The transition of the Austrian energy system to a high penetration of wind energy - a participatory integrated assessment of the social acceptance: final report

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FINAL REPORT

A) Project data

Short title:	Trans*Wind*
Full title:	The transition of the Austrian energy system to a high penetration of wind energy - A participatory integrated assessment of the social acceptance
Funding programme:	ACRP 5th call, 2012
Reporting period:	01.09.2013 - 31.12.2015
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Project costs:	235.285 €
Funding amount:	230.959 €
Klimafonds-Nr:	KR12AC5K01257
Date:	28.04.2016

B) German and English summary

1 Kurzfassung

Die Akzeptanz stellt einen entscheidenden Faktor in der Entwicklung der Windkraft dar. Umfragen belegen, dass die Windkraft ein sehr positives Image in der Bevölkerung genießt. Konkrete Projekte sind aber immer wieder mit lokalen Widerständen konfrontiert. Die Annahme oder Ablehnung von Windkraftanlagen kann darüber hinaus nicht einfach durch einzelne Kriterien, wie einer Kosten-Nutzen-Analyse, der öffentlichen Unterstützung erneuerbarer Energien, der Planungs- und Umsetzungsstrategie der Betreiber, der Anzahl der Anlagen, den durch die Anlagen verursachten Lärm, dem Artenschutz, dem NIMBY-Effekt oder den Einflüssen auf das Landschaftsbild erklärt werden (Stadlober and Hahn 1998; Warren et al. 2005; Wolsink 2000, 2007a, 2007b). Die Akzeptanz ist vielmehr von einen komplexen Zusammenspiel vieler Faktoren abhängig, die sich auf individuellen Präferenzen und gesellschaftlichen Wertvorstellungen stützen.

Der Projektansatz basierte auf dem Konzept der sozialen Akzeptanz (Wüstenhagen et al. 2007), wo im Rahmen eines Akzeptanzdreiecks folgende Ebenen unterschieden werden: a) sozio-politische Akzeptanz der Technologien und politischen Handlungen durch die Öffentlichkeit, zentraler EntscheidungsträgerInnen bzw. Stakeholder und PolitikerInnen; b) lokale Akzeptanz, die durch Fragen des Vertrauens und der Gerechtigkeit geprägt ist; c) Marktakzeptanz, bei der die maßgeblichen Akteure die Betreibergesellschaften, Interessensvertretungen, InvestorInnen und KonsumentInnen sind. Diese drei Ebenen beeinflussen sich gegenseitig und werden nicht nur in der Wissenschaft sondern auch in der Praxis rezipiert. Trans*Wind* versuchte diese Grundstruktur aufzunehmen und im Rahmen eines methodisch verlässlichen partizipativen integrierten Assessments, die verschieden Faktoren der sozialen Akzeptanz zu identifizieren und zu bewerten. Auf einer nationalen Ebene wurde dabei mit Schlüsselakteuren in einer eigens dafür gebildeten Referenzgruppe kooperiert. Die Mitglieder dieser Referenzgruppe nahmen an qualitativen halb-strukturierten Interviews, partizipativen Workshops und Gruppendiskussionen teil. Ergänzend konnten mit Hilfe einer partizipativen Modellierung Stromgestehungskosten berechnet werden. Auf der lokalen Ebene kamen ebenfalls Leitfaden-gestützte Interviews, Fokusgruppen und Visualisierungsparcours in insgesamt sechs Fallstudien zum Einsatz. Durch die Verwendung qualitativer und quantitativer Methoden in einer Mikro-Makro-Analyse konnte der inter- und transdisziplinäre Charakter des Projekts gesichert werden.

Dieser Ansatz war notwendig, um zu neuen, praktischen und relevanten Erkenntnissen zu gelangen. Der konzeptuelle Rahmen von Trans*Wind* verfolgte das Ziel, in einem systematischen Ansatz die analytischen Perspektiven des Projekteams mit den Präferenzen und Wahrnehmungen von Stakeholdern und Betroffenen zu integrieren. Der Bewertungsprozess wurde durch ein GIS basiertes Modellierungstool (Where the wind blows – WTWB) unterstützt, welches die paritizipative Modellierung von optimalen Standorten für Windturbinen, abhängig von der räumlichen Verteilung der Windressourcen, erlaubte. Stellungnahmen aus der Referenzgruppen wurden zu einem Kriterienkatalog zusammengefasst, welcher drei Flächenszenarien (min, med und max) für potentielle Standorte von Windturbinen definiert. In viertes Szenario zeigte außerdem das Windenergiepotential, welches sich aus der Anwendung der von den österreichischen Bundesländern definierten Eignungszonen ergibt. Für alle potentiellen Standorte wurden Stromgestehungskoten – die Levelized Cost of Electricity (LCOE) – errechnet und Angebotskurven für Windenergie für jedes der Flächenszenarien entwickelt. Im Minimiumszenario können maximal 3,5TWh an Windenergie bei sehr hohen Kosten von 96 bis 243 €MWh-1 erzeugt werden. Es wäre daher nicht möglich, die Windenergieziele von 3GW installierter Kapazität (was ungefähr bei derzeitigen Kapazitätsfaktoren einer Erzeugungsmenge von 6,3TWh pro Jahr entspricht) des österreichischen Ökostromgesetzes 2012 zu erreichen. Im Medium und Maximum Szenario könnte der derzeitige Windenergieanteil zu Kosten von rund 95€ MWh-1 selbst bei einem Anstieg des Endverbrauchs erhöht werden. Die Modellierungsresultate erhöhten unser Verständnis für die mit dem Windenergieausbau verbundenen Kosten und dienten als Grundlage für die Auswahl der Fallstudien.

Um verschiedene Planungsstrategien und Standortoptionen von Windrädern in einem gemeinsamen Diskussionsprozess zu erörtern, wurde für ausgewählte Fallstudiengemeinden interaktive 3D Modelle entwickelt. Eine Erhebung bestehender Visualisierungstechniken und –methoden zeigte, dass eine breite Palette unterschiedlicher Systeme und Einsatzformen existiert. Einfache Bildretuschen (statische Bilder) sind aktuell der Stand der Technik in Planungsprozessen. Sie stehen aber zunehmend in der Kritik, da die Bilder kaum hinsichtlich ihrer Validität überprüfbar sind und meist nur wenige Standpunkte angeboten werden. Die Kosten betrachtend, gehören Bildretuschen zu den effizienteren Ansätzen und die Verbreitungswege der Bilder in Berichten, Präsentationen oder Webseiten sind sehr einfach umsetzbar.
Interaktive 3D Visualisierungen erlauben eine freies Navigieren durch ein 3D Modell und unterstützen so auch sehr persönliche Motive bei der Orts- und Standortwahl. Individuelle Erwartungen oder Befürchtungen können so ad hoc im Modell geprüft werden, was objektivere Diskussionen in Planungsprozessen fördern kann.
In den vergangenen Jahren sind zwei neue Technologien am Markt erschienen, die ebenfalls Potential haben visuelle Aspekte von Windrädern in einer Landschaft zu vermitteln: Augmented Reality(AR) und Virtual Reality (VR). Sowohl AR als auch VR haben durchaus Potential, einen Mehrwert in der Betrachtung und Bewertung der visuellen Auswirkungen von Windenergie, zu liefern. Aktuell gibt es jedoch noch einige technische Barrieren und Hürden.
Ziel von TransWind war es, den visuellen Einfluss von Windrädern auf eine Landschaft zu bewerten. Dazu wurden im Rahmen mehrerer lokaler Visualisierungsparcours unterschiedliche Anwendungen realitätsnaher Echtzeitvisualisierungen getestet.

Durch die Untersuchung der Fallstudien und die Zusammenarbeit mit der Referenzgruppe konnte Trans*Wind* verschiedene Aspekte der sozialen Akzeptanz beobachten, bewerten und kontrastieren. Die empirische Analyse der Interviews und Fokusgruppen zeigte, dass bei der Planung und Errichtung von Windkraftanlagen es stets zu einem Austausch- und Verhandlungsprozess zwischen unterschiedlichen Perspektiven, Anschauungen und Wertvorstellungen kommt. Grundsätzlich müssen daher Interessierte und Betroffene in die Entscheidungen mit eingebunden sowie Kooperations- und Koordinationsprozesse gestärkt werden.

Auch wenn einzelne Kriterien der sozialen Akzeptanz von den Akteuren als gleichsam bedeutend erachtet wurden, so bleiben weiterhin sehr unterschiedliche Interessen, Einstellungen und Anschauungen bestehen. D.h. Konflikte und Auseinandersetzungen bilden den Kern jedes Planungs- und Umsetzungsprozess, wobei die Vor- und Nachteile der direkt Betroffenen den breiten, aber recht unspezifischen Kosten und Nutzen der Allgemeinheit gegenüber stehen. Scheitert der Interessensabtausch auf lokaler oder regionaler Ebene, d.h. kann keine tragfähige Kompromisslösung gefunden werden, so bleibt der grundsätzliche Konflikt bestehen, dass ein Interessensausgleich zwischen unterschiedlichen Weltanschauungen im Bezug auf die Windkraft nicht möglich ist. Daher ist es wichtig, für geregelte und gerechte Verfahren im Planungs- und Umsetzungsprozess zu sorgen.

Die Prinzipien der Fairness und Gerechtigkeit spielen in der Anerkennung von Entscheidungsprozessen eine große Bedeutung. Diese Prinzipien sind ein zentrales Motiv der eigenen Handlungen und gleichzeitig ein Bewertungskriterium für Handlungen und Entscheidungen anderer. Werden die Entscheidungsfindungsprozesse als fair und gerecht erachtet, so steigt die Anerkennung des Verfahrens oder der Planung. Unter Berücksichtigung dieser Gerechtigkeitsperspektive hat das Projekt Trans*Wind* zentrale Verbesserungsvorschläge formuliert und einen Leitfaden zum Umgang mit der sozialen Akzeptanz von Windkraftanlagen entwickelt.

2 Executive Summary

Social acceptance is considered to be a decisive factor for the development of wind energy. Surveys repeatedly show that while people support wind energy in general, specific wind farm projects often cause local opposition. Local resistance against wind energy cannot be explained by singular issues such as simple cost-benefit calculations, the public support for renewable energy sources, the implementation strategy of the developer, the number of wind turbines installed, the intensity of the turbine noise, the protection of local birds and animals, or the “not-in-my-backyard”-effect (Stadlober and Hahn 1998; Warren et al. 2005; Wolsink 2000, 2007a), although a very dominant influence seems to be the specific value of the landscape, the familiar surroundings and the habitat (Wolsink 2007b). Hence, the acceptance of wind energy depends on a complex set of individual and societal indicators, perceptions and preferences rooted in institutional and socio-political arrangements.

The project’s approach was based on the concept of social acceptance (Wüstenhagen et al. 2007), which is composed of socio-political, market and community acceptance. Wüstenhagen et al. investigated spatial planning and financial procurement systems to assess socio-political acceptance, market innovation, consumer and investors behaviour to explain market acceptance, procedural and distributional justice and trust to contribute to the understanding of community acceptance. The three levels of acceptance do interact, have main actors associated and are influenced by their interactions and contributing expectations.

We recur to this triangle model because it provides a broad holistic framework widely recognised not only in a scientific but also in a practical context. Trans*Wind* established a conceptual and methodological reliable participatory integrated assessment in order to test various factors of social acceptance. On a macro scale the integrated assessment was based on semi-structured interviews, participatory workshops and a group discussion (WorldCafé) with the experts from our stakeholder group, an estimation of the theoretical wind area potential in Austria and a participatory modelling approach to analyse the levelized cost of electricity (LCOE). On the community level focus groups, semi-structured interviews and presentations/tests of visualisation tools were conducted. Both the integration of results from the macro analyses to the community scale and the use of a mixed-method design ensured the inter- and transdisciplinary character of Trans*Wind*.

This approach is needed to gain new, practical and relevant insights, which could not have been obtained merely from scientific or interdisciplinary sources. The conceptual framework of Trans*Wind* therefore aimed at integrating in a systematic way the analytical perspectives of the scientists and their approaches with the preferences and perceptions of the persons concerned about the issue (stakeholders) through establishing a reference group, holding workshops and organising interviews and focus groups. The assessment was complemented by a GIS based modelling tool (Where the wind blows - WTWB), which allowed the participatory assessment of optimal locations for wind power, depending on the spatial distribution of wind resources. Inputs from the reference group were summarized in a criteria catalogue to define three scenarios (min, med and max) for potentially suitable wind turbine sites. These three scenarios were complemented by a fourth scenario that reflects the wind energy potential with suitability zones for wind energy already defined by Austrian federal states. For all potential locations we calculated the levelized cost of energy generation (LCOE) to derive wind energy supply curves for each scenario of potentially suitable wind turbine sites. Under the assumptions of the min scenario, only 3.5TWh of wind energy could be produced at relatively high costs of 96 to 243 € MWh-1. Thus, it would not be possible to meet the wind energy targets of 3GW installed capacity (equivalent to about 6.3TWh assuming current capacity factors) of the Austrian Eco-Electricity-Act 2012. The med and max scenario would allow for further expanding the wind energy share at reasonable cost of about 95 EUR MWh-1 even if electricity demand keeps steadily rising. The modelling results raised our understanding of the related costs and benefits and served as a basis for the case study selection.

In the case studies, Trans*Wind* worked with interactive 3D visualisation tools based on latest visualisation developments to provide real-time and realistic visualisations for discussing and assessing different planning strategies and siting processes related to the visual impact on the landscape. Our research on technologies for 3D modelling in the context of Wind turbine visualisations has shown that different concepts and methods exist. The simple image visualisations (static images) are state of the art in planning processes but they are increasingly criticised as there is no easy way to prove their reliability and the number of viewpoints is very limited. From a cost perspective it is still the most efficient technology and the images can be easily shared in reports, presentations or websites. Interactive 3D visualisations allow users to change their viewpoints interactively depending on personal motifs. Therefore, personal fears and expectations can be addressed which may lead to more objective discussions and exchange of opinions during planning processes. During the project, two very new technologies entered the stage: Augmented reality (AR) and Virtual reality (VR) applications. Both are driven by the fast spread of mobile phones and may provide some additional insights in the visual impact of wind turbines. Nevertheless there are still some technological barriers that leads to positioning errors or unrealistic views due to the missing masking of 3D objects by real world objects (in AR) or are lacking quality due to low screen resolutions of mobile phones (in VR).

