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Edited by
Tomáš Michalek, Lenka Hebáková,
Leonhard Hennen, Constanze Scherz, Linda Nierling
and Julia Hahn

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Scenarios for Potential Biomass Futures in the Tri-National Upper Rhine Region

Martin Knapp, Kira Schumacher and Nora Weinberger

Abstract

The integrative multi-disciplinary approach of the 'OUI Biomasse' project deals with a systemic perspective on bio-energy within the transformation of the energy system on a regional scale. Using scenarios as a central instrument of the concept, most sustainable means of biomass utilization on the way to a cross-border biomass strategy for the tri-national metropolis area named 'Upper Rhine Region' (URR) are investigated. Therefore, special attention is paid to the background of scenario-building and to basic methodological steps for depicting alternative pathways for future biomass utilizations: identification of key factors and an assessment of their respective relevance and incertitude, analysis of cross impacts and a combination of compatible shapes of key factors into scenarios, thus enabling a stakeholder dialogue about the best elements for a regional roadmap to a sustainable utilization of biomass.

Introduction

In the aftermath of Fukushima, Germany's highly discussed accelerated nuclear phase-out and the political endeavours to initiate fundamental changes and transitions in energy production – including an extensive reduction of the usage of fossil energy carriers in order to meet the internationally agreed CO_2 goals (Hoffert et al. 1998)[1] – will radically change the energy system in Germany and in many other countries as well. Today, fossil and nuclear energy carriers account for 85% of the German primary energy supply by 2050, this share should be reduced to a maximum of 20%, mainly to prevent major climate changes. This transformation of the energy system towards a more sustainable energy supply, with benefits in terms of greenhouse gas emissions, energy security and rural development (Commission of the European Communities 2005), entails a growing demand for bio-energy, focussing on biomass as a limited resource for target products in the sectors of heat, electricity and fuels (Demirbas et al. 2009). Thus, biomass has the potential to become one of the major global primary energy sources during the next century (Hall et al. 1997, European Commission 1997, Kartha/Larson 2000). This can be seen in the fact that the sustainable utilization of biomass resources plays a central role in current EU energy and climate strategies (Kautto/ Peck 2012).

Even though the potential of the so far unused biomass is high (Commission of the European Communities 2009), the increasing utilization of biomass brings along great challenges in sustainability due to social, ecological and economic impacts (Upreti 2004). These could spark a discussion on how the expanding bio-energy sector would interact with other demands associated to land use, such as food production, biodiversity, soil and nature conservation (e.g. negative environmental impacts of mono-cropping) and carbon sequestrations (Pregger et al. 2013). A well-known example of this aspect is the competition between fuel tank, feeding trough, and dinner plate. In addition to this, the synergies between the different utilizations have to be taken into account. This would facilitate an improved understanding of the prospects for widely applied bio-energy, for future land-use and for biomass management in general and benefit the question of how the mentioned impacts could be avoided or mitigated.

The 'OUI Biomasse' Project

Against this background, sustainable biomass utilization requires a comprehensive technology-assessment approach taking into account the whole supply chain, divergent usage options, regulatory and industry framework conditions and locally specific environmental and social conditions. This approach was applied in the 'OUI Biomasse' project as a part of which a multidisciplinary collaboration with scientists from all major research institutions in the cross-border Upper Rhine Region (URR) had been set up, unifying the specific knowledge of economists, engineers, physicists, forestry scientists, biologists, chemists and sociologists (DFIU 2013).

The URR consists of four sub-regions (Alsace, North-Western Switzerland, Southern Palatinate and Baden) belonging to France, Switzerland and Germany (Regio Basiliensis 2013). In the URR, 41% of the total area is arable land used for agriculture, growing different types of biomass, such as crops and wine. Although the URR forms a geographically coherent region with regard to natural conditions (e.g. soils, climate), there are substantial differences in legal frameworks, cultures and anthropological views. As land use patterns are changing continuously and to fulfil the needs of the local population, a coherent biomass strategy for the entire region has to be developed. Furthermore, by involving relevant local stakeholders from politics, administration and industry, the project aims to give an important stimulus to environmental policy and innovation for future development of the URR (French-German Institute for Environmental Research 2013). The main goal of the 'OUI Biomasse' project is to propose necessary implementation steps to achieve a knowledge-based sustainable biomass strategy within the transition of the URR energy system by working out a 'Roadmapping Guide for Actors'. Within this interdisciplinary concept, a harmonized method for a transnational estimation of existing and future biomass potentials should be developed at regional scale for the first time.

