

## Research College NRW “Sustainable Energy Systems in the Quarter” – Collection of Abstracts

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### 1 INTRODUCTION

This paper collects the abstracts of the REAL CORP 2020 special topic session “Sustainable Energy Systems in the Quarter” in the order of their appearance for presentation at the conference:

- Wesely, Karin: Towards a better understanding of emotional drivers and barriers in the context of local renewable energy projects – An empirical investigation on homeowners’ motives from a marketing perspective (Work&Progress)
- Slabik, Simon: The Integration of Resource Efficiency in the Building Stock through Efficiency and Sufficiency Measures – Life Cycle Assessment Comparisons and Models
- Taruttis, Lisa; Weber, Christoph: The Impact of Energy Efficiency on Housing and Rental Prices – Evidence from North Rhine-Westphalia
- Treude, Mona: Smart Cities – from the Handling of a Technology Concept to the Transformation Tool of Sustainable Cities
- Kränke, Lisa: Participation in Urban Real World Laboratories – Case Study of Bochum Hamme
- Hernández Galvis, Dione: Digitalisation of the “Energiewende”: Legal Framework for a more Efficient Implementation of Solar Energy in Smart Neighbourhoods
- Kröger, David: Market and Transmission Grid Simulations Considering an Increasing Number of Integrated Energy Systems
- Paulus, Anne: Acceptance of Sustainable Modes of Transport with Focus on Neighbourhoods

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### 2 TOWARDS A BETTER UNDERSTANDING OF EMOTIONAL DRIVERS AND BARRIERS IN THE CONTEXT OF LOCAL RENEWABLE ENERGY PROJECTS – AN EMPIRICAL INVESTIGATION ON HOMEOWNERS’ MOTIVES FROM A MARKETING PERSPECTIVE (WORK&PROGRESS)

To manage the energy transition in Germany and enable a shift from using fossil energy sources to an energy supply based on renewable energies, sustainable solutions for whole communities and quarters need to be developed. When implementing collectively used systems (e.g., block heat and power stations), the resistance and lack of willingness to participate among residents need to be considered, besides technical and legal aspects. Recent research shows that in the context of energy saving investments, financial incentives perform less successful and emotional factors play a critical role in homeowner’s decision making process. Understanding the decision behavior of homeowners, as well as identifying the emotional drivers and barriers of their motivation, is crucial to successfully manage renewable energy projects.

A significant amount of research is concentrated on the acceptability and determinants, (e.g. community identity and trust) of influencing citizens’ willingness to participate in local renewable energy projects. An aspect that only received little attention in this context represents the homeowners’ need for energy autonomy. Studies have shown that people strive for a certain degree of independence, when dealing with

integrating renewables in their energy supply or even long for completely autonomous houses. With regard to this, we assume that people tend to feel more independent with their own heating boiler rather than with a collectively used system. Furthermore, we suggest that this need for autonomy can lead to a lack of acceptance and resistance among residents, when trying to implement sustainable energy systems in quarters. Since the construct of subjective energy autonomy remains unexplored so far, an in-depth study is needed to understand homeowners' motivation and develop a measurement tool for subjective energy autonomy. Additionally, practical implications should be derived to incentivize homeowners to accept as well as participate in neighborly- and community-oriented projects concerning energy efficiency.

Since this investigation represents an explorative approach, a qualitative research design has been chosen. To gain deeper insights, problem-centered interviews will be conducted with homeowners and experts. Interview partners will be determined through purposive sampling to ensure a heterogeneity amongst interviewees. A part-structured guideline is used and improved iteratively after each interview. All interviews are recorded, transcribed and analyzed with the software tool MAXQDA. In addition, a focus group with an energy cooperative owned by citizens is planned to gain further insights.

In conclusion, this study represents a first step into developing a measurement tool for future research, by conceptualizing the construct of energy autonomy through qualitative techniques. Furthermore, it provides insights into emotional drivers and barriers of homeowners' motivation, which are confronted with sustainable community-oriented projects. Besides that, it also contributes to the motivation research in the field of energy saving investments. On this basis practical implications will be derived to activate homeowners to accept and participate in local renewable energy projects in order to successfully manage energy transitions.

