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Editorial

Changing the Energy System towards Renewable Energy Self-Sufficiency—Towards a multi-perspective and Interdisciplinary Framework

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1. Introduction

The transformation of the present energy system into a sustainable one is discussed worldwide. This is also mirrored in a vivid debate in the scientific literature [1–3]. Self-sufficiency attained with the help of electricity, heat, and fuel from renewable energy (RE) in combination with energy saving is seen as one way to establish a sustainable energy system, e.g., [4,5]. Many communities and regions in different countries are facing the challenge of such a transformation of their energy system, and have taken up the objective of achieving energy self-sufficiency through the use of renewables [4,6–8]. The change to a system mainly based on RE is characterized by numerous aspects that have to be taken into consideration, such as political decision-making processes that are increasingly taking place in local governments, the role of citizen involvement, the economic impact of renewable energies, new technological approaches, sustainable land use systems as well as the challenge of adopting energy saving behaviors. Hence, for the analysis as well as implementation of renewable energy self-sufficiency (RESS), numerous social, ecological, economic, and technical factors have to be taken into consideration, which are the subject of very different scientific disciplines. It is exactly this complexity that makes an interdisciplinary analysis on RESS necessary [3]. In light of this, the aim of the special issue "Changing the Energy System to Renewable Energy Self-Sufficiency (RESS)—Selected Papers from the RESS Conference, 15–16 September 2011, Freiburg, Germany" is to generate empirical and theoretical/conceptual insights particularly into regional approaches towards a system mainly based on renewable energies. We are interested, for instance, in the challenges that regional actors in different fields of activity are facing und how they deal with these. Furthermore, we want to explore different methods and conceptual frameworks that can facilitate the analysis of regional

circumstances as well as those at higher policy levels. These issues will be dealt with in selected papers of this special issue that were contributions to the scientific conference "Changing the Energy System to Renewable Energy Self-Sufficiency (RESS)—An inter- and transdisciplinary approach" that was held in September 2011 at the University of Freiburg.

This editorial is structured as follows: In section 2, we will introduce the framework of RESS and highlight the difficulties involved in defining this term. In section 3, we will then give an overview of different thematic aspects that have to be addressed and methods and conceptual frameworks that can help to analyze the impact of RESS and to understand the processes in the regions aiming at RESS in light of different disciplines. This will be achieved through our introduction of the papers that make up the special issue. In section 4, in reference to these papers, we will finally draw conclusions on lessons learned for the framework of RESS.

2. Defining Renewable Energy Self-Sufficiency

The goal of communities and regions to fully supply themselves with renewable energies has triggered the development of different terms and perspectives in the scientific debate—e.g., "energy autarky" [4] or "energy autonomy" [3]. In addition, practice oriented concepts have been proposed, e.g., "100% renewable energy regions" [9], "bioenergy village" [10], "energy revolution", and "energy self-sufficiency" [11]. In the following, we will use the term Renewable Energy Self-Sufficiency (RESS). RESS simplified means the energy demand of a region is covered by the energy produced in the region based on renewable energies (the concept of energy autarky or autonomy is also frequently related to renewable energies [12,13]. However, there is no common definition available for explaining RESS in more detail. Rather, an analysis of the literature related to RESS reveals that there are five different dimensions addressed in relation to the term:

(1) Calculation (How should the amount of energy and other flows connected to the energy system that is needed for RESS be calculated?): Two different systems used as a basis for calculation are often mentioned: (a) a grid connected system, where a balance-sheet perspective is applied—this means a deficit in one energy form e.g., heat, can be replaced by a surplus of another energy form, e.g., electricity, or a deficit at a particular time can be counterpoised by surpluses at another time, cf., [11]; and (b) a stand-alone system where the energy demand in the target area can always be covered by renewables produced in the target area at any time [3] (Schmidt *et. al*. [12] use the terms relative or absolute energy autarky).

(2) Content (Which issues are addressed, like electricity/heat/fuel/energy saving?): It is not always the goal of RESS to encompass all energy flows, often the focus is on electricity and heating [10,14]. With increasing frequency, energy saving is also addressed as a "necessity" for achieving RESS [5,11].

