

Policy Development for Societal Challenges: The Collaborative Agent Based Modelling Policy Framework

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Abstract. Developing effective policies for addressing societal challenges is difficult. Often these challenges involve multiple domains at the same time. Also, the involved stakeholders have different incentives and are thus not always willing to support suggested policies. Policy developers, on their own, have a hard time to compile all the relevant knowledge, interpret the dynamics between stakeholders, and provide policies that will be accepted by all. It has been argued for a long time that Agent Based Modelling (ABM) can help policy developers understand the complex societal challenges and devise better policies. Due to its accessible nature ABM also lends itself well for participatory modelling to involve stakeholders in the policy process. This improves to quality of the policy model and the willingness of the stakeholders to accept a resulting policy. So, why is ABM not used more often by policy developers?

In this paper we argue that a major obstacle for the acceptance and uptake of ABM in policy development is that we have failed to properly fit ABM in the policy development process. We propose a new framework that aims to make ABM an effective tool within the policy development process by focusing on the process of building an ABM with stakeholders as part of the overall policy making process. The framework is a result of our experiences with policy development in the Netherlands and how ABM is perceived as added value in that context. We illustrate the use and possible impact of the framework with a case-study.

Keywords: Agent-Based Modelling, Goals of Models, Model Purposes, Policy Development, Policy Process, Participatory Modelling, Collaborative Modelling, Societal Problems, Societal Challenges, EV-transition, Case-study

1 Introduction

Our current society has many big challenges, such as climate change and COVID-19. These challenges require actions, usually in the form of policies by governments or others, to be resolved. Within governments, policy developers are tasked with developing policies. Devising good policies for these challenges has proven to be difficult due to the complexity of the phenomena and the diversity of the

involved stakeholders. This makes it hard for humans to comprehend their full extent, and thus, to create good policies [1,2,3].

Agent Based Modelling (ABM) enables one to focus on individuals that are part of a societal challenge in the form of agents with their actions and reasoning. This focus helps to model and structure the challenge making the complexity more comprehensible in various ways [2,4]. ABM also lends itself well for participatory and iterative development with its structure, which makes it accessible for a broader audience with a step-by-step process. Yet ABM seems to fail to gain uptake as a tool in the policy development process. To change this we present our Collaborative ABM Policy Framework as an effective tool to support the policy development *process* for *societal challenges*. This focus differs from the usual focus on solving problems by introducing policies.

1.1 Why we Fail - Missing the Human Aspect

There are many examples of ABM being used in a policy context to help policy development, as is reflected upon in [5,2,6,7]. It has proven to be hard to use ABM for policy development with a lasting impact. This is also seen in the absence of ABM in policy development toolboxes. For example; the newly released (2023) Dutch Policy Compass (Beleidskompas)[8] lists many tools and ways to develop policy, but ABM, or a comparable approach, is not one of them.

When analyzing *why* this is the case it became clear, at least in the Dutch policy context, that there are various requirements that need to be taken into account to offer the needed added value to the policy development process[9]. In the Dutch policy development culture one important aspect of these requirements is the management of stakeholders. The importance of stakeholder management is made explicit in the Advocacy Coalition Framework[10], and is also reflected in the central positioning of stakeholders in the Policy Compass[8].

There are ABM approaches that use participatory modelling to involve stakeholders, but generally they focus on building good models with useful outcomes. To use collaborative modelling successfully in our context we need to get people involved with the policy process to, among others, create more understanding of the challenge and support for a policy choice. This way building a good model is a *means*, not an *end*.

1.2 Societal Challenges, What is the Problem?

When working with Policy developers we see that the conversation often leads to discussions about solving societal problems. The word *problem* implies that we can solve the issue by finding a solution. But in the policy domain things are often not that straightforward. The problems have many different perspectives, domains and parties that are involved. This complexity makes it difficult to know what the *real* problem is and to find a solution that solves it in a good way.

A word that reflects the reality of policy developers better is societal *challenge*. Challenges are difficult and messy, the word conveys that there is more to it than finding the solution. Challenges consist of various problems that are often

discovered during the policy process. This gives rise to the constant question of “which problem should we focus on, what is most important?”.

