EPJ Web of Conferences **33**, 01004 (2012)
DOI: 10.1051/epjconf/20123301004

Sociotechnical scenarios for the Austrian energy system

Michael Ornetzeder*, Harald Rohracher**, Petra Wächter*

* Institute of Technology Assessment of the Austrian Academy of Sciences, Vienna, Austria

** Inter-University Research Centre for Technology, Work and Culture, Graz, Austria

Abstract: Reducing greenhouse gases by 80%, as demanded by the IPCC, is one of the great long-term challenges facing our societies today and will doubtless require transformative changes to current energy regimes. Large-scale system transitions such as the one envisaged for the global energy system in the next 30-40 years can only be realized through complex processes of change involving global, regional, national, and local levels.

In this paper we use sociotechnical scenario analysis to contribute ideas for the transformative change of the current Austrian energy system over the long term and to identify some of the particular policy measures, as well as structural changes and broader shifts in perspective, that would be necessary to deal with such challenges. There is less emphasis on the technical issues involved than on the socio-economic and governance requirements such a shift would demand.

We also explain our experiences with the sociotechnical scenario process and its outcomes. In particular, we identify examples of some critical issues and opportunities within one of the identified key action fields and discuss their various implications for energy policy and everyday practices.

Keywords: Energy system; sociotechnical scenarios; stakeholder involvement; backcasting

1 Introduction

It is generally agreed that the current energy system must undergo a radical change in the near future. Indeed, the EU's Strategic Energy Technology Plan (SET-Plan) calls the reinvention of the energy system in the form of a low carbon model the critical challenge of the 21st century (Commission of the European Communities, 2009). Dealing with such a radical transition requires an awareness of complex learning processes that involve a multitude of actors and levels such as energy providers, policy actors or consumers, social networks, and broader societal contexts. System innovations required for profound change include the reconfiguration of technologies, institutions (e.g. regulation; informal norms such as professional cultures and cognitive paradigms), and social practices (e.g. use patterns, lifestyles), as well as cultural norms and values. The active political and social shaping of such transformations depends on the development of shared visions about possible 'future scenarios' of the energy system and on the continuous adaptation of strategies and action in order to move the energy system in the desired direction. Common learning processes and shared visions are all the more important because actors in the energy field increasingly expect the energy system to be exposed to fundamental destabilisation and change.

*email: ornetzeder.michael@oeaw.ac.at

The E-Trans 2050[1] project (Rohracher et al., 2011) is an attempt to contribute to this ongoing transformation by focusing on 'key action fields' that have high potential for system innovations leading toward more sustainability in the energy sector. Our approach intends to complement existing quantitative modelling efforts. From the outset, the focus is on necessary changes to institutions, social practices, and cultural norms rather than on the precise mapping of technical potentials and desired outcomes. E-Trans 2050 started in 2009 as one of several scenario-building projects within the new research programme of 'New Energy 2020', which supports research and development activities aiming at a long-term transformation of the Austrian energy system. Although the main focus of 'New Energy 2020' is on technological development, socio-economic research plays an integral part by contributing various kinds of 'strategic intelligence'. Here the aim is to provide policy-relevant knowledge, addressing innovation policies in general as well as concrete technological developments and the programme itself. E-Trans 2050 contributes to the programme by identifying socio-economic constellations that are central to the further transformation of the energy system.

This paper gives an overview of the chosen approach and reports on selected findings from the recently finished project. In Section 2, we introduce the overall approach of the project and the methods used. In Section 3, we briefly illustrate the three framework scenarios developed. In Section 4, we present the key action fields that were identified and discuss the potential for system innovations along various sub-fields, using the example of the spatial organization of energy production and use. Finally, in Section 5, we relate our findings to implications for energy policy and everyday practices.

2 Approach and methods of the E-Trans 2050 project

Foresight or scenario studies about the further development of energy systems have already been carried out in abundance, often focusing at various geographical scales (from the global to EU, national and even regional levels) or particular elements of the energy system (e.g. electricity system, renewable energy sources). Most of these scenarios have a strong 'output orientation', i.e., they aim at quantifying future energy consumption.

