

Facilitating the process of carbon abatement policymaking by exposing the complexities of GHG reduction

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ABSTRACT

Binding climate agreements and the necessity to lower greenhouse gas emission levels requires increasing implementation of carbon abatement options and supporting policies on a global level. Due to the wide range of possible strategies, policymakers experience problems in choosing the right carbon abatement strategy. This challenge has led to the creation of the Y-factor, which provides a high-level overview of the complexities to deal with when implementing abatement options. However, the Y-Factor has not yet reached the stage of development to be ready for an introduction into the policy arena. It has not yet established a reputation, and is still relatively underdeveloped in comparison with alternatives and has no proven functionality in real-world situations. By applying the theoretical framework of the policy cycle, conducting focus group sessions and interviews with policymakers, this research has tested the applicability of the Y-factor for policymaking. This led to the conclusion that the Y-factor method could very well assist policymakers in the phase of policy formulation by highlighting the most important implementation barriers and facilitating discussions on how to tackle these. To increase its reliability and subsequently improve its usability for policymakers, it is advised to create carbon abatement reference curves on a national level.

1. Introduction

In October 2018, the International Panel on Climate Change (IPCC) released a report with scenarios revealing the urgency of tackling climate change at a faster pace in order to avoid irreversible damage. An increase of more than 1.5 degrees Celsius would mean that the Earth's atmosphere would become unstable, that CO₂-levels would become uncontrollable, and consequently, temperatures would rise even further [10]. As human beings have been the cause of this change in climate, for many the dust has finally settled that human beings should also be the ones to fight and reverse the processes that are heating up the earth. The assembly of national representatives during COP21 led up to the Paris Agreement. An agreement that has provided every country with binding goals for the emission of GHG reduction [18].

The responsibility for the development of plans and policies to reach the COP21 goals lies with the national governments. In the Netherlands, this led to the development of a national climate agreement. Formulating and executing the necessary policies presents a large challenge for many countries, because the number of carbon abatement options to choose from is very extensive and the exact outcomes of these options remain relatively unknown. A method that has been widely used amongst researchers and policymakers in order to facilitate the choice for the right abatement options is the marginal abatement cost curve (MACC). This curve shows carbon abatement options in a bar graph and ranks them on their marginal abatement costs (€/ton CO₂), whilst showing their carbon abatement potential for 2030. From the marginal cost curves that currently exist, the MACC from McKinsey is leading in academic literature [14].

This economic way to analyze abatement options has been leading in literature, public and private sector but is

also increasingly contested. It is claimed that abatement options should not only be ranked on marginal costs but that the associated benefits need to be taken into account too [19]. Furthermore, an argument against the suitability of MAC-curves for prioritising, is that complexity in behavioural aspects, technological issues and uncertainties are overlooked by only taking into account marginal costs [11]. The latter arguments have been the main driver for Chappin to construct a new method, which incorporates all forms complexities that might hamper the implementation of abatement options, the Y-factor [4].

The Y-factor addresses a wide range of complexities that determine why an abatement option may or may not be hard to realise. Apart from financial factors hampering the implementation of carbon abatement option, the Y-factor includes three more categories; multi-actor complexity, physical interdependences and behavioural complexities. These categories are further specified in twelve socio-technical barriers (three per category), which collectively determine the Y-factor score for a carbon abatement technology. Each of the factors is scored on a tripartite scale. Either a 0, 1 or 2 can be attributed to these factors. The meaning of the scores differs per factor, as a majority of the criteria has a qualitative nature. With twelve factors to be scored with either a 0, 1 or 2, the score that an abatement option could get ranges from 0 to 24, with 0 being 'easy to implement' and 24 being 'nearly impossible to implement'. Figure 1 shows the 12 different Y-factor barriers.

