Willingness-to-Use Models for Climate Policy

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Abstract

Participatory Integrated Assessment (PIA) approaches are increasingly used in the development of regional climate policies. Such approaches ensure consideration of multiple perspectives on climate change, while simultaneously respecting decision stakes. This is expected to increase commitment to the acceptance of climate policies.

Integrated Assessment Models have been applied extensively in these PIAs to provide quantitative scientific insights of future consequences of climate change policies. Models have, therefore, become an important source of information for participants of PIAs. Here we investigate how participants assess their willingness-to-use (WTU) model results in PIAs supporting climate policy appraisal. We present a conceptual model of WTU assessments, assuming that participants often assess WTU implicitly based on their own expectations and on scattered information provided by scientists. The information needed by the participants therefore follows from the WTU criteria they implicitly use. This varies with their perspective and the aim of the PIA. Scientists can use various analytical methods to provide the relevant information for helping participants assess WTU, including sensitivity analysis, uncertainty analysis, scenario analysis, and more elaborate frameworks that simultaneously address perspectives and model assumptions.

We argue that, in PIAs, WTU is often not explicitly assessed by participants. We illustrate this for one example, the Delft Process, a PIA in which results from a global integrated climate model were used. An explicit WTU assessment, such as suggested by our conceptual model, could improve information provided by scientists so that it better matches information needs of participants for assessing their WTU models.

1. Introduction

Participatory Integrated Assessments (PIA) can be defined as "an IA approach in which social stakeholders… contribute their knowledge and policy preferences to the assessment of complex policy problems" (Schlumpf *et al.*, 1999: 2). PIAs often involve dialogues between scientists, decision makers and other stakeholders. Participatory research is increasingly used in Integrated Assessments (IA) of climate change (Dahinden *et al.*, 2000; Kloprogge and van der Sluijs, 2006).

Climate change, being characterized by large uncertainties and high decision stakes, is an example of a Post-Normal problem on which multiple legitimate perspectives on the problem exist (Funtowicz and Ravetz, 1993; Van de Kerkhof and Leroy, 2000). For such problems, Funtowicz and Ravetz (1993) propose a Post-Normal science approach which, as opposed to the routine puzzle-solving approach of 'normal' science, explicitly manages uncertainties and explicates values. In a post-normal approach, an 'extended peer community' of stakeholders

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evaluates the quality of scientific inputs to decision-making so that the multiple legitimate perspectives on the problem are taken into account. Therefore, PIAs can help find solutions for climate policy that are scientifically credible as well as socially legitimate.

In addition, stakeholder participation is often used in IAs because it can foster learning - both by including stakeholder knowledge in the IA and by generating new knowledge through exchange of ideas between participants - and because it can improve implementation by involving actors that can implement climate policy options (Fiorino, 1990; Stalpers *et al.*, forthcoming).

Integrated Assessment Models are promising tools for use in PIAs. However, it can be difficult to use models so that they meet participants' needs and requirements. Models have been applied extensively in IAs of climate change, and are means of using scientific knowledge as a basis for policy making (Dowlatabadi, 1995; Parker *et al.*, 2002; Schröter *et al.*, 2005). Using model results in PIAs is a promising means of making scientific knowledge accessible to participants, thereby enhancing the use of scientific knowledge in PIAs (Toth and Hizsnyik, 1998; Dahinden *et al.*, 2000; Yearley *et al.*, 2001; Siebenhüner and Barth, 2005).

Understanding the willingness of non-scientist participants to use model results is an important precondition for effective use of a model in PIA (henceforth, 'participants' refers to non-scientist participants, *i.e.* all participating stakeholders except those participating solely in their capacity as scientists). We define *Willingness-to-Use* (WTU) as the extent to which participants are willing to use model results as a source of information for their input to an IA (see also Box 1). The explicit or tacit assessment of participants of their WTU model results is then the *WTU Assessment*. We distinguish between WTU Assessment, which is the participants' assessment of their WTU model results, and the Integrated Assessment (IA) within which the WTU Assessment takes place.

This paper aims to investigate how participants assess their WTU model results in PIAs supporting climate policy appraisal. The focus is on the process by which information pertaining to the WTU is requested and supplied and the criteria stakeholders apply to assess WTU.

