Towards Increased Policy Relevance in Energy Modeling

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ABSTRACT

Historically, most energy models were reasonably equipped to assess the impact of a subsidy or change in taxation, but are often insufficient to assess the impact of more innovative policy instruments. We evaluate the models used to assess future energy use, focusing on industrial energy use. We explore approaches to engineering-economic analysis that could help improve the realism and policy relevance of engineering-economic modeling frameworks. We also explore solutions to strengthen the policy usefulness of engineering-economic analysis that can be built from a framework of multi-disciplinary cooperation. We focus on the so-called 'engineering-economic' (or 'bottom-up') models, as they include the amount of detail that is commonly needed to model policy scenarios. We identify research priorities for the modeling framework, technology representation in models, policy evaluation and modeling of decision-making behavior.

Introduction

In recent years the importance of energy policy has been demonstrated around the world. Climate change, deregulation, economic supply of energy services, and other challenges have an impact on energy policy. Energy efficiency is likely to play an important role in any future policy development. At the same time energy-policy instruments are departing from the traditional instruments. These developments increase the need for effective tools to evaluate the impact of these policies. Policymakers rely on scenario studies to evaluate, ex-ante, the potential effects of certain developments and policy-choices. This is frequently done using models that try to estimate the effect of the choices on e.g. energy use and economic welfare. However, all models, almost by definition, have shortcomings. One of the main shortcomings of current models is the lack of the capability to properly assess the effect of policies on energy use, especially now that policies change to non-monetary instruments. Historically most tools were reasonably equipped to assess the impact of a subsidy or change in taxation. However, these tools are insufficient to assess the impact of a voluntary program or that of revenue recycling. Hence, a critical evaluation of the models used to assess future energy use is needed (Laitner et al., 2003).

We explore promising pathways for pursuing complementary or alternative approaches to engineering-economic analysis that could help improve the realism and policy relevance of modeling frameworks. We also explore solutions to strengthen the policy usefulness of engineering-economic analysis that can be built from a framework of multi-disciplinary cooperation. To this purpose we try to address three research questions:

- What are the (new) requirements for engineering-economic analysis posed by non-price energy and alternative policies?

- What are the strengths and limitations of conventional engineering-economic approaches in addressing non-price and alternative policy measures?
- What are promising areas to focus research and model development to help accelerate improvements in the realism and policy relevance of engineering-economic analysis?

We focus on the so-called 'engineering-economic' (or 'bottom-up') models, as they include the amount of detail that is commonly needed to model policy scenarios. Kydes et al. (1995) have reviewed a number of econometric models for long-term energy modeling but have not addressed technology-rich engineering-economic models. We focus on the industrial sector, as this is one of the most challenging sectors for modeling due to its wide variety in economic, technical and policy characteristics within a single sector. We also focus on models and studies that have a limited time horizon, i.e. approximately 20 years. Although long-term models have certain advantages (e.g. effect of R&D, and stock turnover), they are less helpful for the (often) short-term interests of policy design. We use a multi-disciplinary team with a long experience in energy modeling from different backgrounds. The team represents authors with a background in the economic, technical and social sciences. The paper is based on a larger report (Worrell, Ramesohl and Boyd, 2003).

Energy Efficiency Policy in Industry

The practical design and implementation of energy policy strategies aiming to improve energy efficiency in industry represent a demanding task. Measures have to be adopted that account for the complex technical, economical and organizational structures which distinguish industry from other end-use sectors. There are various options to influence energy use in industry. Important parameters include the level and nature of activity in the target group, the nature of inputs, supply of heat and power, state of process technology, state of cross-cutting technology, and, the quality of operation and maintenance practices. A considerable variety of policy instruments have been created in the past decades, challenging the standard modeling approaches. On the one hand, there are an increasing number of energy/CO_2 tax schemes, providing market-based price incentives to reduce energy use. However, these schemes are often combined with exemption rules or they are designed as hybrids, opening a range of possibilities for industry to mitigate the tax burden. On the other hand, during the 1990's a series of new policy instruments has been developed that represent a changed philosophy towards policy intervention:

- First, there has been a growing acknowledgement of the complexity of cause-impact relationships in industry that impede an efficient policy intervention, especially under a situation of asymmetric information. Triggered by a new spirit of public-private-partnerships, different voluntary approaches emerged in various countries. Especially in the case of negotiated agreements, a tax break or regulatory relief is bargained in response to the industry's commitment to achieve a certain energy efficiency or emission reduction target. Many of the voluntary schemes include supporting public policies such as financial assistance, audits and information dissemination.
- Second, there is a growing understanding of the socioeconomic dimension of industrial energy efficiency. As any other aspect of production, energy use in industry is a result of company decision-making and corporate behavior. Acknowledging the

changing demand for policy support, various non-market based instruments have been introduced to reduce the relative influence of these barriers. Hence, besides the economic aspects of decision-making, the informational, organizational and cultural dimensions gain importance as policy issues.