The E-Trans 2050 project thus did not aim to contribute further quantitative modelling of energy scenarios, but to complement existing scenario models by putting more emphasis on their socio-economic, cultural, and institutional foundations and by asking whether such sociotechnical visions of the future may also result in additional perspectives and strategies to foster the transformation of the energy system towards more sustainability. To this end, a number of existing scenarios which were perceived to be the most advanced in dealing with socio-economic aspects were chosen and then screened for the socio-economic assumptions upon which they based their different development corridors. The roughly 40 scenario studies analysed ranged from global energy scenarios (e.g. World Energy Council, 2007; Shell International, 2008; Raskin et al., 2002) to various national scenarios (e.g. Anderson et al., 2005).

Based on the analysis of trends, drivers, and inputs from the existing literature and energy models, we developed three framework scenarios with different socio-economic conditions (see Section 3). As a next step, stakeholders and experts from various

[1] This project is funded by the Climate and Energy Funds and carried out under the 'New Energy 2020' programme.

backgrounds discussed and advanced the scenarios interactively in two workshops. The interdisciplinary composition of the participants helped to incorporate different perspectives to describe more profoundly the complexity of the energy transition. It was possible through the development of scenarios to combine expectations and visions of the future with transformation paths and political strategies. By defining a number of socio-economic categories, the participants of the workshops identified a number of key action fields for system innovation for each scenario. Once these key action fields had been identified, the stakeholders were asked to evaluate the potential of these for system innovation.

In the final part of the project, we explored the chosen key action fields in more detail, focusing on issues that had leveraging effects on the energy system. The normative scenarios were specified in each key action field and were complemented by backcasting workshops: backcasting is a particular form of scenario process with an explicitly normative angle. While forecasting generally attempts to predict the most likely future developments, backcasting attempts first to generate particularly desirable images of the future and then to search for possible ways of reaching this future state (Robinson, 2003). Backcasting thereby emphasises the societal room for manoeuvre in shaping future developments, e.g., via the implementation of particular policy measures. Thus, in a backcasting process it is not uncommon to develop scenarios that deliberately include the breaking of current trends.

This approach should provide new insights because of the participation by experts in the three key action fields and should extend the range of possibilities for further action and strategy development that are generally taken into consideration. The aim was to find and investigate some central issues within the key action fields that would have the potential to foster system innovation and influence the energy system to a wide extent, and which would be relevant for the transition path. These central issues can be seen as subfields of key action fields, with related actors and institutions, and within these subfields it should be possible to discuss critical issues and opportunities.

3 A set of energy scenarios for 2050

Based on existing energy scenarios, technology roadmaps, forecasts of the availability of energy resources, etc., a first framework of energy visions was drawn up by the research team. The following basic types of possible developments were prepared.

(1) Moderate optimisation scenario: optimization of the energy system and its modernisation;

(2) Sustainable energy system scenario: radical change to a sustainable energy system;

(3) Break-down scenario: economic crisis and energy crisis.

We then envisioned more or less plausible and consistent pictures of developments in the energy system, with its actors, institutions and rules, under different socio-economic framework conditions for each of these basic scenario types. Participants in the two workshops were then asked to further substantiate and differentiate the basic scenarios provided by the project team. The main emphasis was on embedding the technological options within the socio-economic, cultural, and institutional contexts of a sustainable energy system, as well as on developing consistent visions and scenarios.

Table 1 gives an overview of the main points of the scenarios, including a description of the status quo of the energy system in 2050. The scenarios are thus based on two approaches: first, existing scenarios, projections, and forecasts were used to develop a

framework for three possible visions for the future. The scenarios were then fleshed out further in two workshops with experts and other stakeholders and differentiated into two or three sub-scenarios, widening the range of possible futures.

