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Evaluation of a visual analytics decision support tool for wind farm placement planning in Alberta: Findings from a focus group study

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ABSTRACT

In socially-embedded tasks like planning the location of wind farms, certain evaluation methods have been used to establish the viability of decision support tools. These methods often consider the usability and technical functionality of decision support tools, users' tasks, and other important characteristics. However, such evaluations provide only a partial assessment of the prototype design process because the perception of usefulness, ease of use on tasks, and common barriers to use, from the point of view of the people who use the tool, are not always sufficiently integrated. The study in this article employs the focus group methodology to evaluate AB–WINDEC – a place-specific decision support tool designed to match the socio-technical requirements of stakeholders involved in wind farm placement planning in Alberta. In this context, the main purpose of the focus group was to elicit real-world perspectives from stakeholders who will eventually use the tool. The results of the study suggest that AB–WINDEC can be useful for educational purposes, public engagement, high-level analysis, risk assessment, and collaboration between wind energy decision makers and stakeholders. Feedback from the stakeholders also led to additional requirements and insight on how the design of the prototype needs to be modified to increase its usefulness and ease of use. Further, the findings provided relevant information on social considerations and potential barriers that can influence the acceptance and use of AB-WINDEC in real-world conditions.

1. Introduction

The development of wind farms has significantly increased during the last 20 years in Canada. Given that a typical wind farm can contain several hundred wind turbines and cover hundreds of square miles (Leung and Yang, 2012), their planning and building frequently presents a critical challenge for land use planning. One such problem, and often one of the most difficult to resolve, is the selection of locations where these wind farms can be built (Ramírez-Rosado et al., 2008).

In Alberta, there is currently much debate about the potential impacts of wind farms on other land uses (Alberta, 2008; Armstrong et al., 2005; Cheryl and Marilyn, 2010; Ingelson and Kalt, 2010; Johnson et al., 2011; Macarthur, 2010; Weis et al., 2010). At the heart of this land use planning problem is the need to protect public interests and to weigh these interests against the rights and interests of individuals and private organizations who are proponents of wind farm development (Chernoff, 2015; Coles and Taylor, 1993; Fabos, 1985). As public concern about the impact of wind farms has grown, conflicts between public and private interests are also on the rise. One reason for this is that public planning decisions regarding wind farm placement locations tend to involve multiple stakeholders, including planners, regulatory officials, industry developers, conservationists, municipal officials, public interests groups, and land owners (Thibault et al., 2013). In a broad sense, stakeholders can be described as individuals or groups that have an interest or concern in an issue. These stakeholders come to the debate with different preferences, different values, and knowledge. Moreover, their decision making is often influenced by different social, economic, and political factors (Cathcart, 2011). In addition to being spatially-explicit, a feature that most wind farm placement planning processes have in common is that they have multi-criteria issues that require consideration (Talinli et al., 2011). These scenarios, and the range of social issues and their inter-relationships, call for a more focused decision making, and highlights the need to improve ways of analyzing complex information (Dye and Shaw, 2007; Kiker et al., 2005), in order to make decisions that would be fair to all parties (Khan, 2003).

Clearly, both the results of the decision-making process and the technologies that facilitate the process are important considerations in the Alberta context. Peer-reviewed research has generally supported

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the view that decision support tools are one of the promising solutions that can aid multiple stakeholders in understanding complex information when assessing potential placement locations (McKeown et al., 2011; Moiloa, 2009; Ramírez-Rosado et al., 2008). Part of the attraction to such tools, according to Moss et al. (2014), is their ability to harness place-specific data, facilitate data storage, analysis, and visualization. Harnessing the power and potential of decision support tools could help focus attention on the real issues that inform the decisions on placement locations for wind farms (Cathcart, 2011), and could thus enhance capacity for evaluating placement alternatives (Wang, 2015).

With the foregoing, there is little doubt that the complexity of decision support problems like wind farm placement planning requires the development and application of new tools capable of incorporating not only numerical data, but also qualitative information used by stakeholders involved in the decision-making processes (Poch et al., 2004). This problem presents a difficult challenge for systems designers (Carlsson et al., 2011; Perini and Susi, 2004). Dozier and Gail (2009) opined that effective decision support tools could lead to more satisfactory decision-making processes and outcomes if their development processes are guided by empirical research. Other authors have argued that the understanding of how decision support tools can be developed and successfully integrated into decision processes is critically important in increasing their acceptance (Kushniruk and Patel, 2004; Maguire, 2001). Many poorly designed systems tools exist because often the perspectives of the people who use the systems were not integrated in the development process (Lu and Cai, 2000).

With the increasing involvement of stakeholders in wind farm planning processes, it is expected that decision-making would become more interactive and complex, demanding interactive and visual-based tools to manage it. Accordingly, a recent design study by researchers at the University of Calgary empirically examined ways in which a visual analytics decision support tool can be developed to address the issues stated above (Adagha et al., 2015a, 2015b). In their work, a socio-technical approach was used to identify the decision support requirements of wind energy stakeholders in Alberta and to develop a conceptual framework in response to the requirements. Their study also determined the underlying attributes of effective visual analytics decision support tools, and how those attributes can be applied to design a tool to match the socio-technical requirements of stakeholders involved in wind farm placement planning in Alberta. Based on the established requirements, attributes, and conceptual framework, a proof-of-concept, web-based Alberta Wind decision support prototype tool (AB–WINDEC) was developed. The concept of AB–WINDEC is based on integrating different interests and views of multiple stakeholders. The systems model is designed to facilitate interactive visualization and analytics, situation awareness, creativity, and collaboration, and to support different phases of the decision process.

This article continues the design series from a formative evaluation standpoint. Evaluation is a crucial component in the design of decision support tools (Hevner et al., 2004). The primary measure of success of a tool is the degree to which it meets the purpose for which it was intended. Such evaluation should elicit feedback on a tool's usability and perceived usefulness, which is crucial to increasing the acceptance and integration of tools in real-world settings. While the idea of designing tools, identifying and monitoring measures of success, and using the resulting information to improve planning tools might appear to be a straightforward process, a myriad of social, technological, and methodological issues makes this a very challenging undertaking. Critical perspectives in research have pinpointed key challenges in doing useful evaluations of decision support tools. Sojda (2007) contends that decision support tools designed to handle complex and poorly structured problems are often not empirically evaluated. Similarly, Newman et al. (2000) noted the implications of focusing an evaluation on intended use and intended users. In the view of Mysiak et al. (2005), what is generally lacking is a consensus about what evaluation methodology to use or what features to assess in the evaluation of decision support tools. Sprague and Carlson (1982) argue that evaluation of a decision support system should be treated as a research activity, which should focus on "value analysis". A number of case studies (e.g. O'hEocha et al., 2012), have suggested that information systems designers would benefit from the inclusion of design evaluation research methods.

AB–WINDEC was designed with careful consideration of how the design process will affect its use in real world settings. From this context, a formal evaluation strategy should highlight the utility of helping intended users screen the most appropriate content, model, methods, and uses for their specific decision support needs (Parker et al., 2015). Such an approach would likely provide useful feedback that can help improve the quality of the product and the reliability of the design process (Hevner et al., 2004).