- Finally, considering the current energy policy practice in OECD countries, it can be concluded that in most cases policy instruments are not applied alone but are combined within a mix, aimed at increased benefits from synergies of individual policy instruments.

Because of the increasing variety in policy-industry interactions and the introduction of new policy approaches there is an increased need for sound assessment of policy impacts and program effects, effectiveness and efficiency. The methodological framework for policy analysis and modeling has to be adapted to the specific characteristics of industrial energy use as well as to the changing policy environment. Special emphasis has to be put on the analysis of impacts as the prime criterion for policy effectiveness. Important implications for policy analysis are:

- Many of the new instruments do not result into a direct effect on energy consumption but contribute to an indirect impact that materializes gradually over time.
- Implementation processes within organizations take time and cause a delay of reaction that adds to technical restrictions resulting from vintages and investment cycles (stock turnover).
- Policy measures can contribute to accelerated diffusion of energy efficiency technologies, e.g. through enhanced dissemination of know-how and experience.
- The combination of policy instruments within a portfolio opens the possibility to increase the effectiveness and efficiency of action.

Conventional Engineering Modeling

Simplistic models with limited technology representation are replaced with more complex models with more comprehensive technology representation, as well as representation of economic feedbacks. Previously, engineering-economic models focused on estimating the technical potential for cost-effective energy savings, while current models are challenged to better estimate what is achievable considering the effect of behavioral aspects as well as policies. Policy modeling has focused on price-based and regulatory policies, but is challenged to include non-price policy instruments (Dowd and Newman 1999). To this aim, the models need to build on interdisciplinary analysis of past experiences, including policy evaluations by social, economic and engineering sciences.

The so-called ‘engineering-economic’ (or ‘bottom-up’) approach is rooted in engineering principles to account for physical flows of energy and the use of capital equipment. This is coupled with economic information to account for energy expenses and investment in capital that is processed through decision-making rules. The form of the decision-making and the way to represent the activities in “industry” is very diverse among the various modeling approaches that have been used to model industrial energy use. The approaches vary in the degree of activity representation, technology representation and technology choice (stylistic or explicit), the goal (simulation or optimization), and degree of macro-economic integration. Table 1 provides a characterization of selected models.

Table 1. Characterization of Selected Energy-Engineering Models

Model	Country of Origin	Technology Representation	Goal of Model	Macro-Economic Integration
AMIGA	US	Explicit	Simulation	Yes
EERA	New Zealand	?	Simulation	No
EFOM	EU	Explicit	Optimization	No
ENUSIM	UK	Explicit	Simulation	No
ENPEP	US[1]	Explicit/Stylistic	Simulation	No
ICARUS	Netherlands	Explicit	Simulation	No
IKARUS	Germany	Explicit	Optimization	?
ISTUM (ITEMS)	Canada/US	Explicit	Simulation	No
CIMS	Canada	Explicit	Simulation	Yes
LEAP	US	Explicit/ Stylistic	Simulation	No
LIEF	US	Stylistic	Simulation	No
MARKAL	OECD/IEA	Explicit	Optimization	No
MARKAL-MACRO	OECD/IEA	Explicit/ Stylistic	Optimization	Yes
NEMS	US	Stylistic	Simulation	Yes

Barriers for energy efficiency improvement are generally not captured in the models. Market barriers often slow the market penetration of energy-efficient technologies and practices. The movement towards considering these aspects contributes to the discussion of creating energy scenarios, but at the present time there is little understanding of how to translate these factors quantitatively into an analysis framework. In principle, these factors can be included in engineering-economic models, as long as they are understood and clearly quantified.