PIAs differ with respect to their degree of involvement of stakeholders (Van de Kerkhof, 2004). Here we consider only PIAs which aim for co-production of knowledge: the IA is carried out in co-production between stakeholders and scientists (Van de Kerkhof, 2004). In these PIAs a WTU Assessment takes place because participants somehow decide what model results they are willing to use for producing the integrated insights in the PIA.

Box 1. Willingness-to-Use concepts

Willingness-to-Use (WTU): extent to which participants are willing to use model results as a source of information for their input to the Integrated Assessment.

WTU Assessment: the tacit or explicit assessment by participants of their WTU model results.

WTU Criteria: the criteria by which participants, implicitly or explicitly, assess their WTU model results.

Perspectives: the perspective of participants on the role of the model in the assessment, on the role of science in the assessment, and on what quality science is needed to support policy addressed by the assessment.

Information for WTU: the information supplied by scientists to participants which is relevant for the WTU Assessment.

Model Analyses: analyses by scientists of the model and of the problem at stake to generate information for the WTU Assessment.

2. Concepts of Willingness-to-Use Assessment

We assume that participants decide on their WTU model results based on the information available and on a set of explicit or implicit criteria. The information flows involved in a participants' decision to use model results can thus be represented by an information demand and supply flows, as shown in Figure 1.

The left hand side of Figure 1 represents information demand, and the right hand side represents information supply. The demand for information follows from the criteria by which participants decide whether to use model results. The supply side is the information intentionally or unintentionally supplied by scientists that is relevant for the WTU Assessment by participants. In practice, participants will use various sources of information including news media, information from the participants' network and previous experience with the model or the issue at stake, but we limit the investigation to information supplied by scientists because this is the only information supply which the PIA research team can improve.

Understanding the demand and supply of information in WTU Assessments can help to find ways to improve the WTU Assessment process and improve the supply of scientific information about models in PIAs.

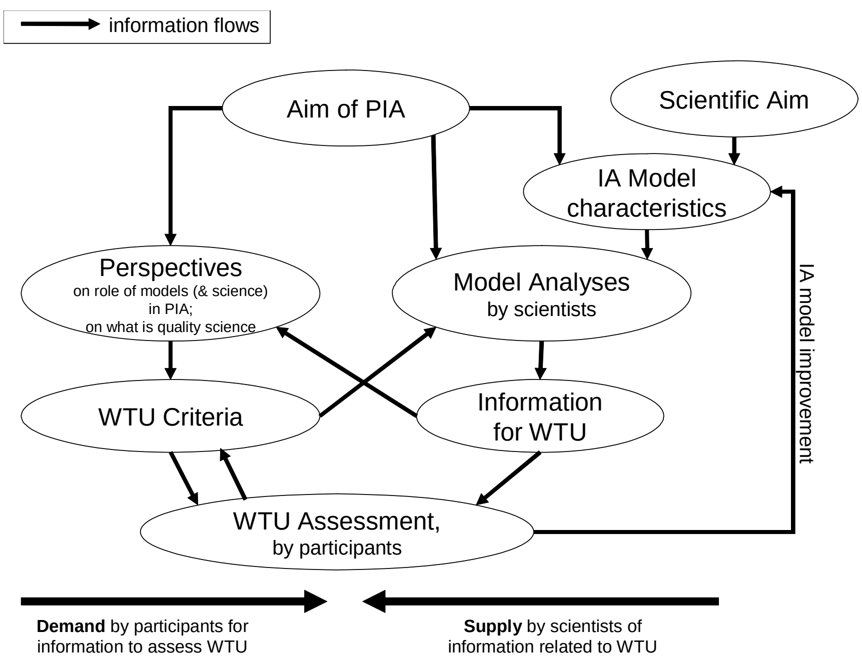

Figure 1. Conceptual model of WTU Assessment: information demand and supply for assessing the WTU IA models. Information demand and supply lie along a dimensional axis of nature of information, moving from stakeholder perspectives (demand) to science (supply). In the WTU Assessment, where demand and supply come together, stakeholder perspectives and science are integrated.