There are many ways in which this knowledge can be elicited in evaluation studies. These include questionnaire surveys, usability inspections, cognitive walkthroughs and observation of stakeholders operating the prototype in real-life situations. More recently, though, there has been a growing trend of using focus group methodologies to support these more conventional methods (Langford and McDonagh, 2003). This is largely due to the interactive and synergetic nature of group discussions, which allows deeper insights, and can facilitate more useful feedback on product design, in ways that may not be possible with other methods (Krueger and Casey, 2001). Furthermore, feedback from focus groups may have a greater chance of identifying new concepts that can be used to refine the design of a prototype system (Anastassova et al., 2007; Nunamaker and Chen, 1990). Thus, an empirical design evaluation can be used to address a wide range of important questions: What is the overall experience of using the prototype? What are the useful and not-so-useful features in the prototype? What are the usability challenges encountered on using the interface? What additional features are needed to improve ease-of-use? In what ways did the prototype meet stakeholder's needs, and what changes would improve its decision support capabilities? Are there any tasks not currently supported by the prototype? What other applications should be considered when re-designing the prototype? What are the barriers to use and integration?

In this study, answers to these questions are rigorously pursued through a series of focus groups with stakeholders in the Alberta wind energy sector. The article first describes the background research and contextual factors that gave birth to AB-WINDEC. It then reports on the methods used in conducting the focus groups. The article concludes with a discussion of the findings, study limitations, and contributions.

2. Research context

2.1. Development of the AB–WINDEC decision support tool

Can decision support tools be designed to meet the specific information needs and requirements of stakeholders? This concept was demonstrated in the Alberta Wind Decision support system (AB–WINDEC) – a prototype decision support tool that incorporates different social requirements, analytical models, visualization capabilities and other technical functionalities, to help stakeholders gather, structure, and analyze data when assessing placement locations for wind farms in Alberta (Adagha et al., 2015a). As the name implies, the AB–WINDEC is place-and-context specific. Although the term 'place-specific' is not well-defined as a resource management and decision support concept, it has been turning up in a number of academic discussions in planning theory and practice, for example, (Bagstad et al., 2013; Carrus, 2005; Cresswell, 2009; Creutzig et al., 2013; Friedmann, 2010; Nordström et al., 2011). As a geographic term, place-specific refers to a sense of place that has meaning and value to people (Williams and Stewart, 1998). Place-specific can also be defined as a social construct formed around shared identity, and information affecting the specific features or the distinctiveness of a given territory (Carrus, 2005).

These definitions are relevant to wind farm placement decision making in Alberta. To be effective in socially-accountable processes, Snyder (2003) and Jankowski et al. (2006) argue that decision support tools should be linked to place-specific issues. Linking place-specific issues would make data processing and integration more easier, and could thus lead to tools that are perceived as useful by stakeholders (Briane, 2004). AB-WINDEC was developed through a conceptual framework, adapted from stakeholders' decision requirements in Alberta. Since decision support requirements must span the gap between the social aspects of stakeholder needs, and the technical aspects of product behaviour, a key question that was addressed in Adagha et al., 2015a was how to translate the requirements into a purposeful tool that can aid the process of planning the placement of wind farms in Alberta.

Further, in consideration of the requirement to integrate the models with the data management system and tasks sequence, the prototype was developed using a modular approach.

The prototype is composed of five different modules such as: Research module, Analytics module, Design Module, Evaluation Module, Reporting Module. Each module has specific functionality and sub-modules that uniquely support the decision analysis. Fig. 1 shows a screen shot of AB-WINDEC's main interface.

The system was developed as a web-based tool to reduce technological barriers and to make information more easily accessible to stakeholders.

2.2. Design and evaluation attributes for visual analytics tools

What attributes are needed to enhance the human-product interaction experience in wind farm placement decision support tools? Identifying the useful attributes and their underlying metrics can be help clarify the foundational design and evaluation goals prior to development, and can also help designers assess the usefulness of decision tools against the stated goals (Alben, 1996). Particularly in the context of wind farm placement planning, incorporating effective attributes of a tool can improve the knowledge of stakeholders involved in the decision-making process.

In Adagha et al., 2015b, there is some discussion as to the attributes of effective tools and how their impact can be measured. The findings introduced a general framework of attributes that could yield insights into how people perceive these tools in relation to their needs. For example, the paper argued that a person's experience of visual analytics is shaped by the ability of the tool to support creativity, utility, situation awareness, collaboration, and interaction. These attributes are distinguished in having their different underlying metrics.

So far, the attributes proposed in that paper have not been applied in real world settings with visual analytics tools. This study presents an opportunity to apply them in a focus group evaluation of AB–WINDEC with wind energy stakeholders in Alberta.

3. Material and methods

3.1. Study design

Focus groups were convened to evaluate the AB–WINDEC prototype tool with wind energy stakeholders in Alberta. A focus group is a method of research that utilizes group discussion to solicit ideas and feedback about a concept or product (Morgan and Krueger, 1998). In focus groups, participants can interact directly with new technologies, articulate their ideas, and provide researchers with inspiration for the design process (Bruseberg and McDonagh-Philp, 2002; Langford and McDonagh, 2003).

Some objectives motivated the study design. The first is that it was necessary to evaluate the utility and effectiveness of the proposed prototype with real stakeholders who are involved in wind farm placement planning. Another goal was to demonstrate the vision of the tool design to stakeholders through a more inclusive form of research (Bertrand et al., 1992). A further goal was to assess how well the prototype met functional goals and usability needs of stakeholders and to stimulate technical innovation. The final goal was to explore insights and concepts that can be used to improve the design of the prototype.

The focus group sessions were conducted between March 2015 and April 2015. Three focus groups were conducted separately in meeting rooms at the University of Calgary campus while one focus group was held in Edmonton. Each focus group session was conducted by a skilled moderator and one assistant. The moderator was responsible for keeping the participants focused around the key questions and to facilitate an open discussion. The assistant's tasks were to take notes, distribute study materials, and assist the moderator. The sessions were conducted in English and each session lasted approximately 2 h.

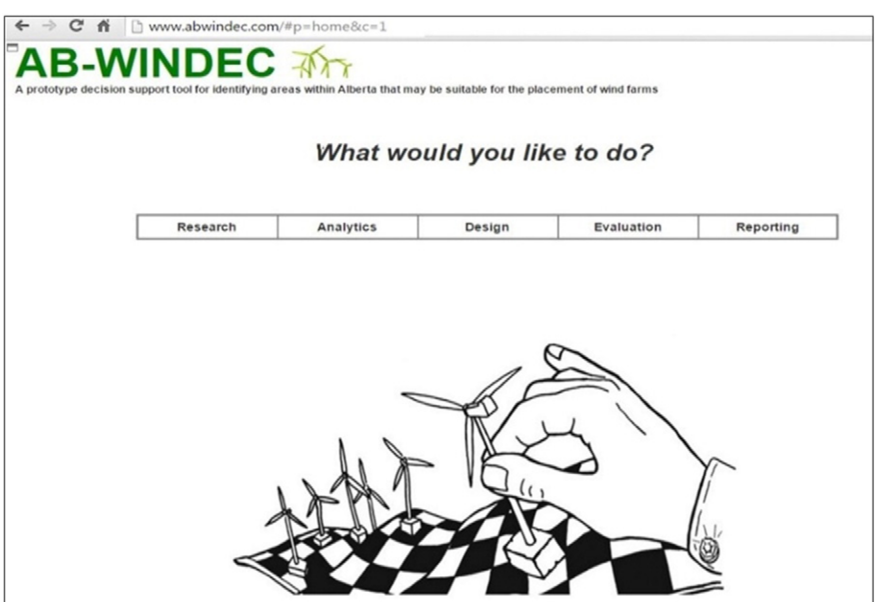

Fig. 1. A screen shot of the main interface, showing an overview of individual modules.