Since the first introduction of the Y-factor in 2016, Arensman [3] refined the Y-factor method by comparing Y-factor barriers with barriers that were mentioned throughout IPCC reports. This led to a refinement of the Y-factor categories and the removal of a 13th Y-factor barrier, which used to be included. Cheung [5] conducted a similar research approach as Arensman, but linked the Y-factor to the theoretic-

Y-factor applicability for policymaking

Category	Factor	Value 0	Value 1	Value 2	Definition
(A) Costs and Financing	Investment cost required (A1)	Absent	Medium	Large	Degree to which the investment in an abatement measure is significant
	Expected pay-back time (A2)	<5 Years	5-12 years	>12 years	Expected time required to earn back the investment for an abatement measure
	Difficulty in financing investment (A3)	Low	Medium	High	The degree to which it is difficult to finance the abatement or attract appropriate financial means
(B) Multi-actor Complexity	Dependence on other actors (B1)	No	Little	Much	Degree of dependence on actions of other actors to successfully implement and execute the abatement measure
	Diversity of actors involved inc. conflicts (B2)	Low	Medium	Large	Degree of diversity of interests, values, roles, skills and expectations of the actors involved. Degree of public acceptance. When opposing interests from the (local) public to the implementation or the abatement option are (expected to be) present, a high score should be given.
	Division of roles and responsibilities unclear (B3)	Clear	Slightly	Unclear	The extent to which the roles and responsibilities for the realization of the abatement option are clear
(C) Physical Interdependences	Physical embeddedness (C1)	No	Medium	High	Degree to which the abatement measure requires physical changes to the environment it is placed in
	Disturbs regular operation (C2)	No	Slightly	Strongly	Degree (duration, intensity) to which status quo/regular operation is disrupted to successfully apply the abatement measure
	Technology uncertainty (C3)	Fully proven	Small	Large	Degree to which the technological performance of the abatement measure is uncertain
(D) Behavior	Absence of knowledge of actor (D1)	High Knowledge	Low Knowledge	No Knowledge	Level of knowledge of the parties responsible for the abatement measure
	Frequency of opportunity (D2)	Often	Medium	Rarely	Number of opportunities for the responsible party to realize the abatement measure
	Requires change in behavior (D3)	No	Slight	Severe	Degree to which the actors involved need to change their day to day behavior

Figure 1: The Y-factor methodology

cal concept of the transition theory. More recently, research on the Y-factor method was conducted by Soana [16], who constructed the first reliable Y-factor abatement curve, by analyzing and scoring 24 different abatement options.

Hereafter, expert interviews were conducted, which confirmed that the curve was valid and insightful. Interestingly, with regards to the envisioned applications of the Y-factor, opinions differed strongly across the interviewed energy strategists. The Y-factor's possible applications ranged across three activities: to support policymaking, research analyses or business strategies.

This article, based on the thesis report by Swart [17], focuses on how the Y-factor could be employed for policymaking. It constitutes the first research on the possible applicability of the Y-factor. The McKinsey MACC was once developed with the purpose to 'serve as a starting point for policymakers when discussing how to best achieve emission reductions'. In turn, this article investigates how the Y-factor could be applied for policymaking. This is done using the following research question: *"How can the Y-factor best be employed for public policymaking?"*

To support this research question, the policy cycle is used as a theoretical framework. The policy cycle characterizes the policymaking process as an iterative process consisting of five different stages. This framework is used to support the research question in order to identify in phase(s) of policymaking the Y-factor can be applied. This will be discussed in section 2. The conclusions from this analysis have been tested in focus groups, which will be discussed in

section 3, followed by conclusions and recommendations in section 5.

2. Theoretical Framework

The policymaking process is a complicated process, which has for decades been debated and been explained by different theories and frameworks. Common approaches, among many others, that help understanding the policy process are the Advocacy Coalition Framework, the Multiple Streams model and the policy cycle. All of these approaches have a certain analytical value and specific focus. However, they have also been subject to substantive criticism.

Of all the theories used to define policymaking processes, the policy cycle is one of the oldest, but still very often used in academic literature. The framework was first introduced by Lasswell in 1951 [12] and separates the policy process into different stages. Contrary to other widely used approaches, the policy cycle is a far more simplified representation of the policy process. The policy cycle breaks down policymaking into five different stages. These stages help to describe the process going from problem identification till evaluation of the policy. The simplicity of this representation of the policy process has led to it both being utilised and criticised a lot. [13].

