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Future discourse: Energy and agricultural turnaround in one area? Modeling of future land use with the software 100prosim

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ABSTRACT

The transformation of an energy system is complex and requires not only technical measures, innovation and changes in lifestyle, but also increasing agricultural land use, especially for the construction of wind turbines or solar panels. Land use for biofuel cultivation is also relevant. Participants in transdisciplinary workshops use the simulation tool 100prosim to create and discuss their new energy scenario and learn about the complexity and requirements of the energy transitions regarding land use for renewable energy. The goal is to create an energy system that is supplied completely through renewable energy, while maintaining the balance between consumption and production. The focus is not on economic but on ecological factors and those related to land use. The holistic view of the tool and the visualization make it possible for participants to get an idea of the size and use of the energy production areas planned. Consequently, participants can identify possible conflicts of use, such as feed production and food security, to be discussed as a basic requirement for determining space for opportunities and a desirable optimum.

Keywords: energy system, agriculture, land use, conflicts of use, renewable energy

1 Introduction

Conventional and fossil fuels have a high energy density, i.e. the distribution of energy is dispersed over a certain area. This means that the occurrence is spatially concentrated and mostly below the earth's surface. According to this, the plants required for extraction and conversion only appear sporadically. By contrast, natural energy flows are characterized by a large distribution with a comparatively low energy density. Consequently, the production of energy from renewable sources means that they occupy a large area, mostly above ground and are, therefore, decentralized. However, the area is also limited, which is why conflicts over land use arise, especially concerning the expansion of wind energy and solar power plants. This especially occurs because the dual use of land already used, such as in the case of agrophotovoltaics, is still limited (Crome 2020). However, the expansion of biomass cultivation areas also leads to land competition, which is reflected in the general public through discussions about "tank or plate" (BfN 2014). In addition to this, biofuels do not always have a good image in the media. Along with an explosion in prices for agricultural raw materials, biofuels are also described in the public perception as a driver of hunger and poverty in the world. Non-governmental organizations, churches and food companies justify this by stating that the increasing use of land for biomass to produce bioenergy results in an increase in world market prices due to the additional demand on open markets; this leads to indirect land use changes of energy crops instead of food crops (DLG 2015). The cultivation of energy maize for biogas plants is also coming under increasing criticism here. Firstly, regarding the social aspect of food

competition but also the reduction of ecological diversity through maize cultivation. These aspects lead to a general rejection of renewable energies in society as a whole (DLG 2014). In addition to these discussion points, wider issues are also of particular importance. Wind turbines erected on agricultural land, for example, are being discussed concerning their effects on adjacent livestock, such as cattle (Troxler 2009). In order to achieve broad participation and acceptance for the transformation to a CO2-neutral energy supply from renewables, new forms of communication are needed that consider the complexity of the issue and offer citizens an opportunity to participate actively (Renn 2015). Current studies show that an energy system sourced from 100 % renewables is generally possible. This target can, therefore, be reached by 2035 (Wuppertal Institute 2020) or, at the latest, 2050 (Prognos, Öko-Institut, Wuppertal-Institut 2020). In addition to technical measures, this requires a change in the lifestyle of society and an open debate on it. The project "Future Discourses in Environmental Communication" at the Osnabrück University of Applied Sciences, Campus Lingen, therefore, addresses different parts of society, for example, stakeholders from agriculture and the food industry, in order to discuss this topic with them. Stakeholders from agriculture and the food industry, in particular, should take a realistic view of the possible limits and competition for use between agriculture and the energy transition, as well as the expansion of renewables in the context of ecological and land use limits. The basic goals are to promote a public debate on the topic, to increase the knowledge of the workshop participants and, thus, to influence the participation and acceptance for the energy transition positively.

2 Material and Methods

Participants in (digital) workshops use the modelling software 100prosim and discuss the complexity and requirements of the energy transition with a focus on land use.

Relevant target groups of the workshops are stakeholders in the field of energy transition, which are defined, identified and grouped before planning the workshops. Within the framework of the project, the stakeholders are clustered into superordinate areas, such as politics, economics, science, associations and professional organizations, agriculture and society. This grouping of actors into profiles is relevant in order to focus the content of the workshops on a comparable level of interest and a similar level of influence of the participants. The agriculture stakeholder group, with its land management, occupies a prominent position in the provision of energy in the context of climate change, the energy transition and the associated expansion of renewables.