3.2. Pilot study

A pilot study was conducted with university students of the Master of Planning program at the University of Calgary. The purpose was to develop and test the adequacy of the research instruments and methods. It was also used to practice the roles of the research team, and to evaluate how the survey population might respond to the interview questions and questionnaires. The pilot study highlighted potential problems such as, poor response to the survey questions. Following the pilot study, the questionnaire layout was redesigned, and some ambiguous questions were either re-worded or discarded.

3.3. Participants

With the endorsement of the University of Calgary's CFREB research ethics committee, the research team enrolled a convenience sample of seventeen participants. There were altogether four focus groups with 3 to 5 participants each. This range, as suggested by Onwuegbuzie et al. (2009), allows for sufficient variation in the discussions. Participants were recruited through official invitation letters sent by electronic mails. Written consent was obtained from the participants before the start of each focus group. Participants were also informed about their right to withdraw at any point.

3.4. Inclusion criteria

Purposeful sampling was undertaken, following the approach prescribed by (Erlandson et al., 1993; Onwuegbuzie and Collins, 2007), to ensure a heterogeneous mix of stakeholders with different backgrounds and interests. The stakeholders were identified based on their experience and their level of involvement in the wind energy sector in Alberta.

Specifically, individuals who met any of the criteria below were targeted:

- Adult (over the age of 21)
- Have reasonable knowledge of, and demonstrated interest in, the issues that relate to the placement of wind farms in Alberta;
- May be affected by the placement of wind farms in Alberta;
- Can influence public opinion about wind farm placement and associated land use issues; or
- Have authority to make land-use decisions affecting wind energy placement in Alberta.

The final sample included wind industry professionals, land owners, analysts, planners, developers, regulators, and consultants (see Table 1). More importantly, the focus group participants represent the population who will use, or supervise the workforce who will use, the proposed decision support tool to be evaluated in this study.

3.5. Data collection

At the beginning of each focus group, the moderator introduced himself and gave a brief explanation of the procedures to the participants. The data collection proceeded in four steps.

3.5.1. Pre-study questionnaire

Before the focus groups began, participants were asked to complete a pre-study questionnaire. This questionnaire was used to collect demographic data which allowed for a better depiction of the focus group participants (see Table 1).

Participants were then shown a PowerPoint presentation describing the background research and the conceptual framework that informed the structural design, the key functionalities, and the capabilities of the AB–WINDEC prototype. Following the presentation, participants were asked to click through the prototype interfaces and menus in a self-directed fashion.

Table 1
A socio-demographic profile of focus group participants.

Gender (N = 17)	n (%)
Male	9 (52.9)
Female	8 (47.1)
Weekly work hours using computers (N = 17)	
0–8	0 (0.0)
8–16	0 (0.0)
16–24	0 (0.0)
24–32	5 (29.4)
32–40	8 (47.1)
40>	4 (23.5)
Stakeholder affiliation (total responses = 38)	
Landowners	5 (13.1)
Planners	4 (10.5)
Conservation groups	8 (21.1)
Energy developers	3 (7.9)
Analysts	2 (5.3)
Consultants	5 (13.1)
Regulators	11 (29.0)
Primary job responsibilities (total responses = 39)	
Research and data collection	5 (12.8)
Evaluation and regulation	12 (30.8)
Feedback and reporting	7 (17.9)
Site layout design	4 (10.3)
Data analysis	5 (12.8)
Advocacy and stakeholder engagement	3 (7.7)
Others: feasibility; planning; policy development	3 (7.7)

3.5.2. Sketches and notes

To give more depth to the focus group data, participants were provided with blank sketch papers and printed versions of the prototype's interface. On the computer screen, participants were let to freely explore the different menus and links in the prototype. However, for links that were not interactive, or had not been fully developed, the following message was made to appear on the screen:

> 'This section of the tool you have now selected is still undergoing development. We would like your help. Please tell or show us, through writing or drawing, what you would expect to find on this page.'

Participants interacted directly with the system and these interactions provided some insights into the usability of the interface. Following this, participants were then encouraged to write notes, draw alternative sketches, or make suggestions or ideas, they may have of each interface, on the sheets provided to them.

The primary aim of this technique was to gain a deeper understanding of the stakeholder requirements beyond the data already provided by the focus group discussions and surveys. The technique was adapted from the blank page technique proposed by Still and Morris (2010).

3.5.3. Group discussions

The discussions were semi-structured. To facilitate the discussions, the prototype interfaces was shown, page by page, on a large display screen. Participants were encouraged to ask questions or share any emerging ideas on how to improve the prototype design to better meet their needs. During these discussions, the participants were asked to critique the decision support capabilities of the AB–WINDEC prototype. There was a core set of questions and some probe questions. Probe questions were posed to participants to elicit their perceptions on the prototype's design, layout, usability, and adaptability to the Alberta context, usefulness and utility. For example, participants were asked to comment on:

- Additional features that would make the prototype a better decision support tool for wind farm placement in Alberta;
- How the prototype currently meets their needs, and to suggest changes that could better meet their needs;
- Tasks they currently perform at work that are currently supported by the tool;

- The useful and not-so-useful features in the prototype; and,
- Requirements that should be considered when redesigning the prototype.

All the sessions were audio-taped. In addition, a video recording of the large display screen was also obtained at each session. With this approach, it was possible to coordinate the audio recording of the discussions with the video recording of participant's interactions with the large screen display. The flow of ideas was greatly improved by incorporating this visual aid. Two digital audio tape recorders were used in each session, to ensure that all comments were recorded clearly and accurately.

3.5.4. Exit survey

At the end of each focus group session, a 12-item exit survey was given to each participant to provide additional information. Some of the evaluation metrics proposed in Adagha et al., 2015b were used in designing the survey questions. The survey included a five-point Likert-type scale and multiple choice questions. The questions probed for features in the prototype that participants may consider useful, or not useful, based on their interaction with the prototype. High scores represented negative perceptions; low scores represented positive perceptions.

To encourage reflection and critical observations, each survey question included feedback boxes for additional comments. This technique of feedback capture has been discussed in Bruseberg and McDonagh (2003). The purpose was to allow participants to reflect on their experiences of using AB-WINDEC, and to state their preferences in more depth than was obtainable in the group discussions.

In addition, the survey scheme was useful in capturing the opinion of focus group members who did not contribute much to the discussions (e.g., members who were relatively silent; members who are less articulate; members who do not want to reveal a different opinion or a different experience from the rest of the group; or members who did not get enough opportunity to speak during the discussions).

3.6. Data analysis

The digital recordings of the discussions were transcribed verbatim and analyzed using the margin coding approach proposed by Bertrand et al. (1992). The margin coding approach can be used to obtain the most thorough information on which to base analysis.

Data analysis involved one of the researchers reading and identifying themes within the data and manually coding these into appropriate categories in line with the research objectives. A second researcher working on the project then independently checked the first researcher's interpretations. The codes and comments were then recorded on an excel spreadsheet to allow for systematic analysis. Both researchers undertook a further review of the codes, referring to samples from the transcripts. This led to a 97% agreement after the differences were resolved through discussions. In addition, quotable comments were marked for reference purposes. A similar strategy was used to analyze the words and drawings made by participants on the sheets given to them. It involved identifying recurring patterns and themes.