The policy cycle approaches the policymaking process from a high level perspective, making it possible to analyse nearly every policy process. The wide applicability of the Y-factor, and its current lack of practical experience in the policy arena are the main motives to use the policy cycle

as a framework to test the applicability of the Y-factor for policymaking.

Within this research, the policy cycle was used as having five different stages: problem identification, policy formulation, policy decision-making, policy implementation and policy, which is the most widely used approach [9]. Some scholars identify extra stages in between the existing stages, such as a monitoring stage before evaluation, or a termination stage after evaluation, but these stages are not considered as a separate stage in this research. Four of the five considered stages will be described below and the possible application of the Y-factor within these stages will be discussed. The phase of issue identification is not addressed, as the Y-factor assumes an already defined issue.

Policy formulation

The policy formulation stage follows the issue identification stage in the policy cycle. Within this stage, policy objectives are specified and multiple policies are formulated to solve the identified issues and meet the set objectives. The main objective of the policy formulation stage is to provide decision-makers with multiple policy alternatives to tackle the issue that has been identified in the first stage.

There are several activities that characterize the process of developing policy alternatives. Dunn [7] distinguishes three categories of activities. This categorization of activities is used to determine if and where the Y-factor could be applied within this stage.

- **Forecasting through the use of scenarios** will be primarily conducted in situations where there are high (scientific) uncertainties: The Y-factor does contain two barriers that could raise the need for a scenario analysis: information on technological uncertainty and unclear responsibilities of actors. However, the Y-factor itself does not contain any information to conduct scenario forecasts itself.
- **Identifying and recommending policy options** can be done by different analyses, such as a cost-benefit analysis, a cost-effectiveness analysis or a multi-criteria analysis: The Y-factor could potentially be used as a tool to conduct these analyses, as it considers multiple criteria and has the capability to address the critical complexities of the possible policy options.
- **Problem structuring or framing** is conducted by using methods such as brainstorming, boundary analyses and argumentation mapping to provide a solid background for argumentation: The Y-factor is a method that ranks abatement options on different qualitative criteria, which are inherently context-dependent [16]. The Y-factor could subsequently be useful to generate and structure discussions between policymakers.

Decision-making

The phase of policy decision-making follows after the formulation phase. Possible policies are drafted during for-

mulation, and consecutively executive policymakers make a final decision on which policy to implement during the stage of decision-making. The decision-making stage shows similarities with the stage of policy formulation as, in both stages, policies are assessed on a set of criteria. However, small distinctions are present. Within policy formulation, policies are designed and developed based on criteria, whereas the stage of decision-making is more about choosing a final policy mix, rather than developing new policies.

There are three main types of analyses that could be executed during the stage of decision-making [15]: a Life-Cycle Analysis, a Cost-Benefit Analysis and a Multi-Criteria Decision Analysis (MCDA). As the Y-factor makes use of multiple criteria to generate new insights, but hardly contains aspects that are needed for a Life-Cycle Analysis or the necessary detail of a Cost-Benefit analysis, the Y-factor is most suitable as a method to conduct a multi-criteria decision analysis. There are multiple possible applications for when to use MCDA [6, 1], which are in line with possible applications of the Y-factor. These are listed below.

- **Choice:** The Y-factor has the potential to select one alternative from a given set of alternatives, by using the twelve different Y-factor barriers.
- **Ranking and prioritizing:** Two similar selection methods, which can be conducted using the Y-factor in order to determine what abatement options might be easier to implement than others. As the Y-factor considers qualitative factors, the comparison and ranking of options must be done with careful consideration.
- **Conflict resolution:** this considers the settling of disputes between parties with incompatible objectives. The Y-factor has the potential to play a role in structuring discussions and highlighting why objectives of different policymakers do not align.

For the Y-factor to be more suitable within this stage, some additions are recommended. An important component for decision-making is the access to information showing the impact that considered abatement options could make. By combining Y-factor scores with the abatement potential and marginal costs of the McKinsey MACC, this could be effectuated. Furthermore, an investigation into the co-benefits of the different abatement options is recommended.