(3) Scale and boundaries (What are the spatial boundaries?): The RESS goal is applied to many territories with a range of sizes from a house over a community, a region to a state. Different literature can be found that also addresses the question of what is the optimal scale for RESS and often the regional level is named, see e.g., [9,15,16]. In the process of defining the boundaries, political or geographical boundaries are often described [3,4].

(4) Normativity/value (What are the principles of measuring (territorial or causative)? What kind of values should accompany RESS and what principles, boundaries, and issues should be addressed?): Most often the measurement is underlined by a territorial principle, because the impacts that correspond with causative principles are difficult to measure. For example, should the energy demand of driving a car outside the regional boundaries be included in the energy demand calculation of the region to which the driver belongs? Often RESS is also linked to the idea of sustainability/sustainable development [4,9,11] and other demands like decentralized approaches with high citizen/stakeholder engagement as a value [3]. This may also include environmental issues beyond climate protection and CO_2 reduction, for instance those related to biodiversity protection and sustainable land use [16].

(5) Decision making process (Who is setting the goal and defining RESS?): The goal of RESS itself, issues that should be addressed and how RESS should be meet (and the values that go along with that) are often a result of social and political decision-making processes that are influenced by different actors [7,11]. In line with this notion, Schreuer *et al.* [17] characterized regional self-sufficiency as being normatively shaped as it represents specific interests through a social and political process: "The negotiation of these goals and of adequate development pathways is tied to an array of conflicting beliefs, values and interests. Taking a closer look at this arena of debate and the micro-level processes of coalition formation and agenda setting therefore highlights the interests and values at stake and the positioning and strategies of actors articulating them" [17] (p. 650). Related to that, RESS is often not defined in detail but rather serves as a boundary objective [7] without a clear definition. This "helps actors from different social worlds to cooperate and communicate while maintaining their autonomy. … This means that the people agreed on renewable energies although they had different motives for supporting it. The issue of renewable energy helps the political pioneers to connect the motives of different social worlds, like the motives of achieving ecological improvement, regional development, and individual prosperity. It also enables the incumbents to identify themselves with the idea or vision of a renewable energy region" [7] (p. 511).

To conclude, it is challenging to define RESS, and even though more and more studies are conducted that focus on it (see above), there is still a lack of understanding related to the processes, diverse impacts and normative assumptions associated with RESS. The papers of this special issue are intended to provide new insights in relation to different thematic aspects and methods and conceptual frameworks that address this gap on the basis of various, mostly regional case studies.

3. Approaching RESS from Different Angles

The transformation of the energy system into RESS entails a fundamental change in the entire socio-technical system. Due to the all-embracing character of the system transformation, the process itself is organized through a diverse bundle of actors from different areas of society. There are politicians, entrepreneurs, farmers, citizens, consumers, conservationists and other stakeholders in the regions who influence the organization of the transformation process in different ways. The people involved in these initiatives often form a network characterized by different types of relationships. Therefore, it is important to understand the process of change towards a new local energy system based

on renewables in terms of the role of actors, and their activities, driving the change. This issue is addressed by Hauber and Ruppert-Winkel [7] in this special issue. On the basis of three regional case studies in Germany that have adopted RESS as a political goal, the paper addresses the questions of how and why the regional processes of change towards a new local energy system based on renewable energies emerged and how these processes have evolved over time. The authors develop a three phase model of transition to better understand the transition process. These phases are a pioneer phase, a pivotal network phase, and an extended network and emerging market dynamic phase. Each phase can be characterized by the (different) types of actors that become active in the process, their specific activities and underlying motives, and the artifacts (e.g., products of human activities like renewable energy plants) involved. The authors identify an interrelated analysis of these elements as important for understanding the process of socio-technical change.