The target group-oriented workshops are generally based on a transdisciplinary communication approach. Consequently, a workshop methodology is used in combination with a simulation tool for 100 % renewable energy scenarios. The workshops are characterized by a cooperative and moderated way of working towards a common goal. Accordingly, participants develop a scenario for the future of energy supply under supervision and moderation. The hosts also stimulate discussion. This increases knowledge and acceptance. These are, therefore, reciprocal learning processes – "Citizen Science" – and not just learning in one direction (Richter et al. 2017).

The workshops with 100prosim are based on the scenario technique. The latter is used to involve experts and stakeholders by constructing scenarios that reveal mental models and, thus, make heterogeneous visions of the future transparent. In contrast to forecasts, the scenario technique is useful for looking at long-term future developments. Accordingly, no statements are made about one future, but several possible alternative futures are considered (Wassermann and Niederberger 2015).

In the course of the workshops, the points of view, opinions and perspectives of the actors from the agricultural and food sectors will be combined in an individual scenario for the future energy supply from 100 % renewables. The software 100prosim is used for the visualization and comparison of the energy scenarios developed. Erneuerbare-Energie-Szenarien e.V. has developed and manages the software 100prosim, which is based on Microsoft Excel. 100prosim is free of charge and open to use. The database of the software is a report for the state government of Lower Saxony "Scenarios for Energy Supply in Lower Saxony in the Year 2050" (Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz 2016). The report assumes that agricultural land will decrease in the future due to more settlement areas, which will be entirely at the expense of arable land. In addition, photovoltaic systems will take up more agricultural land in the future, as they are more efficient than the cultivation of energy crops. With the same amount of electricity, less space is needed for photovoltaic systems than for energy crops. At the same time, the expert opinion no longer provides for the cultivation of energy crops for the production of ethanol. In addition, the approach chosen assumes a halving of the vegetable oil area and a constant cultivation area for short rotation. Only the area under energy crops for biogas is increasing, states the expert report. The use of the limited areas under energy crops for biogas seems more appropriate due to the significantly higher productivity of the area.

The target year for the workshops is assumed to be 2040, which illustrates the urgency of transforming the energy system and the associated framework conditions. The software 100prosim simulates energy scenarios for Germany, i.e. it depicts specific realities for future energy consumption and production in Germany according to the ideas of the workshop participants and presents them graphically in comparison to the status quo.

In a primary user interface, the Cockpit 1 visualizes the energy consumption, on the one hand, and the energy production for the defined target year 2040, on the other. In addition, energy losses, energy surplus and deficit are graphically displayed in the Cockpit. The following sectors are covered regarding energy consumption: Mobile applications, building heat, process heat and electricity applications. Carbon-based raw materials of industry are also included, which are synthesized in the model from green electricity. In the sectors mentioned above, participants can design efficiency and sufficiency according to their own ideas.

Regarding energy production, covering the energy needs of all sectors without fossil energy sources will be ensured. Accordingly, the participants create a future scenario based on wind and solar power, biofuels from energy crop cultivation, hydropower and geothermal energy. 100prosim takes into account influencing factors such as population size, development of the economy and import shares to calculate energy consumption and production. Long-term storage – using hydrogen – is dynamically simulated by the program in order to compensate for fluctuating energy production through wind turbines and solar plants.