We can compare this way of thinking to analysing a complex system. In essence we view a complex systems as a system which has so many components, connections and interactions that it is no longer comprehensible how the whole system works. There are many different formal uses of the word complexity [11]. The description by Edmonds and Meyer [12] fits the context of policy development well:

Complexity: the phenomena of interest result from the interaction of (social) actors in an essential way and are not reducible to considering single actors or a representative actor and a representative environment.

The main point to make here is that many ABM approaches for policy start with a policy problem (for example [7]). But when policy developers deal complex societal challenges their goal is to find and motivate the important policy problems. In this phase of the policy process a policy problem is the goal, a good result. Our framework is geared towards this phase of the policy process.

The organization of the paper is as follows: We have highlighted what current ABM policy development approaches are missing in Section 1.1 and explained the reader more about societal challenges in Section 1.2. We will introduce a case-study as running example in Section 2 to illustrate the application of the framework before focusing on the framework itself. Section 3 introduces the Collaborative ABM Policy Framework and will discuss the separate elements with the illustrative case-study. Sections 4 and 5 provides a discussion on the framework and its use followed by our last conclusions.

2 A Case-Study as Running Example: the Dutch EV-transition

To illustrate how the framework works we will use a case-study as running example to illustrate the theoretical concepts. We do not discuss the case-study in full detail¹. The societal challenge that we will be investigating is the transition of consumers from cars with internal combustion engines (ICE) to electric vehicles (EV) in The Netherlands: the EV-transition. This transition is part of the bigger challenge of counteracting climate change. One measure to counteract climate change is to have zero or negative CO₂ emissions. One of the contributors to CO₂ emissions are ICE’s, which can be replaced by EV’s. But how can we realize this transition from ICE to EV?

In the Dutch policy context the word *transition* is deliberately chosen to convey the idea that it is a gradual change. The Dutch government wants to speed up the EV-transition with effective and efficient policies. A policy simply banning ICE’s might seem very effective, but most political parties would not accept this as their constituency would not be in favour. Thus policies need to

¹ A detailed report is available on request from the authors

be political acceptable to be effective. But what are these policies? Why would they work? Are they acceptable? Who is involved with them and why?

One policy option is to encourage consumers to buy EV's instead of ICE's. To know how to do this effectively policy developers needed to have a better understanding of the EV-transition. They created a monitoring tool to see the progress of the EV-transition. At the start of the case-study the monitoring worked well for financial and statistical aspects. This can be explained due to the fact that the government has direct control over taxation and car registrations. But policy developers realized that more than the financial aspect play a role in the decision process of buying a new car, which should be added to the monitoring. After spending some time on this challenge it was considered rather difficult with their usual way of working and led them to pursuing new avenues. This presented us with the opportunity to apply the framework in a real policy development process context and a realistic case-study. The central question of the case-study is as follows:

Which things, other than the financial aspect, play a role in the choices that people make with regard to buying an electric vehicle or not?

We will give a brief overview of the case-study here to provide the reader with the basic structure of the case-study. Once the central question was defined we familiarized the policy developers with the basics of the framework. We asked the policy developers to provide stakeholders for the case-study. The stakeholders have various perspectives and expertise on the things that influence consumers when buying a new car. Using the framework we created an ABM and an Agent Based Social Simulation (ABSS) with the stakeholders in an iterative and participatory process with various workshops. This process gave us a number of results:

- We gained the insight that there are a lot of indirect things that influence consumers in their behaviour and attitudes towards EV's and ICE's. For example the attitude of other agents such as car dealerships, friends or family affects them. These attitudes can in turn be influenced by many other things, such as education, social status or the ability to make money on car maintenance. Also, the perceived quality and availability of the infrastructure for EV's and ICE's influences consumers.
- We provided a set of indicators (Table 1) that can be added to the monitoring to answer the central question. We created an conceptual ABM (Figure 2) that helps the policy developers and the stakeholders to get a better understanding of the transition to “get a grip on things”.
- The provided indicators are supported by the stakeholders, meaning that conclusions drawn from them are likely to be accepted by the stakeholders.