For the quantitative component, a database within the statistical package for the social sciences (SPSS) 21 software application was used to catalogue data from the questionnaires. The demographic and exit survey data were analyzed using simple descriptive statistics. Descriptive statistics are useful when evaluating a situation by describing important factors associated with that situation, such as demographic, behaviours, attitudes, experiences, and knowledge (Kelley et al., 2003), which applies to the present study. The data were analyzed in conjunction with additional notes and sketches that participants included in the survey. To compliment analysis of the quantitative survey data, qualitative analysis of the open-ended comments and suggestions was also conducted using the margin approach described above. Additional written comments from participants were sorted and analyzed with the rest of the data.

4. Findings

In this section, the findings are described per participants' responses and important themes that were derived from the analysis.

4.1. Participants' demographics

The self-reported demographic data of the 17 participants are reported in Table 1. The sample consisted of 9 men and 8 women who identified with multiple stakeholder affiliations. The resulting sample provided a reasonably representative profile of stakeholders in the Alberta wind energy industry. Indeed, as many as 29% identified themselves as Regulators. The rest of the sample included Conservation groups (21.1%), Landowners (13.1%), Consultants (13.1%). Planners (10.5%), Energy Developers (7.9%), and Analysts (5.3%).

The most frequent primary job responsibility of participants was "Evaluation and Regulation" (30.8%). This was closely followed by 17.9% that reported their primary work tasks as related to "Feedback and Reporting". The rest were split between, Site layout design (10.3%), Data Analysis (12.8%), Advocacy and Stakeholder engagement (7.7%), Research and Data Collection (12.8%), and Feasibility, planning and policy development (7.7%).

Regarding the computer usage habits, up to 70.6% reported that they spend more than 32 h of their work week using computers or tablets. Interestingly, participants in all the focus groups indicated that they use computers or tablets regularly – for a minimum of 24 h in a 40-h work week. These demographic data are comparable with previous results reported in Adagha et al., 2015a, and shows a preference for a computer-based system.

4.2. Experience of use

4.2.1. First impressions

The initial reaction to the prototype ranged from skepticism to curiosity. When prompted on their first impressions, some particpants indicated that they were 'still processing it, and trying to understand how it works'. A few participants complained that some pages didn't load properly. However, most of the participants, it was observed, were quick to navigate through the prototype on their computer screens and were clearly aware that the prototype was a work in progress. Some of the participants 'liked the modular approach', but the general opinion on the menu tabs was divided. A good number of participants indicated that the menus were 'intuitive'. While one participant commented that he was 'not clear on what some of the menu tabs were set up to do'. Other representative comments were also critical of the menu tabs for 'not really describing content' and for not being 'very descriptive'.

In other observations, some participants thought that there were similarities to the user interfaces of software tools like Openwind and windographer. For instance, one opined that 'there is a lot of overlap with a sensitivity analysis tool like Retscreen'. Some participants remarked that 'it was good to see all the relevant data sources' and that the prototype 'seems user focused and still enables access to all data'. Another commented that 'a website like this could be linked to other websites that has information on wind farm development'. One participant thought it was 'something like a white chart where you can throw things on electronically'. While another wondered if the visualization components 'would allow noise modelling capabilities'. Several of the participants asked if they could use the application on their mobile phones. On encountering the location assessment tool for the first time, one participant commented, 'I see that it could restrict where you put your turbines right away, and say, 'this is a good spot or not'.' Overall, the participants' general first impressions could be described as positive.

Table 2
Modules accessed by participants ($N = 17$).

Modules	Yes *n* (%)	No *n* (%)
Research	14 (82.4)	3 (17.6)
Analytics	14 (82.4)	3 (17.6)
Design	9 (52.9)	8 (47.1)
Evaluation	8 (58.8)	7 (41.2)
Reporting	7 (41.2)	8 (58.8)

4.2.2. Perceived ease of use

The Technology Acceptance Model (TAM) (Davis, 1989), and the VADS assessment framework developed in Adagha et al., 2015b, provided a suitable framework for grouping and analyzing participants evaluation of ease of use of the AB–WINDEC prototype. Davis (1989) defined *Perceived ease-of-use* as 'the degree to which a person believes that using a particular system would be free from effort'. Given that effort is a finite resource, an application perceived to be easy to use is more likely to have a higher acceptability.

Participants in the focus groups agreed that controllability of the menu buttons and navigability of the interfaces were important factors that influenced their perception of the prototype. A small minority of felt that some menu labels did not clearly introduce the purpose for the menu buttons. Other participants claimed they had some experience with using similar systems, which perhaps aided their familiarity with AB-WINDEC.

Some complained that the interfaces and menus were not built with 'regular web features' and some hoped that 'significant improvements would be made' in due course. For some, the prototype did not have all the requisite data they needed for analysis.

Perceived ease-of-use was also measured using four exit survey questions, three of which were designed as a five-item Likert-type questions. Participants indicated the extent of their agreement with each item on a five-point numerical scale, ranging from 1-strongly agree to 5-strongly disagree.

Interestingly, the survey question which asked participants to report the modules they successfully interacted with, in terms of clicking and accessing the interface contents, received more 'Yes' than 'No' responses (see Table 2).

This suggests that participants interacted easily with the prototype interface and contents. However, the modules that had the highest accessibility ratio were the *Research* and *Analytics* modules. It should be noted that the responses gathered through the exit survey questionnaires also leaned more towards some positive ratings for *Perceived ease-of-use*, with higher responses in the agreement scales. A summary of the results is reported in Table 3.

4.2.3. Perceived usefulness

Perceived Usefulness was defined as 'the degree to which a person believes that using a particular system would enhance their job performance'(Davis, 1989). In both TAM (Davis, 1989) and the findings in Adagha et al., 2015b, perceived usefulness is considered an important metric that can be used to predict a stakeholder's willingness to use a visual analytics decision support tool.

Results concerning the perceived usefulness of AB–WINDEC during the study period are reported in Table 4, Figs. 2, and 3. Participants were asked to indicate the extent of their agreement with each item on a five-point numerical scale, ranging from 1-strongly agree to 5-strongly disagree. Two other questions in the menu were multiple choice questions. Responses indicated that most participants (76.5%) agreed that the web-based platform was a useful feature to have (See Table 4). Almost 60% of participants perceived the prototype as being applicable and useful to the Alberta wind farm decision process.

Fig. 2 shows the mean score of participants' responses to the multiple-choice question, 'What do you consider to be most useful features in the prototype?' The visualization capability and the data management functionality were rated as very useful. The Interaction features and Task Support were flagged as not very useful. The low scores recorded for Task Support and Interaction perhaps reflect the limited development of the front-end and back-end components.

The perceived usefulness of AB–WINDEC was assessed with specific applications and tasks. Fig. 3 shows the mean score of participants' responses to the multiple-choice question, *'In what ways can the prototype support you in the decision process?'* Mean values greater than 0 indicate more benefit to the participants in these applications. From the chart, participants considered *access to information* as the highest utility they would get from AB-WINDEC. This may be because participants placed a higher value on the educational attributes of the system, as would be reported later in this article. It was interesting to note that the perceived usefulness of *task support*, as reported in Figs. 2 and 3, had similar results. This was probably because the prototype could only simulate a limited number of tasks.

4.3. Design feedback

The focus group activity provides a variety of comments and feedback on several aspects of the design. These are reported in this section and supported by anonymized quotes from participants.

4.3.1. Feedback on stakeholder personas

Most participants expressed a general understanding of the intended purpose of the stakeholder personas, which was to provide tailored login access into the prototype. This disposition was captured in this comment: 'It is OK to sign in as different categories to streamline screens and tasks that are available.'