Through the research in the case studies and the preferences expressed by the stakeholders of the reference group Trans*Wind* identified different and sometimes contrasting patterns of social acceptance, which enhanced our understanding about the economical, political, ecological and social feasibility of wind power plants. Our empirical results showed that all interview partners and focus group participants consider vertical and horizontal cooperation and coordination across different political levels and parties (stakeholders; experts; local to regional decision makers; citizens) to be important. The problem is that the process of interaction between these actors is often conflictual. Different factors could be highlighted explaining this divergence. Such factors can be seen in the conflict of interests, rationales and beliefs which strengthen the problems of coordination and cooperation. Furthermore, any wind energy project is characterised by the basic systemic conflict between nature conservation (protection of wildlife, habitat and landscape) and narratives of ecological modernisation (e.g. climate protection or energy transition). These moral concepts (core beliefs) and policy cores (general beliefs and perceptions in a specific policy field like wind energy) of the participants are unlikely to change. Only the so called secondary aspects, which relates to the implementation of a policy (e.g. instruments, concrete actions), are most likely to change and are subject to learning processes.

Solutions for local wind energy projects can only be found in coordinated processes of cooperation taking into account all patterns of social acceptance. In order to ensure acceptance, decision-making processes have to be reformed, justice sustained and thereby both input and output legitimacy enhanced. All of these factors were taken into account when Trans*Wind* finally established a guideline for various user audiences interested in handling the acceptance and non-acceptance of wind energy.

3 Objectives

Current and future challenges of climate change and the necessary transition towards a low-carbon society puts a great burden on all developed countries and requires policies for promoting renewable energy sources. The transition cannot be achieved without phasing out fossil sources of energy. In other words an ecological modernisation (Jänicke 1997; Weidner 2002) of our society is necessary, which implies substantial environmental policy innovations and improvements in deploying environmentally acceptable energy technologies.

Wind energy is a key technology towards a low-carbon society, because it lowers total system costs in an energy system with high shares of renewables (e.g. Becker et al. 2013; Becker et al. 2015). Increasing the share of renewable energies and in particular of wind power in the Austrian energy production mix is necessary for several reasons: First of all Austria committed itself to comply with EU 2020 climate and renewable energy targets. According to the EU directive 2009/28/EC Austria has to increase the share of renewable energy from 23.3% in 2005 up to 34 % in 2020. This target corresponds with the Austrian "Ökostromgesetz" (2012), which aims at doubling the installed wind power capacity from 1084 MW in 2011 to 2000 MW in 2020. Beyond 2020, the energy sector will require significant additional efforts to reduce carbon emissions and wind power will have to be a significant contributor to cost-efficient solutions regionally and super-regionally (Becker et al. 2013). A co-benefit of wind energy is the decreasing dependence on imports of energy (particularly of fossil fuels). The COP21 in Paris has moved international commitments into the direction of stronger carbon mitigation. The outcome of political processes on the European and national level will determine how far the development of wind energy will be fostered or reinforced until 2030 and far beyond.

However, the lack of acceptance of new technologies and wind power in particular is considered to be a constraining factor in achieving ambitious wind deployment targets. Surveys repeatedly show that while people support wind energy in general, specific wind farm projects often cause local opposition. The EU funded project "WindBarriers" for example has demonstrated that "*30% of non-finalised wind farm projects in Europe are stopped due to lawsuits and public resistance*" (Azau 2011: 30). Social sciences dealing with the notion of acceptance have demonstrated that human behaviour is predominantly dependent on individual perceptions and preferences and not on objective or scientific facts (Covello 1983; Slovic 1987; Rohrmann and Renn 2000). At the same moment, local resistance against wind energy cannot be explained by singular issues such as simple cost-benefit calculations, the public support for renewable energy sources, the implementation strategy of the developer, the number of wind turbines installed, the intensity of the turbine noise, the protection of local birds and animals, or the "not-in-my-backyard"-effect (Stadlober and Hahn 1998; Warren et al. 2005; Wolsink 2000, 2007a), although a very dominant influence seems to be the specific value of the landscape, the familiar surroundings and the habitat (Wolsink 2007b). Hence, the acceptance of wind energy depends on a complex set of individual and societal indicators, perceptions and preferences rooted in institutional and socio-political arrangements.

However, for a long time the concept of social acceptance remained vague or difficult to grasp. Only now scholars begin to contribute to the clarity of understanding. Wüstenhagen et al. (2007) for example distinguished between three dimensions of social acceptance: a) socio-political acceptance, b) market acceptance and c) community acceptance (see Figure 1). They investigated spatial planning and financial procurement systems to assess socio-political acceptance, market innovation, consumer and investors behaviour to explain market acceptance, procedural and distributional justice and trust to contribute to the understanding of community acceptance. The three levels of acceptance do interact, have main actors associated and are influenced by their interactions and contributing expectations. Hahn and Stadlober (1998) already use the dimensions (a) and (c) in a similar way. The common thread between these complementary approaches is that patterns of social acceptance and non-acceptance are dependent on various individual preferences and institutional settings, which have to be investigated when the future development of wind energy should be assessed.

Figure 1: The triangle model of social acceptance (Wüstenhagen et al. 2007: 2684)

4 Project content and results

In Trans*Wind* we recurred to the triangle model of social acceptance because it provides a broad holistic framework widely recognised in the scientific and in a practical context, but we assessed it in a different way using the following mixed method design (see Figure 2): On a macro scale the integrated assessment was based on semi-structured interviews, participatory workshops and a group discussion (WorldCafé) with the experts from a reference group, an estimation of the theoretical wind area potential in Austria and a participatory modelling approach to analyse the levelized cost of electricity (LCOE). On the community level focus groups, semi-structured interviews and presentations/tests of visualisation tools were conducted. Both the integration of results from the macro analyses to the community scale and the use of a mixed-method design ensured the inter- and transdisciplinary character of Trans*Wind*.

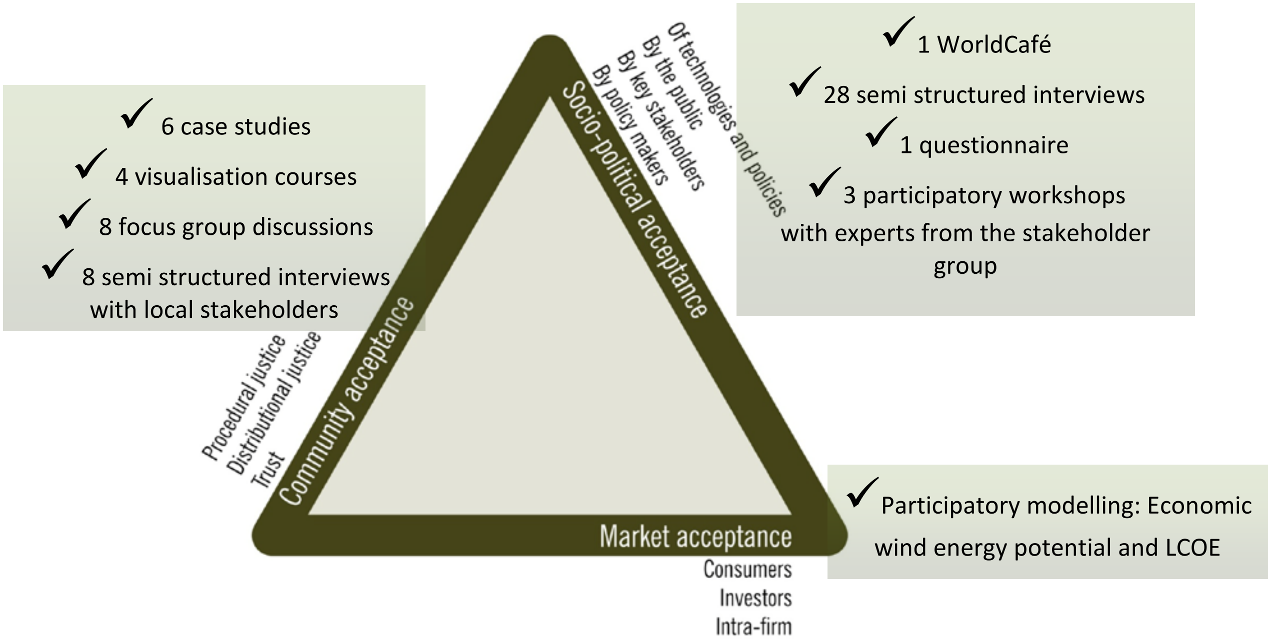

Figure 2: How to assess social acceptance?

Therefore Trans*Wind* established a conceptual and methodological reliable participatory integrated assessment in order to test various factors of social acceptance. Instead of offering solely a scientific description and explanation of social acceptance, we opened the discussion to interested stakeholders (civil servants, developers, representatives of NGOs and lobbying organisations, public authorities, citizens as well as technical experts) from the beginning and worked together with them in order to identify the patterns, drivers, management barriers and opportunities of social acceptance. Hence identifying and prioritizing the factors contributing to the triangle of social acceptance were co-determined by the non-scientific participants in the project and formed an integral part of the participatory integrated assessment.

Two research questions guided our assessment:

1) What are the patterns and determinants of social acceptance of wind energy in Austria?
2) How do the perceptions about the social acceptance differ between expert judgments, stakeholder views and citizen concerns?

In this assessment we framed social acceptance not only as a management task. We go beyond the widely recognised normative assumption that “acceptance” is good and “resistance” is bad. We were interested in reasons how to implement and why to not implement a project. In line with this approach, we conceptualised citizens as active agents in the process of decision-making and not as disturbance factors, which have to be convinced to follow the energy transition. Hence our perception of social acceptance is determined by aspects advocating wind energy and by important elements of opposition at the same time. Here, we report in detail our approach and the results of our research process.

4.1 The stakeholder process

Before Trans*Wind* started the project team discussed a list of potential stakeholders, which could contribute to the research of Trans*Wind* and represent a supra-regional interest in the sector of wind energy. In the first project meeting we agreed upon the following selection process:

Based on a literature review and an online research we first identified 64 individuals who have a stake in the deployment of wind energy. These persons were contacted per e-mail and asked to specify the most relevant actors (organisations or individuals) in the field. We received 199 nominations (response rate 46.88%) and allotted them to four different categories: politics/administration; interest groups (supporters or opponents of wind energy); wind energy enterprises and electricity providers; regulatory bodies. The organisations with the most entries (absolute numbers) in the four groups were contacted and invited to the first workshop, where the reference group was constituted.

This selection process has two advantages: All stakeholders were already informed, when the project officially started. Therefore the capacity to work with the group could be used at the beginning of Trans*Wind*. Secondly, although the reference group is much bigger than in the project proposal suggested, it better reflects the needs of the community to create a discussion forum.

The reference group of Trans*Wind* contains 27-28 organisations (or 33-34 individuals) drawn from a wide range of sectors such as practitioners, experts, civil servants, policy-makers, lobbying groups, wind energy enterprises, environmental NGOs, representatives of the civil society, labour and trade unions (see the list of participants at http://www.transwind.boku.ac.at).[1] The aim of the reference group is to provide feedback at various stages of the research process (see Figure 3), to provide a forum for critical discussion and to guarantee a long-term and institutionalised form of participation.

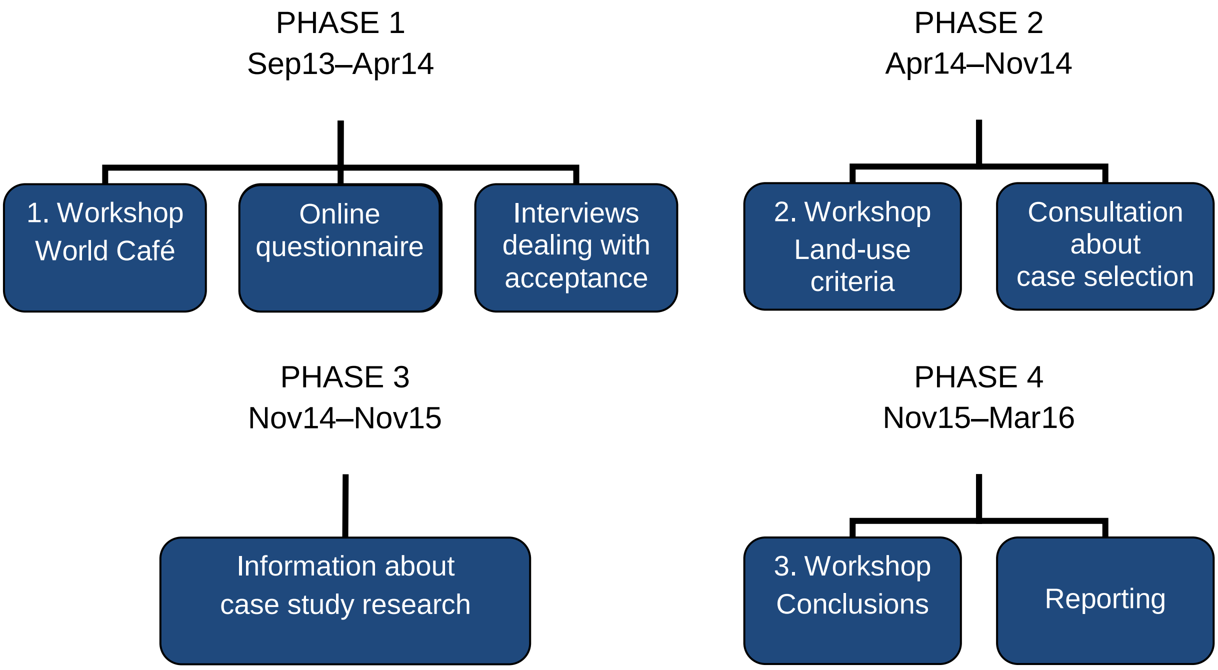

Figure 3: Scope of knowledge integration and levels of co-determination in Trans*Wind*

PHASE 1 (September 2013 – April 2014)

In the first moderated stakeholder workshop the aims of the project and the development of wind energy in Austria were presented, the reference group was constituted, the rules of communication and decision-making were fixed, and the levels of co-determination (from *information* to *consultation* and *co-decision-making*) were declared. This approach was necessary in order to make the participatory processes of Trans*Wind* transparent and conceivable for the stakeholders. As a consequence, the members of the reference group knew from the beginning how much time they should invest and how they could influence the research project. The second half of the

[1] In December 2014 the Austrian Alpine Associtation (Österreichische Alpenverein) withdrawed from the reference group.

workshop was dedicated to a World Café. In small groups, four subject areas were discussed: a) political barriers and benefits; b) siting and planning options; c) future impacts of wind energy; d) social acceptance and justice. The group discussions were moderated and contributed to the qualitative assessment of the social acceptance of wind energy.