This paper wants to focus on one specific research area of this project:[2] building-up scenarios for different alternative developments to analyse their potential impacts under sustainability criteria. Firstly, the theoretical background of the scenario-building is described; then, the methodological implementation within the project is depicted; the final section comprises conclusions.

Theoretical Background of Scenario-Building

Facing growing complexity and uncertainty of social and environmental contexts, such as technological change and biomass utilisation, it is more important than ever to reflect on today's decisions prospectively and to adjust them in a future-oriented and sustainable way. Therefore, the work with scenarios provides a central tool for long-term future prospects for companies, markets, competitors and planning processes for, e.g., political consulting.

The future is generally indicated by complexity as developments and changes interact in multi-layered ways and occur in a partly continuous but also partly disruptive manner. The future is principally hallmarked by uncertainty and insecurity. Considering this, several different future pathways are potentially conceivable. In addition to that, the future is characterized by ambivalence as various possible developments are being or could be evaluated in entirely different ways depending on the perspective of observation. Thus, scenario-building[3] implies a 'scientific investigation of the possible, probable and desirable future developments and shaping options as well as their requirements in the past and the present' (Kreibich 2007, p. 181). In contrast to an image of the future that merely presents a hypothetical future condition, scenarios also describe the developments, dynamics and driving forces from which a certain image of the future arises. Two questions play a decisive role: first, how can the gradual emergence of a hypothetical situation be explained, second, what alternatives exist at each stage of the process for preventing its further development or 'steering' it in a different direction? The scenarios will be expected to generate visions of future developments through the reflection of certain relevant key factors, also referred to as 'descriptors'. The selection and combination of the key factors with regard to a future time horizon is a kind of design work. Here, certain factors and events are intentionally included – others excluded (step: key factor identification) – and correlated in ever-varying constellations based on certain assumptions (step: key factor analysis). The analysis of the key factors can be performed using various methods to explore i) the interdependencies of demographic, social, technological, economic and political developments and ii) which possible future tendencies are imaginable. One method is the so-called Cross Impact-Analysis, which 'provides a number of structured processes for the deduction of plausible developments in the future in the form of rough scenarios and is based on expert judgements about systemic interactions' (Weimer-Jehle 2006, p. 334). 'Its approach is based on the evaluation of interrelations between the most important influential factors in a system by experts who evaluate pairs of these factors (for example as conditional probabilities), and then to find out which scenarios are probable in view of the established network of interrelations [...]' (ibid., p. 336). On the basis of this analysis, the consistent set of key factors is assorted, selected and developed into different scenarios. The aggregation of scenarios can be accomplished by literary-narrative or formalized-mathematical methods.

Scenarios for Potential Biomass Futures at Regional Level within the Project

Based on the preliminary work of other project partners, a set of alternative scenarios of future biomass utilization in the URR until 2030 will be developed. To predict possible future trends, a multiple set of structural criteria and key factors (normative as well as propulsive), influencing the prospective biomass utilization, are getting investigated, selected and evaluated. Besides this, trends for future shapes of these factors for verifying assumptions about biomass availability and economical modelling are being evaluated on the basis of indicators derived from the integrative concept of sustainability (Jörissen et al. 1999). With the help of the scenarios, tendencies of changes in ground cover and land use (LULCC) related to different utilization paths of biomass will be identified (Institute for Technology Assessment and Systems Analysis 2013). One scenario will be a reference scenario 'Business as Usual (BAU)' to respectively shape GIS maps of usable biomass potentials on the basis of trend-extrapolation. The whole resulting set of scenarios will be the basis for deriving biomass potentials and impacts of utilization. Based on the insights from the scenario analysis, possible environmental, economic and social impacts of the different pathways, using sustainability criteria and indicators, will be predicted. Furthermore, a local stakeholder discourse will be launched, enabling the most important interest groups from the administration, politics, industry and science in the field of biomass in the URR to validate the scenario results. The stakeholder dialogue further aims to identify the most preferable scenario characteristics and reassembling them in a 'best-case' scenario, which will subsequently constitute the basis for the final roadmap with pathways, options and recommendations, demonstrating the possibilities and conditions for sustainable biomass utilization in light of the current framework conditions and the sustainability goals in the URR (French-German Institute for Environmental Research 2013).