Methodological approaches for understanding social dynamics that pursue the vision of self-sufficiency through the use of renewable energy sources are also addressed in the paper by Späth [14]. He argues that applying an Argumentative Discourse Analysis (ADA) as developed by Maarten Hajer can help to better understand the processes of change associated with RESS-initiatives. Späth illustrates his argument with a case study on the "Energy Vision" of Murau, a district in Austria that is aiming at energy autarky with regard to heat and electricity by 2015. His discourse analysis relies on in-depth interviews with key actors complemented by participant observation, document analysis and workshops. He finds that three discourses occur in the region that are interlinked: a discourse on "a transition of the (local) energy system towards sustainability"; a second discourse on "local contributions to the mitigation of climate change"; and a discourse on "economic development in the rural district." He points out that "regional development" is increasingly dominating regional politics and was mainly thought of in the sense of "energy projects".

Beneficial economic effects have also been an important aspect for actors in many bioenergy villages in Germany. Based on qualitative interviews with key actors (project initiators) in 25 German villages using bioenergy and other renewable energy sources, such as solar or wind energy, Wüste and Schmuck [18] first describe "the preconditions and the main motives for project initiators" to engage in bioenergy village projects; second and third they present "social success factors" and "impeding factors" for the implementation of a communal bioenergy project; and fourth, they describe outcomes of implementing bioenergy projects, e.g., the interviewees identified acquired professional knowledge about renewable energy, greater nationwide publicity for their village, an improvement in communal life and a feeling of togetherness in the villages, or the creation of added value and other positive economic impacts in the regions.

Likewise, focusing on bioenergy villages, Wilkens and Schmuck [19] present a case study on a village inside a bioenergy-region using Multi-Criteria Decision Analysis (MCDA) in order to evaluate possible energy scenarios for the village and for integrating citizens in this process. To apply this method, scientists developed seven different scenarios for the local energy supply and derived criteria for evaluating these scenarios. The criteria are based on a literature review and discussions with experts and local actors addressing "areas of sustainable development" including ecological, social, and economic indicators, which are explained in detail. In a workshop the criteria were weighted by invited citizens. Afterwards, the scenarios were ranked using the method PROMETHEE and a sensitivity analysis was conducted. Different sets of weightings were then presented to the citizens in a

second workshop and discussed. This resulted in three possible scenarios in favor of using a large biogas plant or a small one without aquaculture. In general, the MCDA applied provided a platform for discussing different perspectives among citizens and for combing these perspectives with scientific data. However, a major challenge for real-world applications was the compilation of data for the scenarios.

As the papers introduced above have shown, one frequently made argument for RESS is the expectation of positive socio-economic impacts at the regional level such as new jobs and local economic growth. Yet, to what extent regions de facto benefit from investments in renewable energies depends, on the one side, on public support programs such as feed—in tariffs and, on the other side, on the number and activities of the local actors who participate in the creation of added values. This includes plant manufacturers and suppliers who are geographically situated inside the regions, as well as the actual output and profitability of the plants. In their paper, Ulrich *et al.* [20] address one important aspect of this discussion and develop a methodology for exploring the distribution of employment effects of renewable energy technologies within Germany. Thus, new methods of regionalization are examined and applied to analyze these effects at the federal state level. These methods make it possible to distinguish between employment effects that are generated through the maintenance of existing plants and those that are generated through the installation of new plants in Germany and beyond (through export to other countries). The new methodology thus shows the difference in gross employment related to renewable energy technologies between the different regions in Germany. Furthermore, the approach helps to understand the indirect employment effects of renewable energy, for instance, effects that are generated by service inputs or the delivery of specific components.

Whereas Ulrich *et al.* [20] focus on employment effects at the level of federal states, Funcke [21] emphasizes added value and employment effects at the municipal level. In his paper, he critically evaluates, adapts and combines existing methods to calculate direct as well as induced added value effects. The developed method makes it possible to determine the number of jobs that are provided within the analyzed value chain. A case study is used to apply the modified methods to the calculation of added value effects through solar power systems in the city of Freiburg. The case study considers all steps of the solar power value chain and takes into account local data from 2009.