Policy Implementation

The implementation stage of the policy cycle follows after decision-making and precedes the evaluation stage. It constitutes the translation of a plan into practice, as the formulated policies from earlier stages are executed [13]. A main characteristic of this stage is that it serves to concretize and further specify all plans that have been made till that moment. It, therefore, has a higher level of detail than its prior stages. There are three core elements that characterize the stage of policy implementation [8]:

- **Specification of program details:** Implementation of a policy demands for an action plan. It must be

clear how laws and regulations must be interpreted and which agencies are responsible for executing the program.

- **Allocation of resources:** The distribution of budgets, personnel and responsibilities.
- **Decisions:** This implies the necessity of a structure on how decisions shall be carried out for individual cases. The effectiveness of the implementation stage depends on how well bureaucracies execute the orders [13].

The stage of policy implementation has a prominent focus on concretizing the outlines of the formulated policy and putting this into action. As the Y-factor indicates complexities for the implementation of abatement options, it can address where policymakers need to pay specific attention to. However, regarding the high-detailed nature of the implementation stage, application of the Y-factor is illogical. To improve the applicability of the Y-factor in this stage, information should be added on what policy instruments (regulatory, financial, informational or organizational) could help to overcome high implementation barriers of an abatement option. The development of this extra function would however not align logically with the current application of the Y-factor, which is meant to provide a high-level overview of complexities.

Policy evaluation

The aim of policy evaluation is to find out whether and to what extent a policy has accomplished its goals or whether it has had other intended or unintended effects. Furthermore, underlying reasons and causalities that have contributed to these outcomes are investigated in order to determine which parts of the policy need to be adjusted for higher effectiveness of the policy. The three different possible outcomes of the policy evaluation stage are : 1) the policy is successful and will be continued, 2) the policy does not fully return its intentions and is modified to be more successful, and 3) the policy is terminated [2]. There are multiple reasons for terminating a policy, varying from a lack of impact, a lack of finances, or a full achievement of the policy goals.

As mentioned in earlier sections of this chapter, the Y-factor can prove its worth by providing a multi-factor approach to the development of policy on carbon abatement related topics. This multi-factor approach can assist the evaluation of policy in a similar way. The Y-factor can be especially helpful for determining the causes of either a successful or failing policy. If a policy has not fulfilled its objectives, this could be related to a wrongly specified focus of the deployed of instruments. However, it is questionable if the application of the Y-factor as a general framework will be effective for policy evaluation, as the necessary level of detail in an evaluation might be too high for the Y-factor to fit in. Furthermore, application of the Y-factor might not be useful if it has not been used for ex-ante evaluation too.

Conclusion

The primary focus of application for the Y-factor will be on the formulation of the policy and the consecutive decision-making. The main argument for this choice is that the requirements for these phases lie closest to the inherent nature of the Y-factor. The formulation phase and decision-making phase benefit from an analysis that helps to compare different policy options on multiple factors. The Y-factor could support this process, due to its twelve criteria that spread across the most important themes hampering the implementation of certain policies. The Y-factor is less suitable for the implementation stage as this stage requires a higher level of detail in the decisions that are made. Even though it might prove more useful than in the implementation stage, the Y-factor also has a weaker match with the evaluation stage because the main strength of the Y-factor lies in combining multiple criteria to come to a decision regarding the formulation of a policy, rather than looking back at what criteria should have been applied beforehand. Figure 2 gives an overview of the possible applications of the Y-factor for policymaking and shows this in a graphical representation of the policy cycle.

3. Testing the Y-factor's applicability for policymaking

The literature review on the policy cycle concludes that the Y-factor fits best within the early stages of the policymaking process: the stage of policy formulation and decision-making. In order to support the application of the Y-factor as a method for multi-criteria decision making, and to provide insights into the complexity of abatement options, a web-based tool was developed. This tool gives policymakers the ability to get insights into the information underlying Y-factor scores, change the relative importance of the 12 different Y-factor barriers, and was provided with a scatterplot graph, which functions as a crossover between the Y-factor and the MACC. The graph shows the carbon abatement potential, the marginal costs and the Y-factor score.