Table 1: Framework scenarios for Austria in 2050

Framework Scenario	Short Description
Scenario 1: Moderate Optimisation	• Steady but slight increase in energy demand • Higher energy efficiency partially compensates for this increase • Large percentage of electric cars replaces petrol- or diesel-powered, especially in urban areas (e-mobility) • New mobility technologies lead to increasing efficiency and CO_2 reduction • Fossil fuels focus more on natural gas than on oil • CO_2 capture and storage is used by big industries • Short-term policy strategies • No profound institutional change
Scenario 2: Sustainable Energy System	• Radical change to smart grids • Decentralised energy production with renewable energy resources • Drastic cuts in personal energy demand • 20% of energy use is powered by fossil fuels • Feed-in of biogas instead of natural gas • Increasing application of electric and biofuel-powered engines • Expansion of public transport • Sustainability solves the social, economic, and environmental crisis
Scenario 3: Breakdown	• Long-term economic crisis and energy crisis with heavy "quality-of-life losses" • Increase in distributional inequalities • Less pressure on the energy system because of reduced economic growth • Increase in renewable energy resources is driven exclusively by economic interests • Countries with strong economies/military hoard access to energy resources, leading to resource conflicts • High costs for fossil fuels • Climate changes more rapidly than previously assumed • Hardly any coordinated global climate protection measures

4 Identification of key action fields

The concept of key action fields is central for the approach developed and applied in the E-Trans 2050 project. Key action fields are structural issues of policy and social action that are likely to be decisive for the future development trajectory chosen. In particular, we tried to identify cross-cutting fields and new problem framings that needed to be dealt with as a precondition for a transition towards a sustainable energy system.

Several key action fields were identified and selected at the expert workshops conducted in the context of the project. The ones that were identified at the workshops cover well-known and well-established key action fields such as economic instruments, international agreements, regulation, education, and technological innovation, but also a number of socio-economic fields that may have been less prominent in previous debates on energy futures. These latter fields, however, are complementary to the more prevalent key action fields and provide important enabling conditions for unlocking the potential associated

with the former. The following action fields were ultimately chosen for deeper investigation in the E-Trans 2050 expert workshops:

(1) The spatial organization of energy production and use;

(2) Reflexive governance using the example of smart grids;

(3) The role of civil society in energy transitions.

The key action fields simply capture the decision areas that are critical for determining the direction of a future energy pathway; they do not yet address the question of which actions to take and which specific issues to address in order to ensure a shift towards the most desirable, i.e., sustainable, pathway. We therefore identified more specific sub-fields within each of the key action fields that would allow us to shift the transformation process in the direction of the most desirable scenarios and avoid the less desirable ones. These sub-fields highlight critical issues, i.e., important preconditions to be met and potential conflicts to be resolved. We will present some results below, using the first key action field as an example.

Example: The spatial organization of energy production and use

As the discussion among the participants has shown, the aspect of land use and space in the energy sector is still far underdeveloped as a research topic. The significant increase in average living space per person and the ongoing urban sprawl have severe implications for energy consumption. Deficits in the implementation of spatial development plans and the distribution of relevant competences at the national, regional, and local levels often lead to unplanned settlement in rural areas and therefore to an increasing demand for energy-intensive resources.

The sustainability scenario highlights the need for new forms of spatial planning, moving towards more coordinated procedures. It underlines the need for legislative reforms, including a variety of spatial planning instruments such as establishing development axes and changing incentives related to transport. On the energy-supply side, the sustainability scenario – in accordance with current policy objectives at the EU level – projects that a very high percentage of energy will be generated by renewable sources, with a notable shift towards decentralisation. There is a stronger focus on regional resources and/or on balancing resource potentials via supergrids, including at the international level. Spatial restrictions and limits to the speed at which transmission grids can be expanded make it impossible to simply summarise the spatial requirements of renewable energy resources. Roadmaps and political objectives regarding the use of renewable energy, no matter what their scale, must reflect the limitations that could arise from conflicting demands for land and other resources.

In order to discuss the spatial issues of energy transitions in more detail, we specified a ‘sustainability scenario’ for the Austrian energy system in 2050 that focused on issues of spatial organisation and was based on eight expert interviews and a literature review (see Table 2). Using this specific vision of the future as a starting point, participants of the backcasting workshop were invited to discuss strategies and necessary milestones that could be helpful in reaching it.