### **3 THE INTEGRATION OF RESOURCE EFFICIENCY IN THE BUILDING STOCK THROUGH EFFICIENCY AND SUFFICIENCY MEASURES – LIFE CYCLE ASSESSMENT COMPARISONS AND MODELS**

The German building stock in 2016 is accounted for 35.3 percent of the total share of energy demand and approximately one third of the greenhouse gas emission in Germany [2, 3]. In order to achieve the climate goals of the German government of a nearly climate-neutral building stock by 2050. It is of great importance to renovate the existing buildings, as the majority of all these buildings will still exist by the year 2050.

Thus, the energetic refurbishment of the building stock is essential for an effective integration of resource efficiency in the building sector. By upgrading the building envelope in conjunction with efficient energy systems, significant reductions in operational heat and electricity demand can be achieved. The neighbourhood level is the small-scale interface between the individual building and the urban building stock.

In this work the development of a neighbourhood-based Life Cycle Assessment (according to EN 15978 [1]) of existing buildings as well as renovations is elaborated initially. The LCA are carried out with the software LEGEP and will serve for the quantification of environmentally relevant effects of the investigated buildings. Here, the analysis is performed on predefined lifecycle phases of the constructions and the used materials. The refurbishment measures include the installation of new windows and doors, insulation on the exterior wall, basement ceiling such as the top floor. An extrapolation of the LCA of different building typologies within the neighbourhood should provide initial results. Due to the subsequent impact on the building material by refurbishment measures, the system boundaries of the LCA need to be adapted. The consideration of the energy production, the infrastructure as well as the open space also requires an adaption of the system boundaries. The definition of a suitable functional unit forms a further investigation aspect. It is used to quantify the performance of a product system as a reference unit. A comparative analysis of area-related and resident-related results should provide insights into the resource efficiency and environmental impact of the different refurbishment measures. The calculations are drawn up in different neighbourhoods in Germany, whereby finally a control of the developed methodology by the application at an existing neighbourhood is carried out.

The multifunctional analysis approach on the neighbourhood refers to the objective of this work. The work aims to elaborate a coherent analysis of the construction material and modernization. The environmentally

relevant impacts are compared. Thus, the energy systems in connection with operational and supply-technical approaches within the neighbourhood can be evaluated in detail.

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#### **4 THE IMPACT OF ENERGY EFFICIENCY ON HOUSING AND RENTAL PRICES – EVIDENCE FROM NORTH RHINE-WESTPHALIA**

In Germany, about 35% of the final energy consumption as well as about one third of the CO<sub>2</sub> emissions are related to the housing sector. According to the Energy Efficiency Strategy for Buildings (ESG), the German government aims at a climate-neutral building-stock by 2050 to reach the goals defined in the Climate Action Plan 2050. Increased energy efficiency of buildings is one of the main targets formulated in the ESG, which can be achieved notably through energy efficient retrofits.

In order to identify some potential monetary benefits and possible rental premiums for private homeowners and for landlords when investing in retrofits for a better energy performance of their buildings, we investigate whether energy efficiency is reflected in the property value of single-family houses as well as in rental prices. We focus on North Rhine-Westphalia as the federal state with highest population and highest energy consumption. More specifically, we also examine whether there are heterogeneous effects in the Rhine-Ruhr metropolitan region, which is the largest urban area in the state and used to be the industrial heart of Germany, compared to more rural areas in NRW. With about 99,000 individual observations for single-family houses and 388,000 observations for rental units on a 1km<sup>2</sup>-grid-level for the period 2014 to 2017, this study adds to the literature 1) by examining the effect of energy efficiency on housing values and rents on a more small-scale level and 2) by specifically investigating regional disparities in this context.