The Demand Side of WTU Assessments

There can be various criteria which participants consider relevant for assessing WTU, and we refer to these as *WTU Criteria*. WTU Criteria can remain implicit or they can be explicitly articulated by the participants. The WTU Assessment can results in a clarification of WTU Criteria, represented in Figure 1 by the arrow going from WTU Assessment to WTU Criteria.

Participants' WTU Criteria will likely be determined by participants' perspectives on the role of the model in the PIA, and more generally on participants' perspectives on the role of science in the PIA. For example, if participants perceive the role of the model to be modest, they will likely be less critical than if the model results forms main argument of the PIA. Participants' WTU Criteria also depend on their perspective on what constitutes sufficient quality of science for policy. For example, the level of accuracy participants demand depends on whether participants are more risk-seeking, risk-accepting or risk-aversive (Van Asselt and Rotmans, 1996).

We assume that participants' perspectives on the role of the model in the PIA are determined by the (perceived) aim of the PIA. The role which participants want to attribute to the model will likely depend on whether the model results and other sources of information (e.g. results from measurements, results from other models, experiential knowledge) contribute to the aim of the PIA.

WTU Criteria

In a WTU Assessment participants assess the utility of model results. We can borrow from research on 'boundary work' a useful taxonomy of three information attributes: relevance, credibility and legitimacy (Cash *et al.*, 2003). These three can be considered WTU Criteria. Although alternative taxonomies exist, this taxonomy is relatively comprehensive and applicable to information 'value demand' of decision makers (and other stakeholders) (McNie, 2007).

Relevance (termed 'salience' in (Cash *et al.*, 2003)) refers to the extent to which information is relevant given the needs of stakeholders. Relevance of model results considers such aspects as spatial and temporal extent and resolution (Dumont *et al.*, Submitted); whether essential components of the studied system are modeled; and whether the model includes variables or 'leverage points' (Meadows, 1999) of the system that can be managed.

Credibility refers to the "scientific adequacy of technical evidence and arguments" (Cash *et al.*, 2003: 8086). Credibility considers aspects such as the scientific and technical believability of model results (Tuinstra, Forthcoming) and the internal consistency of the model and scenarios used (Van Aardenne, 2002). Stakeholders often assess credibility indirectly by reputation of the modeling institute and 'reputation' of knowledge used – *i.e.* the standing of knowledge in scientific community.

Legitimacy refers to the extent to which the process of information production is unbiased and takes into account divergent stakeholder values, beliefs, views and interest (Cash *et al.*, 2003). Legitimacy also includes whether value-laden assumptions (Van der Sluijs *et al.*, 2005) in the model match with users' perspectives.

Accuracy and transparency are two model characteristics from which relevance, credibility and legitimacy may be assessed. The accuracy of a model can determine on the one hand if the model is relevant, *i.e.* if the model can answer relevant queries given its uncertainty. On the other hand, the accuracy of a model can also determine if model results are credible, *i.e.* if conclusions drawn from the modeling exercise are valid given the uncertainties. Many typologies of uncertainties exist which may serve for sub-classification of WTU Criteria (e.g. Van Asselt and Rotmans, 1996; Van der Sluijs, 1997; Gabbert and Kroeze, 2003; Sarewitz, 2004; IPCC, 2005; Peterson, 2006). The IPCC Guidance notes on addressing uncertainties for the Fourth Assessment Report (IPCC, 2005) lends well for classifying WTU Criteria because it can easily be related to different aspects of using a model: the model inputs, the model itself, and the real future. It is therefore expected to be transparent to non-scientific stakeholders. The typology is (1) *value uncertainty* – uncertainty from e.g. missing, inaccurate or non-representative data, inappropriate spatial or temporal resolution, and poorly known or changing model parameters; (2) *structural uncertainty* – uncertainty from e.g. inadequate model form, processes not considered or wrongly specified, and ambiguous system boundaries; and (3) *unpredictability* – uncertainty from unknowable future developments, e.g. human behavior and chaotic behavior of complex systems. The corresponding WTU Criteria are (1) accuracy of model inputs and parameters, (2) accuracy of model structure, and (3) accuracy in the face of unpredictability.