Table 2: Long-term vision for sustainability in the field of energy and spatial organisation

Long-term vision for 2050	
Main aspect	Changes envisioned
General data	- Population in Austria: 9.5 m (2010: 8.4 m) - Gross domestic energy consumption: 800 PJ (approx. 50% less than in 2010) - Electricity consumption is about 20% more than in 2010 - Renewable energy sources cover 90% of domestic needs - CO_2 emissions are 80% below 1990 levels
Energy prices	- All forms of energy are much more expensive than in 2010 - Fossil fuels are about twice as expensive as renewable forms of energy - Percentage of household expenditure on energy mirrors 2010 (around 7%) - Social distortion is prevented through the tax system and through transfer payments
Infrastructure	- Energy is used extremely efficiently in all areas - Power grid is completely modernised (new and efficient equipment, smart grids, super grids) - High-efficiency devices are the norm - About 50% of building stock meets the passive-house standard; the rest exceeds 2010 low-energy building standard
Spatial dimensions of production and use	- Widespread use of renewable forms of energy - Use of renewables adapted optimally to local and regional conditions - Previously existing capacities are upgraded and slightly expanded - Consumption and production are located in close proximity - Widespread use of energy cascading
Mobility and transport infrastructure	- Energy demand for mobility is below 2010 level - More efficient technologies, reduced traffic volume - Improved public transport system - Compact settlement patterns ("short distances") - High proportion of bicycle traffic - Highly efficient logistics solutions for goods transport
Settlement structures	- Urban centres and medium-sized cities are the main areas for living and working - Suburban areas are compact; high quality of life in these neighbourhoods - Outlying regions are of little economic importance - Settlement in rural areas has decreased; remaining rural settlements are populated by elites; more nature reserves than in 2010

The discussion in the workshop again made clear that changes in spatial organisation that affect the production and consumption of energy depend on a multitude of interconnected factors. Among other aspects, the discussion revolved around technological innovation, administrative and legal reforms, binding political targets, the greening of the tax system, demonstration projects, regional networks, and international trends. Even so, when focusing on specific aspects of the overall topic the participants were able to formulate a number of recommendations concerning both main aspects of the topic (settlement structures, mobility and infrastructure) and more specific items such as the development of large-scale demonstration projects.

A major part of the discussion focused on the development of sustainable settlement structures. Important goals in this area are to reduce the energy that buildings and mobility demand and to enable the widespread use of renewable forms of energy. New developments should be compact, built according to ultra-low energy standards, connected to district heating systems (if available) and public transport systems, and optimised for the use of solar energy. Existing settlements are to be transformed gradually, according to these

criteria. Changes in building regulations, zoning plans, and the fiscal transfer regime between the federal government, federal states, and municipalities were considered very important in achieving these goals. However, most participants of the workshop agreed that the subsidy schemes provided by the federal states are the most important and effective tool to stimulate changes in the building sector in the short run (including a shift from subsidies for new construction to refurbishment and densification measures). It will be much easier to change these schemes than to alter building standards and similar regulations, and given the high impact of subsidies in the building sector the effects were expected to be large. Some of the major barriers identified in this field were long-standing practices in the construction sector, powerful ideals such as “the happy family in the detached house”, and the sheer number of construction plans for which permissions have already been issued.

Mobility, the second main field of discussion, was regarded as a major precondition for modern society, and the projected goal of reducing the demand for mobility in 2050 to below 2010 levels was soundly rejected. Workshop participants instead preferred to aim for reductions in mobility-induced energy consumption. In addition to the changes in the settlement structure already discussed, they focused on improving public transport systems and developing e-mobility. The public transport system should be improved in close cooperation with other means of transport to solve the “first and last mile problem” in an environmentally sound way, e.g., through the use of electric vehicles or electric bicycles. E-mobility was also seen as an opportunity to loosen the perception of a close association between individual mobility and car ownership (fewer privately owned cars could help to increase the attractiveness of public transport). Moreover it was stated that public transport systems have to be improved through the use of information technology to optimise the interplay of different subsystems and the implementation of attractive tariffs and transparent accounting systems.

The development of large-scale demonstration projects was discussed as an additional strategy on the path to energy-efficient spatial organisation. Such projects could be seen as experimentation fields that are an attempt to integrate the various requirements and aims as defined in the long-term vision for 2050. Learning from such experiments was seen as an important precondition for the further and more widespread dissemination of sustainable solutions. As local and financially limited projects, these experiments could be realised on a short-term basis that would be primarily dependent on political will and financial resources and more or less independent of substantial changes in the regulatory system. In order to have as much of an impact as possible, these projects should either be located in sparsely populated suburban areas or in smaller cities acting as regional centres, both of which sites were seen as crucial for future developments.