Part of the modelling approach was an online questionnaire, which was also presented at the first stakeholder workshop. The survey aimed at assessing the general attitude towards wind energy and preferences for future expansion, defining areas that should be excluded from wind power production, setting distance limits and collecting reasons for excluding those areas (see section 4.2 for the results of the survey). 23 out of 28 member organisations, i.e. 82% of the reference group, completed the questionnaire.

PHASE 2 (April 2014 – November 2014)

In spring 2014 we organised 28 semi-structured interviews with representatives of all member organisations of the reference group. The interviews were conducted face-to-face and lasted from 57 to 104 minute. They were based on an interview guidebook, recorded and literally transcribed. The aim of the interviews was to deepen various aspects of social acceptance from a stakeholder's point of view. They provided us with a thorough overview about the planning and siting decisions and related conflicts or problems addressing different aspects of social acceptance. The analysis (coding and examination) of the interviews is elaborated in "qualitative assessment of the social acceptance of wind energy" (see below). An additional side-effect of the interviews was to foster the cohesiveness within the group of stakeholders and to motivate them to contribute to the research of Trans*Wind* and to take part in the workshop(s).

In the second workshop the results from the online questionnaire (see section 4.2) were presented and discussed. On the basis of the survey and a literature review, the research team established a criteria catalogue, were different types of topological restrictions and distance limits to technical infrastructure and protective areas were compiled. The aim of the catalogue was to introduce a minimum, medium and maximum scenario for the theoretical wind area potential in Austria. During the workshop the stakeholders were able to evaluate the spatial, technical and topological parameters and distance limits again (didactic tool: matrix and glue dots) and to suggest new criteria (e.g. tourism; development of urban areas). This was followed by an intense discussion and a revision of the criteria catalogue. At the end of the workshop the participants agreed that the medium scenario, where no consensus could be found among stakeholders, should be elaborated by the scientific team of Trans*Wind*.

After the workshop one topological indicator (working with sea levels or timber lines) were put to a vote (because an agreement in the workshop was not possible to find) and the final version of the matrix (with a minimum and a maximum wind deployment target) was approved.

According to the literature, some of the most dominant indicators influencing the acceptance of wind energy are the specific value of the landscape, the familiar surroundings and the habitat (Wolsink 2007b). Therefore the case study selection should account for the importance of tourism, wood land and the alpine scenery in Austria. In addition wind energy is not only restricted to the topological area of lowlands (in the Eastern parts of Austria), but could also be employed in tableland, intermediate shelf and alpine areas. As a consequence, the case study selection reflects two scenarios: a) the repowering of existing wind turbines and further concentration of wind sites in the East; and b) the diversification of wind farms throughout the country.

A preliminary list of potential (primary and secondary) attributes for the case study selection was sent to the stakeholders of the reference group and the feedback (four written statements) was incorporated (consultation process).

The workflow of the case selection included two steps. The first step was based on the following list of (primary) attributes:

- Theoretical wind area potentials of med scenario

- Topology of Austria (lowlands, tablelands, foothills of the Alps, alpine areas)
- Wood land (municipalities with more than 80% or less than 10% wood land in relation to the municipal area)
- Importance of tourism (high, low, no information)
- Structure of urban development (dispersed settlement, rural or urban character)
- Austrian federal states ("Bundesländer")

According to this pre-selection, about 35-40 municipalities were chosen and the following questions (secondary attributes) were specified:

- Is the municipality a climate and energy model region?
- Is there a wind farm constructed or planned?
- Has the municipality potentials for repowering?
- Is there a citizens' group active opposing wind energy?
- How could the public participate when the wind project was planned and constructed (conflictive situations)?
- Who is operating the wind farm?

The case selection resulted in a sample of 24 Austrian municipalities which represents the primary and secondary attributes according to a most different case design. In approval with the members of our reference group (consultation process including two written and three verbal statements) the list was grouped and prioritised according to the requirements of scenario a) and b) (see above) and six different focal points:

- Summer tourism (*Sankt Gilgen*, Ratten, Arriach, Himmelberg)
- Winter tourism (*Hinterstoder*, Bad Mitterndorf)
- Wood land (*Bärnkopf*, Gutenbrunn, Dorfstetten, Draßmarkt, Königswiesen, Zemendorf-Stöttera)
- Repowering (*Parndorf*, Neusiedl am See, Weiden am See)
- Local protests and conflicts (*Himberg*, Wiesmath, Schwarzbach, Bromberg)
- Alpine area with a high level of technical and economical potential of wind energy (*Fischbach*, Langenwang, Haag, Haidershofen, Weistrach)

(*the finally selected case studies are presented in italics*)

PHASE 3 (November 2014 – November 2015)

During the research in the local case studies we informed the group of stakeholders by means of written updates (e-mails) about the processes of negotiations (first contacts with mayors and local councils, assignment of a common understanding), methods (visualisation courses, focus groups, interviews) and implementation (local workshops) (see section 4.5 for a detailed description of the local case studies).

PHASE 4 (November 2015 – March 2016)

In the third and final participatory workshop the preliminary results of Trans*Wind* were presented and discussed with the members of the reference group. The feedback was used to make some of the conclusions more comprehensive. The stakeholders were informed about the design of the local case studies and the implementation of the workshops. In addition they were able to test the visualisation course developed for the local case studies and judge the different technologies with the questionnaire. At the end of the workshop, the stakeholders evaluated the project and its participatory efforts verbally. They were informed about the plan of the project team to organise a public event (after the official end of the project) in order to disseminate the results to a general public, about their possibilities to review the final project reports (*consultation process*), to co-produce a guideline dealing with the social acceptance of wind energy in Austria and to take part in an online questionnaire evaluating the stakeholder process.

4.2 Modelling of wind power potentials

Trans*Wind* assessed the Austrian wind energy potential in a participatory modelling approach. Therefore, we included inputs from an online questionnaire, e-mail consultations and two stakeholder workshops into the GIS based modelling tool "WTWB - Where the wind blows" (Schmidt et al. 2013). The model uses data of the Austrian wind atlas (Krenn et al. 2011) and simulates wind speeds on an hourly basis for each hectare in Austria.

Participatory modelling approach

To give stakeholders the possibility to articulate their preferences and give inputs at all stages of the participatory modelling process, we conducted an online survey and several e-mail consultations and organized two stakeholder workshops with the members of our reference group (see Figure 4). Federal state authorities, especially those from Burgenland and Styria, contributed with their experience from previous planning processes and their expertise on regional spatial planning laws in the context of wind energy. Wind park developers provided information on the technical restrictions (e.g., the maximum feasible slope). Experts from nature conservation groups highlighted relevant ecological restrictions, such as the type of protected areas that should be excluded.

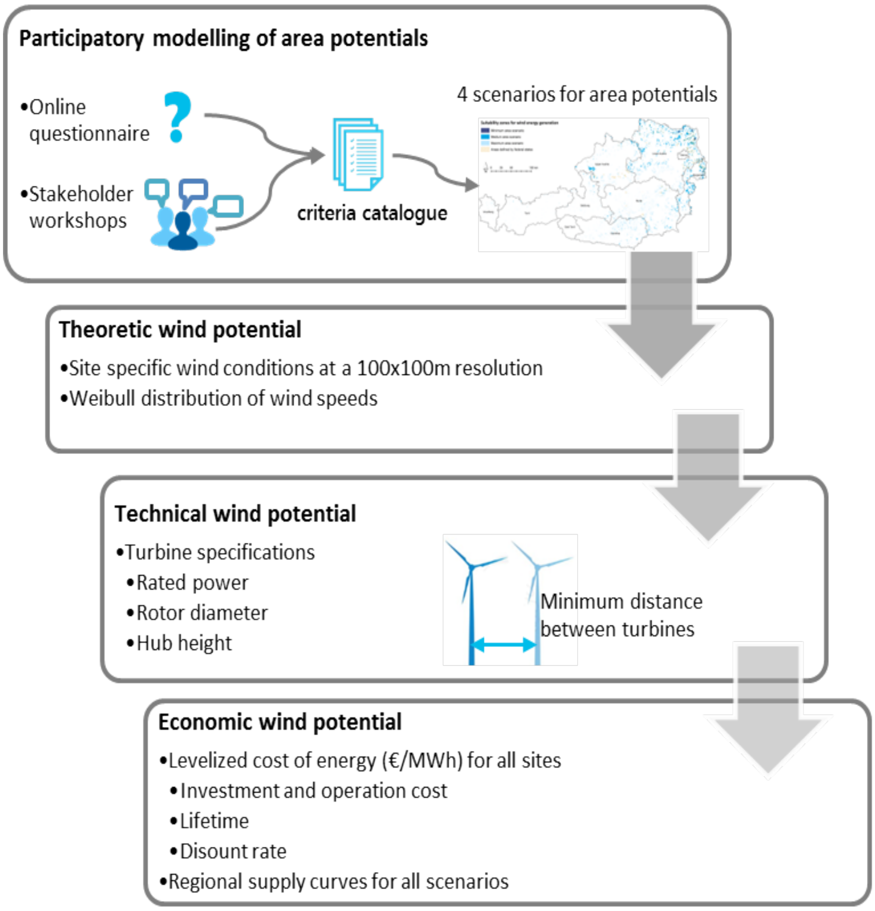

Figure 4: Overview of the modelling steps to derive four scenarios of the economic wind energy potential for Austria

The results from the online questionnaire revealed priority areas for future wind power production and define minimum distance limits. The majority of the respondents agreed that wind energy can contribute to mitigate climate change (78%), reduce the dependence on fossil fuels (74%) and that it is an economically feasible source of renewable energy (65%). Concerns were raised about the impact on the landscape (65%) and conflicts with nature conservation (48%), especially possible negative impacts on birds and bats (43%). The suitability of different land use categories has been evaluated quite similarly by most stakeholders (Figure 5). However, the suitability of forests is seen very controversially with 12 respondents (52%) assessing forest areas as very suitable or suitable for wind energy and 11 respondents (48%) arguing that they are unsuitable or very unsuitable.

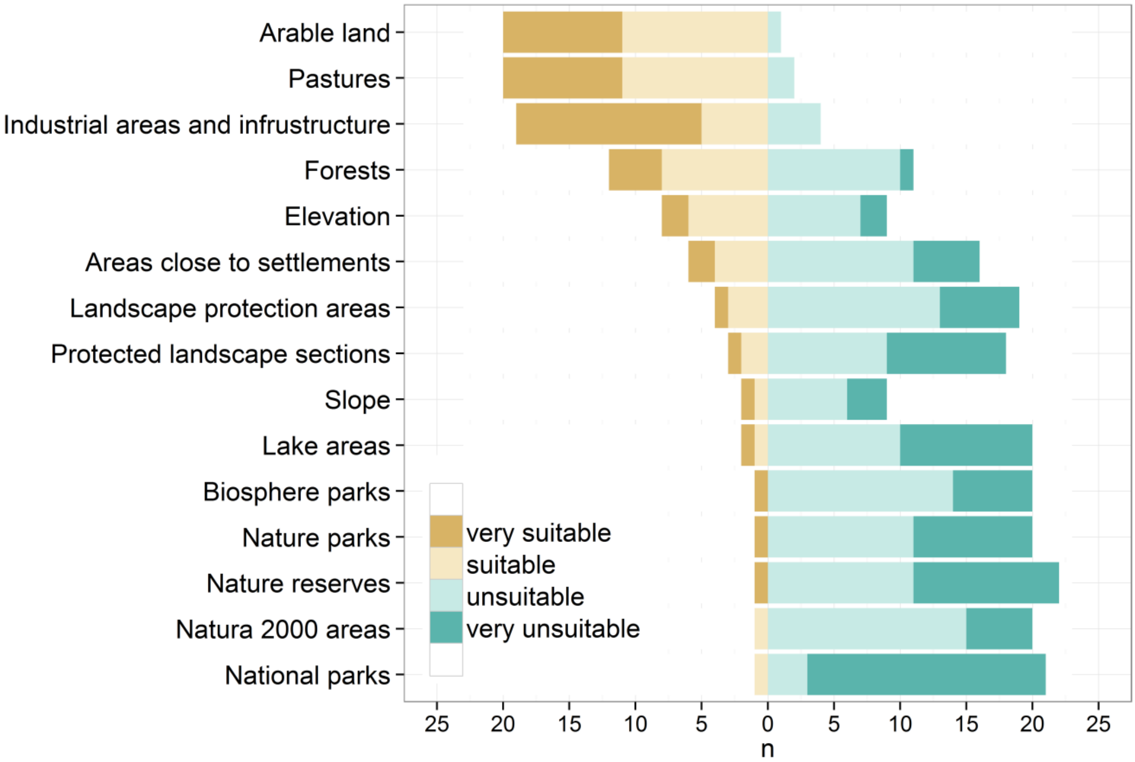

Figure 5: Suitability for wind energy of different land use categories according to the members of the Trans*Wind* reference group (n=23)

The results of the online questionnaire were summarised in a criteria catalogue (Table 1) and used to define three scenarios (min, med and max) for potentially suitable wind turbine sites.