Transparency is the degree to which a model can be understood by other experts or non-experts. Transparency is a pre-condition for assessing other WTU Criteria. For example, assessing relevance requires understanding of the model structure; assessing credibility requires understanding of the internal consistency of the model; and legitimacy requires accessibility of value-laden assumptions in the model.

The Supply Side of WTU Assessments

The information scientists can supply about a model is limited by the analytical methods available to generate information relevant to the WTU Assessment. We refer to such analyses as *Model Analyses*. Model analyses can be broad in scope, and include not only analyses on the model but also analyses of the problem at stake.

The choices scientists make for what information to present and what analyses to perform likely depends on their perception of the PIA’s aim and the model characteristics. The model characteristics determine what analyses are possible.

Model characteristics depend in turn on the aim for which the model is built, which may be the same as the (perceived) aim of the PIA or, if an existing model is used, may be the scientific aim for which the model was originally built.

Model Analysis Methods

Model Analyses can include, for instance, participatory methods such as workshop discussions and interviews on the relevance, credibility or legitimacy of a model, and non-participatory methods such as uncertainty analysis and related methods, scenario analysis and expert judgment, but also more elaborate frameworks combining these, such as the Numeral Unit Spread Assessment Pedigree (NUSAP) system (Van der Sluijs *et al.*, 2005) and the Pluralistic fRamework for Integrated uncertainty Management and risk Analysis (PRIMA) (Van Asselt, 2000).

A recently developed method makes explicit the argumentative structure of the model (Cuppen *et al.*, forthcoming). The method thereby revealing the grounds on which the model is based and answering questions such as: why are which variables taken into account; and why are which assumptions (explicitly or implicitly) made? The method is based on the notion that a model is an argumentative structure in itself, and uses the Toulmin model of argumentation (Toulmin *et al.*, 1979; Toulmin, 2003). This method may be a promising Model Analysis method because it increases the transparency of the model structure, and thereby helps users to make judgments on the relevance and credibility of the model.

Links Between Demand and Supply

We argue that there are two links between the demand and supply sides in a WTU Assessment (Figure 1). The first link is between *WTU Criteria* and *Model Analyses*. When scientists select what information about a model they will present to participants, they can base this choice on their understanding of (or assumptions about) the participants' WTU Criteria.

The second link is between *Information for WTU* and *Perspectives*. Participants' perspectives can be influenced by the information supplied by scientists. For example, after learning about the possibilities and limitations of a model, participants may revise their idea of what the role of the model in the PIA is, and may want to attribute the model a larger or smaller role in the PIA. In another example, participants could expect they need a model with high accuracy to fulfill their needs, but find that the model has high uncertainty while still providing sufficient insight in the modeled system and thus fulfilling participants' needs. In this case, participants change their perception of what constitutes sufficient quality science for policy.

Model improvement

The WTU Assessment can result in participants' recommendations for improving the model, which can be implemented by the model team (represented in Figure 1 by the arrow from WTU Assessment to Model Characteristics). Participants can then assess their WTU the improved model. This may lead to an iterative cycle of WTU Assessment and model improvement.

Matching Supply and Demand

An appropriate choice for Model Analyses by scientists would be one in which the information supplied matches the demand for information by participants, so that participants have sufficient information to assess, for themselves, what their WTU the model is. An appropriate choice of Model Analyses can be made by basing the choice of Model Analyses on participants' WTU Criteria, as represented in Figure 1 by the arrow from WTU Criteria to Model Analyses.

Inclusion of this information flow can result in an iteration between scientists and participants in order to appropriately assess WTU: participant perspectives determine WTU Criteria; WTU Criteria in turn are an input to Model Analysis producing information on WTU, based on which participants may revise their perspective of the role of the model (or science) in the PIA or on what constitutes good quality science.

3. WTU Assessment in practice

Table 1 shows examples of PIAs dealing with climate change which aim for co-production of knowledge in which participants did (a part of) the IA and therefore had to consider whether to use information from models. Therefore, we expect that WTU Assessments occurred in these PIAs.

In this section we shortly illustrate how the WTU Assessment process works in practice by a preliminary examination of one of these PIAs: the Delft Process.

Table 1. Examples of PIAs in which models were used.