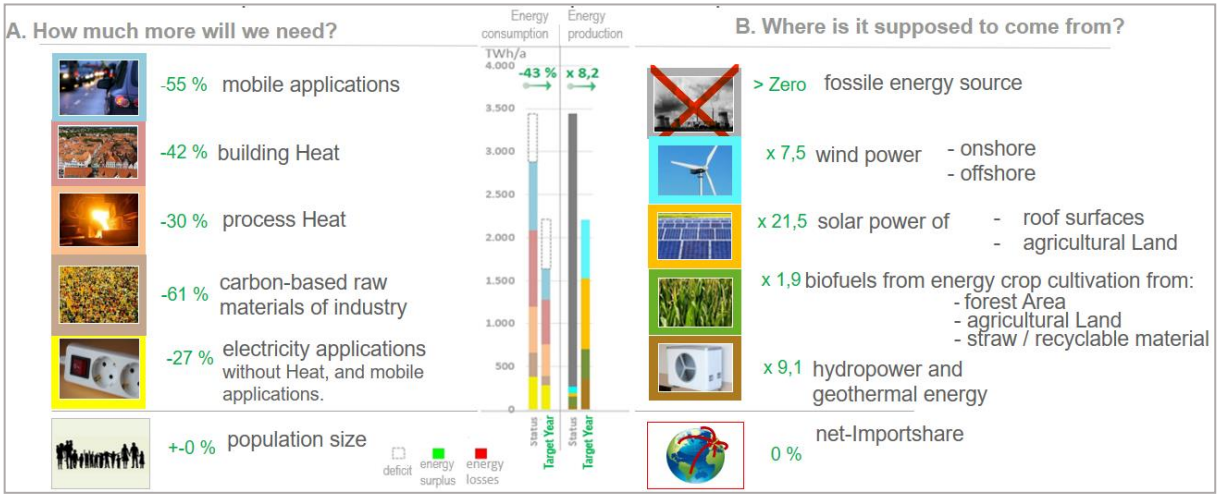

Figure 1. Cockpit 1 – the primary user interface.

The expansion of renewables is discussed in the context of ecological and area-dependent limits, and questions of acceptance are also addressed. The potentials of the agricultural area used energetically for solar open space and energy crop cultivation are visualized in the secondary user interface, Cockpit 2. In order to achieve a stable coverage of demand, these energy gaps must be filled mainly by wind and solar energy if, in contrast to today, massive imports are to be avoided.

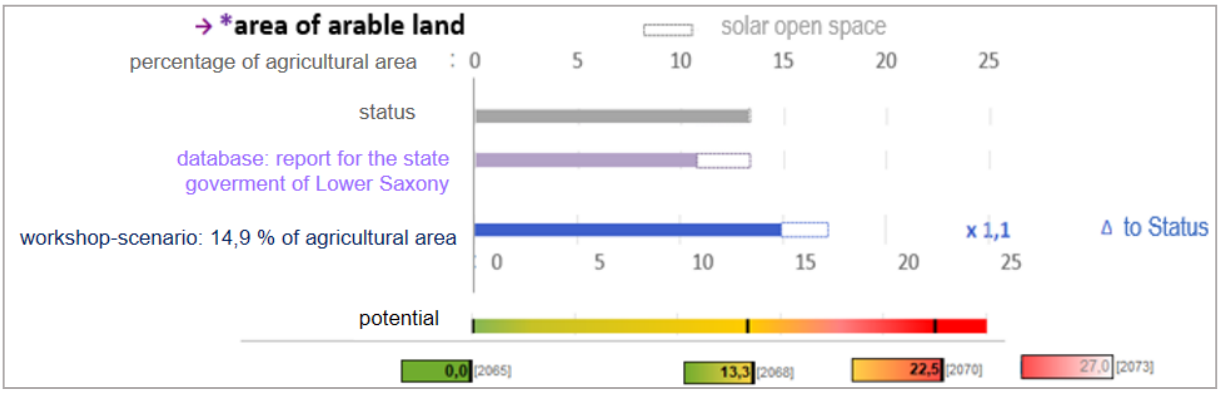

Figure 2. The potentials of the agricultural area used energetically for solar open space and energy crop cultivation are visualized in the secondary user interface, Cockpit 2.

3 Results

As a result of a workshop, stakeholders in the agri-food sector will build a consensus on land use by expanding renewable energy in the context of environmental and land-dependent limits.

The first workshops were conducted with industrial engineers students from different universities, i.e. participants did not have a connection to or a background in the agriculture and food industry. Feedback from the first workshops indicated that the visualization of the energy system by the modelling software 100prosim, together with the interactive application, provides a good overview of both the entire and the integrated energy system. The participants learn about different technologies for climate-friendly energy production and can evaluate expansion targets.