In the min scenario, we consider several strict restrictions and large setbacks to protected and settlement areas so that all of the stakeholders agreed that no more areas should be excluded as potential sites. This implies that even the most restrictive stakeholders with respect to wind power deployment agreed that such a scenario would be feasible from their point of view. The max scenario was chosen in a way so that the stakeholders agreed that no more areas should be considered to be potentially suitable, i.e., by using lower setbacks to protected and settlement areas (max scenario). This implies that even the stakeholders with greatest interest in wind power expansion agreed that wind power should not be deployed beyond that point. The min and max scenarios represent the lower and upper bounds of the acceptable wind energy potential in Austria from a socio-political perspective, as defined by the stakeholder group. The large bandwidth of the min and max scenario made it difficult to draw conclusions about the potential contribution of wind energy in Austria. To provide a more meaningful estimate within this range we defined a med scenario. Due to the heterogeneity of the stakeholder group, it was not possible to reach consensus on the med scenario. Therefore, assumptions and offset distances of the med scenario are based on current national and federal state legislations and recommendations by experts and from previous studies. To provide a reference value for our three scenarios, we also calculated the economic wind energy potential for the suitability zones defined by the federal states of Burgenland, Lower Austria, Styria and Upper Austria.

Table 1: Restrictions for the wind area availability in the scenarios min, med and max

	wind area scenario min	med	max	GIS data-set	reference
topological restrictions					
above alpine forest line		excluded		Kilian et al. (1994)	questionnaire
maximum slope	5.7°	8.5°	11.3°	SRTM DEM 90m	stakeholder workshop, wind-data.ch (2014)
water bodies		excluded		Corine LC 5	stakeholder workshop
distance to settlements and infrastructure					
settlement areas	2000m	1200	1000m**	IACS	questionnaire, stakeholder workshop
buildings outside of settlement areas	1000m	750m	750m	OSM buildings [a]	federal legislations
building land outside of settlement areas	1000m	750m	750m	land use plans	federal legislations
built-up areas (industrial and commercial units, mining areas,) [b]		300m		land use plans	
railways		300m		OSM	stakeholder workshop
roads (motorways, primary and secondary roads)		300m		OSM	stakeholder workshop
airport public safety zones [d]		5100m		AustroControl	AustroControl, BMUB (2009)
power grid (>110kV)		250m		OSM	APG, stakeholder workshop
protected areas					
national parks	excluded (+3000m)	excluded (+2000m)	excluded (+1000m)	CDDA	questionnaire, stakeholder workshop
Natura 2000 (habitats directive sites)	excluded (+2000m)	excluded	potentially suitable *	Natura 2000	questionnaire, stakeholder workshop
Natura 2000 (birds directive sites)	excluded (+2000m)	excluded	excluded	Natura 2000	questionnaire, stakeholder workshop
other protected areas [e]	excluded (+2000m)	excluded	excluded	CDDA	questionnaire, stakeholder workshop
important birdlife areas	excluded	potentially suitable *	potentially suitable *	IBAs	stakeholder workshop
major migration routes for wild animals	excluded	potentially suitable *	potentially suitable *	ACC, Köhler (2005)	questionnaire
forest areas	excluded (+1000m)	only commercial forests (excluding communities with a forest share below 10%)	only commercial forests	Corine, Austrian forest development plan	questionnaire, stakeholder workshop
lakes (>50ha)	3000m	1750m	1000m	Corine LC 512	questionnaire

a.) data quality varies regionally; b.) considerd for Burgenland, Salzburg, Tirol, Vorarlaberg and Vienna d.) radius of 5100m around airports; e.) biosphere
* requires site specific assessments; ** Lower Austria 1200m

Acronyms
ACC (Alps-Carpathians Corridor), APG (Austrian Power Grid AG), Corine LC (Coordination of Information on the Environment Land Cover), CDDA

References
BMUB - Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2009). Abschätzung der Ausbaupotenziale der Windenergie an
Kilian, W., Müller, F., Starlinger, F. (1994). Die forstlichen Wuchsgebiete Österreichs. FBVA-berichte 82, 60.
Köhler (2005). Habitatvernetzung in Österreich - GIS-Modellierung von Mobilitäts-Widerstandswerten für waldbevorzugende, wildlebende Großsäuger
wind-data.ch (2014). Windenergie-Potenzial - Ausschluss-Kriterien. http://wind-data.ch/windkarte/potenzial.php.

In a second workshop, six months later, we discussed the criteria catalogue for the scenarios of potentially suitable wind turbine sites with our stakeholder group. The recommendations and comments of the key stakeholders were collected and used to update the criteria catalogue. Experts from regional land use planning authorities argued that current settlements and buildings as well as potential future settlement expansions should be considered. Therefore, we gathered information on land-use plans to include land that was dedicated as a building area as an additional exclusion zone. Our approach to generally exclude or include forest areas was criticized for being too simplistic. Stakeholders suggested that the main function of a forest area (productive, protective, recreational and social welfare function) according to the Austrian forest development plan (Fürst and Schaffer 2000) should be integrated, and only those areas with prevailing productive function should be considered to be suitable. Another concern that has been raised is whether the defined maximum elevation for wind sites is a proper criterion. Critics argued that using the alpine forest border line instead of the maximum elevation would better reflect topological differences between Eastern and Western Austria. For the integration of the alpine timber line as a new criterion we used results from a study of Kilian et al. (1994). Wind park developers noted that the assumed maximum slope of up to 20°, which we had taken from a previous study on the wind potential in Austria (Prinz et al. 2005), was unrealistically high. According to the wind energy experts in our stakeholder group, it was not economically feasible to build wind turbines on sites that are steeper than 5.7°. Values from scientific literature are usually much higher, ranging from 11.3°, or 20% (Grassi et al. 2012), to 15° (Gass et al. 2013; Winkelmeier et al. 2014) and 16.7° or 30% (Lütkehus et al. 2013). Therefore, we assumed a range between the expert values (5.7°) and the lower values that were found in literature (11.3°). In a third step, the redefined values for the min and max scenario were approved by all of the stakeholders. The contributions and results were collected on our project webpage (http://www.transwind.boku.ac.at) to encourage continuous stakeholder feedback.

Integration of stakeholder inputs and modelling of the economic potential

The inputs from our reference group contributed to improve the quality and the legitimacy of the results. In total, the 28 experts from the various organisations provided a diverse picture of social, economic and technical barriers that have to be considered for assessing Austria's future wind energy potential. Discussions in the workshops revealed that the definition of the theoretical wind area potential is a key issue that determines the acceptance of wind energy. Therefore, the collection of geographic information to represent the different land use categories was one of our key tasks. To represent their attitudes towards the suitability of different land use categories for wind energy generation, we collected GIS data on land use categories, topology, settlement areas, federal land use plans, protected areas and important habitats and migration routes for wild animals, infrastructure, the regional alpine forest line and the main function of forests. A detailed overview of data-sets and data sources is given in Table 1.

The design of support schemes for wind energy is another important factor for the economically optimal locations for wind power turbines. As the future support scheme for renewable energy in Austria is ambiguous and unpredictable, the implementation of different policy options into the existing optimization model was neglected and allowed us to use more resources for the GIS modelling which was strongly discussed by stakeholders. The economic potential was directly derived by calculating levelized costs of electricity (LCOE) for all feasible locations and generating supply curves based on the different scenarios for the theoretical wind area potential and the future energy demand without using the optimization model. The following modelling steps were used to derive the supply curves: After modelling the theoretical wind area potential using the available GIS data, the theoretical wind energy potential was calculated by simulating mean hourly wind speeds from the Weibull distributions provided by the Austrian wind atlas.

In the next step, we transformed wind speeds to power production by applying power curves of specific wind turbines. Also, the maximum number of possible turbines was determined by implementing a minimum distance between two wind turbines of 6 times the rotor diameter. In the last step, we calculated the LCOE for all wind sites, applying a wide range of estimates from literature for investment and operation costs, the discount rate and wind turbine lifetimes (Table 2). The supply curves were generated by sorting and summing up the LCOE of all potential wind energy sites.

Table 2: Parameters for LCOE calculation

parameter	unit	value
installed capacity	MW	3
rotor diameter	m	100
investment cost	Euro / KW	1600- 1900
operation cost	Euro / MWh / year	16 - 32
lifetime	years	20
discount rate	%	5

Scenarios for Austria's energy demand in wind energy share in 2030

Many targets for renewable energies and also for wind energy are defined as a relative share of the final end energy demand. To provide a feasible bandwidth for the end energy demand in 2030 and the resulting wind energy generation we used four scenarios (Table 3). We assume, that in the best case, the demand can be stabilized at the level of 2013, and in the worst case, the demand will continue to grow with the same annual rate of 1.5%, as observed on average in the last 10 years. To reach renewable energy targets for wind power, these scenarios would require an annual wind energy generation between 6.2 and 16.1 TWh for 2030.

Table 3: Scenarios for the future wind energy generation depending on the electricity demand in 2030 and the targets for the share of wind energy in total energy generation.

		Development of the electricity demand until 2030	
		Stabilisation on the level of 2012 (62 TWh)	Increase by 1.5% p.a. to 84TWh
Wind energy	10%	Scenario 1 (6.2 TWh)	Scenario 2 (8.05 TWh)
	20%	Scenario 3 (12.4 TWh)	Scenario 4 (16.1 TWh)

Results for the theoretic area and economic wind energy potential

The area of potential wind turbine sites ranges from 74 km² in the min scenario up to 2285 km² and 3305 km² in the med and max scenario, respectively (Figure 6). This is equivalent to 0.1%, 2.7% and 3.9% of Austria's total area, respectively.

federal state	area km²	Wind area potential (km²) min	med	max
Burgenland	3966	14	408	550
Carinthia	9546	0	121	293
Lower Austria	19199	59	1258	1497
Salzburg	7163	0	43	98
Styria	16416	0	221	452
Tyrol	12652	0	13	35
Upper Austria	11991	0	214	368
Vienna	415	0	0	0
Vorarlberg	2602	0	5	12
Austria	83949	74	2285	3305

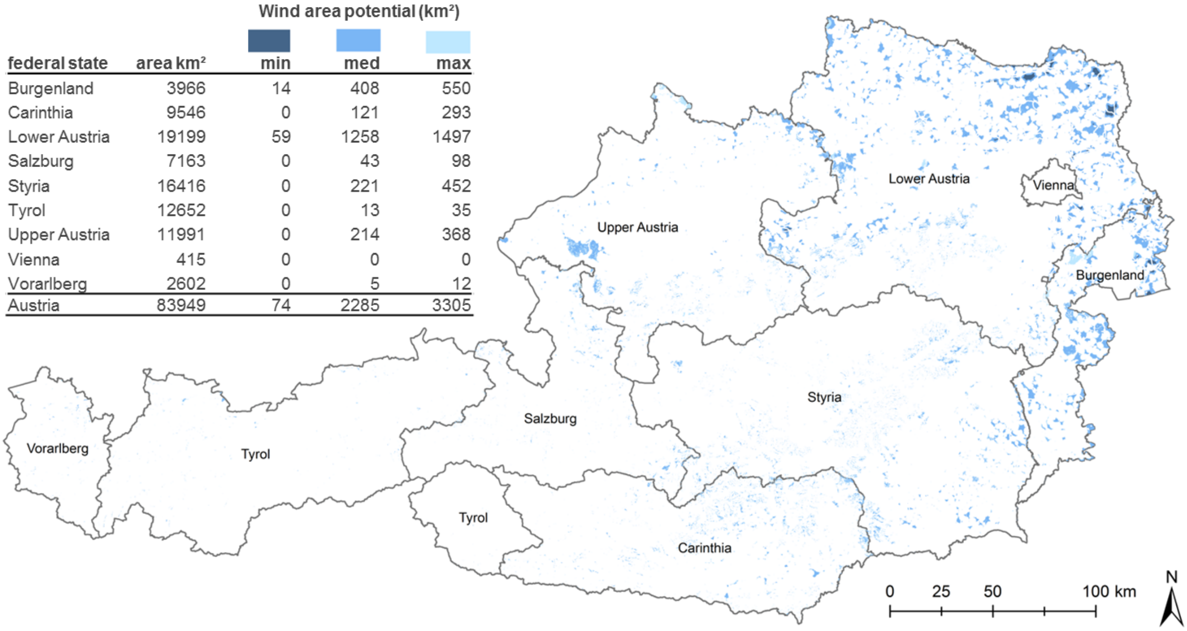

Figure 6: Range for the levelized cost of electricity generation (LCOE) for the three scenarios on the theoretical wind area potential

In the min scenario only Burgenland and Lower Austria offer potentially suitable sites. In the med scenario the Eastern federal states Lower Austria and Burgenland contribute 45% and 15% to Austria's area potential, followed by Upper Austria and Styria with about 10%, each, and Carinthia and Salzburg with about 5% and 2%, respectively. The share of the other federal states is less than 1%. In the max scenario the relative contribution of Burgenland and Lower Austria decreases slightly, as suitable areas in most other federal states more than double compared to the med scenario. The suitability zones of Burgenland, Lower Austria, Styria and Upper Austria (other federal states have not defined such zones, yet) amount to 482 km² or 0.57% of Austria's total area. About 60% of the suitability zones are located in Lower Austria.

Assuming that the best wind turbine locations are utilized first, the LCOEs increase with the installed capacity. The supply curves in Figure 7 visualize the relationship between installed capacity and the marginal LCOE for all scenarios of potentially suitable wind turbine sites. As the potentially suitable wind turbine sites decrease, the corresponding supply curves become steeper. The economic wind energy potential at a given price level varies considerably between the area potentials scenarios.

