belief that it would always balance each other out.

Nash Equilibrium: According to Hanley,Former (et al) (1998); each player select one of the actions within the game and all the players accepted that it is in the case of making such a choice. The selected action to a player, other players have chosen their action when given, which can be played (in the sense of return) is the best action for all players, and if this feature is provided ,these actions constitute a Nash equilibrium. Here players, they can choose simple actions, and multiple actions they can opt to play with a certain probability. According to the other theory approaches that appears more complex this theory; Hardin's(2000) book, descriptive of the subject in the literature, the most recognizable example is the (prisoner's Dilemma) can be read through the example. The prisoner's dilemma, which is known to be two criminals in the different interrogation rooms have been tried to be forced to confess their ensured crimes. Police is aiming the confession to be easier by making a deal with the suspects. According to the agreement, one of the suspects testifies against the other and the other remains silent, the one who testifies will be released and the other who remains silent will be sentenced to10 years imprisonment. If they both do not testify against each other and remain silent, both 1 year imprisonment, if both testify against each other they will both be imprison for 5 years. At the end of the game both players have a short-term prison sentence to be preferred to the longer one, and each one will not gain any benefit from reducing the penalty of assuming that the other prisoner's dilemma, zero-sum games are considered as. However, prisoners that are expected from an environment of trust, based on individual interests rather than the decision to higher productivity in the long run, in the short term, low-efficiency, they continue with the decision to testify against each other. Game theory approaches to sustainable development and the players that are observed when the sole purpose of the bond is established independently from other players, to maximize their own profits. Here, environmental issues, therefore, according to the model of sustainable development to be adapted to the desired behavior; long-term investment, instead of the height of purposeful work and productivity; in the short term, a temporary solution, fast, efficient but low profit approach, represents human nature on the economic behavior. The belief that an individual is able to increase the welfare of other individuals due to the use of natural resources-waste, the use of distribution represents. It would balance out supply and demand balance of the market in accordance with their belief that no it's not the end of existence, emphasizing the consumption of like represents. Nash equilibrium in the approach of all societies, on the global level, and equal with interest in a holistic way, to move in the path of sustainable development strategies in an environment of insecurity produced concluded that would not be possible.

4.Discussion and Conclusion

Finally in the results section of the study, the questions are: non-sustainable consumption, How does that affect the concept of Urban planning? Urban planning tools in this context, How can they be re-editable? In fact, the content and scope of the questions; is not only the discipline of planning, covering all relevant disciplines, inter or trans-discipline is to describe a discussion of the environment. “The phenomenon of consumption, the economic system of the conscious and unconscious communities, particularly the media element is driven with a phenomena that” it is a fact that is publicly accepted (Baudrillard, 2013). However, the questions according to the response received from the literature in search of related topics; every creature, even though the yield is low in the close process that maximize profits in the long term high yield without general to observe the behavior can be specified.

First systematic thought in the ring; the relationship of the green economy and sustainable development and consumer relations in the cycle of the rebound effect of the subjects in this study have been analysed. Every one of the key words in the review has been questioned in connection with another theoretical. The result that is to be accessed; replacement of the current economic system in order to ensure sustainable development, or the economy in terms of being compatible with the other components to the understanding of sustainability has been on the introduction of naivety. Ecological economies, and which is an example of this approach, which is one of the most important components of the green economy with regard to energy efficiency that may not be serving the purpose is understood. Here intervenes and consumption habits or lifestyle questioning the necessity of the human factor has been identified. In this context, especially environmental issues within the scope of the study of economic behavior, game theory has been interpreted as a general topic.

In the latest systematic thought point; independently of each other, all living things on earth has been on wanting to maximize their own profits. For that reason they lived or attack the current global economic system is still supported. Instead of holistic and long-term mindset with contributing to sustainable development, focuses on understanding individual and collective consumption and economic growth empoze. But the human can intervene and all creatures cycles for more destructive effects, hence it is more observable.

For this reason a human being who can think, should be trained in accordance with the behavior of consumption, should be directed behaviors. For the discipline of planning, at this point, the approach adopted on the basis of the objectives of sustainable development for the future of sustainable development in 3E or which they adopt all the components approach, on the components of consumption "element/pressure can be said for the importance. The components of sustainable development into a slippery floor is prepared, the element that creates conflict and tension between each other in this context, is an element of consumption. The components of sustainability in the planning studies, the present neo-liberal economic there is no requirement to be addressed by considering the plane again. While the planning tools that are adapted to 3E's also seen first have to consider the phenomenon of consumption, and how, by whom it should be directed. Sustainability approach away from its own logic and being applicable for this reason, a critique of the romantic approach. The main purpose of Urban planning since the 1970s, which is only due to the element of the sustainability of consumption, planning of scientific, social and economic, rather than supporting the validity puts you at risk. In this context, in order to increase the prosperity of the people of the individual and an increasingly science of existing planning, on the social process of participation and governance, especially in vehicles is expected to develop policies, arguments over consciousness. More for the extension of the practice of urban sustainability, these practices are also supported by both public administrations and the private sector that will contribute to achievement and the purpose of the provision of urban planning, it is believed.

Solar heat strategies for Vienna: identifying regions with highly reliable and affordable potential

Julia Forster[1], Sara Fritz[2], Nikolaus Rab[2]

[1]A1 Vienna University of Technology, Department of Spatial Planning, Interdisciplinary Centre For Spatial Simulation And Modelling Vienna - SIMLAB, julia.forster@tuwien.ac.at;

[2]A2 & A3 Vienna University of Technology, Institute Of Energy Systems And Electrical Drives, Energy Economics Group, fritz@eeg.tuwien.ac.at; rab@eeg.tuwien.ac.at;

Keywords: solar heat, economic potential, 3D city model

ABSTRACT

A techno-economic heating energy system model for Vienna (Austria) is developed. Based on an existing solar potential map, different solar heat strategies can be evaluated economically and ecologically. The resulting share of installed solar heat units for every building is displayed in a 3D city model. This 3D model allows city planners to study the spatial impact of these strategies. Results are reported for three different scenarios, which differ in the assumptions regarding policy frameworks.