3 The Collaborative ABM Policy Framework

Now that the stage is set with the goal for the framework to support the policy development process and an illustrative case-study we can take a closer look at

the framework. The framework is inspired by Companion Modelling [13], which focuses on using participatory model development for collective decision making. Its development follows the Design Science [14] methodology and the framework can be seen as an artefact. An artefact is validated by testing it in its problem context (the policy development context) and evaluate its effects. We will now discuss all the separate elements of the framework as visualized in Figure 1. Each element is referenced by number.

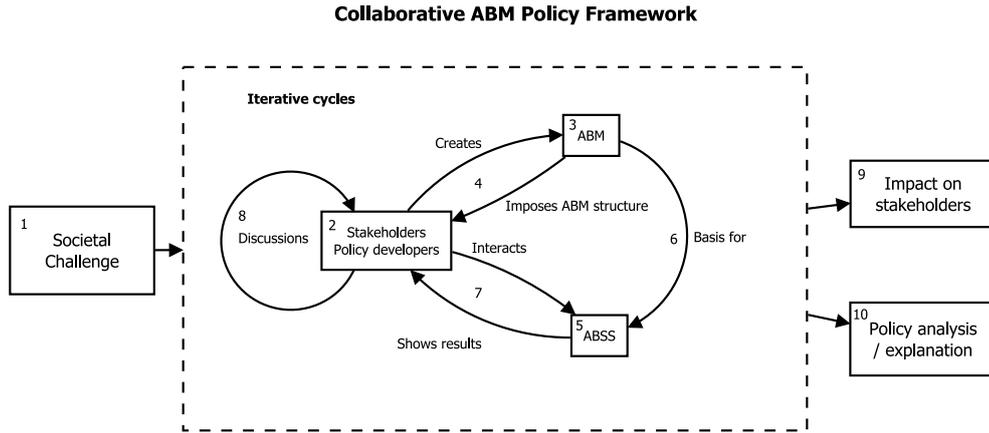


Fig. 1: Collaborative ABM Policy Framework

1. *The Societal Challenge* sets the context of the work in the framework. Defining this is a primary responsibility of the policy developers before the framework can be properly used. The broader societal challenge is defined by the policy developers: the transition from ICE to EV. The specific question has been scoped by the policy developers to only look at consumers and to focus on non-financial factors that affect them in the transition. Their concrete goal is to improve the monitoring of the transition.
2. *The group of people involved* consists of stakeholders and policy developers from the Ministry of Infrastructure and Water Management (I&W). The stakeholders are experts, representatives or directly affected people. In the case-study we had various representatives of groups with different perspectives, such as the ANWB² (consumers), BOVAG³ (car dealerships), Milieu Centraal⁴ (sustainability) and the VER⁵ (EV driver association). Having a good group of stakeholders has proven to be important. For example, the

² <https://www.anwb.nl/over-anwb/vereniging-en-bedrijf/organisatie/english-page>

³ <https://www.bovag.nl/>

⁴ <https://www.milieucentraal.nl/over-milieu-centraal/about-us/>

⁵ <https://www.evrijders.nl/>

ANWB added the insight that the lack of tow hitches on EV's is currently stopping their more elderly members from considering an EV because they want to go on holiday with their caravan. This group mainly consists of people who are 55 years or older, have more money available than younger demographics and consist of more than 1 million members of the ANWB. This means that tracking the % of EV's with tow hitches available for purchase gives insight in the transition.

It is the primary responsibility of the policy developers to supply good stakeholders. If we find new relevant stakeholders during the process it is up to the policy developers to decide if they should be involved or not.

During the case-study we separated the stakeholders into perspective sub-groups, without including policy developers. This gives us the option to 1. focus on one perspective and 2. to give the stakeholders more freedom in what they share. We explicitly stated that we as facilitators would not share quotes traceable to individuals outside a group.