To achieve these objectives, certain relevant influencing factors are taken into consideration on the basis of a comprehensive Internet and literature review. Following the analysis of publication references, a thematic clustering was conducted to allow for a better handling of the variety of factors resulting in seven clusters: agriculture, economy, energy supply, nature conservation, social/human population, politics and technologies. Through the basic search strategy, about 120 factors were identified in the first step. In the second methodological step of the key-factor identification, the assembled factors were discussed at an internal expert workshop to reduce the wide range of factors to a relatively manageable number of potential scenario descriptors. The reduced quantity of 46 factors was then fed into a small-scale questionnaire to be spread among the project group and the associated partners (stakeholders). This survey made it possible to carry out evidence-based decision-making based on benchmarks such as 'uncertainty' and 'relevance': all experts received the clustered factors and were requested to nominate the most relevant and uncertain factors (in their opinion) on a scale of 0 (irrelevant, certain) to 3 (relevant, uncertain) points, whereby each expert could allocate points up to the maximum of number of topics multiplied by 1,5 (author's specification regarding statistical literature). This advance ranking represented the first expert feedback on the influencing factors. As no topic was allocated zero points in the evaluation, and even the topic with the lowest score was considered essential by at least one expert, the preliminary strategic key-factor selection was factually confirmed by the experts. These results were then anonymized and aggregated in a ranking list of recommended key-factor priorities. The above-mentioned auxiliary distinction between the clusters was eliminated. The ranking of the topics represented the methodological starting point of the following expert workshop, which was designed in such a way that all key-factor 'candidates' could be discussed. The experts gave valuable advice on the grouping of factors with lower granularity with regard to their level of detail into groups of higher granularity, such as the regional structure of politics, governance styles, political priorities, economy, change of values, demographic development (population growth), mobility, technology development, availability of resources, social infrastructures (e.g. mobility needs) and global development (e.g. oil price, climate change). All these key factors should be taken into account, e.g., population growth and economic development are principal factors behind overall bio-energy use. Assumptions about technology development, energy system transformation and changes in the energy intensity of economic activities do influence the translation of bio-energy use into the demand for different energy forms. In addition to the relevance of systems engineering, the development of non-bio-energy technologies is crucial for the ultimate demand for energy from biomass as well. Resource-focussed assessments take the form of inventories of potential bio-energy sources, and of carrying out an evaluation of possibilities for utilizing the sources to fulfil energy purposes.

Based on this, the second methodological step in the ongoing work will be to correlate the identified and selected key factors in varying constellations on the basis of certain assumptions. The following analysis of the key factors aims to explore the reciprocal actions between those potential scenario descriptors and to evaluate imaginable future tendencies. To achieve this, it is planned to put the interdependencies and tendencies up for discussion and to build up a matrix containing judgements, which express the influence of each descriptor on each of the other key factors. These judgements will be gained through verbal analyses and intuitive logics (Huss/Honton 1987) by asking experts until spring 2014.

Outlook and Conclusions

After having finalized the basic preparatory steps described before, the results will all be assembled within a set of alternative scenarios describing various aspects of conceivable general future biomass utilizations. For that purpose, firstly, a comprehensive description of the status quo of all relevant aspects of biomass utilization is to be performed. Starting from this characterization, trend-lines for the future development of the shapes of each key factor are depicted, to build up a referential scenario 'business as usual'. Major framework conditions' trends assumed to be stable and varying shapes of factors directly influencing general biomass utilization pathways are to be combined into further scenarios for possible alternative biomass-utilization developments. Therefore, the results of the explorative analysis described in the previous section will be combined with clearly diverging normative visions of future biomass usage patterns, e.g. on the one hand, strategies of perceiving all options within the limits of regulatory and legal framework for a maximum exploitation of the identified biomass potentials or, on the other hand, privileging targets of nature conservation for upholding ecosystem services, the overall appearance of the landscape as well as its recreational value. These examples show how the description of possible extreme future developments by scenarios can illustrate the range of biomass utilization alternatives.

The preceding paragraphs showed how the scenario-based technology assessment approach, applied within the 'OUI Biomasse' project, was set-up to enable a knowledge-based dialogue between various stakeholders and thus support the building-up of a sustainable regional biomass strategy for the cross-border region of the Upper Rhine. Based on a transnational estimation of biomass potentials, opportunities are drawn for research and development to generate new applications and both innovative and sustainable technologies. Possible environmental, economic and societal aspects and impacts of different transition pathways are going to be illustrated in the alternative scenarios and can thus serve as highly relevant knowledge opening new perspectives for stakeholders from regional politics, public administrations, industry and the society of the transnational URR. This also offers good prospects to initiate the implementation of new subjects and elements for both regional and transnational governance as decision-making for energy transition thus far is still lacking advisory structures for societal and political addressees.

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