The workshop participants recognize the limits of energy-saving possibilities through efficiency and, thus, the important role of sufficiency in the context of the energy transition. At the same time, it is also clear to the participants that usable energy flows in the future will no longer be able to keep up with an uninhibited increase in demand. Regarding this general reduction in consumption and the 4 necessary expansion of renewables, conflicting objectives are evident, which are discussed during the preparation of the scenario.

Participants assessed the potential for energy crops to produce biogas in a different way in the workshops. The students of one university looked critically at the future cultivation of energy crops. They agreed that 10.9 % of arable land will be used for energy crops to produce biogas in the 2040 target scenario. It was justified, on the one hand, by competing uses with food production and, on the other, by the higher energy yields from wind and solar power on a smaller area.

The students from another university created a scenario in 2040 in which 21.6 % of arable land is used to grow energy crops for biogas. The students justified the increase with the fact that the consumption of meat in society is decreasing, which means that the agricultural land for growing feed is also decreasing. Consequently, more arable land can be used for the cultivation of energy crops for biogas.

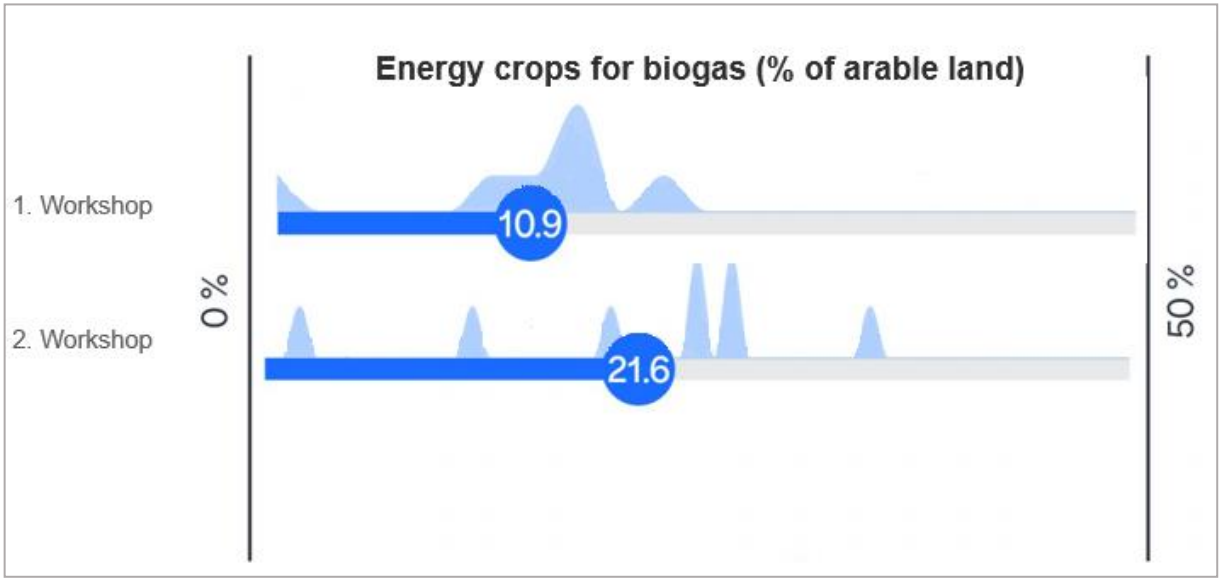

Figure 3. In the workshops, participants assessed the potential of energy crops to produce biogas in a different way using the tool Mentimeter.

4 Conclusions

The workshops of the energy project “Future discourses in environmental communication” generally address current questions on the energy transition in the context of the agricultural and food sector in an original way. A consensus on land use by developing renewables in the context of ecological and land-dependent boundaries can, thus, be seen as a qualified contribution to the social debate – not only in the sense of a stimulus but also as a contribution to its objectification. Further digital workshops and, if possible, offline events will be held in the agri-food sector in the current year 2021. Furthermore, the tool will be further developed, if necessary, in a follow-up project and, at the same time, the workshops will

continue to be held, as it is assumed that this type of knowledge transfer can contribute to an increase in acceptance and optimized participation.

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