1. Introduction

1.1. Motivation

The heat sector causes a huge share of a city's energy demand: in Vienna 41 % of the final energy demand is used for heat and domestic hot water demand (Stadtvermessung Wien (41), 2013). Actually, less than one percent of this demand is supplied by solar heat - a negligible share of the theoretical potential of 27.2 TWh (Haas et al., 2013). To exploit this theoretical potential for solar heat, investments in buildings heating technologies are necessary. These investments have to be done by the building owners and therefore subsidies and political strategies can be helpful to influence these decisions and the share of renewable heating technologies.

For a sustainable long-term planning of a city's energy system, the strategies have to be analyzed from an economic and social point of view too. The increase of decentralized solar heating technologies can worsen the economic feasibility of centralized supply by district heating due to a decrease in demand. The interdependencies between the centralized and decentralized heat supply as well as the interdependencies between the investment decision of the building owners, the government and strategies of district heating operator require an interdisciplinary analysis.

Such an interdisciplinary analysis aims to indicate the reduction of the total costs for heat supply, the reduction of the CO_2 emissions and the share of each technology for different strategies. In addition, it is necessary to provide the results for scenarios differing in subsidies and strategies in a decision support tool to analyze the long-term effects.

This approach addresses the following research question:
"How do solar heat strategies influence the energy system and the spatial footprint of a city and which consequences arise for its total costs, the CO_2 emissions and the share of renewables?"

1.2. State of Art

In recent years many different 3D city models have been developed for computing the theoretical potential for solar energy in urban areas (see for example (Hofierka and Kaňuk, 2009) and (Erdélyi et al., 2014)). However there has been little work on the economic viability for solar energy strategies that are trying to exploit these potentials. Up to now no simulation model exists for future heat demand and supply of all buildings in a city that includes an economic and ecological analysis of the impact of solar heat strategies, as well as the visualization spatial planning.

The well-established model Invert/EE-Lab considers the heating related investment decision of building owners due to legislatives, subsidies and obligations (for detailed description see (Müller, 2015), selection of projects and publications: (Kranzl et al., 2014a), (Müller and Kranzl, 2013), (Müller et al., 2010), (Kranzl et al., 2014b)),. It describes the future development of buildings heat demand and the share of the different heating technologies for the building stock. In particular it can be used for the analysis of the impact of solar heat strategies on the building owner's decisions. However when concerning the entire heating energy system the supply side sub-model for district heating, described in 2.2.2. Optimization model for district heating supply, is needed. Many other existing models like (Blesl, 2002), (Neuffer and Witterhold, 2001), (Hausladen and Hamacher, 2011), (Hensel, 2013) or (Nielsen and Möller, 2013) focus on the optimized expansion planning of existing district heating networks and also considers the heat supply. The development of the buildings' heat demand is not considered explicitly it's considered via endogenous scenarios.

3D city models in general support multilevel and procedural planning processes as cooperative planning instrument used in the "Model of Vienna" ((Freisitzer and Maurer, 1985)) or problem solving strategies in planning environments based on trainings formulated by Walther Schönwandt ((Schönwandt et al., 2011)). The aim to help city planners and policy makers is also included in a project of the ETH Zürich in collaboration with IBM, ESRI and the Imperial College London, named "Smart Urban Adapt". This project wants to support "european cities with next-generation decision tools, to design development paths for the 1-ton-CO2-society."(Weinstock, 2013, p.120-124) It comprises a scenario-based low carbon development path assessment. In 2011 Daniel Segraves and Adrian Smith dealt with the goal to reduce carbon too. They designed a "decarbonisation tool" for the city of Chicago. It is a comprehensive decision support tool within a 3D graphic environment, that incorporates carbon tracking, building energy analysis, design and planning optimization.(Weinstock, 2013, p.120-124).

1.3. Overview

To evaluate solar heat strategies economically and ecologically we introduce a techno-economic model of the entire heating energy system of a city with three different sub–models, described in section 2.2. However, it should be recognized that the areas of highest economic potential for solar heat is not necessarily the preferred optimal location. This is determined by the impact on the cityscape especially in the historic center. Thus simulations of visual axis for economic reliable solar heat units are needed for spatial planning. Therefore we build a 3D spatial simulation described in section *2.3 3D spatial simulation*.