Under the assumptions of the min scenario, only a total of 3.5TWh of wind energy could be produced at relatively high costs of 96 to 243 € MWh-1. Thus, it would not be possible to meet the wind energy targets of 3GW installed capacity (equivalent to about 6.3TWh assuming current capacity factors) of the Austrian Eco-Electricity-Act 2012. The different area availabilities of the med and max scenario result in only little differences for the LCOE of wind energy production below 25 TWh. Within both scenarios, even ambitious wind energy targets could be met at reasonable costs of less than 100 € MWh-1. The large bandwidth of LCOE results is caused by different assumptions for investment and operation costs and the discount rate.

The Austrian green electricity act of 2012 foresaw a wind energy production of approximately 6 TWh (3 GW installed capacity) for 2020. The marginal baseline LCOE for attaining this target ranges from 86.83 EUR MWh-1 in the max scenario and 87.82 EUR MWh-1 in the med scenario up to 91.20 EUR MWh-1 for federally defined suitability zones. The light-colored areas (Figure 6) indicate the uncertainty range for the marginal LCOE based on the different assumptions for investment and operation costs and the discount rate (Table 3). For the most optimistic assumptions (low investment and operational costs) the marginal LCOE was between 8% and 14% lower than the marginal baseline LCOE. For the most pessimistic assumptions, the marginal LCOE was 16% to 20% higher than the marginal baseline LCOE.

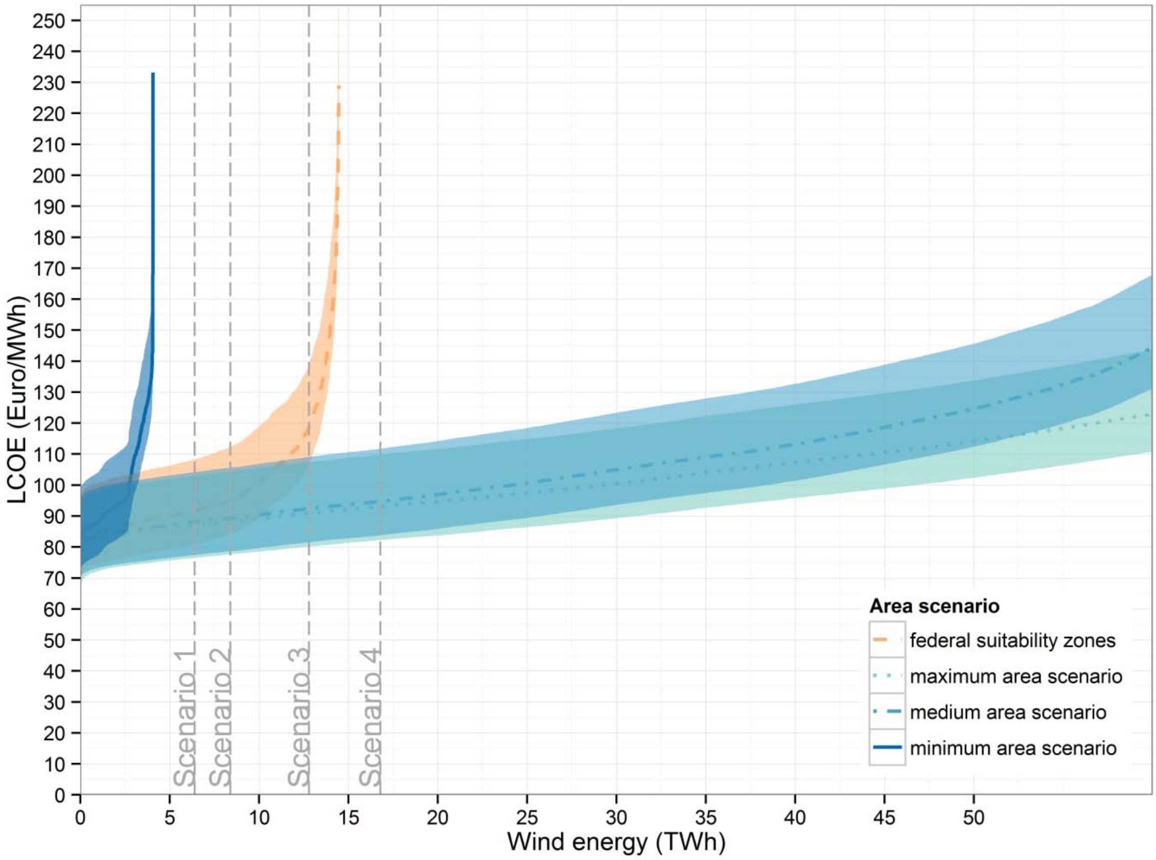

Figure 7: Supply curves showing the economic wind energy potential for the four scenarios (min, med, max and federal suitability zones). The lines show the marginal baseline LCOE and the light-colored areas indicate the range between the minimum and maximum marginal LCOEs based on the input parameter assumptions.

Many targets for renewable energies and also for wind energy are defined as a relative share of the final end energy demand. Thus, the development of the end energy demand determines the costs for attaining a certain wind energy share. The grey dotted lines in Figure 6 indicate the wind energy generation that is necessary to reach a 10% and 20% wind energy share under different assumptions for the energy demand in 2030. At an end energy demand of 62.0 TWh, i.e., a stabilization of demand at 2013 levels, the marginal baseline LCOE for attaining the 10% target (scenario 1) varied between 86.92 EUR MWh^{-1} in the max scenario and 87.95 EUR MWh-1 in the med scenario up to 91.45 EUR MWh^{-1} for the federal suitability areas. Assuming that feed-in tariffs are calculated based on our LCOE calculation, the annual costs for reaching the 10% wind energy share under a feed-in tariff scheme are 3.8% and 4.9% (23.8 and 30.7 million EUR) lower for the med and max scenario compared to the federal suitability zones. If the end energy demand increases to 84 TWh in 2030, the suitability zones already defined by federal states will not provide sufficient areas to increase the wind energy share to 20% (scenario 4) and even the costs for stabilizing the share at 10% (scenario 3) increase significantly to 110-140 EUR MWh^{-1}. In the med and max area scenario the LCOEs in scenario 4 increase to about 95 EUR MWh^{-1}.

The spatial distribution of optimal wind turbine sites varies significantly for the different area potentials. Figure 8 compares optimal wind turbine locations for the suitability zones defined by the federal states (Burgenland, Lower Austria, Styria and Upper Austria) and the medium area potential. It demonstrates that in the medium area potential, the economical optimal expansion of wind energy takes place in Burgenland, Carinthia, Lower Austria and Styria. The difference between federal suitability zones and the medium area scenario becomes more evident with increasing wind energy shares (scenario 3). In this case, it would be necessary to use the majority of federally defined suitability zones – also those in Upper Austria and Western parts of lower Austria with less favourable wind conditions. In the medium area potential, wind power expansion would concentrate mostly in Burgenland and the Eastern parts of Lower Austria, where already now the majority of wind installations can be found. In the medium area scenario, the total wind energy generation would remain constant in Styria. However, different sites would be selected, which leads to slightly higher average full load hours and a reduction in installed capacity of about 30 MW (or ten 3MW turbines). In the medium area scenario, Carinthia could contribute 2% and 3% to the total wind energy generation in scenario 1 and scenario 3, respectively. The higher availability of sites with good wind conditions in the medium area scenario compared to the suitability zones defined by the federal states leads to higher average full load hours and requires less wind turbines to reach a certain total wind energy production. In scenario 1, the total number of wind turbine installations decreases by 4% and by 9% in scenario 3.

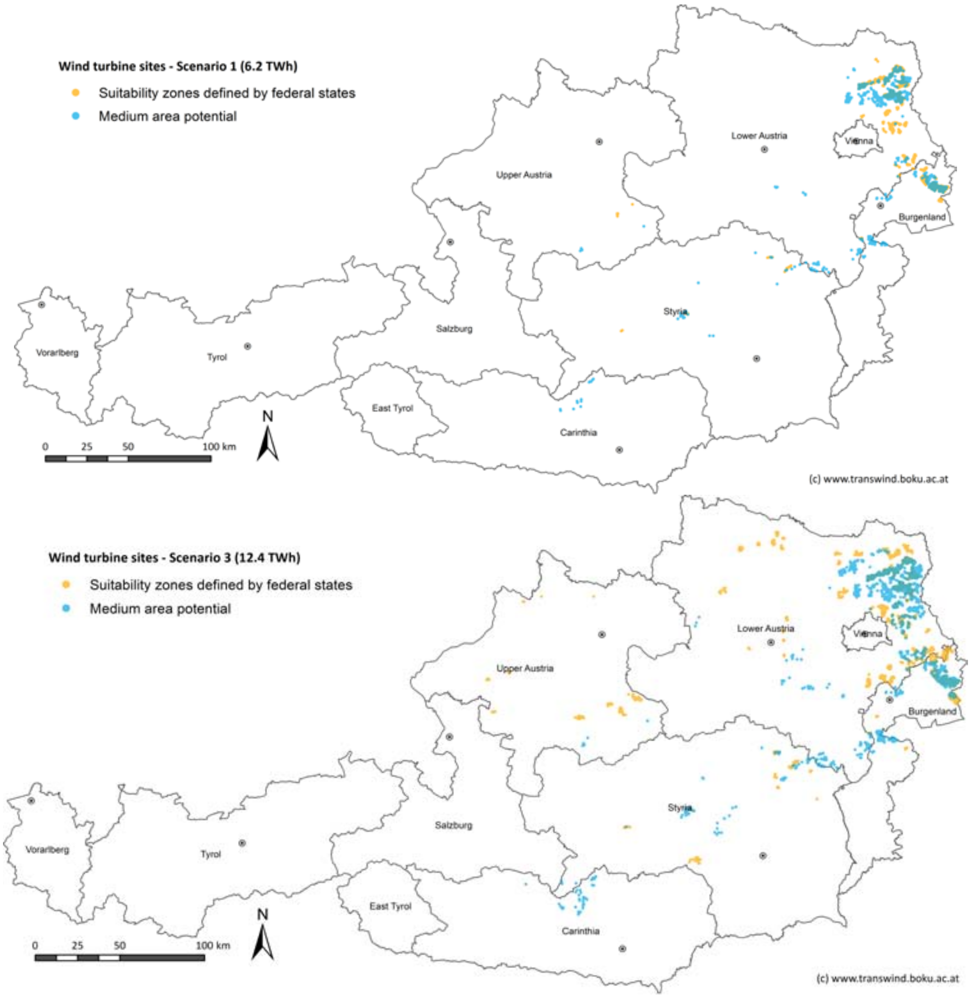

Figure 8: Optimal wind turbine locations for suitability zones defined by the federal states (Burgenland, Lower Austria, Styria and Upper Austria) and the medium area potential in scenario 1 (6.2 TWh) and scenario 3 (12.4 TWh)

4.3 GIS-based visual indicator to assess the visual impact of wind turbines in a landscape

To allow for an indicator based assessment of the impact of wind turbines on the landscape in the different scenarios, a GIS-based visual indicator was developed. Such GIS-based indicators for the visual assessment of planned wind parks exist and are based mainly on viewshed analysis. The problem in these approaches is that usually the visibility is calculated in a simple visible/not visible scheme (0/1) negotiating aspects of distance and partial masking of wind turbines by relief or forest areas. Therefore we developed a GIS-based calculation model to produce weighted viewshed maps based on different studies addressed landscape impacts of large infrastructure (Brahms and Peters, 2012; Weise et al., 2002; Welsch et al., 2012).

In a first step we developed a weighted viewshed indicator for our medium scenario at Austrian level (see Figure 9). Relief calculations are based on the STRM elevation model with a resolution of 80m. To assess view limitations caused by forest areas, we added forest areas from the JRC forest dataset by adding a constant height of 20m for these areas to the elevation model. Many viewshed analyses consider a 10km radius, but as in many Austrian regions the visibility of wind turbines is much wider (mainly due to the flat plain regions and dispelled agricultural landscapes), we consider a radius of 20km for our analysis.

The weighted viewsheds were calculated per single potential wind turbine and then aggregated over a statistical sum-function to produce a nation-wide map on the visible impact of wind turbines for the current situation and the scenarios.

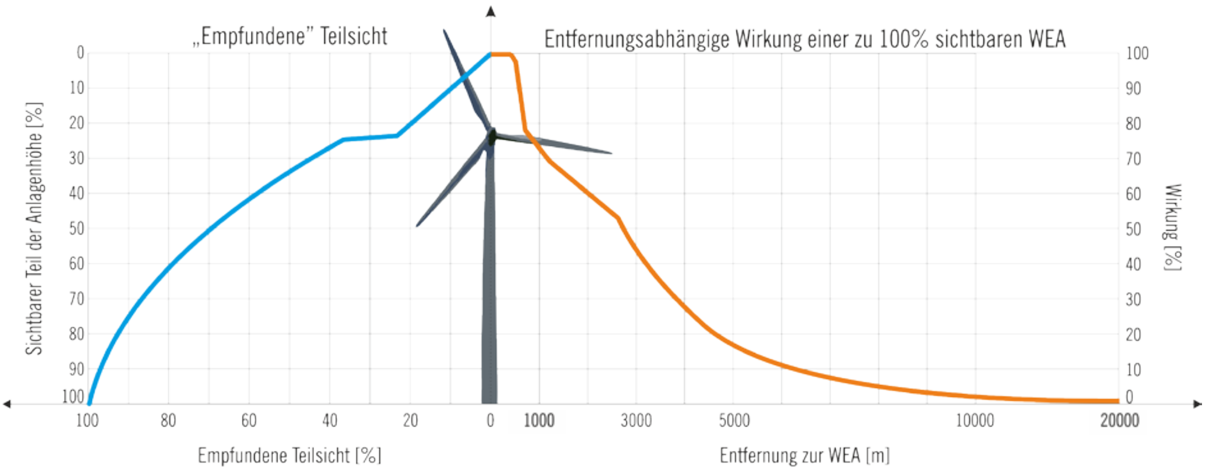

Figure 9: Weighted impact of partial masking and distance to wind turbines (WEA) (Brahms und Peters, 2012, modified)

4.4 Development of interactive visualisation tools

For the case studies, we developed innovative visualisation methods for wind turbines in the landscape, as the impact of wind turbines on the landscape was identified as being one of the most important factors of acceptance on the local level. Four visualisation methods and techniques were identified and evaluated: 1) static images (with video support), 2) Game engines and game engine equivalent technologies 3) Augmented Reality and 4) Virtual Reality visualisations.