3. The *conceptual Agent Based Model* is an ABM that is easily interpretable by the stakeholders and policy developers. The ABM's that have been created in the case-study use the MoHub framework [15] as structure for the agents. The models are formed by post-its that represent agents and interaction descriptions and lines to show relationships on whiteboards. This way models can be created by the stakeholders themselves, easily changed and digitized by a simple photo. With this simplicity we could organise the workshops at locations familiar to the stakeholders, such as the ANWB office. All these aspects contribute to a sense of ownership and acceptance of the models.
4. *Building the conceptual ABM model* is done by the groups during workshops. Step by step more post-its and lines are added to the board to create the model according to the rules that ABM puts forward. As the models become bigger discussions take place about the meaning and definitions of the agents, the relationships between them and the interactions. This improves the understanding of the societal challenge, the understanding of each other and makes assumptions explicit. For example one discussion was about a "battery quality guarantee" by the BOVAG for second-hand EV's. Some stakeholders saw this as a guarantee from BOVAG to consumers. Others saw this as a guarantee by BOVAG members (car dealerships) to consumers, which was the real situation. The fact that we have a guarantee is true in both cases but the model differs and affects consumers differently.

In the previous example only one situation was "correct", but this does not mean that the other is *wrong*. Emotions, "non-rational" reasoning, lack of knowledge or other ways of interpreting things by individuals are important to understand their behaviour. People make choices based on what they perceive, even if this is "incorrect". These are things that we uncover and make explicit during the process of making the ABM's.

5. *The Agent Based Social Simulation (ABSS)* is a computer simulation of an ABM and can be built, run and observed on a simulation platform. Many different platforms are available to create an ABSS. For the case study we

used Repast⁶. The simulation produces data that can be presented with graphs, datasets, animations of agents or by other means. With Repast we have the option to live-view the simulation and change parameters in the user-interface with sliders or numbers.

ABSS also offer the option to use data, if available, to feed the simulation. In our case-study no suitable data was available, but a data-set on the Dutch demographic car buyers and their preferences could have been useful. Without the ABM and the ABSS this lack of data would have been less explicit, it helps in finding what kind of data would be useful to make better analysis.

6. *ABM is the basis for the ABSS*. The conceptual ABM provides a roadmap for all the things that can be implemented in the ABSS. It provides priorities and structure for the development of the ABSS. Which agents should be implemented first, which properties do they have, who should they interact with, how should they interact, how do they reason? This roadmap can be created by making a description of the conceptual ABM with the Overview, Design concepts, and Details (ODD) protocol [16].

In the case-study we focused on the consumer, which has been selected as the first agent to implement. While implementing this agent we realized that buying an EV or ICE as the primary choice is *not* well suited to measure the transition. People on average buy a car once every 5 years. but their preference for EV or ICE can change every day, not only when they buy a car. This led to a focus on the *attitude* of the agents towards ICE's and EV's on a continues scale, for all types of agents that can have an attitude on this topic. Think of car dealers, the social surrounding and the media. It also brought to light that *attitude* is a key component that we can measure in real life for the transition, an insight we would possibly not have had without the creation of the ABSS. It illustrates how process of formalisation for the ABSS increases understanding of the societal challenge.

The implementation has been done by the facilitator as no dedicated developers were available and the facilitator had the expertise to implement an ABSS in Repast.

7. *Exploring the simulated societal challenge* with the stakeholders shows the stakeholders how their ideas for the conceptual model works. This triggers an explorative process with the stakeholders; “does it really work how I expected it to work?”. It helps them pose new questions and figure out what needs to be improved in the conceptual ABM. This starts a new iteration of the process in which a more refined conceptual ABM and, in turn, ABSS is made.

The case-study implemented the approach of Heidari et al.[17] for the reasoning of consumers. This approach uses Swartz-values to determine how agents evaluate the world and make decisions. For example, some consumers are heavily influenced by their perceived social standing and want to be *early adapters*. This results in them quickly adopting EV's if someone within their social network has also done this, they want to be seen as “cool and impor-

⁶ <https://repast.github.io/>

tant”. Whilst others care less about others and find “ease of use” more important, which often leads to them adopting new technology once it is well developed.