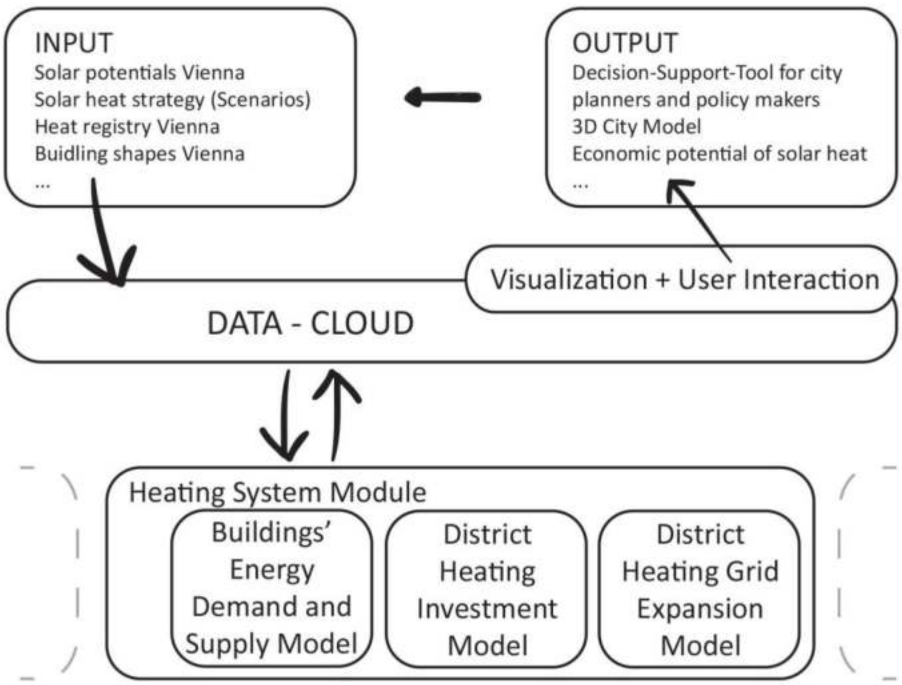


Figure 1: Overview of the evaluation platform environment

For our calculation we will use three different scenarios for subsidies until 2030, that can be found in section *3.2 Scenario Description and General Assumptions*. We will build our economic computations on the existing solar potentials computed by the Viennese municipal department 41 (Magistratsabteilung 41 der Stadt Wien), for an overview see *3.1 Data set* .The results of the economic and ecologic assessment can be found in section *4. Results* as well as in screenshots of the 3D spatial simulation.

2. Methodology

2.1 Methodological Framework

We use a techno-economic model for a city's heating energy system and a 3D spatial simulation in order to evaluate different solar heat strategies based on economic, ecological and spatial planning criteria. Based on a data cloud, the involved sub-models of the heating energy system model (see *2.2.*) are connected to this cloud enabling the data transfer. On top of the data cloud, a visualization environment is involved, displaying a 3D simulation of the installed solar heat and illustrating the considered scenarios with the predefined parameters. The visualization environment also enables user interaction and predefined parameter control. Figure 2 shows an overview of the visualization framework, including the sub-models.

2.2. Modelling heat demand, supply and related infrastructure

For evaluation of solar heat strategies by economic and ecological criteria we set up a techno-economic model for the entire heating energy system. Modelling only the building owners' investment decisions for different solar heat strategies is insufficient for city planning: rising capacities of decentralized heating technologies have a strong influence on the economic viability of district heating and subsequently on the overall CO_2 balance of a city's heating energy system. Many district heating systems rely on combined heat and power plants that have a thermodynamically highly efficient use of fuel. Thus a substitution by solar thermal heating may be undesirable in the short-run. On the other hand extending the existing district heating grid causes additional costs that have to be taken into account for investment decisions. Thus the heating energy system model for Vienna for evaluation of solar heat strategies consists of three parts:

a. a simulation model for the future development of the buildings' heat demand and supply. It considers the economically based investment decisions for increasing energy efficiency as well as heating technologies including solar heating.
b. an optimization model for the investments in district heating plants based on the buildings' district heat demand computed in (a). It will give a cost-minimal investment strategy for district heating based on the future demand.
c. an optimization model for the district heating grid expansion. It maximizes the heating network operator's profit with possible new connections of building blocks to the existing grid.

The results of the heating energy system models comprise the investment costs in heating systems, the share of all technologies as well as the corresponding CO_2 emissions. Figure 2 shows an overview about the methodological framework. Moreover we provide a more detailed description of the mathematical foundation in the following sections.