This tool was used to present the Y-factor to participants of focus groups. Focus groups, which were used to test the applicability of the Y-factor for policymaking, and to test the conclusions drawn from the policy cycle analyses. The focus group methodology can be typified as a qualitative research method, which is conducted with a group of at least three people. Within a focus group, the goal is to generate discussions on predefined questions or case material. The argumentation behind the choice for using focus groups, is twofold. First of all, focus groups discussions generate more insights in a shorter amount of time than one-on-one interviews would do. Moreover, the generated discussions, if moderated well, can lead to different insights because the participants trigger new ideas with each other. Not only content can be registered, but observations can also be made on the Y-factor's ability to support group discussions. Secondly, with the predefined questions and case materials, the focus group methodology naturally provides the possibility

Y-factor applicability for policymaking

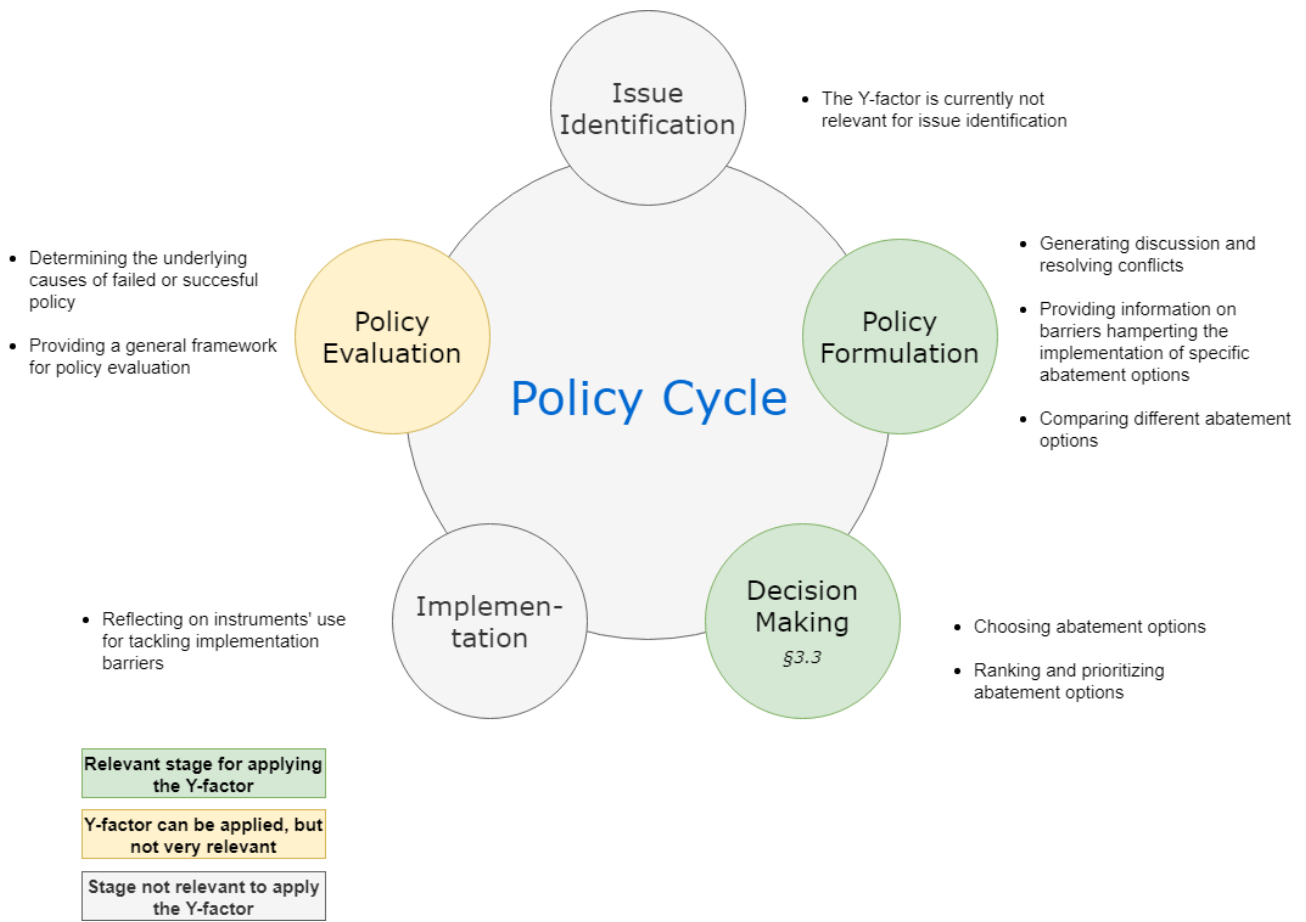


Figure 2: Phases of the Policy Cycle

to recreate real-world situations within discussions.

In total, two focus groups were conducted. One focus group was held at the Delft University of Technology with three MSc students from the faculty of Technology, Policy and Management. The other focus group was held at CE Delft, which is a research institute that delivers advice on climate related issues to public organisations. Both focus groups had three participants, and had a duration of 90 minutes. The discussions were preceded with a presentation, which described the background of the Y-factor research. All participants were given access to the web-based Y-factor tool.

Apart from the two focus group sessions, three 1-on-1 semi-structured interviews were conducted at public policymaking organisations in the Netherlands. These were conducted to generate more insights into current policymaking processes concerning the choice of carbon abatement options.

4. Results

In this section, the findings are described according to the important themes that were derived from the focus groups and interviews.

Applicability of the Y-factor for policymaking