1) Static images are a state of the art method to visualize planned wind turbines and to simulate their appearance in the landscape. The method is mostly based on taken photos where wind turbines are retouched using specific software products or image processing software.
2) When it comes to interactive 3D models, specific demands regarding data integration, user experience and modelling efforts appear, which need to be addressed. Therefore we performed

a literature and web-based research on existing technologies. One category in this context are game engines that allow users to create own levels within its gaming environment. Some of the most powerful engines such as the Cry engine or the Unity Engine are free for non-commercial or educational use and can provide a very impressive graphical experience. Nevertheless they are mostly designed for smaller levels and have no specific tools and interfaces to integrate large-scale GIS data easily. Therefore the modelling effort is too time consuming for a systematic use in participation processes. Further, most of these engines have a very high demand regarding processer speed and the graphic card. For architectural purposes, a visualisation suite named Lumion3D exists that provides a very easy to use interface and a high graphical quality. As the largest spatial extent in Lumion3D is 4x4km, it is however not suitable for wind turbine visualisation. The last program we have tested was the Virtual Terrain Project software package (VTP). It is an open source software suite that comes with a builder (VTPBuilder) program, a program for entity management (CManager) and an interactive 3D environment (Enviro). The software looks a bit out-dated but has a very straightforward and logical workflow for the systematic integration and visualisation of GIS data in Enviro. The concepts are comparable to one of the leading landscape visualisation programs named Visual Nature Studio. Regarding the graphical quality it is not comparable with the latest game engines but it provides a realistic 3D environment. VTP has the most efficient workflow for the preparation of interactive landscape models with a large spatial extent. A further advantage is that the software is released under an Open Source License which means, that it is provided for free on multiple platforms and can be modified to fit specific demands. Beside the interfaces to GIS data, methods for the automatic creation of 3D houses (block models) based on a given foot plan, a building height and a roof style helps to model a large amount of houses in an affordable time. 3D models are supported in the Open Scene Graph Format (OSG) and can be integrated using point data with X/Y-Coordinates and additional information such as filepath, scalefactor and rotation. The information will be provided using GIS point data within the Shapefile-Format (shp).

3) Augmented reality is popular since years in product presentation but have not reached a broader spatial context. Smartphones provide GPS positioning, orientation sensors and a camera which means, that the basic information that is necessary to show geo-referenced models (e.g. wind turbines) overlaid with the real environment (using the camera) is technically possible. Problems occur due to issues with the accuracy of the sensors. The GPS provides a position accuracy up to 5m which is enough to provide an accurate positioning in relation to the position of potential wind turbines. The main issues has to do with the orientation sensor, as in mobile phones the orientation is calculated based on movement recognition mainly based on GPS and accelerometer sensor data as magnetic compasses will not work due to magnetic hardware parts in smartphones. This means that the position accuracy is sufficient while the user is in motion, but when the position is constant, the model starts to rotate which means the position of the wind turbines shifts significantly. Another crucial problem is the recognition of the concealment of wind turbines due to the relief, other infrastructure or vegetation elements. This problem can only be addressed by integrating these structures into the 3D model as elements but this works only for small areas.
4) Virtual Reality (VR) seems to be the next “big thing” in the entertainment market, but only little hardware that provides a fully featured VR environment is available in the moment (e.g. Oculus Rift). Nevertheless, smartphones represent a tool that can be transformed into a VR device with little technological expansion by using VR headsets for smartphones. In a basic application, stereo videos and images can be presented and technologically enhanced with head position recognition using the built-in sensors.

From the perspective of the technical development process, retouched images (1) are very simple to create. They provide a high level of photo realism. Additionally, these images can be easily implemented in Websites, brochures or in on- and offline surveys. Nevertheless, the level of immersion is very low, and the users cannot change perspectives or parameters easily. Although those images are static, the wind turbine itself can be animated using video animations and the formats are suitable to transfer to different media. More possibilities for interaction and immersion can be provided by producing full 3D models (2) that can be applied to different media. The challenging task in this context is the modelling effort, as normally, wind infrastructure can be seen over long distances due to their size and huge areas have to be visualized therefore. This issue can be partly solved using databases on interchangeable landscape elements and textures as well as a detailed GIS database to enable an efficient workflow. As 3D models are flexible regarding the platform of presentation, it can be used within gaming engines that can generate highly detailed and realistic environments. In addition it can provide highly immersive experiences using latest VR technology. On the other side, the production of content for gaming engines is very time consuming, requires a lot of experience and contains some obstacles to install the content on a computer (e.g. user rights, etc.). Lower level 3D models can be provided using GIS 3D engines (e.g. ESRI City engine, Biosphere 3D) or the 3D options of Google Earth. The final approach to visualize wind power infrastructure is the application of Augmented Reality (3) which means, that 3D models of objects like wind turbines interact with the real environment using the real time camera view of mobile devices like smart phones or tablets.

4.5 Local case studies

Based on a multiple set of criteria (see section 4.1) we selected six potential case study municipalities. In the following step, we needed to find out if the visualisation techniques described above can transport a different level of information to our target group (residents of the case study municipalities) and if so which kind of information is majorly transported. Therefore we developed a workshop setting with a fictive planning project (including a so called visualisation course), which should be tested in four (Bärnkopf, Fischbach, Hinterstoder, St. Gilgen) out of the six case studies. The aim of the two additional case studies was to deepen our understanding about local conflicts and opposition to already developed wind energy projects (Himberg) and about the case of repowering (Parndorf). In both cases we decided that visualisation efforts are not applicable. Therefore we worked with qualitative semi-structured interviews (four in each case study) instead of using the workshop setting and visualisation course.

The project leader of Trans*Wind* contacted the responsible authorities (principally the mayor) to explain the project's aims and to negotiate a possible commitment of the municipality. In a personal appointment the issues at stake (tasks, responsibilities, and methods) were discussed between the project leader and the mayor and an agreement made. All of our first choices agreed to take part in the project. To gain the interview partners, the snow ball approach was used. Interview partners were mayors, members of the local councils, representatives of citizen initiatives, nature conservationists and wind energy operators. Participants of the workshops were recruited by distributing a direct mail to all households (see Table 4) in the municipalities, by advertising the event on local websites and in newspapers and by cover letters to selected decision makers from politics, business and civil society. If the wind infrastructure of the fictive planning project could been seen from neighbouring communities, also representatives of these municipalities were asked to take part in the workshop.

Table 4: Amount of leaflets and cover letters distributed in the case studies

Amount of ...	Bärnkopf	Fischbach	Hinterstoder	St. Gilgen
Leaflets to households	132	533	335	1.327
Cover letters to selected decision makers	17	18	20	20

The local case study workshops consisted of four different stages: (1) detailed project description, (2) visualisation course with three different visualisation techniques (static images, interactive 3D model, and virtual reality), (3) survey to evaluate the experiences and handling, (4) moderated focus groups to discuss the social acceptance of wind energy.

In the detailed project description, the project team provided all relevant information about a fictive planning project. Furthermore, also the way that led to the fictive planning project and the selection as case study municipality was transparently communicated within presentations, posters and peer to peer discussions. Then participants were able experience the explained scenarios with three diverse visualisation techniques by themselves. Therefore black cardboard boxes were created to guarantee a level of immersion and therefore a focus on the shown scenario and technique. First, people were able to see the fictive wind energy project from different selected perspectives within a self-controlled procedure of the state of the art method of static images (Diashow). Second, the scenario was displayed as an interactive 3D model, where test persons were able to decide their point of interest by themselves, but within a rectangle in the size of 20 x 20 km. Third, a preliminary prepared tracking shot was provided to experience with the technology of Virtual Reality. The project team provided technical assistance if needed. After people passed all three stages of techniques, they were asked to take part in a survey that focuses on the handling of the technique and the quality & plausibility of the visualisation itself. In the last part of the survey, participants were asked to evaluate the overall performance of the experienced technologies from 1 (very good) to 5 (not sufficient). The results (see Figure 10) show a slight dominance of the interactive 3D model, with 43% evaluating the technology as very good, followed by the performance of the static images (38%) heads up to the performance of the virtual reality technology (37%). Surprisingly the static images and the virtual technology method are close together, although regarding the evaluation of the single variables the static images tend to be clearly favoured. Speaking of time consumption and economic factors it seems that the mature system of creating static 3D images shall be favoured but the interactive 3D model performs better in all quality and trustworthiness oriented indicators (trustworthiness, realism, the assistance of evaluating the landscape scenery and the support of the power of imagination). On the other hand participants favour the static images regarding the handling of the technology (navigation, independent handling and the possibilities for interaction) and the suitability for participation processes. Both technologies perform excellently in the transportation of information which may be rooted in the detailed preliminary project presentation and the transparency throughout at the beginning of the visualisation course.

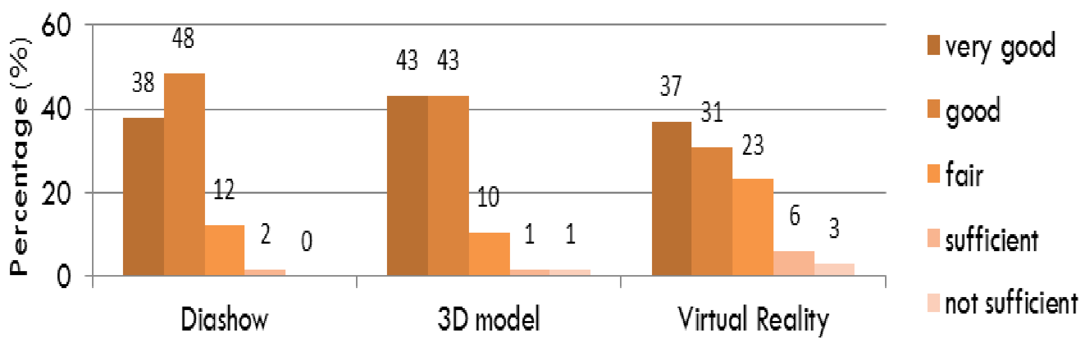

Figure 10: Overall performance of the tested methods, N=70

After the visualisation course, the participants were divided in to a group of “interested citizens” and “local to regional decision makers” and were invited to take part in focus groups (with a maximum of twelve people in each group). The distinction was carried out on the basis of a preliminary stakeholder mapping in each municipality and in approval with the mayor. The reason behind this selection was to differentiate between public and expert opinions. In addition, the participants should be able to raise their ideas, beliefs and attitudes in a trustful atmosphere, where no hierarchy is presumed or expected. The focus groups should provide an open and trustful debate about the advantages and disadvantages of the fictive planning project.

78 participants visited the local workshops in the municipalities. Thereof 66 citizens and decision makers took part in the eight focus groups. Compared to the public relation efforts advertising the local workshops, only a modest number of participants took part in the event. In addition young people, representatives of tourism and decision makers from neighbouring communities were underrepresented. These shortcomings were counterbalanced by very active participants, which attested the format and implementation a high level of expertise and professionalism. The visualization courses were a credible and reliable input for the lively discussions in the focus group. After the workshops, the transcripts of the focus groups and the most important results of the survey were sent to the participants.

4.6 Qualitative assessment of the social acceptance of wind energy

Additionally to the project steps described above, Trans*Wind* conducted various qualitative and quantitative methods (workshops, interviews, focus groups, questionnaires, modelling) assessing the concept of social acceptance. In total, the qualitative material for assessing social acceptance therefore consists of 28 semi-structured interviews with the experts from our stakeholder group (representatives of energy providers, national and regional administrations, protectors of environmental law, NGOs, environmental organisations, trade and labour unions, planning offices, renewable energy lobbying groups), 8 focus groups (composed of 34 local decision makers and 32 citizens) and 8 semi-structured interviews with citizens and decision-makers from the local case studies and one WorldCafé, which was conducted during the first stakeholder workshop. The qualitative material therefore directly integrates all project steps. The interviews and focus groups tackled the issues of governance, acceptance, participation and justice during the planning and siting process of wind farms. Both the interviews and the focus groups were using a comprehensive guidebook, which consists of key questions relevant to the research questions. The qualitative data was analysed regarding different forms of participatory methods, planning options, technological potentials and ecological constraints. For analyses, the software Atlas.ti was used and a coding scheme was established. The codes were derived from the interview guidebook (deductive method) and supplemented in an inductive way. This iterative method guarantees that all patterns of social acceptance were collected. The qualitative content analysis is based on the protocol of the WorldCafé and the transcripts from the interviews and focus groups.

Patterns of social acceptance and non-acceptance of wind energy

In the core of our analyses rest the preferences and values of stakeholders, local to regional decision-makers and citizens on the jurisdiction, political and social parameters, ecological constraints and technical feasibility of wind farms. The following patterns of social acceptance and non-acceptance were prioritised by our respondents. Hence this is not an exhaustive list. The focal points are a result of the sample and represent the stakeholder's interests.[2]

- *Effects on the landscape scenery*: Our interview partners and focus group participants mentioned the landscape scenery as the most important impact on social acceptance. People have a perception of industrialised landscape scenery caused by more and more visible wind turbines. In

[2] The following items were only relevant for some respondents in our study – therefore they do not allow general conclusions: hunting; community based financial participation opportunities (like community joint venture enterprises or an investment for private equity); the costs of green electricity for households; the necessity of a societal transformation in regard to changes in life-style, consumer or mobility patterns; loss in value of private properties; public acceptance of wind energy (opinion polls); feed-in tariffs.

addition they regard wind turbines as a limitation of the recreational function of the local environment. The irritation is caused by the visibility of the turbines itself, the rotating blades and the navigation lights. In addition wind turbines on hilltops or on mountain backs are highly visible and alter the perception of the landscape scenery tremendously (especially in alpine land). In contrast some participants emphasized habituation effects. People in their young days are getting used to energy landscapes and do not regard wind turbines as a negative impact on landscape at all.