Most models have historically addressed policy through modeling the implementation costs of measures for energy efficiency improvement. The relatively simple modeling approaches included the effect of subsidies and energy taxes on the costs and the degree of implementation. Some models included the effect of RD&D policies through assuming 'learning-by-doing' curves for energy conversion technologies. The latter modeling approach has not yet been used widely for energy efficiency technologies. This also demonstrates the need for a better understanding of the effects of energy efficiency policies. Comprehensive ex-post evaluations of energy efficiency policies are necessary to improve modeling approaches. Especially, modeling of new policy developments like voluntary programs and non-fiscal policies remain a challenge for the energy modeling community (Worrell, Price & Ruth 2001).

Challenges

In scenario construction the modeler is challenged by a number of problems in defining the basic assumptions of the model. The *choice of available technology* under BAU

[1] The model was developed in the US but is most widely used in Eastern Europe, Central/South America, and Asia. The level of technology detail for the industrial sector varies widely.

conditions is critical, as shown by the CEF study (IWG 2000) as well as Roop and Dahowski (2000). In scenario studies focusing on longer-term scenarios the assumptions on technology development under future policy conditions are even more important. *Structural change* has been recognized as another major driver for change in overall industry energy intensity. Structural change can be separated in inter-sectoral (e.g. a change to a larger fraction of light industry in the economy) and intra-sectoral (e.g. a change in feedstocks without a substantial effect on product quality). Generally, the same structural development pattern is assumed for all policy scenarios as well, even when the modeled changes may have a profound effect on the energy system (such as long-term GHG concentration stabilization scenarios). While this makes it possible to compare the results of the policy scenarios in a systematic way, it underestimates the flexibility of economic responses to important challenges to the energy and economic systems (Jorgenson et al. 2000), and hence may lead to overestimating the costs of policy scenarios.

Modelers try to capture the *achievable potential* for energy efficiency improvement given the economic and policy assumptions for each scenario. In most engineering-economic models there is a two-stage approach to estimating the achievable potential, starting with a database of options and a selection-method, using economic criteria, to estimate the potential under different scenario conditions. However, there is a wide range of production processes that use energy in myriad ways so that end-use classifications are more complex than in other sectors. Another technical issue of great importance concerns industrial *cogeneration* (CHP). Although CHP is recognized in many countries as an important energy efficiency option, and is the subject of specific policies in as many countries, we found that often the integration of CHP in the model is rather limited. Sometimes, CHP is an 'afterthought' to the model. In modeling as well as in business practice emphasis has to be put on integrated approaches aiming at optimizing energy use at production sites in a holistic manner.

The selection to estimate the achievable potential, however, is often done in a simplified way using a discount rate, varying from a social discount rate to one that closely matches hurdle rates. The assumptions on actual *performance of existing capacity and stock turnover* are of equal importance. Some industrial technologies have long economic and technical lifetimes. Because relatively large energy efficiency improvements can be achieved when existing capacity is replaced by new, the assumptions on lifetime, age distribution and turnover rate are essential. Furthermore, market *penetration* patterns of energy efficient technologies may not be as smooth as the typical S-curve may suggest. These market penetration patterns may arise from differences between potential adopter characteristics, like costs and energy savings, or as the result of exposure. A few studies start to address the learning-by-doing effects by incorporating cost-development curves for power generation equipment, (e.g. Joskow and Rose 1985). Speed of adoption estimates based on diffusion models have been made for energy efficiency technologies, but these estimates have not made much impact on engineering-economic models, nor have those estimates made substantial inroads to understanding policy impacts.

As discussed above, firm *decision-making behavior* is often incorporated in a simplified way, disregarding any differences in technology characteristics or target group features. The challenge faced by modelers is the limited experience and empirical data on how to translate qualitative knowledge on decision-making behavior for energy efficiency into quantitative parameters. Tied in closely to decision-making behavior is the economic evaluation of energy-efficient technologies. Most models do not include a full description of the *costs and benefits* of energy efficiency measures but rely on limited economic information, excluding transaction costs, opportunity costs, as well as productivity benefits.

The ultimate challenge for all energy models remains the representation of policies and policy impacts in the scenarios. As standard engineering-economic (and econometric) models are restricted to model the likely impact of price-based policies (e.g. energy price increases, subsidies), the policy demand for modeling non-price based policies remains a challenge for energy modeling. Most importantly, impacts on energy-related decision-making and barrier removal need to be analyzed.