All in all, the discussions in the workshop produced a number of ideas for policy measures, especially regarding the reorganisation of settlement structures. Only some of them, however, – the development of demonstration projects, for instance – could be discussed in more detail. Other ideas will need to be picked up and elaborated further in upcoming research projects.

5 Consequences for energy policy and everyday practices

Based on the results of the backcasting exercises on energy and spatial organisation, we may discuss the following three short-term consequences for energy policy measures.

First, it seems inevitable that better coordination of energy policy, spatial planning, and land-use regulation issues is needed on the whole. This would require the establishment and/or improvement of integrated planning structures at the national and regional levels, the redesign of building subsidy schemes, the closer adjustment of land development plans to energy efficiency and sustainability criteria, and the fostering of increased cooperation across municipal and county lines in the future.

In order to support the further expansion of renewable energy resources, it will be necessary to rebuild regional structures in a way that matches available resources to the existing demand for energy services as closely as possible. It will therefore be important to provide regional resource management plans and to develop and implement local and regional energy strategies. Moreover, a reallocation of political and legal competences seems essential – one that goes across and beyond the existing political-administrative structures.

A third set of measures deals with the development and implementation of sustainable settlement showcases. Radical new settlement models that combine new social and organisational structures with the latest energy technology and transport infrastructure are not yet available in Austria, but such models were given high priority in the backcasting workshop as a first step towards a more sustainable energy system. In order to get these models to work in practice, social actors from the research, technological development, planning, architectural, and political fields must work together in close cooperation with investors and on-site users. Hence it is necessary to develop appropriate developer and participation models and to establish appropriate policies and frameworks. The implementation of innovative settlement showcases would be an important first step towards a more sustainable energy future and could open up much-needed opportunities for social and technical learning.

Changes in the spatial organisation of housing and mobility as briefly outlined above would certainly have a number of implications for present energy practices. Most obvious are the necessary shifts in mobility patterns: car use to meet short-distance mobility needs would be replaced by new and existing public transport systems (shared taxi systems, automated people movers, etc.) as well as by energy-efficient individual solutions (e-bicycles, e-vehicles, etc.). Shorter distances from home to high-capacity public transport system stops will help to satisfy everyday mobility needs completely without the use of private cars, as will smart information systems. Other important changes will affect the way that people interact with their residential surroundings. The densification of suburban areas means that we may expect a shift to more urban conditions in those areas, with less private green areas, more shared spaces, etc., but that we may also expect the local infrastructure to improve.

Of course, the implications for energy policy and social practices as reported above are limited by the constraints of the chosen workshop design and most of them refer to the Austrian context. However, in more general terms these results show what it would mean to link the urgent need for action in the present day to a long-term vision for sustainable energy.

References

Anderson, K., Shackley, S., Mander, S., Bows, A., 2005. Decarbonising the UK – Energy for a climate conscious future. Tyndall Centre for Climate Change Research, Norwich.

Commission of the European Communities, 2009. Investing in the development of low carbon technologies (SET-Plan).

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R., Swart, R., 2002. Great transition: The promise and lure of the times ahead. A report of the Global Scenario Group. Stockholm Environment Institute, Boston.

Robinson, J., 2003. Future subjunctive: Backcasting as social learning. Futures 35, 839-856.

Rohracher, H., Schreuer, A., Späth, P., Ornetzeder, M., Wächter, P., Weber, M., Kubeczko, K., Paier, M., Knoflacher, M., 2011. Nachhaltige Energie der Zukunft: Soziotechnische Zukunftsbilder und Transformationspfade für das österreichische Energiesystem (E-Trans 2050). Bundesministerium für Verkehr, Innovation und Technologie, Wien.

Shell International, 2008. Shell energy scenarios to 2050. Shell International BV, The Hague.

World Energy Council, 2007. Deciding the future: Energy policy scenarios to 2050 – Promoting the sustainable supply and use of energy for the greatest benefit of all. WEC, London.