However, some participants wanted a clearer definition of how the access and security privileges are streamlined to each stakeholder persona. They wanted to know what was in store for them when they log in using a specific persona. One participant said:

> 'When I clicked on the login page as a consultant, it didn't verify that I am a consultant or land owner. Is that going to be something that the finished product will have?'

Another participant, a land owner, remarked:

> 'For now, it looks like, as a land owner, I can transfer to anybody's page. If there are no restrictions, then I don't know what having the different personas achieve.'

Table 3
Perceived "ease of use" of AB–WINDEC prototype ($N = 17$).

	Easy to click through menu buttons *n* (%)	Satisfaction with menu buttons & contents *n* (%)	Menu buttons were effective *n* (%)
Strongly agree	4 (23.5)	1 (5.9)	1 (5.9)
Somewhat agree	10 (58.8)	7 (41.2)	10 (58.8)
Neutral	2 (11.8)	8 (47.1)	4 (23.5)
Disagree	1 (5.9)	1 (5.9)	2 (11.8)
Strongly disagree	0 (0.0)	0 (0.0)	0 (0.0)

Table 4
Perceived usefulness of AB–WINDEC prototype ($N = 17$).

	Web-platform was useful *n* (%)	Prototype improved knowledge of wind farm placement issues *n* (%)	Layout of interface aided understanding *n* (%)	Prototype is applicable to the Alberta decision process *n* (%)
Strongly agree	2 (11.8)	0 (0.0)	2 (11.8)	2 (11.8)
Somewhat agree	11 (64.7)	7 (41.2)	9 (52.9)	8 (47.1)
Neutral	4 (23.5)	2 (11.8)	3 (17.6)	6 (35.3)
Disagree	0 (0.0)	5 (29.4)	2 (11.8)	1 (5.9)
Strongly disagree	0 (0.0)	3 (17.6)	1 (5.9)	0 (0.0)

Some suggested an authentication protocol that would give each persona private access to the final web-based system and eliminate the possible of security vulnerabilities.

> 'One of the things the system has to do at the beginning is to know who I am before I am given access. What I could do is to make sure the system asks for an email address and a password code. And then the system will automatically check whether the email address is valid. And if it isn't, then, sorry you can't get in. That way, we don't get trouble makers going in.'

4.3.2. Feedback on research module

The prototype has a research module, with data integration capabilities and search engine functionality, designed to meet the information-seeking requirements of stakeholders. During the focus groups, participants used the *Data Manager* to operate customized data queries. They were also shown how to use the search function to generate search results.

The search tool was popular with participants for its capability to facilitate basic search on wind energy information specific to Alberta. Several participants indicated that they would use the search tool to perform research tasks. One participant remarked that 'there is value in everyone having the same access to the same data in this decision support tool'.

4.3.3. Feedback on analytics module

Many of the focus group participants expressed positive comments regarding the data viewer interface-that allows integrated visualization of data on spatial and chart views. They were particularly impressed with the capability to visualize their own data and data drawn from the *data manager* in the research module. Representative comments regarding the *Analytical Module* included:

> 'From a land owner's perspective, I think the analytical tool is really cool. They can throw in different criteria and see how it changes the overall picture. They can also use it to analyze multiple sets of complex of data easily with the visualization component.'
>
> And:
>
> 'The data viewer is a useful tool for visualizing data because most of the databases in Alberta are trying to go spatial.'

However, ensuring that relevant datasets were in the data viewer was important to most participants. This view was reflected in the following comments:

> 'Looking at the map data, I think it is important to ensure that the title actually match what the data is. For example, you have a visualization of migration corridors, but it is not specific as to the type of wildlife or if it is specific to wind energy.'
>
> And:
>
> 'The visualizations in the data viewer, for example, the migration corridor and wind speed visualizations, do not show up as a yes or no derivative. You might want to have something in there that would just say a 'yes' or a 'no'.'

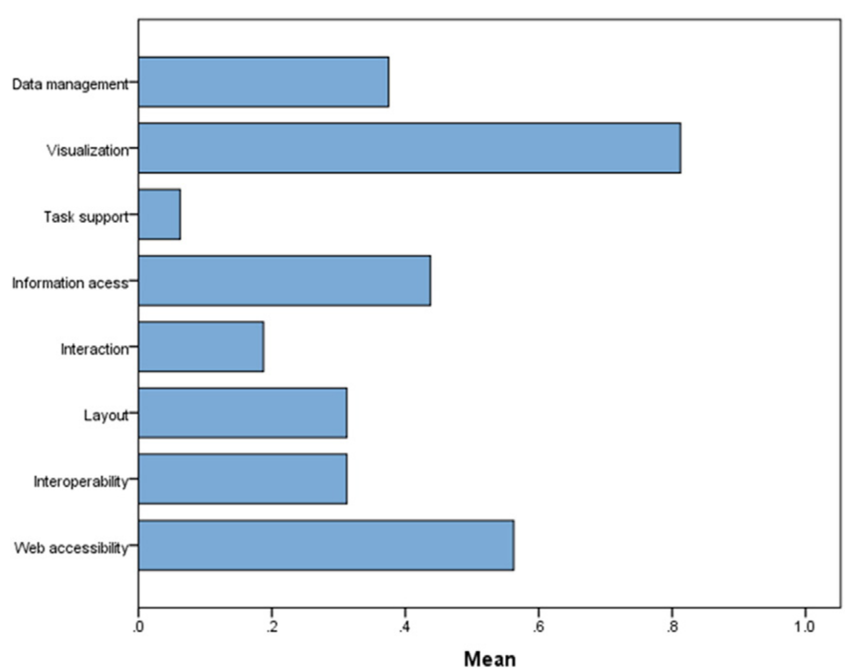

Fig. 2. Perceived usefulness of selected features in AB-WINDEC.

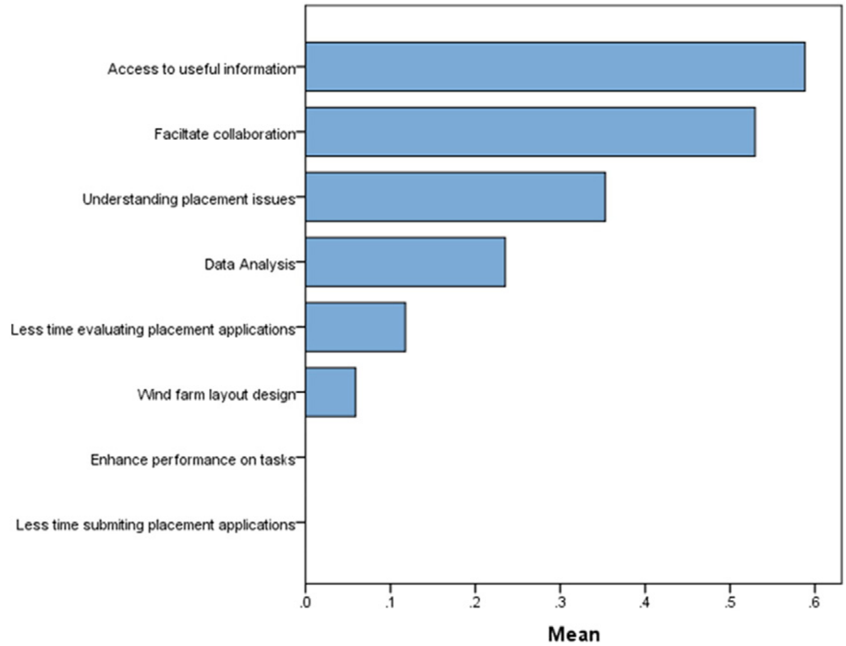

Fig. 3. Perceived usefulness of AB–WINDEC in the Alberta wind farm decision process.