Another significant challenge for RESS, the complex of sustainable land use management, has even more facets: Transformation of the energy system to RESS is related to changing land use systems (especially for bioenergy). Competing land use management concepts are needed that consider land use systems not only as a resource base for energy crops, but also take into account their role regarding climate protection, biodiversity conservation, landscape aesthetic and agricultural production for livestock and food. Therefore, on the one hand, spatial planning is an important tool for regulating land use conflicts; on the other hand, the use of residual materials, e.g. from agricultural lands or grasslands, are considered to be a promising strategy. These issues are addressed in the special issue drawing on different case studies:

First, Wächter *et al.* [22] reflect on the importance of linking the vision of a sustainable energy system with spatial planning. They present the results of a backcasting workshop with experts that addressed a sustainable energy scenario for Austria by 2050, which was developed on the basis of interviews and a literature review. They identify—with reference to the spatial dimension in Austria—key issues for the transition to sustainable energy structures, including : providing plans on regionally available renewable energy sources and energy flows; changing the conditions for new settlement structures

(e.g., permissions for new settlements could be bound with special sustainable criteria, new subsidy schemes); strategies for integrating existing settlement into more sustainable structures; planning on a new regional scale determined by energy supply aspects beyond classical political-administrative regional structures; and visions, role models and new practices addressing a more sustainable life-style in Austria mainly targeting a reduction in energy demand. They conclude that linking energy with space offers significant opportunities for a more sustainable energy system in Austria. Therefore, "it would be of decisive importance to improve the coordination of energy policy, spatial planning, and land-use regulation issues on the whole. Among other aspects this would require the establishment of new integrated planning structures at the national and regional levels" [22] (p. 206).

Second, Terrapon-Pfaff [23] shows that with certain agricultural process residues, the production of energy can be advanced and simultaneously the sustainability of prevailing land-use practices can be improved. Her findings are based on a case study in Tanzania. In this case, study, the link between the energy system and the land use system is documented by applying a set of sustainability indicators, especially in order to demonstrate the positive and negative effects on the land use system (soil fertility, water use and quality, biodiversity, *etc.*) by using agricultural residues for energy generation.

Third, Pick *et al.* [24] focus on the biogas production potential of economically usable green waste drawing on a regional case study in Germany. They focus on biomass potentials of residual grasslands including roadside edges, conservation grasslands subject to low intensity use (landscape maintenance sites), riparian stretches along ditches and streams, and municipal green spaces (public lawns, parks and sports fields). However, the case study also demonstrated that most of the theoretical biomass potential cannot be utilized for the production of energy because of various technical, legal, ecological or economic constraints. In the end, only municipal lawns and green spaces can be accessed in practice in order to yield suitable substrates.

Another challenge to the achievement of RESS is the integration of new technologies into the lifestyles of the people living in the regions, which also influences local societies and the environment. Ortiz *et al.* [25] review different 'experiences from implementing community-based projects by analyzing four case studies in different developing countries (India, Peru, Laos, Tanzania). Based on a comparison of the projects they identify practical elements that are of importance in overcoming socio-economic challenges related to the introduction of modern energy services. Furthermore, an analytical framework which combines insights from participative approaches and analytical tools from the socio-technical transition framework is presented to systematize the practical findings. Whereas Ortiz *et al.* [25] compare the experience of different case studies, Shelby *et al.* [26] use a transdisciplinary approach to conduct an in-depth case study on sustainable housing. They present the lessons learned from a partnership between a Native American community and scientific organizations in order to develop together a sustainable housing design. For the cooperation between the different partners the authors created a co-design methodology which takes the partners' different value systems regarding sustainability into account. The methodology applied shows how Native American nations can collaborate with scientific organizations to utilize engineering expertise to co-design solutions that address the needs and values of the tribes.