Applying a hedonic regression, we find a negative relationship between energy consumption measured in kWh/m<sup>2</sup>a and asking prices per square meter for single-family houses. This implies that energy efficiency (which results in less energy consumption) has positive effects on property values: a one-unit increase in energy efficiency results, on average, in a 0.06% increase in asking prices per square meter, holding everything else constant. For rental units, we find weaker, but also statistically significant positive effects of energy efficiency on asking rents. If energy consumption decreases by 1 kWh/m<sup>2</sup>a, rental prices increase, on average, by 0.018% per square meter. When including energy efficiency ratings instead of energy consumption measures in our regression, we find that an “A”-rated flat is offered with a rental premium of 0.42 €/m<sup>2</sup> compared to average “D”-rated units, whereas “H”-rated flats are offered with a 0.77 €/m<sup>2</sup> discount.

Additionally, we find evidence for regional disparities: In the Rhine-Ruhr metropolitan region, energy efficiency has weaker effects on asking prices for single-family houses compared to all other districts in North Rhine-Westphalia. While a one-unit increase in energy efficiency results in 0.07% higher asking prices per square meter in the latter, it only results in a 0.04% price increase in the Rhine-Ruhr area. For rental prices we see opposite effects: In the metropolitan region, a 1 kWh/m<sup>2</sup>a decrease in energy consumption is related to a 0.019% increase in rents per square meter whereas it amounts to 0.015% in all other districts. These differences become even clearer when again looking at energy efficiency ratings. An “A+”-rated flat (compared to “D”-rated ones) is offered with a rental premium of 0.90€/m<sup>2</sup> in the Rhine-Ruhr region and only with a premium of 0.18€/m<sup>2</sup> in all other districts of NRW.

#### **5 SMART CITIES – FROM THE HANDLING OF A TECHNOLOGY CONCEPT TO THE TRANSFORMATION TOOL OF SUSTAINABLE CITIES**

Smart cities are on everyone's lips, promotional programmes, city rankings and beautiful promises make digital design appealing to cities - but it is no surefire success.

Tolerance and rather acceptance are needed, knowledge and understanding, information and media must be conveyed and the differences between these understood. Also the knowledge about one's own rights, the forwarding and the handling of data are the prerequisites for this acceptance of the people who live surrounded by data collecting street lamps. Technology has left many people behind in the areas surrounding smart cities.

How do you create a smart urban design without a smart surveillance state like Georg Orwell or Big Brother? These are the questions that today's cities are asking themselves - cities that sometimes have historical reasons, their own functionalities and dysfunctions, which besides the daily business of collecting dog tax or providing daycare places must become smart in order to be attractive and to be allowed to play in the Smart City Rankings?

To approach these challenges, this paper takes a closer look at two smart cities. One will be a new quarter under construction in a city that does not lack a good image.. The second city, which will be examined in more detail, is an existing quarter. The depiction of two neighbourhoods at different stages of development is deliberately chosen because the focus is not on the technological equipment of a neighbourhood but on knowledge, cooperation, actors and networks.

## **6 PARTICIPATION IN URBAN REAL WORLD LABORATORIES – CASE STUDY OF BOCHUM HAMME**

Cities play an important role in the societal and academic discourse on sustainable development. They are places where societal transformation takes place and where social, economic and technical solutions are developed and new strategies are implemented. They are considered to have a „transformative power“ (WBGU 2016). However, cities are also places where the Grand Challenges are most evident.

Cities are subject to continuous change. Urban renewal projects aim to promote the development of a city and its various neighbourhoods. One of the key factors for a successful urban renewal process is often seen in the participation of the local community. Participation in neighbourhoods is therefore both: a component of transformation strategies and an objective of sustainable transformation. Citizen participation has the ambition to increase the legitimacy of decisions. However, it does not always fulfil this ambition. One reason is that participation takes place at a late stage in the process. In some cases even when everything has already been decided. Other reasons are the low percentage of citizens who participate and the lack of representativeness in participation.