4.3.4. Feedback on location assessment tool

Several participants were open towards the analytical modelling capability of the tool. Many participants found the capability to apply different criteria and weights to evaluate potential locations very useful. This view was summed up by a comment from this participant who said: 'It is useful to see there are analytical models within the system that can help us make informed decisions'.

However, some wondered if the location assessment tool can be designed to incorporate the regulatory requirements from multiple agencies. 'It is one thing to know about the regulatory requirements,' one participant said, 'and another thing to successfully build it into the system's scoring model.'

There were some specific requirements about the assessment criteria and the weights that should be used in the location assessment tool. One participant asked for 'a flashing red panic button' design as 'a warning label' for the decision bar. Other representative comments were:

> 'You might want to distinguish the setbacks from specific roads. Some roads are subject to restrictions by Transport Canada, while some roads are not.'
>
> And:
>
> 'Using only the number of turbines is not enough. It is necessary to add the height of the turbines and the diameter of the blades because that also affects noise calculation.'
>
> Also:
>
> 'The criteria in the model should not be set up as a continuous mathematical variable. For example, you cannot use continuous variable to analyze potential impact on sage grouse in placement locations.'

Overall, there was an expressed need to add more data points and menu features that enhance the 'compatibility' of the tool.

4.3.5. Feedback on design module

Several participants strongly felt that the current implementation of the design tool was rather out of depth for an industrial-type application on turbine placement layout and wind farm buildable area design. As one participant, a consultant, remarked, 'I think the design piece is quite ambitious. The layout design, using site-specific data, would be a lot to incorporate into the functionality of this tool.'

Similarly, participants felt that ensuring sufficient spacing between turbines required a lot of specialization, which would be a lot to ask from AB-WINDEC.

> 'Building something like that would be challenging. The wind layout design process is iterative, there is a feedback process. For example, when designing a wind farm layout for noise, the noise outcome depends on the placement of the turbine. So there is a whole lot of optimization schemes that is involved.'

The consensus was that there were already more specialized tools currently being used for wind farm layout design.

4.3.6. Feedback on evaluation module

Most of the focus group participants seemed to like the idea of the evaluation module, but expressed doubts about its ability to support the regulatory tasks and processes. For example, one of the participants said:

> 'I see that there is an attempt to simulate the multi-agency sign-off processes in the evaluation component of the tool, but it doesn't really get there electronically. The actual process is more specific and more complicated than what this tool is offering now.'

There was some consensus that the design of the evaluation module would need to incorporate more information about the stakeholders' workflow processes before it can be integrated in the decision process. This view is mirrored in the following comments from three different participants:

> (From focus group 1):
>
> 'I would say you are much happier leaving out the evaluation section for now, but if any group is going to use it to evaluate sites or projects then you have to specialize it down to the very granular levels of interests and process.'

(From focus group 2):

'It is good to see that the designers put some thought in the evaluation component, but it is something I think could be probably useful in the next 10 years.'

4.3.7. Feedback on reporting module

Several participants were happy with the intuitiveness of the *Reporting Module* and its potential to facilitate analytical communication and smoother generation of reports and charts. 'This could save me precious hours each day,' one participant reflected.

Some of feedback focused on the visualizations that can be generated on the reports. 'I would like to know how charts can be inserted in the reporting forms and where it goes from there,' one participant said. Another participant was unsure how she 'landed on the reporting side of it'. Other participants wondered if the report interface could automatically connect to their datasets.

4.4. Potential applications

4.4.1. Educational tool

A good number of participants felt that the learning experience they got from using the prototype outweighs its decision support capabilities. This was a major theme that was consistently mentioned in all the focus groups. One participant had this to say:

'This could be an educational tool to get people to a level of information where they feel that they can oppose or dispute a project on equal ground with the people that are proposing it.'

Another said:

'My experience is that people often approach wind farm projects with a lot of wrong information. This tool can help provide basic information about the size of turbine, what the noise level would be, what threats are there to wildlife, and so on. Some of that basic information would be extremely valuable in informing the local community.'

Others comments from other groups appeared to support this view:

'I do see value in the tool in settings where you have multiple stakeholders and multiple interests. It is easy to use and can educate the stakeholders quickly. The ability to visually represent issues, in stakeholder's meetings, cannot be underestimated.'

And:

'The public can also use it to inform themselves if they want to intervene and all that stuff. Sometimes, when you are at open houses, a lot of people may want to know more about certain issues like, for example, migration corridors for bats. So, they can use this tool to play around and learn about the things they want to know more about.'

4.4.2. Public engagement

Participants in the groups uniformly agreed that AB–WINDEC would be a useful tool for a public engagement approach that goes beyond the usual open house mechanism. Some opined that the collaborative capabilities of the tool can support wider public participations in placement decisions in a way that significantly reduces conflict and improves a project's outcomes.

'Something like this is potentially valuable to people who might be impacted by wind farm development, and who do not have the resources to consult sophisticated tools or to engage consultants.'

Another participant thought that 'it could be used as part of a big stakeholder session, in which everybody has an opportunity to provide input around a particular issues, problems, or decisions, and the system collects all the data so that stakeholders, and can look at it and say, " here is what everyone is saying".'

4.4.3. High-level analysis

Most participants indicated that they would use AB–WINDEC as a high-level screening tool for multiple locations. Many opined that the tool would be useful to stakeholders who are considering potential development areas in the province.

'This tool would be useful for high level analysis before you can dig into the details. For example, it would be good for preliminary high level assessments like determining access to transmission or assessing the wind resource potential at a particular location.'

Other participants felt it could be useful as a '*quick and dirty method to screen down about 200 potential locations to about 5*'. In this respect, there were suggestions to use the tool in analyzing issues of scale using the approach of 'go' or 'no-go- areas'. One participant explained this concept further:

'At the high level, you are not constrained as much because all it does is show you, you know, the areas where you can or cannot build wind farms on. It is not aiding the kind of judgement that needs to be made at the end of the decision process.'

Another participant's comment also reflected this view:

'For me, I would find it more useful to help evaluate land use proposals. You know, to get a bigger picture thing.'

4.4.4. Municipal-level risk assessment

There were suggestions that municipal authorities could use AB–WINDEC as a risk assessment tool to get a picture of where other land uses might be affected by the placement of wind farms. The general thinking was that the tool would be useful to municipal district planning authorities because they tend not to have the in-house specifications for wind farms. One participant, a planner, discussed the practicability, stating:

'I think there is possibility at the municipal level for a tool like this. It could be useful for risk analysis and optimization, given the various constraints and thresholds points we consider when making decisions.'

Another participant stated, *'Right now, it looks like it would be more useful for landowners and planners to insert their constraints'.*

4.4.5. Collaboration tool

While reflecting on their current workflow practices, some participants suggested that AB–WINDEC can support 'working together', 'ability to exchange information', and 'greater communication' with other stakeholders in the wind energy industry. However, participants also stressed that research needs to be done to get to that stage:

'It might work as a collaboration tool, but I think there is still a lot of steps and a lot of things to be covered before you get to that.'

Many participants thought that the web-based nature of the tool could provide a communication channel with regulatory authorities, and may thus increase productivity and reduce the long waiting periods for applications to be approved. As one participant explained: 'The fact is we often find it challenging getting feedback from the multiple agencies we are obligated to deal with. This would be a great tool to make things faster.'