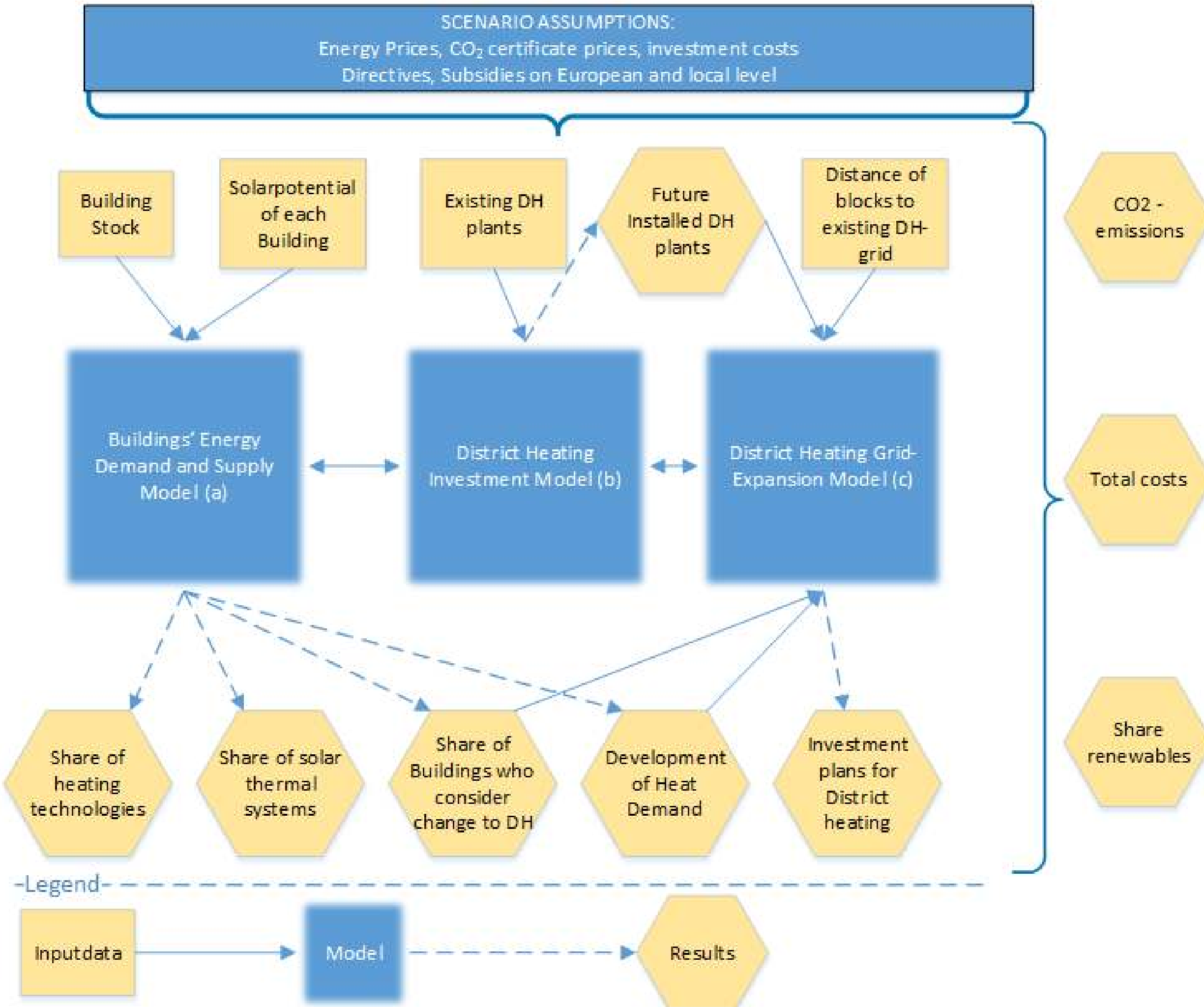


Figure 2: Overview of the methodological framework

2.2.1. Simulation model for buildings' heat demand and supply

For the simulation of the buildings' heating demand up to 2030, the share of solar heat, district heating and other heating technologies, the existing techno-socio-economic bottom-up modelling tool Invert/EE-Lab is used (for detailed description see (Müller, 2015)). The model uses a cost based logit approach to describe potential future paths assuming the consumer's decisions strongly depend on the costs of technology. These costs cover energy prices, connection costs for grid-bounded heating systems as well as obligations or subsidies. The buildings are grouped by their area of settlement, usage of building, building size, construction period, quality of thermal insulation and installed heating system. With the usage of areas of settlement the building can be located within the city and a distinction for different connection costs to the existing district heating network is possible.

2.2.2. Optimization model for district heating supply

The model for district heating plant investments assumes that investments are based on aiming minimal generation costs. The optimization program for the district heating system is based on a generation expansion planning model (GEP), a well-established linear program (De Jonghe et al., 2011). A simple model for short-term CHP planning of (Lahdelma and Hakonen, 2003) will be used to adapt the standard GEP formulation for district heating investments.

For every year $t \in T$ the district heating plants $i \in I$ are associated with fixed costs F_i (in Euro/kW). Heat generation is optimized for every hour. For every plant $i \in I$ we consider the sets of extreme points of the (convex) feasible generation region J_i.For the j_{th} extreme point then we have corresponding variable costs of cogeneration $V_{i,h,j}^{h}$ (in Euro) with generation of $g_{i,h,j}^{h}$ $\mathrm{kWh_{th}}$ heat and $g_{i,h,j}^{el}$ $\mathrm{kWh_{el}}$ electricity for every hour $h \in H_t$. The optimal generation can be displayed as convex combinations with weights $\lambda_{i,h,j}$ with $j \in J$. (see (Lahdelma and Hakonen, 2003) for details)

Investment decisions are modelled via the binary variables

$$n_{i,t} \coloneqq \begin{cases} 1 \; opening \; plant \; i \; in \; period \; t, \\ 0 \; else. \end{cases}$$

If the plant already exists $n_{i,t}$ can be set to 1, i.e. $n_{i,t} \coloneqq 1$ for all $t \in T$. Further we need to include the spot electricity market with spot price s_h (in Euro/$\mathrm{kWh_{el}}$) for every hour $h \in H_t$. Note that all monetary values are discounted and all decision variables are non-negative.

In such a two-stage formulation, $n_{i,t}$ are the first-stage decision variables, $\lambda_{i,h,j}$ the second stage decision variables. Thus we have the program:

$$\min_{n} \coloneqq \sum_{t\in T}\sum_{i\in I}\sum_{s=1}^{t} F_{i,t}\eta_{i,s} + \sum_{t\in T}\sum_{h} O_h(\eta_{i,t}),$$
$$O_{h(\eta_{i,t})} \coloneqq \min_{\lambda} \sum_{i\in I}\sum_{j\in J_i} V_{i,h,j} - g_{(i,h,j)}^{el} s_h \lambda_{i,h,j}$$

To ensure that heat and power generation is within the feasible operation region of every power plant and only proceeded in already built plants, suitable constraints are included. Moreover heat generation has to meet district heating demand for every hour. Additionally technical linear operation constraints for district heating plants can be added, e.g. temperature requirements for the district heating system.

2.2.3. Optimization model for district heating grid expansion

The investment optimization for the district heating grid expansion is based on the results of the module (a), shown in Figure 2, grouped by building blocks. The objective of the mixed-integer linear program model with several investment periods is to maximize the heating network operators profit P_i, under consideration, that already connected blocks can't be disconnected as long as there is heat demand for district heating. The costs for the grid extension/expansion c_{inv} and the costs for heat generation c_g are considered, as well as the capital costs c_{cap} and operation costs c_{op}. The revenues R_{tot} respect the base price p_{base} dependent on the blocks heat load in MW and the demand charge p_{dc}, which arise from the heat demand in MWh. The objective function is to maximize the profit Π, where r is the interest rate, T the considered horizon, P_b the connected heating load in MW of the building block and $D_{b,t}$ the heat demand in MWh per block.

$$\max_{x_{b,t,}} \Pi = \sum_{t=1}^{T} \frac{R_{tot,t} - c_{tot,t}}{(1+r)^t}$$

$$R_{tot,t} = \sum_{b \in B} \left(p_{base,t} + p_{dc,t} D_{b,t} + p_{base,t} P_b\right) x_{b,t}$$

$$c_{tot,t} = c_{cap,t} + c_{op,t} + c_{Inv,t} + \sum_{m=1}^{12} c_{g,m,t}$$

Due to cost variations within the year for the heat generation costs c_g, these costs are calculated on monthly base. The decision, whether a block is connected to the district heating network or not is formulated as a binary variable $x_{b,t}$.

$$x_{b,t} \coloneqq \begin{cases} 1 \; if \; block \; b \; is \; connected \; in \; period \; t, \\ 0 \; else. \end{cases}$$

This binary variable also indicates blocks, which are already connected to the existing heating network and influences the capital costs c_{cap}, the operation costs c_{op} and the costs for the grid extension/expansion c_{Inv}.