Name	Aim of PIA and geographical scale	References
Delft Process	Provide a platform for dialogue between policy makers and environmental scientists and make the IMAGE model more policy relevant	(Van Daalen *et al.*, 1998)

Name	Aim of PIA and geographical scale	References
Integrated Assessment of Vulnerability to Climate Change and Adaptation Options in Netherlands	1) Assess impacts of climate change in the Netherlands; 2) Develop adaptation options through a participatory process; 3) Assess cross-sectoral interactions of CC impacts & adaptation options	(Van Ierland *et al*., 2001)
Re-evaluation of the Netherands Long-Term Climate Targets	Identify indicators for climate impacts and threshold values with Dutch stakeholders and back-calculate the corresponding state (temperature rise) or response (emission reductions) that correspond to "avoiding dangerous impacts"	(Gupta *et al*., 2004)
Regional Climate Change Impact and Response Studies in East Anglia and North West England (RegIS)	Investigate regional impacts of climate and socio-economic change using computer modeling and stakeholder discussion	(Holman and Loveland, 2001)
Advanced Terrestrial Ecosystem Assessment and Modelling (ATEAM)	Assess European vulnerability to global change	(Schröter *et al*., 2004)

WTU Assessment Process

The Delft Process (Van Daalen *et al*., 1998) aimed to provide a platform for policy-science dialogue on issues on the COP3[4] agenda, and to make the IMAGE 2.1 model (Integrated Model to Assess the Global Environment) more policy relevant. The Delft Process consisted of five two-day workshops, each attended by about 15 policy makers and senior policy advisors of the Ad Hoc Group of the Berlin Mandate (AGBM) involved in the negotiations leading up to the Framework Convention on Climate Change (FCCC) Kyoto Protocol. The participants were from Europe and developing countries, and most sympathized with an “environmentally oriented point of view” (Van Daalen *et al*., 1998: 278). The IMAGE model is a geographically explicit policy simulation and evaluation model, which couples a general equilibrium economic model, a population model, and models of the energy-industry system (to quantify industrial emissions), terrestrial environment system (to quantify land use change related emissions and CO_2 exchange with the biosphere) and the atmospheric-ocean system (to quantify atmosphere-ocean interactions), and “aims to contribute to scientific understanding and support decision making by quantifying the relative importance of mayor processes and interactions in the society-biosphere-climate system” (IMAGE-team, 2001). Model outputs include CO_2 concentration, changes in temperature and precipitation, impacts on agriculture and sea level rise.

Each of the five workshops consisted of one-and-a-half days of presentation and discussion of model results followed by a half-day session in which participants prioritized their requested analyses using a computerized meeting facility. These requests included suggestions to change the model to make it more relevant; requests for additional information on, for example, the validity of the model; and requests for running the model using different emission scenarios. The prioritization of requested analyses is a form of WTU Assessment, as participants reflect on how the IMAGE model can be improved to make it more useful to them. Between workshops, there was time and resources to improve the model so that participants knew their comments would be used.

Participants of the Delft Process were not asked whether or not they wanted to use the results of the IMAGE model, and as such there was no explicit WTU Assessment in the Delft Process. Rather, participants were asked for *what purpose* they could use the model results, so that the role of the model was adjusted to what participants were willing to use the model for.

[4] third Conference of Parties to the Framework Convention on Climate Change in Kyoto, where the negotiations for the Kyoto Protocol took place.

This occurred in an iterative process: as the workshops proceeded and participants got better acquainted with IMAGE's possibilities, they could identify what purposes they could use the model for.

WTU Criteria

Participants' requested analyses imply what WTU Criteria were important for participants. IMAGE is designed to quantify climate impacts, most of which become manifest on the long-term, *i.e.* toward the year 2100. In the first workshop, participants requested analyses focusing on shorter-term emission profiles rather than the long-term emission profiles presented by the IMAGE team, reflecting the AGBM's focus on short-term policy action (Van Daalen *et al.*, 1998). This implies that IMAGE needed to meet the *relevance* WTU criterion by focusing on the short-term. Attention on the short-term remained throughout the Delft Process workshops. In the second workshop, this led to the conceptualization of the 'Safe Landing Analysis' (SLA), an analogy for landing an aircraft safely: reducing emissions too quickly costs too much, and reducing emissions too slowly means risking unacceptable climate impacts. From the third workshop onwards, attention of participants shifted to the SLA rather than the IMAGE model itself, because the SLA became more relevant as the need arose to link long-term impacts to short-term policy targets. Although the relevance of the IMAGE model became less, it was still needed to lend credibility to the SLA by quantifying impacts of the long-term climate targets from which the SLA deduces short-term emission profiles.