In addition to the participation of citizens, the WBGU also argues for the participation of the scientific community. The WBGU describes science as a „catalyst for urban development“ (ibid: 356) and recommends a „transformative science“ (WBGU 2011: 22 and in detail: Schneidewind and Singer-Brodowski 2014). The core elements of this concept of science are inter- and transdisciplinarity. Real world laboratories and related concepts provide a corresponding methodological approach in the context of a transformative science (for "Real World Laboratories": Schneidewind & Scheck 2013, for "Urban Transition Labs": Wiek & Kay 2015, for "Living Labs": Liedtke et al. 2015).

In the research on urban development real world laboratories on city or neighbourhood level have become an important approach in recent years. Especially in German-speaking countries an increasing number of real world laboratories has been established. One of these real world laboratories is Bochum Hamme. It is a joint endeavour of the City of Bochum as municipal partner and the Bochum University of Applied Sciences as academic partner. The cooperation focuses on the scientific monitoring of the urban renewal process in Hamme by the Bochum University of Applied Sciences. The scientists' task is to bring together people and institutions in the neighbourhood as well as actors from local politics and the city administration.

The presentation will focus on the cooperation between city, university and citizens. It illustrates particularly the aspect of participation and discusses the possibilities and limitations of real world laboratory approaches. The research design, the characteristics of Bochum Hamme (especially the social structure), the constellations of key actors and the results of two participation events carried out by Bochum University of Applied Sciences will be presented.

The interdisciplinary and transformative approach of the project refers to geographic city research, but also addresses the question of legitimacy, which is particularly relevant from a political science perspective.

## **7 DIGITALISATION OF THE “ENERGIEWENDE”: LEGAL FRAMEWORK FOR A MORE EFFICIENT IMPLEMENTATION OF SOLAR ENERGY IN SMART NEIGHBOURHOODS**

The aim of the research is to develop a proposal in order to optimize the current German legal framework for the development of the German “Energiewende” through digitalisation and for the more efficient use of solar energy in neighbourhoods.

The existing German legal framework is no longer seen as a motor, but rather as an obstacle to the German “Energiewende”. In the area of solar energy, there is a specific problem: homeowners are becoming entrepreneurs due to the problem of tenant flows. In addition, solar power cannot be distributed in neighbourhoods. The main question will therefore be to what extent the existent German legal framework will have to change in order to harness the opportunities offered by digitalisation for the energy industry. The focus will be on energy law, civil and contract law, data protection and IT security law.

First of all, the current status of the German legal framework will be examined. Then, a comparative analysis of the other modern legislations will follow. Various regulatory approaches and “best practices” examples may as well be used to develop a reform proposal. The comparative analysis will focus on the EU level. Nevertheless, the inclusion of supra-European best practices cannot be ruled out. The countries that will serve as comparative goals will be determined after the deficits in the German legal framework have been identified. This will make it easier to assess which regulatory approaches/frameworks/means of control or similar can be used in Germany.

The main topics of investigation are the so-called “smart contracts”, the IoT, the digitalisation as a megatrend and the new business models (these would represent the connection to neighbourhoods, e.g. the prosumers and the distribution of solar energy in neighbourhoods). The term “neighbourhood” is initially alien to German (energy) law, nonetheless there are neighbourhood-relevant arrangements in the sense of criteria which can be helpful for the formation and demarcation of a neighbourhood. We must acknowledge the inexorable development of new scenarios that are not yet provided for in our current legal dimensions or framework conditions. The unimaginable developments in the technological field with which we will be confronted represent for our institutions and our coexistence in society great challenges. However, it is necessary to acknowledge the importance that the conditions of our legal framework have, since they can decisively influence the actors involved. Without extensive digitalisation of the energy industry, it will be difficult to achieve the intended “Energiewende”. Following the motto “Think Global, Act Local”, this interdisciplinary approach helps to answer the main questions of the Graduate School on the one hand, and on the other hand to shape the future social and political challenges in a positive way.

## **8 MARKET AND TRANSMISSION GRID SIMULATIONS CONSIDERING AN INCREASING NUMBER OF INTEGRATED ENERGY SYSTEMS**

The joint generation of electricity and heat in combined heat and power (CHP) plants and the generation of heat using power-to-heat (PtH) systems based on renewable energy sources (RES) open up the potential for decarbonizing the heating sector. At the same time, electricity-heat cogeneration technologies can help to integrate intermittent electricity generation from RES into the system. Depending on their design, CHP plants have one or two degrees of operational freedom. In CHP plants with two degrees of freedom, the feed-in of thermal and electrical power can be partly controlled separately from each other and thus contribute to the integration of RES in the short term.