2.3 3D spatial simulation

For further evaluation of the economically and ecologically reliable solar heat strategies by means of their spatial footprints, we propose a 3D spatial simulation. It serves as a decision support tool and is based on the output data of the heating energy system model, in particular the future installed solar heat units per building. It allows spatial analysis in a three-dimensional virtual space.

The computed installed solar heat units data is joined with the building shape data via an ID number defined by the GIS data source for buildings of Vienna. These GIS based data can include several parts of a building complex with the same ID. We dissolve all building complexes via their IDs and the maximum height of all parts will be assigned to the building complex. Thus a two dimensional map can be designed with the solar heat units for the considered scenarios in specific city quarters over time as well as the distribution of solar heat units in the whole city.

Based on this 2D city map, areas of particular interest, determined by the city planner can be displayed in bigger scale and transformed in a 3D city model with a rule based procedural 3D modeling software

(ESRI City Engine). The two dimensional building shapes are extruded to three dimensional objects, roofs and front buildings. A 3D city model is evolved which enables the possibility to change single object's appearance via defined color intervals corresponding to the data it represents. The underlying data determine the visual design of the spatial objects.

To enable interactive user control and multi-scalar viewing options, the use of a web viewer (ESRI) is beneficial. Especially the possibility of implemented features like sun altitude simulation within diurnal variations offers advantages for the user.

3. Data and Case Studies

3.1 Data set

Two main data sets are used for this case study: the "Solar potential registry of Vienna" (Wiener Solarpotential Kataster) provided by the municipal department 41 and the "Heat registry of Vienna" (Wärmekataster Wien) provided by municipal department 39. The Solar potential registry of Vienna (GIS data set) is a land register for the solar potential in Vienna and includes the area suitable for solar thermal and photovoltaic potential for every single building. The Heat registry of Vienna (table data set) contains every single building from Vienna with the construction year, actual heat demand and its geometry like total gross floor area, ground area, number of floors, etc... The theoretical potential for solar thermal is the basis for the actual used potential up to 2030, determined with the simulation model.

To match the data structure for the used models (see chapter *2.2.1. Simulation model for buildings' heat demand and supply* for detailed description) some modifications and pre-calculations are necessary: In a first step, the data for the solar potential has to be matched to the building stock database and as the potential for the simulation model depends on the available roof area and the algorithm of simulation model is for segments and not for every single building, the roof area as well as the area for the theoretical potential has to be averaged. For visualization purposes GIS data sets representing streets, parks, etc. of the Open Government Data[1] Platform are used.

3.2 Scenario Description and General Assumptions

Three exemplary scenarios, based on those described in (Müller and Kranzl, 2013), are considered. These scenarios are adapted for the situation in Vienna, since the scenarios in (Müller and Kranzl, 2013) represent the situation for policy instruments for whole Austria. It's necessary to mention here, that the considered scenarios don't represent the actual situation in Vienna, they just should point out potential developments dependent on different policy frameworks.

[1] https://open.wien.gv.at/site/open-data/

- Scenario 1 - WEM (With existing measures): This scenarios represent roughly the existing policy frameworks implemented in spring 2012 in Austria. The Scenario considers investment subsidies for heating systems and for refurbishments up to 2030. (see detailed description in (Müller and Kranzl, 2013))
- Scenario 2 - WEMpluSol (Additional Solar thermal subsidies): In addition to the policy frameworks from Scenario 1 the investment subsidies for solar thermal are increased.
- Scenario 3 - WAM (with advanced measures): In addition to the WEM Scenario additional budget for renovations is available and the renovation quality increases within the simulation horizon. (see detailed description in (Müller and Kranzl, 2013))

The focus of the analysis of all scenarios is on the actual building stock. New buildings due to the increase in population are neglected. However, buildings newly constructed due to demolition are included in the case study. In addition, the competition between photovoltaic and solar heat isn't the focus of this study either.