The not-in-my-backyard (NIMBY) effect was only put forward sporadically. It is used much more as a metaphor concealing other concerns about wind energy.

- *Nature and wildlife conservation*: The second important objection regards negative impacts on protected areas (e.g. Natura-2000, biosphere reserve) and the protection of species, birds and bats. Every siting process for a wind energy project requires on-the-ground surveys regarding the impacts on wildlife and wildlife habitat to receive the environmental permit. The parties who have a legal standing in the environmental impact assessment can assign local screening mechanisms to assess risks and impacts to wildlife. If conflicts are detected by these expert surveys in the permit process, the specific project has to be modified or even stopped. In most cases operators have to implement detection and deterrence technologies or provide compensating areas and measures (e.g. nesting sites, wetlands, and afforestation). In addition, conflicts with the nature and wildlife conservation have a strong veto power in the decision-making process. They are therefore sometimes exploited by citizens' initiatives or action groups, who are against the siting of a wind project. Operators are consequently complaining about the associated planning risks and increased investment costs. They are stressing the argument that the wildlife is already benefiting from wind energy projects by reducing the hazardous effects of climate change or by providing compensation areas. However, the conflicts between nature conservation and climate change are irresolvable. While ecologists highlight that there is no compromise between the two objectives possible, operators frame their performance as already environmental friendly.

Still, there is a common understanding that data in the field of bird and bat migration is missing and more (publicly available) research is needed. The recording and use of important bird life areas (IBAs) in various decision-making processes (like the federal suitability zones) is a first attempt to close this gap.

In future a special emphasis should be put on the ecological impacts of wind energy projects in wood land, where so far no comprehensive information is available in Austria.

- *Impact on human ecology*: Our qualitative content analyses show that our interview partners perceived the following most important impacts on human ecology: noise (inkl. infrasound), shadow, ice shedding, and impacts of navigation lights. Turbine noise, shadow effects and ice shedding vary with distance, atmosphere and terrain. The operators argue that due to the Austrian spatial *legislation* requirements regarding the *distance* to dwellings most of these impacts of human ecology are limited. The residual impacts have a stake in the environmental permit and are tackled by expert surveys. Measures, which reduce the negative effects, could be a noise optimised operation mode, heated rotor blades, ice shedding warnings, shut-off mechanisms, or a relocation of the wind turbine. However, on the community level the discourse is shaped by revealed emotions and fears linked to these effects on human ecology and often lead to disputes and conflicts. The respondents emphasised infrasound as the most dominant issue in this confrontation. Therefore every siting and planning process should be responsive to these treats, because it often determines the degree of local acceptance.

- *Public participation, trust and transparency:* To engage citizen and local stakeholders in the planning and siting decisions is a decisive moment and task in the implementation process. All respondents agreed that operators have to inform the municipality (mayor and citizen council) and the general public as early as possible. They should be informed about the project's basis conditions, the expected location, the local investments and benefits, the environmental, human and ecological effects and the possibilities to engage in the decision-making process (e.g. to voice an opinion in the environmental impact assessment). Public relations (press releases, newspaper articles), info-days, site inspections and face-to-face contacts were mentioned as appropriate methods of information. These tasks have to be strictly planned and conducted in comprehensible, transparent and trustful ways. Responsible for the management should not only be the operators, but also other entities like citizen initiatives, the citizen council or members of the civil society. Emphasis should be put on local opinion leaders (e.g. secondary residences) as a pivotal group. However informing citizens is not enough to engage them. Local stakeholders should have a say in the decision-making processes and be able to negotiate the quantity, height and location of wind turbines. From the operators point of view, this aims at bringing the project to its appropriate size and dimension and to make it ready for the environmental impact assessment. From the citizens' point of view, they can trust in a transparent process, where their fears and objections are seriously taken into account.

Introducing a public opinion poll ("Volksbefragung") in a municipality could raise the accountability and legitimacy of decision-making. At the same time it does not provide an arena for conflict resolution or fair negotiations. Hence it often leads to a polarisation of local communities. In addition operators seem to be reluctant to this political instrument, because such votes often receive large negative publicity.

- *Distribution of benefits and losses*: The distribution of benefits among the local parties affected by the wind turbine is a delicate issue. First of all operators have to complete contracts with the municipality ("license agreement" e.g. for the use, maintenance and repair of roads) and the land owners (legal provision about the servitude rights). In both cases money is spent (several thousands of Euro per wind turbine and year) to compensate negative effects or economical losses. Some respondents claimed that these payments are used to buy votes or interests. Operators instead assert that this money is an integral part of the siting and planning process and make good economic sense. However, in regard to social acceptance it is very important to distribute and utilise these payments meaningful (e.g. dedicated to specific purposes; mutual fund solutions) in order to reduce enviousness and distrust (e.g. between land owners and the residential population). In addition the parties involved should try to achieve an equal distribution not only within a municipality, but also among the neighbouring communities, which are affected by the wind farm.

- *Energy strategies and political leadership*: Although public support of renewable energy and the discourse about climate change boost the use of wind energy, our respondents assert a lack of political leadership in regard to policy coherence and consistence. There is no common understanding about the development of wind energy from a national to a regional and local perspective and only very little policy coordination across federal state (Bundesländer) boundaries. The Austrian eco-electricity act ("Ökostromgesetz") makes the renewable energy targets explicit, but without negotiating it with the local to regional administrative levels responsible for the implementation (spatial planning, zoning, requirements regarding distance). On the positive side, four out of nine federal states in Austria have defined suitability and exclusion zones for wind energy to reduce conflicts with local communities and to make the planning for operating companies more reliable (Burgenland with a pioneering role). However, this instrument of political steering was e.g. released too late in the case of Lower Austria and is not legally binding in Upper Austria. There is a general national to local energy strategy missing, where the development of wind energy is embedded and supra-regional planning and siting decisions are taken. In addition most of the respondents state that the introduction of energy efficiency measures and the definition of reduction limits should be an integral part of the energy strategies and would definitely foster the social acceptance of wind energy.

On the community level it is necessary to frame the issue at stake as a regional energy project, which means to communicate why it is important and to link it to other energy measures like the promotion of renewable energy (subsidies), the creation of electric vehicle charging stations or the refurbishment of the street lighting, etc.

- *Impact on tourism:* Compared to the other patterns of social acceptance, the impacts on tourism were surprisingly much less discussed in our study although three out of six case studies were characterized by a middle to high degree of utilization by summer- or winter tourists. Especially the group of operators did not expect many negative effects on the tourist industry. However, as in the Alpine scenery the visibility of wind turbines and the relevance of tourism gain more importance, nature conservationists, local decision-makers and citizens are afraid of damaging the recreational functions of homeland and economical losses e.g. due to declining overnight stays. Hence the impact on tourism strongly correlates with the perception of a landscape for recreation.

- *Economic sustainability:* Wind sites, which received problems in terms of too little distances to dwellings in the past will be removed (dismantling) and others will be replaced by less but more powerful turbines, which increases the total capacity in MW (repowering). After 15 or 20 years of operation, citizens probably will get used to an industrialised landscape scenery. The new turbines have to pass through the approval procedures including an environmental permit, but the respondents do not expect new conflicts with respect to nature conservation or human ecology. The financial distribution from the operators to the municipalities and land owners will be negotiated again. Current examples showed that these sites will get more expensive for wind operators. Consequently, most of the interviewees regarded the process of dismantling and repowering as a win-win-situation. There are only two negative effects – one is an increased visibility. That way, the current distance limits should be reconsidered in the case of repowering. Another concern is about environmental and resource economics. The current support regime (fixed feed-in tariffs for 13 years; afterwards market rate) supports the dismantling of the turbines after this period although the service lifetime is about 20 years. From a financial point of view, the repowering after 13 years makes sense under the current regulation scheme, but it may constitute a waste of important resources.

5 Conclusions and recommendations

Through the participatory integrated assessment approach Trans*Wind* was able to address the following major needs:

(1) The need to broaden our understanding of the concept of social acceptance through a participatory assessment approach.

(2) The need to link the assessment of subjective and objective parameters for the assessment of wind power projects in an integrative analysis.

(3) The need for information, which reflects the stakeholder uncertainties and needs and is relevant to “real-world” decision-making processes.

(4) The need to gain additional political, technical and economical insights about the integration of wind power into the national energy system.

Trans*Wind* assessed scenarios for Austria’s wind energy potential for Austria in a participatory modelling approach. We included stakeholder perspectives to define criteria for suitable areas for wind energy generation. Our results demonstrate that the Austrian renewable energy target according to the Eco electricity act (2012) of 10% wind energy until 2020 can be met with the suitability zones that were defined by federal states at the current demand levels. However, to successfully continue the transition to a low-carbon electricity system for Austria, higher shares of wind energy may be required after 2020. Our scenarios illustrate that there is a significant trade-off between the acceptability of wind turbine expansion by key stakeholders’ and generation costs. Future legislation (e.g., the required distances of wind turbines to settlement areas) can significantly affect the LCOE of wind energy. More restrictive criteria for wind turbine sites will therefore require higher feed-in tariffs - and more wind turbines - to achieve the same level of wind energy production. Those costs are passed on to the electricity end-consumers, who pay a levy for green electricity. Experiences from Germany show that higher electricity costs can further decrease the acceptance of expanding renewable energies. The challenge for policy makers will be to find the right balance between limiting wind production to sites with minimal negative effects on landscape scenery, human health and the environment and providing enough potential wind turbine sites to allow the deployment of wind energy at feasible costs. Minimizing expansion costs, which directly affect end consumer electricity rates, while ensuring that important land-use restrictions are taken into account to guarantee acceptability, is a delicate act and implies that future expansion targets may have to be adapted according to technological developments (which reduce costs), to changes in social acceptability and to alternative low-carbon technologies. We propose that a continuous process of consultation with important stakeholders on the national level be established to openly discuss these trade-offs. The model developed within this project can be used to assess the impact of various regulations (e.g. tighter restrictions on the minimum distance to settlements or protected areas) on the LCOE of wind energy.

We assessed the Austrian wind energy potential in a participatory modelling approach. Therefore, we modified the existing GIS based modelling tool “WTWB - Where the wind blows” (Schmidt et al. 2013) to include inputs from our reference group. To give stakeholders the possibility to articulate their preferences and give inputs at all stages of the participatory modelling process, we conducted an online survey and several e-mail consultations and organized two stakeholder workshops. Inputs from the reference group were summarised in a criteria catalogue to define three scenarios (min, med and max) for potentially suitable wind turbine sites. These three scenarios were complemented by a fourth scenario that reflects the wind energy potential with suitability zones for wind energy already defined by Austrian federal states. For all potential locations we calculated the levelized cost of energy generation (LCOE) to derive wind energy supply curves for each scenario of potentially suitable wind turbine sites. Under the assumptions of the min scenario, only 3.5TWh of wind energy could be produced at relatively high costs of 96 to 243 € MWh-1. Thus, it would not be possible to meet the wind energy targets of 3GW installed capacity (equivalent to about 6.3TWh assuming current capacity factors) of the Austrian Eco-Electricity-Act 2012. The med and max scenario would allow for further expanding the wind energy share at reasonable cost of about 95 EUR MWh-1 even if electricity demand keeps steadily rising.

In Trans*Wind* an evaluation of four identified visualisation methods and techniques was done: 1) static images (with video support), 2) Game engines and game engine equivalent technologies and 3) Augmented Reality and 4) Vitual Reality visualisations. First, the suitability regarding several developed indicators was evaluated (e.g. accessibility, usability, distribution, suitability for different communication strategies etc.). Also a database of landscape elements and textures was generated, to optimise the creation process. Another topic was the development of a GIS based indicator to assess the visual impact of windturbines at a larger spatial scale. A viewshed approach is common in many planning processes, but they are often limited to a simple visible/not visible decision. Therefore we developed a GIS model to calculate weighted viewshed depending on distance and masking effects.

Our research on technologies for 3D modelling in the context of Wind turbine visualisations has shown that different concepts and methods exist. The simple image visualisations (static images) are state of the art in planning processes but they are increasingly criticised as there is no easy way to prove their reliability and the number of viewpoints is very limited. From a cost perspective it is still the most efficient technology and the images can be easily shared in reports, presentations or websites. Interactive 3D visualisations allow users to change their viewpoints interactively depending on very personal motifs. Therefore, personal fears and expectations can be addressed which may lead to more objective discussions and exchange of opinions during planning processes. A problem with interactive environments is that the production costs are very high as many data needs to be gathered in the field and 3D modelling is a very time consuming process. Additionally, most available 3D engines are lacking automatic GIS data processing. Further, interactive models, need fast computers and good graphic cards and needs an installation process to run the model on a computer. Also usage barriers occur as untrained users are often overwhelmed with the autonomous navigation using keyboard, mouse or a joystick. Our approach has shown that there are free tools available that can operate interactive 3d models even on common office computers. The modelling effort can be reduced by developing some automatisms in data processing but needs specific expert knowledge. Depending on the landscape composition, the modelling efforts vary very strong. During the project, two very new technologies entered the stage: Augmented reality (AR) and Virtual reality (VR) applications. Both are driven by the fast spread of mobile phones and may provide some additional insights in the visual impact of wind turbines. Nevertheless, there are still some technological barriers that leads to positioning errors or unrealistic views due to the missing masking of 3D objects by real world objects (in AR) or are lacking quality due to less screen resolutions of mobile phones (in VR). VR applications require the same modelling efforts than interactive 3D models but can provide a more immersive 3D view.

Besides the visualisation and communication of case studies we have also developed a GIS based viewshed indicator to evaluate and compare visual impacts of wind turbines at a larger scale. Viewshed analysis is common in planning processes but is often lacking specific weights for distance or masking. Addressing these aspects needs a more complex modelling especially when it comes to large scale analysis (e.g. Austria) as each wind turbine needs to be calculated separately and then joined using raster statistics. Compared to the non-weighted approach, our indicator is based on a more reliable approach as it considers distance and masking of a wind turbine in a landscape. Nevertheless additional information such as protected areas, touristic sites, recreation places, etc. is needed to compare the indicator on with different sites.