The stakeholders could explore the simulation by changing parameters of the simulation in the user interface, such as EV infrastructure adoption or how much people would adhere what is seen as the norm with regards to car choices. Whilst not implemented in the case-study, changing aspects like population density, reasoning systems of agents or enacting certain policies would also be possible. This empowers the stakeholders to explore “What if?” scenario’s.

In the iterative process the participants explored the importance of agents affecting the attitude of consumer. This shifted the question from “what influences the consumer?” to “what influences the consumer influencers?”. In turn we explored this question by extending the conceptual ABM with attitudes of the other agents in the model. We implemented the attitude of the most important agents in the simulation; car dealerships, mass media and how well the road infrastructure suited EV’s. This addition provided the participants with levers to change the influencer attitudes and explore these effects on the consumers. The results of pulling these levers can be seen in the output of the ABSS.

During the case-study we found a drawback in this phase of simulation exploration of the framework. To facilitate the exploration by stakeholders well a good userinterface is needed. With Repast we were limited to graphs, 2D topological maps of the social network and data output. By changing the sliders and input direct effects could be seen in the graphs, which is good, but not good enough. We saw that the stakeholders were struggling with interpreting the output of the model, let alone explore the simulation themselves unsupervised. As facilitator we had to offer more support for the exploration than we expected before hand. This can most likely be fixed with better tools

8. During the whole process *important discussions emerge* that are not directly related to the content of the model or simulation of the societal challenge. In the case-study these discussions revolve around questions like “what is our role?”, “how do we work together?” and “how does this fit in our policy theory?”. These types of topics might seem obvious, something the policy developers in the case-study agreed with. At the same time they admitted that they often skip these discussion or don’t do them often enough. Using the framework made the importance of these discussions clearer.
9. Every collaborative framework has *impact on the stakeholders*. In the introduction we reflected on the importance of managing the stakeholders in the policy development context for policy acceptance and that most ABM approaches do not take this into account. By explicitly giving this aspect a place in the framework users will be encouraged to take it into account. In the case-study we did this by making time to reflect with the stakeholders how they feel about their relationship with the government and how being part of this process affects them. The stakeholders voiced that they felt more

listened to and better understood the complexity of the situation and the challenge that the policy developers face.

In the Dutch policy context building relationships and trust with each other is at least as important as the context and process of a policy. To create a shared language and trust the conversation between the stakeholder is needed.

Top 15 indicators		
#	Indicator	Primary Agents
1	After-sales income of EV compared to ICE	Car dealerships and their representatives
2	Number of EV-ambassadors at car dealerships	Car dealerships
3	% of test drives with EV's compared to ICE's	Car dealerships
4	% of people who agree with "EV's are the norm"	Social Network
5	% of EV's in car manufacturers catalog	Car manufacturers
6	Attitude of the media	Social Network and Media
7	EU CO2 targets for manufacturers (2021, 2025, 2030)	Car Manufacturers
8	Total Cost of Ownership (TCO) EV compared to ICE	Social Network
9	Profit margin on sale of EV compared to ICE	Car dealerships
10	Number of municipalities with car scrapping subsidies	Municipalities
11	Number of municipalities with low-emission zones	Municipalities
12	% of cars sold that are EV's	Car dealerships
13	% of EV's available on secondhand market	Social network
14	Local availability of charging points	Social network
15	Public sentiment	Social network

Table 1. Top 15 indicators

10. *Policy analysis and explanation* generally focuses on the more tangible artefacts like reports with recommendations. To conclude this case-study a report was written as well. The report included a top 15 (Table 1) of most the important non-fiscal indicators to monitor the EV-transition and the primary involved agents for these indicators. This top 15 list is created by ranking all the indicators that were found (100+) by importance with the stakeholders and policy developers.