Participants requested more information on impacts associated with climate change indicators of IMAGE, such as the rate of temperature change per decade, and information on impacts associated with the Safe Landing goals. These two requests are implicit references to the relevance WTU criterion (specifically comprehensiveness of the model and spatial resolution).

In the third workshop, participants discussed the assumptions behind the indicators for the SLA: "Selecting critical values of the indicators is a political choice and relates to the amount of risk which is considered acceptable" (Van Daalen *et al.*, 1998: 270). This discussion implies participants assessed their WTU the IMAGE model though the *legitimacy* WTU Criterion (specifically value-ladenness).

In the first workshop, participants requested information on uncertainties of the model, and on model validation. In the second workshop, the IMAGE team presented only some of the requested uncertainty information, but in that and subsequent workshops no more requests were made for uncertainty-related information. A possible explanation is that the IMAGE model was perceived by participants as being 'best available knowledge' after peer reviewed scientific publications on the model, and that participants were not interested in technical model details (Van Daalen *et al.*, 1998). This implies that the *credibility* WTU Criterion was assessed indirectly through the 'reputation' of the model rather than accuracy.

Although participants had indicated in the second workshop that they were less interested in detailed model information on accuracy, a model comparison was presented in the fourth workshop which was not received well by participants. Model comparisons can be used to (in part) establish model credibility, but in this case, there was no demand for such information by participants so that the supply of information did not match the demand.

The WTU Criteria were not explicitly elicited, but became apparent indirectly through the prioritization of requested analyses. Therefore, only WTU Criteria that were not met, or for which participants did not have enough information to assess, were articulated.

4. Concluding remarks

We presented a conceptual model of the demand and supply of information in WTU Assessments. The conceptual model assumes that participants assess their WTU models on the basis of the WTU Criteria relevance, credibility and legitimacy. On the basis of the conceptual model we propose that supply of information can match participants' demand if the WTU criteria of participants are taken into account when scientists select what Model Analyses to apply to provide information for participants.

The Delft Process illustrates how the demand and supply of information in WTU Assessments occur in practice. The WTU Assessment in the Delft Process was only partly explicit because participants were not asked whether they wanted to use the model, but only for what purpose. In the Delft Process, information for the WTU Assessment was supplied by the IMAGE modeling team in the form of model presentations, and the demand for information was structured using a computerized meeting facility for prioritization of participants' requested analyses to make IMAGE results more useful. Participants in the Delft Process implicitly referred to WTU Criteria in their requests for analyses. These WTU Criteria related to relevance, credibility and legitimacy. The Delft Process illustrates how participants' WTU a model may change during the assessment, where the IMAGE model was relevant in the first workshop for quantifying long-term climate impacts for setting long-term targets, and in later workshops the SLA became more relevant as attention shifted to short-term greenhouse gas emission targets. Overall, the supply of information seemed to match the demand for information in the Delft Process because the IMAGE team supplied information on the basis of participants' requested analyses. One exception is the model comparison presented in the fourth workshop which was not well received by participants. Model comparisons are common practice for modelers to (in part) establish model credibility, but in this case, participants had no demand for more information on model accuracy.

We argue that an explicit WTU assessment as suggested by our conceptual model can improve information provided by scientists so that it better matches information needs of participants for assessing their WTU models. In such an explicit WTU Assessment WTU Criteria are explicitly elicited from participants, and these WTU Criteria could be used to select what model analyses should be carried out and what information should be supplied to match participants' information demands.

We conclude that in the Delft Process the WTU Assessment was only partly explicit. It should be realized that, of the PIAs listed in Table 1, the Delft Process is likely the PIA in which most attention was paid to WTU. Our analysis may therefore be an indication that in many PIAs, WTU assessments are implicit or even non-existent. It would be interesting to analyze this in more detail in further studies using, for example, the PIA cases listed in Table 1.

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