During periods of negative residual load, particularly large-scale PtH systems can be used to transfer surpluses from the electricity sector into the heat sector and use them there. The additional use of heat storages make it possible to decouple heat generation and heat consumption over time, further increasing the flexibility of the overall system.

Within the research project, Sustainable Energy Systems in Neighbourhoods (Nachhaltige Energiesysteme im Quartier NEQ), an existing European electricity market and transmission grid simulation framework is being further developed to be able to map the realistic operation of CHP plants and PtH systems and to examine and evaluate their effects on electricity markets and grids.

In order to model the heating sector, the locations, installed generation facilities and storage technologies as well as heat demands of a large number of district heating networks in Europe have been researched and temporally resolved. Subsequently, additional operational restrictions and degrees of freedom resulting from the sector coupling as well as different target functions of producers are considered and implemented. Finally, the unit commitment of CHP plants and PtH systems as well as heat storages can be determined and examinations regarding flexibility and grid load can be carried out. Preliminary results show apparent changes in European electricity markets due to the joint examination of both the heating and power sector.

The second phase of the research project deals in particular with research questions regarding integrated energy systems at the neighbourhood level – for example examinations considering the effects on markets and the grids for different penetration rates of solution approaches developed at the neighbourhood level.

## **9 ACCEPTANCE OF SUSTAINABLE MODES OF TRANSPORT WITH FOCUS ON NEIGHBOURHOODS**

This research is interested in conditions which lead to changes in behaviour regarding mobility decisions. Transport systems have significant impacts on the environment. To reach the climatic objectives for 2030 it is crucial to involve passenger transport. The quantity of vehicles is still increasing and results in traffic jam especially in cities and metropolitan areas. To solve the problem of overloaded roads, air pollution and land consumption it is important to implement new forms and systems of mobility and change the individual behaviour. For the successful implementation of new forms and systems in sustainable passenger transport the acceptance by the residents is essential. Therefore, the project addresses the following research questions: What are the conditions under which people accept sustainable energy-efficient modes of transport for routinely ways in their city and neighbourhood? When are investments in e-mobility, season-tickets for public transport or membership in sharing communities for people reasonable?

Previous studies have shown many factors such as local contexts, distances, availability, attitudes and routines which influence mobility decisions. Moreover, car owners use cars more frequently, even for unnecessary routes or for reasons of convenience. So there is need for research of the acceptance of changes in behaviour and private investments in sustainable transport among people.

Since most ways start and end at home it is necessary to consider the mobility situation in neighbourhoods as the residential places. To change the mobility behaviour of individuals it is important to determine their context of living, working and moving. Accordingly, neighbourhoods with focus on the opportunities in the living environment are sensible as research areas.

Based on three selected neighbourhoods in Bochum, the demands and needs of local people in regard to sustainable modes of transport are supposed to be examined. On that point, about 1,200 people (about 400 per neighbourhood) should be asked via a written survey about their usual mobility behaviour. The survey contains questions about the access to vehicles or season tickets, distances travelled and the modes of transport usually used, as well as socio-economic and socio-demographic factors. Furthermore, as some means of transport involve investments, such as buying an e-car or a season ticket for public transport or binding to a car-sharing community, we will ask how likely such investments are.

As a result of the project, concrete actions to process sustainable energy-efficient mobility in neighbourhoods will be developed. These recommendations arise from the acceptance among the people. The aim is to save energy and resources and increase the livability in neighbourhoods through shifting car ways to more energy-efficient means of transport such as bicycles or public vehicles.

An advantage of this severe quantitative approach is that in consequence of a rule-based selection process of the research areas, the results are much easier to transfer to other neighbourhoods. Especially this part is more difficult or even impossible to survey in qualitative approaches such as living labs.