In addition to this core topic, several other issues need to be mentioned. Special attention is needed for the modeling of *R&D policies* because R&D investments will likely lead to improved performance of existing and new technology and develop future technologies. Challenges are the links between (current) R&D expenditures and the speed of R&D progress and future technology availability and performance. *Economic feedbacks* can have an important impact on the effectiveness of energy efficiency policy, e.g. the "rebound effect" (Schipper 2000). Most studies of the rebound effect have focused on non-industrial energy use, and show a limited impact on the achieved savings. Also, revenue recycling is a relatively new phenomenon in energy taxation and used in the new taxation schemes in Europe. Generally, models have difficulty to fully estimate the potential impacts of these economic feedbacks. In policy scenarios the *program costs* are often not fully considered, as data on the effectiveness and efficiency of industrial energy policies is difficult to find in the literature (Martin et al. 1998).

Finally, there are some general challenges that affect any modeling effort. Foremost of all, is the *uncertainty* in data and data quality. Analysis of all uncertainties is often very difficult (Scott et al., 1999). Many studies qualitatively discuss data quality issues, but in most studies there seems to be no systematic analysis of the impact of data uncertainties on the scenario results other than for costs of the policy scenarios. This will remain a challenge for the energy analysis community and the policymaker. The problem of data quality and data use in the model is also related to the *transparency* of the model.[2] A transparent model makes it easy for the user and policymaker to evaluate and value the quality of the scenario results. On the other hand, the increasing complexity to deal with the difficult relationships between energy use, environment and economy, make it very difficult to maintain transparency. The trade-off between transparency and complexity remains essential to the users of these studies to value the results. Typically, models focus on regions or countries, while a few integrated models include the global economy (subdivided in a varying number of regions). With the changing dynamics of energy policy the *system boundaries* of these studies may not be sufficient. For example, the opportunity of emission trading or the clean development mechanism under the Kyoto Protocol will likely affect the costs of emission reduction for different regions, as demonstrated by many models.[3] Still, energy efficiency policy may only affect a specific region and hence the user/policy maker may only be interested in the specific country or region for the assessment.

[2] There is anecdotal information demonstrating how modelers themselves became the "victim" of the lack of transparency of their own models. However, this is generally not reported in the scientific literature.

[3] It should be noted, that often the reduction in emission mitigation costs due to (international) emission trade or other 'flexible mechanisms' as defined under the Kyoto Protocol, is the result of simplified or uncertain assumptions on the costs of emission reduction opportunities in the other regions.

Pathways to Improve Energy Models

Models have been constructed principally as forecasting tools focused on energy market questions of what quantity and type of energy will be consumed in the future. Having origins in the economics of resource depletion and having grown in substantial use after the oil price shocks of the seventies, these models have price (costs) as their principle drivers. The modeler is rarely asked to predict what policies will be in place in the future, so policy regarding energy markets that do not *directly* influence prices or costs, e.g. excise taxes or environmental controls, are incorporated as part of the status quo and are rarely explicitly represented in the models. In this section we identify and distill the directions and trends that can revalue the contribution of engineering-economic models to energy analysis in order to meet the challenges discussed above (see Figure 2 for an overview). The diversity of remaining challenges can be condensed to two complementary problems:

- approaching the complex and dynamic nature of behavior of decision makers and related transformation effects in the market systems, as well as the impact of policy on the behavior, and;
- coping with the technical diversity and complexity of the industrial production system.

With regard to both challenges, new modeling approaches can mitigate existing deficiencies of economic-engineering modeling but cannot fully overcome conceptual limitations of modeling per se. Given this perspective, models will hardly be able to fully cover all relevant aspects of industrial energy policy, and important missing parameters need to be addressed by other tools. Accordingly, policy analysis needs to be grounded on a kind of "heuristic competence" that allows it to master a cleverly composed methodological diversity (a network/cluster of 'micro models'), rather than "celebrating a worship of bigger and better modeling" ('mega models'). Hence, due to the inevitable restrictions models cannot stand alone but need to be explicitly embedded in a more comprehensive analytical strategy, which recognizes the strengths and weaknesses of the different tools.