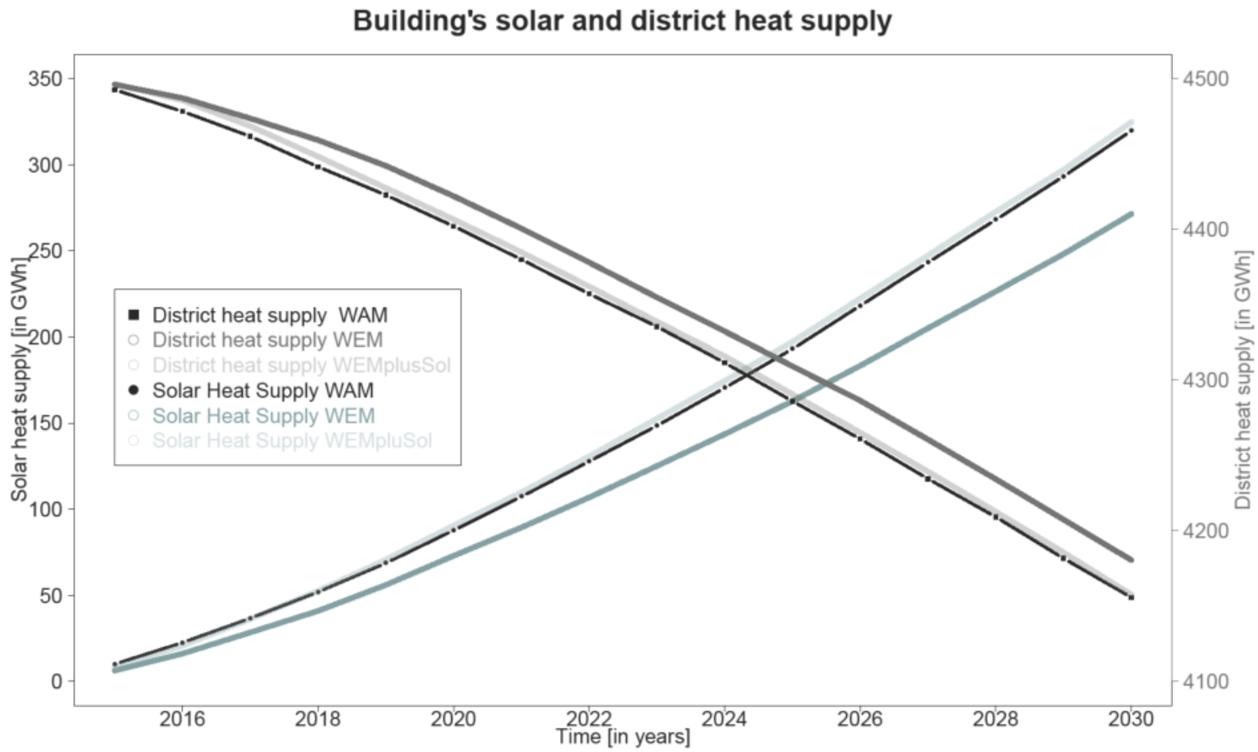
The yearly price increase varies in average during the simulation period between 1.02% for gas and 0.76 % for district heating, the two mainly used energy carriers for heating and domestic hot water in Vienna. (In 2013, share of gas in final energy consumption: 42.3 %, share of district heating: 40.6 % (Statistik Austria, 2014)) For climate data, the hourly averaged temperature values for the years 2012-2014 are used (Source: Wien Energie).
We assume constant losses for district heat distribution amounting to 7.5 %[2].

4. Results

To compare the results for the different scenarios, the following indicators are used:

- Average CO_2 Emissions (kg/GWh) for heat and domestic hot water supply.
- Cumulative costs for the building's heat and domestic hot water demand from 2015 until 2030. These costs include the annuity of investments in refurbishments, the annuity of constructions of new buildings and investments in heating systems as well as subsidies for refurbishments and heating systems and annual energy dependent consumption costs and operation and maintenance costs.
- Share of solar heat and district heating in the final heat consumption in 2030.
- Additional average generation costs for district heating in 2030. These costs include future annualized investment costs for new heat plants as well as fuel costs in 2030. They do not include investment costs for already existing plants.

[2] Source: http://www.nachhaltigkeit.wienerstadtwerke.at/oekologie/energieerzeugung-bereitstellung/energieeffizienz.html



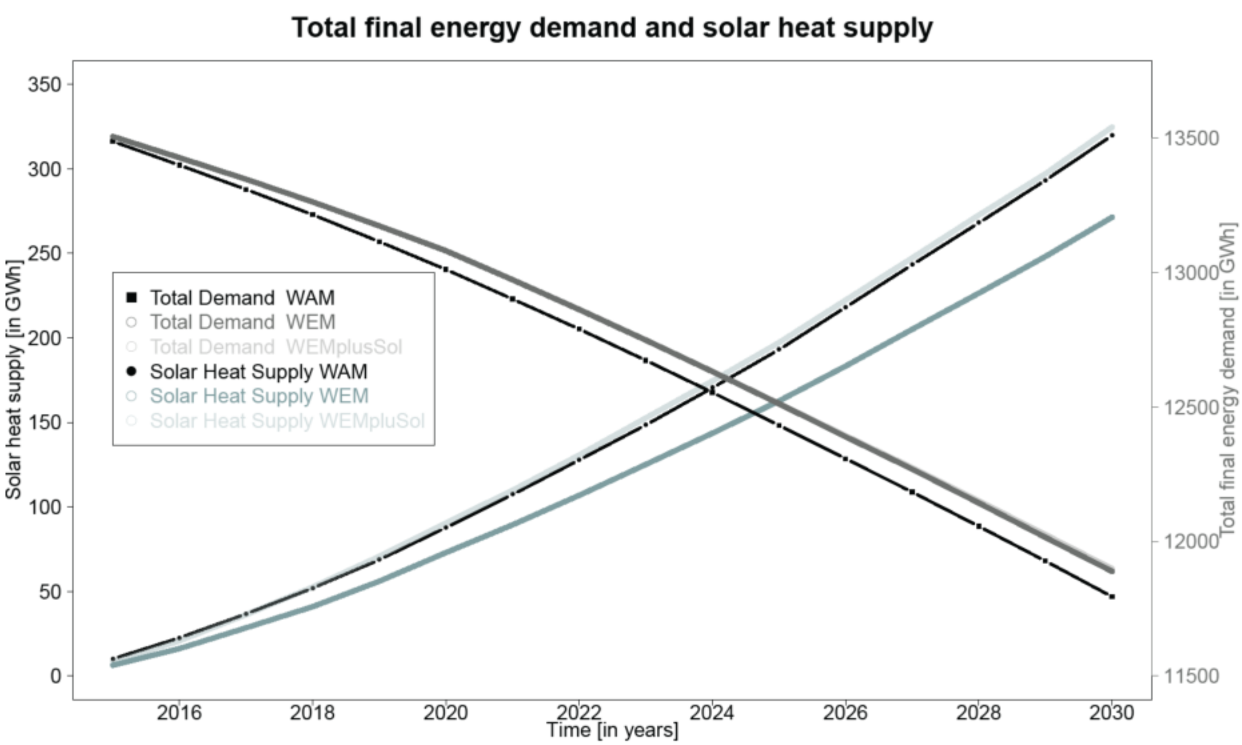


Figure 3: Development of the building stock's (Residential and office buildings) final energy demand for space heating and domestic hot water

In Figure 3 final energy demand (FED) for buildings in GWh in total and for district heating and solar heat is depicted from 2015 until 2030. The FED in total remains the same for the WEM and WEMpluSol scenario since the WEMpluSol scenario considers higher subsidies for solar heat with no additional incentives for the building owners to decrease their energy demand. The FED for the WAM scenarios decreases until 2030 by approximately 105 GWh. The impact of the additional solar heat subsidies is highlighted in the plot for the district heating demand and the solar demand: Here, the same change in demand for the WAM scenario and the WEMpluSol can be seen.