4.5. Perceived issues and concerns

Security, data sharing, system monitoring, data quality control, and the possibility of system manipulation were identified as some of the issues that could prevent the tool from gaining wider acceptability with stakeholders in Alberta.

On data sharing, although participants agreed that AB–WINDEC showed great agility as a repository that can integrate a variety of local wind data, the major concern was that many beneficiaries would not be willing to upload and share their own data. One participant expressed this succinctly: *'Many stakeholders would like to benefit from the data input by other stakeholders, but, unfortunately, I don't expect them to show the same willingness in uploading their own data to the system'.*

Similarly, some participants envisaged data proprietary issues in the future: 'When you start getting into the site-specific factors, that's when you start getting into the proprietary data issues,' one participant stated.

Several participants were concerned about the quality control on data and files that are coming into the system. 'I would like to know how data is stored and monitored on the system', was a common refrain. Some participants opined that it was becoming increasingly difficult to scale and index data from multiple data sources. 'It would be difficult to accommodate different data types, data sources, indexes, and queries.'

The issue of security was a concern as well. Most participants felt that the security of the system needs to be addressed, stating, for example, some 'concerns with the issues of confidentiality and security in the system'. Indeed, some participants in the focus groups expressed concerns about the possibility of system manipulation: 'I would be worried about the proponents gaming the system and shoe-horning their projects into the best score.'

Similarly, some participants argued that AB–WINDEC does not have a monitoring system, and that certain controls are not in place. One participant said: 'I am wondering who should be monitoring the system. Is it a government or is there one person who takes it on? Or is there going to be a private company monitoring it.'

Several participants thought the system design was well-intended, but that the prototype was rather 'over-ambitious' and may not fit into the decision process. One said:

> 'I am not sure it would fit for actual regulatory mechanism, because different agencies have different things they use for their assessments when making decisions on placement locations. Sometimes the things they look for are subjective.'

4.6. Design modifications

The focus groups suggested several improvements to the current design. These were:

4.6.1. Stakeholder persona login protocol

Several participants suggested that the persona login approach should allow for stakeholders' data, weightings, models, criteria, designs, etc. to be saved, retrieved and resumed later.

For the tool to be relevant for project application and submission, participants suggested that wind farm planning submissions should be assigned a unique number. They also recommended that access to the tool should be based on stakeholders personas and profiles.

4.6.2. Noise modelling capabilities

Some participants emphasized the need to enhance the prototype's noise modelling capabilities, since the turbines are laid out mostly with regards to noise constraints. One participant recommended using the 'doubling of distance technique' to estimate distance between wind turbines and noise receptors, explaining:

> 'At the screening level, getting the system to gauge the distance between the turbines and potential receptors might be suitable proxy way to get around the noise modelling challenges.'

Another participant added:

> 'You can get noise data from manufacturers. In AUC rule 12, there are various calculations you can use to propagate noise to the potential receptors.'

Other participants simply wanted the noise modelling to analyze impact on wild life locations, for instance: 'I would be interested in using the tool to understand more about low–frequency noise and how it can affect near tropical migrants that might be nesting.'

4.6.3. Assessment of transmission lines

Many participants believed the prototype can be optimized to support assessment of transmission lines and access to transmission lines. Some wanted the capability to visualize utility corridors and transmission lines. One of the participants articulated it in this comment:

> 'Existing tools tend to focus on other issues like wildlife, noise, etc., but not on transmission. I think this tool would really be useful as pre-assessment tool for high-level analysis of transmission availability and options.'

4.6.4. Financial modelling

Focus group participants stated that the biggest technical enhancements in the prototype should come the form of financial module that can analyze the economic opportunities for land owners and local communities. Several participants stressed that the financial modelling should have the capability to calculate potential carbon credits from wind energy development. As one explained:

> 'The financial model in the tool should reflect the dollars per megawatt hour analysis of siting a wind turbine. It should also have the capability to correlate the variable power price with predominant wind regime. This would allow stakeholders to optimize the price discount relative to the pool price.'

4.6.5. A "social value" module

Several participants were interested in how to bring the social values of communities into the wind energy decision process. Participants wanted to see a social value module that is designed to support stakeholders' considerations of potential impacts of placement locations – to ensure that wind energy development activities have positive effects on people's values. This wish is reflected in the following comments from different participants:

- *'It would be interesting to see how this tool can connect to the social value and community level of the decision process.'*
- *'Part of what I envisage for the assessment part of the tool is the capability to allow the people to pick from a list of social considerations that influence where development can happen or priorities that reflect elements that people want to preserve in a landscape.'*

The general opinion was that having a social module would answer some broader questions surrounding some of the placement issues and would help ensure fairer decision outcomes.

4.6.6. Location assessment tool

Some participants suggested that the location assessment tool within the analytics module should be upgraded to a standalone module. It was generally accepted that a fully optimized location assessment module can help stakeholders find the best land use solution if based on setbacks, constraints and indicators that are already used by stakeholders. As one participant indicated: 'It may be useful to work with stakeholder groups to come up with the criteria and the indicators they want, and then you can go away and incorporate it into the location assessment tool.'

Most participants wanted the capability to optimize placement locations using their own values and criteria. For example, one participant thought it would be interesting to model the optimal number of turbines that can be for a location, using the location assessment tool:

> 'In the location assessment tool, it would be useful to have a feature which can tell you, that to optimize a particular site you would need a certain number of turbines.'

Some participants also wanted the location assessment tool to be connected to the data viewer. One participant said: 'I think it would be nice to have a functionality where you can export the data and criteria you analyzed on the location assessment tool to be visualized in the data viewer.'

In addition, some participants suggested that the 'decision bar' feature, in the location assessment tool, should provide more detail when providing assessment scores on some selected locations.

4.6.7. Tiered decision system

Participants suggested a more flexible approach, similar to the U.S. fish and wildlife wind energy guidelines, where the decision support system is broken into tier system. This participant emphasized the importance of this approach:

> 'The constraints in each tier will automatically apply to any potential location you are reviewing for wind farms. When you get past one tier, you move to tier 2, tier 3 and so on, which is like what you have in AB-WINDEC, moving from research to analysis to design and then to evaluation. When you get to the end, you are at the stage of approvals.'

4.6.8. Scaling approach

Some participants felt that incorporating a 'Scaling' technique in the tool can be useful in categorizing some of the placement issues. One participant familiar with the technique shared:

> 'You can put wind resources areas on a regional scale which shows areas where there are wind and areas where are no wind. Coming down to the municipal level, you can also create scale of 'go' and no-go areas. And you can use a scale all the way down to the site-specific issues. This way you can get a better perspective of what the issues are on a regional, provincial, or municipal scale.'

The scaling technique was also suggested as a way of enhancing the educational attributes of the prototype.

> 'If the tool can work on a provincial, regional, municipal, versus site scales, then I think it can meet the educational needs of stakeholders, which would, in turn, feed into the decision support process.'

4.6.9. Data integration

Some participants wanted to implement more rigorous data integration procedures in the system. For example, some argued that specifying the acceptable data formats will enhance quality control on data going the system. One illustrative comment was:

> 'I suppose there is a way to specify that data being brought into the system should be in a specific coordinate system. I just mean that if that is a requirement of the system, then one should be more explicit in saying that, you know, "make sure your data is in a specific coordinate system".'