The explanation of the complexity of the societal challenge has been visualized in an aggregated conceptual ABM; Figure 2. This ABM visualisation depicts the 10 most important agents in yellow when looking at the non-fiscal indicators that can influence the EV attitude of consumers. The purple boxes indicate the type of interaction between agents and the green boxes are indicators that are related to a specific agent. It is important to note that this model is non-exhaustive.

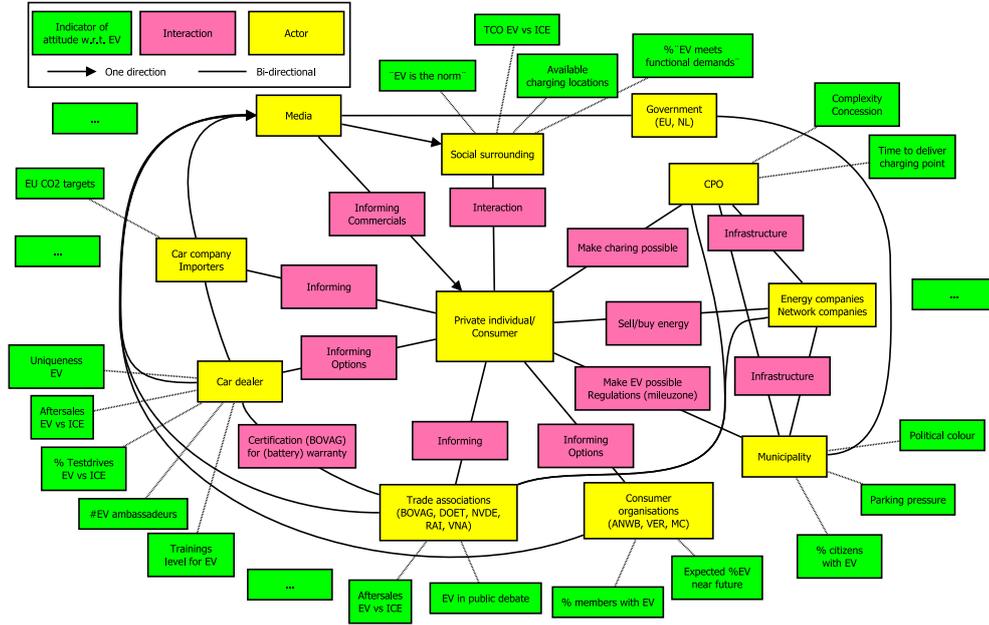


Fig. 2: Aggregated Conceptual ABM for the EV-transition.

4 Using the Framework in the Policy Process Practice

During the design of the framework we focused on facilitating interactions with stakeholders and having an easy to understand process. We have seen in the case-study that this works, but it is something that needs constant attention in order to do well. The choice to use an iterative approach has also proven to be important. At every step of the process in our case-study we have had to adjust course to account for new process dynamics, changes in the working environment and (un)feasibility of possible activities. We set up structural meetings with the policy developers to discuss the process and decide the next step take, continues project management is essential.

One example of flexibility is the tension on how to model a complex system. This tension is illustrated in Figure 3. Every model is somewhere in the depicted space between the axis of simplicity and validity, and between formality and generality. During the process the participants learn more about the dynamics of the system. They are forced to make meaningful decisions which moves the model along the axis. These decisions can, among others, reflect political or ethical choices to be made for possible policies.

An other challenge is to find situations where the framework is useful and policy developers are willing to use it. We have found that policy developers who face open and difficult questions without too much political pressure are the most receptive to use the framework. In our running example the concrete

question was summarized as “*help us to get a grip on the non-fiscal indicator*”. Practically this translate to “*help us find the most important dynamic and the right question*”. Because the facilitator was provided for free perceived investment by the policy developers was minimal. This led to a low-risk and potential high-reward situation for the policy developers.

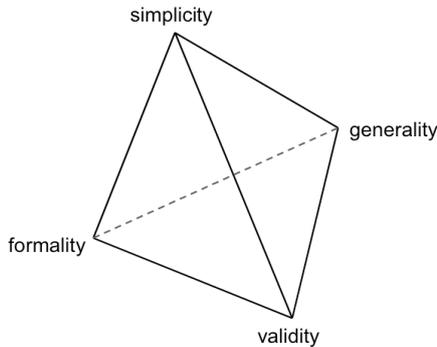


Fig. 3: Some of the tensions in modelling[11].