Table 1: Overview economic and ecological assessment

Scenario	Avg. CO_2 emissions [$kgCO_2/kWh$][3]	Cumulative Costs demand side [Mio. €][4]	share solar in 2030 [%][5]	Share district heat in 2030 [%][5]	Generation Costs district heat 2030 [€/MWh][6]
WEM	0.2248	3031.7	2.20 %	35.16 %	19.87
WAM	0.2239	3028.3	2.70 %	35.23 %	19.81
WEMpluSol	0.2236	3034.7	2.73 %	34.94 %	19.80

In Table 1 the indicators for all three scenarios are shown. Due to the lowest final energy demand in the WAM scenario and the same demand for solar heat and district heat as in the WEMpluSol scenario, WAM scenario has the lowest CO2 emissions. In addition, because of the reduction in the energy demand, the additional costs in the WAM scenario are balanced and the lowest average costs for the considered simulation horizon can be seen. As the building's energy demand and supply model gives a similar decline in demand for all three scenarios there will be no difference in district heat generation costs and investment decisions computed by the district heating investment model. In all three cases a modest change of the generation portfolio by installing 50 MW of heat pumps is cost-optimal. Thus the district heat generation in Vienna would still be mainly based in these scenarios on CHP plants with heat-only boiler station for peak load and incineration plants for based load. As the generation portfolio remains widely unchanged the additional generation costs can mainly attributed to fuel costs (gas) and the gains/losses of electricity generation by CHP plants.

- 3 Calculations based on the following values for CO2-emission: Gas: 0.252 kg/kWh, Oil 0.299 kg/kWh, Coal: 0.34 kg/kWh, electricity: 0.157 kg/kWh, district heating: 0.211 kg/kWh, Wood: 0.025 kg/kWh, wood pellet: 0.052 kg/kWh
- 4 The Cumulative costs of the demand side include the annuity of investments in refurbishments, the annuity of constructions of new buildings and investments in heating systems as well as subsidies for refurbishments and heating systems and annual energy dependent consumption costs and operation and maintenance costs.
- 5 The share is defined as the proportion of solar energy resp. district heating in the final energy consumption.
- 6 These costs include future annualized investment costs for new heat plants as well as fuel costs and gains/losses from electricity generation by CHP plants in 2030. They do not include investment costs for already existing plants.

Screen shots of the 3D spatial simulation are shown in Figure 4-Figure 6. In all three figures the probability of installing solar heat units until 2030 for different scenarios is displayed. In Figure 4, a 2D map of a city quartier in Vienna is displayed. This 2D map gives an overview of the impact of solar heat strategies. The City planner can choose some areas with particular interest that can be shown in a 3D partial simulation as shown in Figure 5. Here, two scenarios can be considered simultaneously. Moreover this 3D spatial simulation allows for more detailed street views too (see Figure 6).

Figure 4: 2D city map with the share of installed solar heat units in comparison to the theoretical potential until 2030 for WAM scenario

Figure 5: 3D Spatial simulation with the share of installed solar heat units in comparison to the theoretical potential of installing solar heat units until 2030 for WAM (right) and WEM (left) scenario

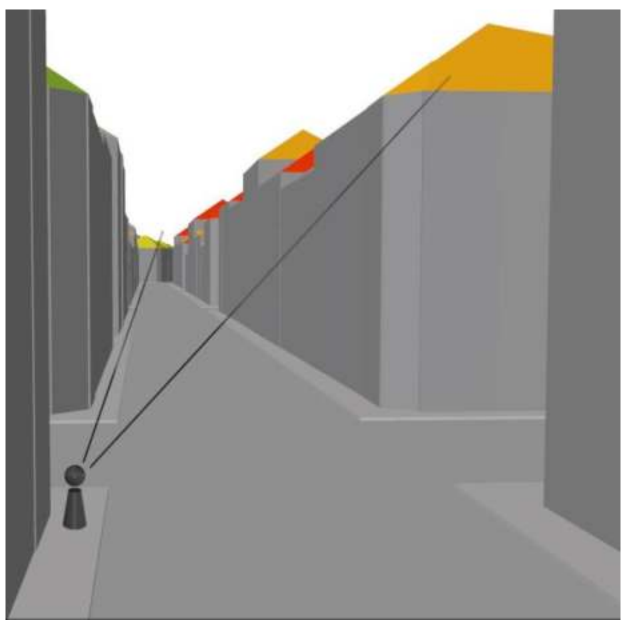


Figure 6: Street view within the 3D spatial simulation

The interactive (ESRI web viewer) version (see Figure 5) is available under: http://tinyurl.com/oebhcbl. It enables the comparison screen for two scenarios (WEM: Scenario 1; WEMpluSol: Scenario 2) for the year 2030. The Legend for the online tool is shown in Figure 4.

5. Conclusions

In this paper we developed a methodological framework for evaluating solar heat strategies based on economic and ecological indicators. Further we implemented a 3D spatial simulation of the probabilities of installing solar heat units for every building roof in Vienna. This allows an additional analysis of the possible spatial impact of economic and ecological reliable solar heat strategies. As seen in Figure 4 an economic assessment of theoretical solar heat potentials yields a quite different distribution of the most favored locations for solar heat. This can be attributed to the fact that many buildings with high theoretical solar heat potentials may already have economically or ecologically efficient heating systems installed. Thus we believe that such an analysis is essential for reliable city planning. Furthermore, we believe that using a 3D spatial simulation enhances city planning, since this is the easiest way for displaying spatial impacts.