Through the methodological approach of Trans*Wind* using quantitative, qualitative and participatory methods, crucial patterns the social acceptance of wind energy could be identified. To better understand the social acceptance and non-acceptance of wind projects, it is necessary to confront different expert judgements about what they regard as important with the preferences and perceptions of citizens and local decision-makers. Therefore, we clustered the statements of selected respondents into a group of i) nature conservationists / ecologists (protectors of environmental law, representatives of environmental organisations); ii) operators / wind lobbying groups; iii) local decision-makers (e.g. mayors, representatives of political parties, the local council, tourism associations, medical scientists); and iv) citizens. Through the qualitative content analyses of the interviews and focus groups, we could categorise the patterns of social acceptance and its perceived importance (see Table 5). Table 5 shows a very coherent picture of interests. For operators, most of the patterns of social acceptance seem to be very important or important, which means that they show an interest in the concerns raised by nature conservationists/ecologists, local decision-makers and citizens at the same time. Nature conservationists and ecologists concentrate on effects on the landscape scenery and aspects of nature and wildlife conservation, where they have the expertise and a stake in the future development of wind energy. On the local level, the perceived importance of most of the critical patterns of social acceptance overlaps. Citizens do only regard energy strategies, the impact on tourism and repowering as less important than their political representatives. However, showing an interest in the patterns of social acceptance raised by others does not mean that there is no controversy or conflicts of actions. Hence solutions for local wind energy projects can only be found in coordinated processes of cooperation taking into account all patterns of social acceptance.

Table 5: Patterns of social acceptance and its perceived importance by the respondents (*** = very important, ** = important, * = somewhat important)

	Experts / stakeholders		Locals concerned about the issue	
	nature conservationists / ecologists[1]	operators / wind lobbying groups[2]	local decision-makers[3]	Citizens[4]
Effects on the landscape scenery	***	***	***	***
Nature and wildlife conservation	***	***	*	*
Impact on human ecology	*	***	***	***
Public participation, trust and transparency	*	***	***	***
Distribution of benefits and losses	*	***	***	***
Energy strategies and political leadership	**	**	***	**
Impact on tourism	**	*	**	**
Economic sustainability (repowering)	*	***	**	*

[1]Nature conservationists / ecologists: 10 interview partners from the reference group and local case studies
[2]Operators / wind lobbying groups: 10 interview partners from the reference group and local case studies
[3]Local decision-makers: 34 participants of the focus groups and 4 interview partners from the local case studies
[4]Citizens: 32 participants of the focus groups

Addressing the different and sometimes contrasting patterns of social acceptance enhanced our understanding about the economical, political, ecological and social feasibility of wind power plants. Our empirical results show that all interview partners and focus group participants consider vertical and horizontal cooperation and coordination across different political levels and parties (stakeholders; experts; local to regional decision makers; citizens) to be important. The problem is that the process of interaction between these actors is often conflictual. Different factors could be highlighted explaining this divergence. Such factors can be seen in the conflict of interests, rationales and beliefs which strengthen the problems of coordination and cooperation. Furthermore, any wind energy project is characterised by the basic systemic conflict between nature conservation (protection of wildlife, habitat and landscape) and narratives of ecological modernisation (e.g. climate protection or energy transition). According to the advocacy coalition framework (Sabatier & Jenkins-Smith 1993; Sabatier 1998) these moral concepts (core beliefs) and policy cores (general beliefs and perceptions in a specific policy field like wind energy) of the participants are unlikely to change. Only the so called secondary aspects, which relates to the implementation of a policy (e.g. instruments, concrete actions), are most likely to change and are subject to learning processes. Therefore we suggest that future projects should focus on aspects of justice and fairness, because they are on the individual level an important motive for action (or in-action) and can be seen as a precondition for acceptance (Rawls 1971; Rawls, 2001; Baasch 2012). The following list highlights how justice and fairness on a procedural and distributional level could be enhanced:

Procedural justice

- The quality of the siting and planning processes in terms of good governance:
    - To inform citizens comprehensively and in a early stage
    - To communicate in a trustful and transparent way
- Participation and openness of decisions:
    - To engage citizens in formal and informal processes and methods of participation
    - To let citizens and local decision makers participate in the negotiations about the quantity, height and location of the wind turbines

- The use of reliable and trustworthy visualisation techniques, which provides enough possibilities for interaction (cf. the results in WP4)

Distributional justice

- The local diversification of monetary benefits:
  - To distribute compensation payments in a fair and justified way (e.g. balancing between different municipalities; spend revenues on fixed purposes)
- Governance mechanisms and coordination among different levels of policy-making
  - To assess the availability of land and suitability zones in subject to the levelized costs of electricity (cf. the results of WP3) and to adapt renewable energy targets according to these analyses
  - To diversify wind turbines according to the technical and economical potential of wind energy in Austria (cf. the results of WP3) and to link this development to super-regional and regional spatial planning procedures, combining bottom-up and top-down approaches
  - To combine and balance renewable energy production targets with concrete and mandatory energy efficiency measures

In order to ensure acceptance, decision-making processes have to be reformed, justice sustained and thereby both input and output legitimacy enhanced. All of these factors need to be taken into account when engaging stakeholders and civil society in decision-making processes about the future wind energy infrastructure.

On the basis of these results and conclusions Trans*Wind* established a guideline for various user audiences interested in handling the acceptance and non-acceptance of wind energy. The guideline was critically discussed within the group of stakeholders and is published at the project website http://www.transwind.boku.ac.at/ as a key document disseminating the results.

7 Working and time table

M = milestone
W = workshop

Workpackages (WPs)	1 09_13	2 10_13	3 11_13	4 12_13	5 01_14	6 02_14	7 03_14	8 04_14	9 05_14	10 06_14	11 07_14	12 08_14	13 09_14	14 10_14	15 11_14	16 12_14	17 01_15	18 02_15	19 03_15	20 04_15	21 05_15	22 06_15	23 07_15	24 08_15	25 09_15	26 10_15	27 11_15	28 12_15	29 01_16	30 02_16	31 03_16	32 04_16
WP1: Managing inter- and transdisciplinarity																																
M1.1 Project implementation plan		M																														
M1.2 Knowledge transfer and dissemination plan		M																														
M1.3 Kick-off and monthly project meetings for quality and progress control																																
M1.4 Interim and final project reports														M																		M
WP2: Integrating stakeholders																																
M2.1 Built-up a reference group with 15-20 stakeholders		M																														
M2.2 Organise two participatory workshops and one scenario workshop			W1						W2																		W3					
M2.3 Case selection														M																		
M2.4 Qualitative assessment of the social acceptance of wind energy				M						M											M						M				M	
M2.5 Establish guidelines for various user audiences																																M
WP3: Modelling of wind power potentials																																
M3.1 GIS model updated					M																											
M3.2 Model parameters aligned with outcome of stakeholder workshop												M																				
M3.3 Model structure (i.e. optimization) updated													M																			
M3.4 Model scenarios run																M																
M3.5 Model validation by stakeholders																	M															
M3.6 Model scenarios re-run, preparation of input for case study selection																		M														
WP4: GIS analysis and development of interactive visualisation tools																																
M4.1 Database on 3D infrastructure				M																												
M4.2 GIS-based visual indicator to assess the visual impact of wind turbines in a landscape														M																		
M4.3 Real-time 3D environments for the case study regions																M																
M4.4 Validated GIS-based visual indicator based on the input from the questionnaire																																
WP5: Local case studies																																
M5.1 Organise 2-3 focus groups in each case study region																						M			M		M					
M5.2 Coding scheme and analyses of audiovisual tapes and transcripts																							M			M		M				
M5.3 Report on the participants views on the various aspects of community acceptance																											M				M	
WP6: Dissemination, knowledge transfer and evaluation																																
M6.1 Four working papers finished																	M															
M6.2 Four scientific manuscripts prepared to be submitted to scientific journals																												M				M
M6.3 Four presentations at national and international conference								M												M		M			M							
M6.4 Policy briefs on the basis of the guidelines established in M2.5																																
M6.5 Documentation and results from evaluation of stakeholder process																																M
M6.6 Redesign of the conceptual and methodological approach of TransWind																												M				M

8 Publications and dissemination activities

All dissemination activities within Trans*Wind* can be found in the following table and at http://www.transwind.boku.ac.at:

Title	Medium	Date & Location
	Scientific Dissemination	
Conference presentations & posters		
Den Ausbau der Windenergie sozial verträglich gestalten? Eine inter- und transdisziplinäre Annäherung, Poster (Schauppenlehner, T.; Scherhaufer, P.; Höltinger, S.; Salak, B.; Schmidt, J.)	15. Österreichischer Klimatag	2-4 April 2014, Innsbruck, Austria
Bewertung des Landschaftsbildes im Zuge der Errichtung von Windkraftanlagen auf Waldstandorten (Salak, B.; Schauppenlehner, T.; Brandenburg, C.; Jiricka, A.; Czachs, C.; Höltinger, S.; Scherhaufer, P.; Schmidt, J.)	Naturschutzfachliche Aspekte von Windenergieanlagen auf Waldstandorten in Deutschland, Österreich und der Schweiz	24-25 June 2015, Munich, Germany
Low-cost immersive 3D visualisations for evaluating visual impacts of wind parks using smartphones and free software (Schauppenlehner, T., Salak, B., Höltinger, S., Schmidt, J., Scherhaufer, P.)	Energy Landscapes: Perception, Planning, Participation and Power	16-18 September 2015, Dresden, Germany
Application, opportunities and constraints of different landscape oriented 3D visualisation techniques for communication and participation processes of wind energy projects, Poster (Schauppenlehner, T.; Salak, B.; Höltinger, S.; Schmidt, J.; Scherhaufer, P.)	The European Climate Change Adaptation Conference (ECCA) 2015	12-14 May 2015 , Copenhagen, Denmark
Das ökonomische Windkraftpotential Österreichs - ein partizipativer Modellierungsansatz (Höltinger, S.; Salak, B.; Schauppenlehner, T.; Scherhaufer, P.; Schmidt, J.)	16. Österreichischer Klimatag	28-30 April 2015, Vienna, Austria
Zur sozialen Akzeptanz der Windkraft in Österreich. Inter- und transdisziplinäres Arbeiten in Theorie und Praxis (Scherhaufer, P. Höltinger, S.; Salak, B.; Schauppenlehner, T.; Schmidt, J.)	16. Österreichischer Klimatag	28-30 April 2015, Vienna, Austria
Gewichtete Sichtbarkeitskarten zur Bewertung der visuellen Präsenz und Landschaftsdominanz potentieller Windenergieanlagen in Österreich, Poster (Schauppenlehner, T.; Salak, B.;	16. Österreichischer Klimatag	28-30 April 2015, Vienna, Austria

Scherhaufer, P.; Höltinger, S.; Schmidt, J.)		
Soziale Akzeptanz von Windkraftanlagen (Scherhaufer, P.)	Die Energie der Alpen	22-23 October 2015, Garmisch-Partenkirchen, Germany
Mixed method design as a supportive tool for evaluation of interactive 3D approaches to enhance objectification in wind energy planning processes (Salak, B., Brandenburg, C., Schauppenlehner, T., Scherhaufer, P., Schmid, J., Höltinger, S., Jiricka, A., Czachs, C.)	Permanent European Conference for the Study of the Rural Landscape (PECSRL)	5-9 September 2016, Innsbruck, Austria
Journal articles		
Where the wind blows: Assessing the effect of fixed and premium based feed-in tariffs on the spatial diversification of wind turbines (Schmidt, J.; Lehecka, G.; Gass, V.; Schmid, E.)	Energy Economics	2013.
Simulation of disaggregated load profiles and development of a proxy microgrid for modelling purposes. (Zeyringer, M.; Andrews, D.; Schmid, E.; Schmidt, J.; Worrell, E.)	International Journal for Energy Research	2014.
Austria's wind energy potential - a participatory modelling approach to assess socio-political and market acceptance (Höltinger, S., Salak, B., Schauppenlehner, T., Scherhaufer, P., Schmidt, J.)	Energy Policy	Accepted.
Dissemination to stakeholders and the general public		
Stakeholder workshops		
1st stakeholder meeting	Workshop	27.11.2013, Vienna, Austria
2nd stakeholder meeting	Workshop	19.5.2014, Vienna, Austria
3rd stakeholder meeting	Workshop	19.11.2015, Vienna, Austria
Case study workshops		
“Windenergie polarisiert” (1)	Workshop (Visualisation	16.6.2015,

	course and focus groups)	Bärnkopf, Austria
"Windenergie polarisiert" (2)	Workshop (Visualisation course and focus groups)	29.6.2015, Fischbach, Austria
"Windenergie polarisiert" (3)	Workshop (Visualisation course and focus groups)	24.9.2015, St. Gilgen, Austria
"Windenergie polarisiert" (4)	Workshop (Visualisation course and focus groups)	6.11.2015, Hinterstoder, Austria
Newspaper articles		
Windparks: Ein gigantischer Nachbar (Hanka, Sophie)	Die Presse	15.2.2014 (online) 16.2.2014 (print)
Größer, höher, grüner? (Schröder, Aline)	Wiener Zeitung	3.10.2014 (online)
Public events		
Final project presentation *("Windkraft polarisiert: Ergebnisse aus einem transdisziplinären Forschungsprojekt")*	Public event	7.3.2016, BOKU, Vienna, Austria
Presentation of the visualisation course at „Lange Nacht der Forschung"	Public event	22.4.2016, BOKU, Vienna, Austria
Guideline		
Guideline for various user audiences interested in handling the acceptance and non-acceptance of wind energy ("*Leitfaden zum Umgang mit der sozialen Akzeptanz von Windkraftanlagen*")	Guideline	April 2016

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