It is also important to consider the context in which we use the framework. The average policy development process differs from the scientific process. Goals such as “getting a grip” are not as clear as we are used to in a scientific process, yet they can have a big impact on society. In the same line results and outcomes will be subjective as we work with real people and messy issues. It is important to constantly keep in mind what offers added value in a responsible way despite having potential vague and subjective results.

5 Discussion and Conclusion

Reflecting on the framework and using it in the EV-Transition case-study, we reiterate the importance of the modelling *process* for the policy development process. The importance of carefully thinking about the purpose of models is rightfully stressed in previous work [4]. An observation we make here is that it is not sufficient to take the purpose of *the model* into account but it is necessary to also carefully consider the purpose of *the modelling process* as discussed in [18]. To this end, the Collaborative ABM Policy Framework considers the following modelling additional purposes:

1. *To gain a better understanding of the complexity of an issue and the system in which it is incorporated.*

The most important indicator from Table 1 (after-sales) is a good example. After-sales is the main income source for many car dealerships. EV’s require less maintenance while maintenance is the main after-sales activity. If more and more EV’s replace ICE’s it will result in less profit for car dealerships, which will result in car dealerships to close or change their business model.

2. *To improve alignment in world views between stakeholders.*

This is illustrated by the fact that Figure 2 and Table 1 are the result of a collaborative modelling and joint priority setting process. This means that the stakeholders and policy developers share joint priorities, language and understanding of the situation. This alignment increases the acceptance of a policy or decision that affects the stakeholders and their followers. They feel more involved and understand the reasoning behind a decisions better.

3. *To give policy developers clear next steps for the policy process. These steps are explicitly not “enact this and that policy”.*

For example; in the case-study the policy developers were advised what types of data to gather with the list of indicators from Table 1. This is a step they can take themselves to get closer to developing good new policies.

Each of the three purposes validate the framework for the use within the policy development process. Our goal for the framework is to make the use of collaborative ABM modelling *useful* in the policy development process. The policy developers and the stakeholders voiced that it helped them with all three purposes and that they were one step further in the policy development process.

The application of our framework in the case study illustrated *how* to fulfil these purposes. Our case-study also help us move closer to validating the principles for impacting the policy development process with ABM discussed in [18]:

1. Acceptance is more important than correctness or validity.
2. Stakeholders are taken into account during development.
3. It is not about finding The Answer, it is about finding valuable insights.
4. Create value for the problem context without relying on empirical data.
5. Communicate in an understandable way.
6. Explicitly state what the ABM does and doesn't do.

We have also identified a number of issues that need further resolved to improve the approach. One is the current lack of good platforms of ABSS that have both suitable user interfaces for laymen and offer enough programming power for modellers. A remedy for this might be to have more developers that can work on the ABSS, which leads to the second issue. We estimate that one needs at least 6 FTE to have the needed quality and speed to be considered useful in practice. In our running example we had 0.4 FTE available which was clearly a limiting factor. This also ties in with the third issue: result presentation. Policy developers are used to reports with conclusions and advice, but these more often than not can't convey all the learnings of the process. We need to have a better way to present the results. An other open question is the question of where in the policy process our framework has the most value. We know it's in the earlier stages, but it's desirable to have a more actionable description.

To conclude, we introduced the Collaborative ABM Policy Framework and illustrated it with the EV-transition case-study, which is a societal challenge in the Netherlands. Next to the process results, conceptual ABM and top 15 indicators stakeholders have been positive about the way of working. Interestingly, stakeholders also express that they have understood the extent and complexity of the societal challenge better through the process; *‘I knew it was complex, now I understand why it is complex!’*. At the same time, they enjoy being taken seriously and would love to continue using the framework. These are results that we would not have been able to get if we had not used the Collaborative ABM Policy Framework.

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