Concerning the results for the city of Vienna, we want to raise several points: The theoretical solar heat potential differs severely from the economic potential. However solar heat subsidies don't have displacement effects on the usage of district heating in a city. In our computations mainly usage of gas for heat supply decreases by purely economic reasons. This is very satisfying from an ecological point of view and eases the implementation of solar heat strategies for city planners. Finally we have to emphasize that our 3D spatial simulation is designed as a decision support tool for city planners only. For detailed and reliable analysis, city planners need to define buildings, where installments of solar heat units (panels) are undesirable. Furthermore they have to define visual axes that have to be preserved due to historical or cultural reasons.

6. Acknowledgment

This project would have been impossible without the support of Wiener Stadtwerke Holding AG, Wien Energie and the PhD course URBEM. Further we would like to thank Stefan *Dürauer (MA 41) and Christian Pöhn* (MA 39) for providing us the data sets on building solar potential registry, GIS building data and heat registry.

7. References

Blesl, M., 2002. Räumlich hoch aufgelöste Modellierung leitungsgebundener Energieversorgungssysteme zur Deckung des Niedertemperaturwärmebedarfs. Universität Stuttgart, Stuttgart.

De Jonghe, C., Hobbs, B.F., Belmans, R., 2011. Integrating short-term demand response into long-term investment planning (Cambridge Working Papers in Economics No. 1132). Faculty of Economics, University of Cambridge.

Erdélyi, R., Wang, Y., Guo, W., Hanna, E., Colantuono, G., 2014. Three-dimensional SOlar RAdiation Model (SORAM) and its application to 3-D urban planning. Sol. Energy 101, 63–73. doi:10.1016/j.solener.2013.12.023

Freisitzer, K., Maurer, J., 1985. Das Wiener Modell - Erfahrungen mit innovativer Stadtplanung; empirische Befunde aus einem Großprojekt. Wien.

Haas, R., Ajanovic, A., Dietrich, R., 2013. Energie! voraus; Energiebericht der Stadt Wien; Daten 2011 / Berichtjahr 2013.

Hausladen, G., Hamacher, T., 2011. Leitfaden Energienutzungsplan.
Hensel, P., 2013. Optimierung des Ausbaus von Nah- und Fernwärmenetzen unter Berücksichtigung eines bestehenden Gasnetzes. Universität Paderborn, Paderborn.
Hofierka, J., Kaňuk, J., 2009. Assessment of photovoltaic potential in urban areas using open-source solar radiation tools. Renew. Energy 34, 2206–2214. doi:10.1016/j.renene.2009.02.021
Kranzl, L., Hummel, M., Matzenberger, J., Müller, A., Toleikyte, A., 2014a. ACRP - Austrian Climate Research Program: Power through Resilience of Energy Systems: Energy Crisis, Trends and Climate Change (PRESENCE), Austrian Climate Research Programme ACRP 3rd Call. Climate and Energy Fund.
Kranzl, L., Toleikyte, A., Müller, A., Hummel, M., 2014b. LAYING DOWN THE PATHWAYS TO NEARLY ZERO-ENERGY BUILDINGS: A toolkit for policy makers.
Lahdelma, R., Hakonen, H., 2003. An efficient linear programming algorithm for combined heat and power production. Eur. J. Oper. Res. 148, 141–151. doi:10.1016/S0377-2217(02)00460-5
Müller, A., 2015. Energy Demand Assessment for Space Conditioning and Domestic Hot Water: A Case Study for the Austrian Building Stock. TU Wien, Wien.
Müller, A., Biermayr, P., Kranzl, L., Haas, R., Altenburger, F., Bergmann, I., Friedl, G., Haslinger, W., Heimrath, R., Ohnmacht, R., 2010. Systeme zur Wärmebereitstellung und Raum-klimatisierung im österreichischen Gebäudebestand: Technologische Anforderungen bis zum Jahr 2050. Endbericht Zum Forschungsprojekt.
Müller, A., Kranzl, L., 2013. Energieszenarien bis 2030: Wärmebedarf der Kleinverbraucher (Endbericht). Energy Economics Group (EEG) TU Wien, Wien.
Neuffer, H., Witterhold, F.-G., 2001. Strategien und Technologien einer pluralistischen Fern- und Nahwärmeversorgung in einem liberalisierten Energiemarkt unter besonderer Verücksichtigung der Kraft-Wärme-Kopplung und regenerativer Energien, Band 2. Arbeitsgemeinschaft Fernwärme e.V.
Nielsen, S., Möller, B., 2013. GIS based analysis of future district heating potential in Denmark. Energy 57, 458–468. doi:10.1016/j.energy.2013.05.041
Schönwandt, W.L., Hemberger, C., Grunau, J.-P., Voermanek, K., von der Weth, R., Saifoulline, R., 2011. Die Kunst des Problemlösens: Entwicklung und Evaluation eines Trainings im Lösen komplexer Planungsprobleme. DisP - Plan. Rev. 47, 14–26. doi:10.1080/02513625.2011.10557130
Stadtvermessung Wien (41), 2013. Solarpotenzialkataster (geodata solar potential Vienna) [WWW Document]. URL https://www.wien.gv.at/stadtentwicklung/stadtvermessung/geodaten/solar/ (accessed 11.5.15).
Statistik Austria, 2014. Energetischer Endverbrauch 1993 bis 2013 nach Energieträgern und Nutzenergiekategorien für Wien (Detailinformation) [WWW Document]. URL http://www.statistik.at/web_de/statistiken/energie_und_umwelt/energie/nutzenergieanalyse/index.html (accessed 11.5.15).
Weinstock, M. (Ed.), 2013. System city: infrastructure and the space of flows, Architectural design Profile. Wiley, London.