During each of the focus group sessions and interviews, participants were asked how they would envision the Y-factor to be most suitable within the policymaking process. Many recognized the ability of the Y-factor to provide a high-level overview of many different abatement options. This overview would help policymakers to get insights into the main complexities that need to be considered before implementing new policies. Participants mentioned that, because the Y-factor is quite generic, it would be most useful in an early stage of the policymaking process. Figure 3 shows the results of the questionnaire that was filled in by the focus group participants. When asked for the possible application of the Y-factor for policy evaluation, several participants addressed that this would be possible, but would not be in line with the core strength. Moreover, a participant mentioned *"If the Y-factor were to be used for policy evaluation, it would have to be used ex-ante as well, in order to see if progress was made"*.

When asked how they would foresee the Y-factor to be used for policy formulation, the participants shared expertise from their own experiences. They addressed how most decisions for policymaking are made based on financial criteria. At CE Delft, marginal cost curves are very popular. They did however recognize the need for an integral way to assess

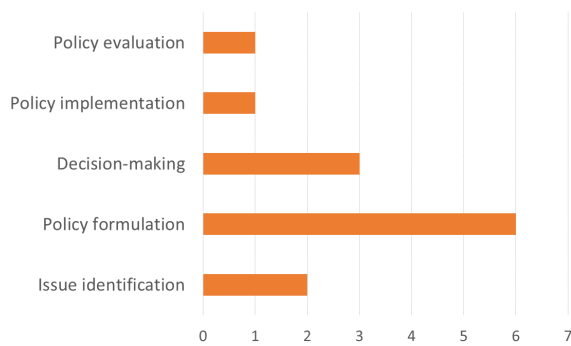


Figure 3: Y-factor in policy cycle

policy options on other than financial criteria and envisioned the Y-factor to be suitable after using a MAC-curve.

Y-factor as a reference curve

The Y-factor currently consists of 24 abatement options that are scored on their implementation complexity using 12 barriers. This information was used to create a global reference curve. Because the criteria are of a qualitative nature and only scored on a 3-point scale, and the abatement options are scored within a global scope, some participants questioned its suitability for mimicking real-world complexity. All participants agreed that the Y-factor would be able to explain complexities best on a national level. Different than for marginal costs alone (as is the case with the MACC), the implementation complexity in the Y-factor is more geographically bound. A main reason for this is that laws and regulations can differ strongly per country, which influences the complexity of implementation on multiple aspects. Furthermore, multi-actor situations are organised differently per country, the physical landscape differs and finally, most climate policy is formulated on a national level rather than on a supranational level.