Among others, two general aspects are of importance for designing such a strategy. First, s*ound specification of modeling tasks and system boundaries*, i.e. an appropriate choice of analytical questions in relation to the capability of a modeling tool. A sound specification of policy questions and analytical tasks together with the choice of a suitable tool is needed. Secondly, d*ata uncertainty* is an essential element in interpreting the results of a model calculation. In certain areas it is needed to develop the statistical foundation. At the same time, however, it has to be acknowledged that perfect data sets cannot be achieved so that efforts need to be concentrated on crucial areas. Empirical work, therefore, should focus on parameters that turn out to be of greatest relevance to sensitivity analysis in order to identify possible biases. However, it will not be possible to reduce all uncertainties; hence, in presentation of modeling results acknowledging the uncertainties is essential.

Figure 2. Matrix of Challenges, Recent Advances in Modeling and Remaining Issues

New approaches from research	enhanced technologi-cal	endogenous technical learning	Incorporation of material flows	enhanced economic flexibility	adaptation of discount/ hurdle rates	estimation of program costs	macro-economic integration	Integration of stochastic elements	Integration of other disciplines	*open questions and tasks*
Challenges to modelling: scenario construction and basic assumptions:										
Definition of BAU case		+	+	++					+	How much change/ flexibility is already BAU?
choice of available technology	++	++	+							What is the future set of options?
representation of structural change	+		++	++			+		+	What are drivers, trends, directions?
Technology and opportunity representation:										
degree of technology specification	++		++							What degree is appropriate?
Cogeneration	+		+							Complete picture of practice?
market and institutional barriers	+	+	+		+				+	Interaction market actors?
socio-economic barriers	+	+			+				++	Conditions changing behavior?
assumptions on actual performance	+	+			+			+	+	Actual treatment of technologies in business practice?
market penetration patterns	+	+			+				+	How to aggregate individual adoption behavior?
Definition of costs and benefits	+	+	+	+	++				+	Nature, dimension and persistence of costs/benefits?
Representation of policies and instruments										
barrier related instruments	+	+			+	+			++	Impacts, synergies and persistence of effects?
R&D policies	+	++	+	+	+	+			+	Impacts, synergies and persistence of effects
economic feedbacks		+	+	++	+	+	+		+	Role of energy efficiency as source of economic change?
Program costs		+			+	++			+	Nature, dimension and persistence of costs/benefits?
General aspects										
data uncertainty	+		-		-	+		+		Scope and limits for better data?
Transparency	-	-	-	-	-					Trade-off between accuracy and simplification?
system boundaries	-		-				+			Appropriate choice of questions and tools?
Open issues	technical complexity	learning with EE technologies	modeling material flows		economic behaviour	evaluation methodology			transfer of knowledge	

Note: Symbols: ++ symbolizes a direct contribution; + symbolizes a potential contribution; – means a problem or possible negative effects.

The development of new modeling approaches starts with a critical assessment of the policy needs and the impacts of these needs on the modeling tools needed. A careful analysis of the policy questions raised to modelers is essential to develop the right tools. These tools include ‘micro-models’ developed to understand a specific policy- and research-question. The lessons learned from micro-models can be used to “re-integrate” the micro-models into larger models using modern computing and modeling techniques, such as object-oriented programming and agent-based simulation models. These techniques allow a diversity of approaches being used within a larger framework.

The consequences of an improved interface between user and modeler for modeling include:

- Playing down the importance of models as such, but instead focus on the interfaces of appropriateness, inputs, assumptions, *and* model structure. The choice of the model structure, and careful analysis of input and assumptions for the questions asked is essential.
- Less emphasis on normative approaches in terms of optimization, due to a relatively weak foundation of a strong message.
- More emphasis on a supportive role in terms of policy simulation, i.e. through quantitative assessment of impacts and interdependencies. These models would be better equipped to improve understanding for policymakers.
- Improved modeling of interaction mechanisms between scenario development and technology. Policy scenarios reflect not only changes in the energy demand and supply, but also changes in the relationship with other important scenario parameters.
- A multi-disciplinary view at technology and its implementation in modeling will help to improve understanding of technology diffusion and role of policy.
- More dynamic representation of technology with an emphasis on technological learning and side effects of technology is another reflection of energy policy.

Improving Models: Technology and Opportunity Representation

To make better use of the technical diversity in industrial production models a research agenda is:

- Conducting (empirical) studies that investigate technical and economic aspects and provide data to improve modeling assumptions but that cannot be integrated directly into modeling (including negative cost options);
- Including technological learning effects in the performance, costs and diffusion of industrial energy (end-use and conversion) technologies;
- Using detailed modeling of production functions (either in physical or economic terms) to study structural change in the economy, including economic flexibility;
- Detailed understanding of the assumptions in the reference scenario;
- Current advances in research that hold particular promise are incorporation of material flows, enhanced economic flexibility, and learning effects.