To achieve the goal of RESS it is often stated that, in addition to the expansion of renewable energies, a considerable reduction in energy demand is necessary. In this regard, energy efficiency strategies in particular are discussed but also strategies for adopting less affluent lifestyles, especially

for industrial countries. In fact, it is not clear which measures in the long term contribute to real reductions in energy demand. This point is made by Stablo and Ruppert-Winkel [5], who reflect on the controversial discussions around the topic of energy conservation that are found in the scientific literature. In doing so, they focus on the interrelationship between the goal of RESS and the goal of energy saving. On the basis of an inductive longitudinal case study on a municipality in Germany which is aiming for RESS by 2020—mainly based on interviews, participant observation, and document analysis—they reconstruct how the topic of energy saving is related to the goal of RESS in the discourses of the actors. They also consider the conditions that enable local actors to act although they are confronted with a plurality of visions of how to achieve RESS and energy saving. They found that it was environmentally concerned citizens who were bringing the topic of energy conservation into the political discussion. Important conditions associated with that were, e.g., rising energy prices, the development of respective regulations at the national level and the emergence of subsidies for energy conservation. The dominant "local value added" narrative (compare also Späth [14] above), including local RE use and also energy conservation (e.g., through refurbishments), brought people with different visions of economic development together focusing on the RESS goal.

4. Conclusions

As is usually the case for contributions from a conference, the selected papers of the special issue "Changing the Energy System to Renewable Energy Self-Sufficiency (RESS)—Selected Papers from the RESS Conference, 15–16 September 2011, Freiburg, Germany" cover a lot of ground. They address different thematic issues that consider RESS from economic (e.g., local added value), over social (e.g. key-actor-networks) and ecological (e.g., biodiversity and bioenergy) aspects to technical (e.g., integration renewable energy in houses) aspects. In this way, they demonstrate the interdisciplinary nature of RESS.

All papers have in common that they are based on empirical data, in most cases regional case studies. To sum up and relate the findings to the five dimensions introduced in Section 2, three key contributions to the framework of RESS can be identified. We learned about:

a. The regional political and social processes of RESS and how these can be analyzed (Stablo/Ruppert-Winkel [5], Hauber/Ruppert-Winkel [7], Späth [14], Wüste/Schmuck [18], Wilkens/Schmuck [19], Ortiz *et al.* [25]), mainly addressing dimensions 5 (decision making process) and 2 (content);
b. The economic impact associated with a system predominantly based on renewables and how to measure this impact (Ulrich *et al.* [20], Funcke [21]), mainly addressing dimensions 1 (calculation) and 3 (scale and boundaries);
c. Options for shaping RESS in a more sustainable manner (Wächter *et al.* [22], Terrapon-Pfaff [23], Pick *et al.* [24], Shelby *et al.* [26]), mainly addressing dimension 4 (normativity/value).

The last point addresses the question of what a sustainable energy system based on renewable energy actually is. Obviously, sustainability entails much more than addressing CO_2 emissions. This leads to the question of how RESS can be achieved through social-ecological means that address aspects of social justice and ecological sustainability [16]. An extensive expansion of renewables is

associated with changes in land use and conflicting interests. This has become particularly apparent in the field of bioenergy, where a huge debate on conflicting interests related to land use for the production of energy has emerged in recent years, see e.g., [27–30]. These debates and issues are also linked to the question of who is defining what sustainability in RESS means? The "who"—question is related to the old debate on expert (scientific) knowledge *versus* local knowledge and related to that, the role of scientists: neutral or neatly intertwined with the research "subjects" and influencing their behavior. In this special issue, different approaches for dealing with these questions can be identified. Most of the papers address a specific challenge of RESS using scientific methods largely on the base of case studies. In doing so, they consult local experts from the regions to gain their knowledge [7] or to discuss knowledge that was derived by scientists beforehand [19,22]. Yet, Shelby *et al.* [26] went a step further. They define sustainability together with local stakeholders in relation to their co-designed houses. Here, the relevance of transdisciplinary approaches in addressing complex questions of problem-orientated sustainability science is illustrated [31,32]. In any case: the integration of local and practical knowledge seems to be essential for RESS [10,26,33]. That is, what we might call a transdisciplinary approach is found to be very fruitful for dealing with RESS.

It goes without saying that further research related to the different dimensions of RESS is needed. To integrate all the debates and findings that are actually present in this field, we introduce RESS as a framework with five different dimensions (see section 2) which can help to systemize the research on RESS and define its contribution to scientific progress.

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Conflict of Interest

The authors declare no conflict of interest.

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