As mentioned briefly in the introduction of section 3, the participants were introduced to a web-based tool that displayed the Y-factor digitally. It was also provided with the options to change values of Y-factor barriers or to attach relative weights to barriers in order to highlight increased complexity of tackling certain obstacles. These options were regarded as interesting, but multiple participants were hesitant with regards to its added value. They were afraid that the reliability, and with that part of its added value, would be lost if the users of this tool would be given freedom to change relative weights.

Where participants were critical on some aspects of the Y-factor reference curve, most of them were very enthusiastic on the Y-factor MACC scatterplot graph. The scatterplot, showing the complexity of the Y-factor, combined with the abatement potential and marginal costs from the McKinsey MACC was highly valued by all interviewees, because of its ability to capture a lot of information, whilst remaining easy to understand.

Generating discussions

"This could have been very interesting for the negotiations for the Dutch climate agreements". This quote came from one of the focus group sessions. It was part of a conversation on how to make best use of the Y-factor's information. It was recognized by participants that nowadays, many discussions on implementation complexities often lack a structure, which makes it hard to reach a consensus. The Y-factor allows for the comparison of different abatement options on the exact same criteria. In this way it can be prevented that policymakers have two different conversations using different arguments. Another interviewee mentioned how the Y-factor would be "interesting to use to collaboratively come to a consensus on the most complex issues to address".

During the focus groups, it was observed that the discussions needed to be triggered by the moderator and did not always appear spontaneously. The discussions that turned out the most productive, originated when comparing different abatement options. Addressing and discussing Y-factor values of one specific abatement option did not lead to many discussions. Participants mentioned that they had insufficient knowledge to call values into question.

Room for improvement of Y-factor

During the interviews and focus groups, feedback was given on the Y-factor method, regarding the choice of factor distinction, factor levels and scoping of abatement options. With regards to the choice and segregation of the twelve Y-factor barriers, there were two points that were discussed extensively. First, during two of the interviews, the increased complexity due to laws and regulations was stressed. This is not incorporated as a factor, partly because different laws have influence on different barriers. Second, a doubt was risen on whether the Y-factor was specific enough with scoring on 3 levels per factor only. One participant was convinced that this was not the case, and at the TU Delft focus group this doubt was shared. When this distinction was addressed at the CE Delft focus group, there was an understanding for this doubt. However, they envisioned that specification to a 5 or 7-factor level would lower the validity of the scores, because the complexity would for many abatement options be too hard to indicate. A final notion on this point by a participant of the CE focus group, was how the Y-factor would become more relevant if more expert opinions would be collected on a 3-factor level and showing a confidence interval, rather than increasing the amount of scoring categories to 5 or 7.

All of the participants acknowledged the importance of the barriers that constitute the Y-factor. However, the barriers were not always easily distinguished. In three cases, a participant addressed the relative importance of accounting for local resistance. All three times, the participant was looking for the factor addressing local resistance within the category of behaviour, whereas the multi-actor complexity should have been addressed. It is therefore recommended to either create a manual on how to use the Y-factor or to ensure a moderator is present on the first occasion that the Y-factor

is introduced to new users.

5. Conclusion

This research showed that the Y-factor can definitely have its added value for policymakers. Although there is an increasing awareness that the choice for options to reduce GHG emissions cannot be solely built upon financial considerations, policymakers acknowledge that there is currently no suitable alternative that incorporates more aspects. Within the early stages of the policymaking process, the Y-factor could become a respectable method to provide an integral and structured way to assess carbon abatement options and to facilitate discussions with policymakers. The Y-factor has the potential to present a high-level overview indicating the implementation complexity of a wide range of abatement options. This information is suitable to function as a starting point for policy discussions. Asked for the best application of the Y-factor and its supporting tool, policymakers advised to construct reference scores and reference Y-factor curves on a national level. This is because the majority of carbon abatement policies are formulated on a national level, and moreover, because most of the considered complexities are very context-specific. Context-specific in the sense that laws and regulations are often determined on a national level, and that the organisation in terms of involved actors are too.

Apart from the creation of national reference curves, it is recommended to further develop the Y-factor by clarifying the implementation barriers in order to prevent misunderstandings. Moreover, scoring more abatement options and further validating the current options would increase the reliability and usability of the Y-factor.

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