Improving Models: Behavioral Representation

With regard to the behavior of decision makers and the development of markets, more insights are needed in:

- Qualitative and quantitative studies on decision behavior and the socio-cultural background which determines the effectiveness of instruments, providing the basis for modeling assumptions;
- Improved understanding of technology diffusion and penetration patterns, as a function of firm behavior.
- Current advances in research to improve the understanding of decision-making behavior in firms, and modeling thereof, adaptation of discount rates/ hurdle rates, analysis of technology diffusion patterns, evaluation of energy-efficiency and other policies on technology diffusion, evaluation on effectiveness and efficiency of energy policies, as well as estimating program costs contribute to this pathway.

Improving Models: Policy Representation

A sufficient representation of policies and instruments demands a proper definition of policy instruments and a sound analysis of real world implementation features (i.e. likely degree of implementation and administrative deficiencies, free riders, interrelations with other policies, etc.). This means a realistic representation of the practice of implementation, representation of the non-energy policy background in scenario definition, assessment of policy mixes, determining the policy and program effects, and including the program costs.

Conclusions & Recommendations

Any modeling effort will have to challenge the issue of the trade-off between realism and transparency. The recommendations for future research below have to be viewed from the perspective of these trade-offs. We do not advocate a single all-inclusive approach, but rather propose to focus on the issues below in the further development of the models.

To allow improved modeling of policies and its effects on technology diffusion and behavior we need a better understanding of technology diffusion and of the effectiveness and efficiency of policy instruments, through ex-post **policy evaluation**. Research should aim at innovative ways to study the effectiveness and efficiency of policies. New ways are needed to translate the impact of policies on the micro (or firm)-level to the macro-levels of the technology diffusion process. Especially important is the need to account for synergies or unintended consequences of energy policy mixes as well as other policies. This research item is a plea to policymakers to include policy evaluation in the development of new policies as an integral part of that policy.

New **modeling approaches for the decision-making framework** and process are needed that can be used in the economic-engineering models. These approaches need to be able to include barrier representation (e.g. lack of information), decision-making behavior, as well as the effect of policies (see above) on decision-making. Especially the impact of non-monetary policies and policies aiming to reduce certain barriers are important areas that are in need of innovative modeling techniques. Such modeling approaches need to be translated from the behavior of individual firms to the larger model. Innovative economic research may offer different successful approaches, such as multi-agent modeling and other approaches. The contributions of social sciences in the debate on firm behavior (e.g. corporate culture) need to be included to come to successful modeling approaches.

Technology representation has shown to be a key area, in which short-term efforts can make an important impact. Technology representation in modeling has to focus on two main items, firstly, the technical description of the technology/measure, and, secondly, the relationship between technology and the implementation trajectory. The technical description of a technology should appropriately reflect the full nature and the dynamics of the technology. Researchers should include the non-energy benefits in the quantitative description of a technology. Research in the learning effect of energy-efficient end-use technologies is needed to accurately reflect the dynamics of technology development in energy models. Finally, the level of disaggregation (or number of technologies) will depend on the purpose of the modeling effort. A drive towards models relevant for policymakers will increase the need to include more technologies, rather than fewer. Research should aim to improve the understanding of the diffusion of technologies, so to better link technologies to a specific decision-making/implementation trajectory. Current models apply a similar diffusion model to most energy-efficient technologies. In reality, other benefits than energy may drive implementation. This is linked to a proper quantification of the non-energy benefits, but is also linked to other non-energy related regulation that may affect implementation of a specific technology. The improved understanding should lead to categories or groups of technologies with specific characteristics allowing improved modeling of technology diffusion.

Finally, the development of a uniform but public **modeling framework** to integrate existing and future modules/models would be a major step forward. Similar to an open software development environment, it would allow for innovation in different parts of the total model, and allow easy integration in existing models. We propose to base this framework on object-oriented programming/modeling. Object oriented programming allows transparency and at the same time flexibility in modeling approaches. This would allow researchers to focus on a selected part of the larger model, without the need to construct a total model. It would ease the communication of different modelers from various backgrounds, and help to focus modelers to focus on their strengths, and reduce weaknesses of an overall model. Research should determine a common structure and the information needed to facilitate communication between the 'objects'.

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