5. Discussion

The wealth of ideas that emerged from the analysis of both qualitative and quantitative sources of data perhaps reflects the prevailing views and range of interests among wind energy stakeholder groups in Alberta. Significant insights are discussed below.

5.1. Mitigating potential barriers to acceptance and adoption

5.1.1. Broad design scope

There was consensus that the prototype was 'ambitious'. Several participants expressed concern that some aspects of the tool, namely *Design, Evaluation* and *Reporting* modules were 'doing a little too much', yet without offering significant advantage over existing tools. Nevertheless, several insights can be drawn from this. First, the assertion points to the benefits of adopting a modular design strategy. Participants could appreciate each module as independent sub-divisions of the system, while recognizing the separate functionalities they provide. With this interpretation, they could also compare the tools they currently use with the capabilities offered in each module. Thus, integrating unwanted components to AB–WINDEC could lead to lower acceptance levels. Furthermore, reducing the design scope makes it easy to focus design efforts on the modules that stakeholders want and to optimize those capabilities accordingly.

5.1.2. Inadequate access to data

As far as key stakeholders in the wind energy development in Alberta are concerned, the study demonstrates that inadequate access to data are perceived to be the most severe barriers to the decision-making around wind farm development at regional, municipal and provincial levels. This stems from proprietary and 'format' limitations that prevent the availability of several datasets in the prototype. Improved access to data can be accomplished by developing AB–WINDEC as a formidable data repository. Nevertheless, the seeming lack of trust among stakeholders who are in competition for placement locations appears to be a big impediment. Also, the process of incorporating datasets into a decision support system requires data to be modified into a standard format that can be used by the system. This is because of the vast quantity of data come in different shapes and sizes. If all stakeholders accept a specific standard for data integration, then convergence of data formats could be easily achieved.

5.1.3. Security

There was consensus, across the focus groups, that security was an important issue with AB-WINDEC. Participants were keen to know what measures were in place to ensure reliability and confidentiality of data in the system, and how to protect the system from manipulation. Access to data, for example, is made more difficult by the stakeholders' insistence on having effective security protocols in systems. Participants felt that the lack of stringent verification procedures may discourage the real stakeholders from using the system. This kind online interaction, according to participants, requires a secure technology platform.

5.1.4. Usability

In the discussions, some of the participants felt the interactions with the menu buttons lacked specificity, even after receiving explanations on how the different menus were designed to work. Poor usability, it was gathered, may discourage stakeholders from incorporating the tool in the decision-making process.

5.1.5. Presentation of complex information

Some participants were concerned that many of the menu buttons and interfaces do not offer simple ways of accessing complex information, and that this may lead to limited access to relevant material. This calls to mind the need to design the interface with a clear and consistent conceptual structure, and to link the menu content to interactive visual cues that are familiar to stakeholders in Alberta.

5.2. Social footprint versus technical requirements

Several participants expressed that they would value input of social requirements in future design considerations for AB-WINDEC. The emphasis on this point is perhaps a recognition that all large-scale, commercially available wind farm development projects today come with their own set of significant environmental and social concerns.

The implication is that technical requirements that go into the planning, construction, and operation of wind farms should also include the social footprint and the social needs of the environment in which they operate. Specifically, a credible weighting summary of social impacts and site-selection options for the local economy, land use, climate change, available compensation, and benefits-sharing arrangements should be integrated in the AB-WINDEC development process. The benefit of this socio-technical approach is therefore about joint optimization, with a shared emphasis on achievement of both productivity in technical performance and usefulness of a technology in real world conditions. If applied, it would facilitate a more useful interaction between people and technology in the wind farm placement planning process, and usher in a sensible path to decision-making in Alberta and other communities where large-scale wind farm development poses serious social challenges.

5.3. Value propositions and applications

Consensus from the focus groups indicates that prototype can be adapted to other applications, which may increase the number of stakeholders who could use it and make decisions about wind farm placement. Participants offered several potential applications where AB–WINDEC can bring greater value to the wind farm placement decision process. However, the results suggest that AB–WINDEC can provide better decision support when deployed as an educational tool. It seems logical that participants would appreciate an educational application because it permits a simple learning approach and a more accurate understanding of the complex decision issues.

Findings from this research can help close the gap between the conflicting stakeholders' interests, regulatory constraints, increase legitimacy and responsibility in land use decisions, thus improving the chances of achieving mutually acceptable trade-offs. Adapting the prototype to these applications will likely increase its effectiveness and chances of adoption in Alberta and in others contexts with decision support issues, product design challenges, multiple stakeholders and conflicting interests.

6. Limitations

The limitations of this study are significant and should be acknowledged. In the first place, recruitment of participants was a major hurdle for this research, given that specific stakeholder profiles were required in the inclusion criteria. Consequently, the study was based on a convenient sample of 17 stakeholders, which may not be considered statistically significant. However, this limitation is addressed by the purposeful approach and inclusion criteria used for the sampling. Thus, the final sample of participants represent significant groups in the targeted stakeholder community, and participants tend to speak on behalf of their groups. To minimize selection bias, participants were randomly assigned to the 4 focus groups from the pool of 17 participants.

There was invariably a very large amount of data, mostly on audio tape and questionnaires, supported by notes and sketches, which presented a challenge in reporting the findings. It is relatively easy to bias the outcome by inclusion or exclusion of key statements, by choosing points of view, or by taking comments out of context. However, to reduce the risk of drawing incorrect conclusions, quantitative analysis methods were used in tandem with the rigorous qualitative analysis procedures.

Third, data from the surveys provided new information that may not have been discovered in a traditional focus group study. The usefulness of the survey scheme lay in its ability categorize self-reported ratings of participants and to provide some structure to the analysis. Descriptive statistics offered a more contextual, easily understood analysis of the data. While other statistical methods may be useful in making wider-reaching inferential analyses, the efficiency of the descriptive statistics approach was sufficient for the scale of study and the study goals. Nevertheless, it is important to note that the numbers used in the results do not convey the impression that the distribution can be projected to a wider population of stakeholders. It is not the intention of this study to generalize.

7. Conclusions

The study in this article evaluated the utility of AB-WINDEC to support the wind farm placement decision-making process in Alberta. The focus group methodology was designed as a combination of research methods, including survey questionnaires and blank paper techniques, to evaluate the effectiveness of the prototype design for its intended purpose. These methods helped in gaining stakeholders' impressions and perceptions about AB-WINDEC, and in stimulating design ideas that would be reflected in the new version of the prototype.

As part of a continuous design cycle, findings from the focus groups have provided compelling feedback regarding the nature of decision support required by wind energy stakeholders in Alberta, the attributes that are more effective and efficient, and the barriers that must be addressed if AB-WINDEC is to realize its full potential. In addition, the study has increased current understanding of how stakeholders interact with tools and has shed light on several other requirements that influence the success and acceptance of decision support tools in the wind farm planning process in Alberta.

One of the most challenging issues in the location of wind farms is how it clearly brings forward tensions between different levels in society, given that the environmental benefits of wind power are often visible on a global and national level, while the negative effects are usually felt on the local scene. Therefore, the results of this study are particularly important from the standpoint of industry and government agencies involved in the placement of wind farms in Alberta, because the tool can aid consensus-building where the preferences of stakeholders are in conflict. Another conclusion that emerged from this work is that successful implementation of an effective decision support tool requires a clear understanding of the interplay between the technical and social requirements. Given the findings, further research should prioritize certain aspects of the tool – particularly the modules that support educational learning, data integration, and high-level analysis. The outcomes should be tailored to the information needs and social considerations of stakeholders.

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