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Generating policy alternatives for decision making: A process model, behavioural issues, and an experiment

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ABSTRACT

The generation of alternative policies is essential in complex decision tasks with multiple interests and stakeholders. A diverse set of policies is typically desirable to cover the range of options and objectives. Decision modelling literature has often assumed that clearly defined decision alternatives are readily available. This is not a realistic assumption in practice. We present a structured process model for the generation of policy alternatives in settings that include non-quantifiable elements and where portfolio optimisation approaches are not applicable. Behavioural issues and path dependence as well as heuristics and biases which can occur during the process are discussed. The behavioural experiment compares policy alternatives obtained by using two different portfolio generation techniques. The results of the experiment demonstrate that path dependence can occur in policy generation. We report thinking patterns of subjects which relate to biases and heuristics.

1. Introduction

Real-world decision problems related to the environment, society, and industry easily become complex when one needs to satisfy multiple goals set by multiple interest groups and stakeholders. There are seldom simple decisions concerning only one goal or a set of predefined alternatives. By having alternative policies, the decision makers can better understand the range of possibilities and the diverse interests of the stakeholders. The availability of alternatives is essential for the decision makers and the stakeholders to be able to identify the preferred one. Alternative policies can be generated so that they represent a different mix of interests and perspectives. These policy alternatives typically consist of bundles of elements, the generation of which is also an essential part of the policy process. For example, in a policy to address an environmental problem, the elements in the bundle can be various actions taken in different locations and at different times, as well as monitoring rules and possible charges or compensations to people or stakeholders (see, e.g., Mustajoki et al., 2004 and Gregory et al. 2012). Even a yes-no decision about accepting a nuclear power plant licence needs to be made in the context where the decision makers can see and evaluate the policy alternatives which would remain if a no-licence decision would be made (Hämäläinen 1990). The situation is similar across different problem areas such as development of business strategies, designing measures against a pandemic like COVID 19 (Goyal and Howlett, 2021), or planning of military operations (Vego, 2006).

Research papers on decision modelling typically focus on the models and start from a well- defined problem setting with clearly defined decision alternatives. Yet, in a policy setting, the decision alternatives are seldom fixed. Instead, the alternatives are generated and revised during the process interactively so that they reflect the overall interests and possibilities. Modelling can help in identifying new actions but there can be actions which do not directly relate to the impacts on the system in question, such as communication patterns and monitoring rules, which are typically found only in the deliberations of the participants. There can also be actions which are a priority for participants but do not necessarily relate to the problem of focus. Such situations can be met both in environmental and organisational problems.

When the policy elements and impacts are easily quantifiable one can treat policy generation as a multi-criteria portfolio decision analysis problem. Such problems can be approached by different computational approaches and the decision makers' preferences are usually explicitly modelled in the process (Salo et al. 2011). Lahtinen et al. (2017b) discuss the use of portfolio decision analysis in environmental modelling and Liesiö et al. (2021) provide a recent review of the field. In this paper, our focus is, however, on settings where the computational approach is not applicable.

The generation of alternatives is an important stage in any major policy decision making project. In this paper we present a model for a

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structured process for the generation of a diverse set of policy alternatives. The general framework allows to apply different strategies in the distinct stages of the generation process..

Today, it is widely acknowledged that behavioural effects can have essential impacts in model supported decision making processes (see, e.g., Hämäläinen at al. 2013, Hämäläinen 2015, Franco et al. 2021). Yet, the fact that biases and behavioural issues can have an impact when generating policy alternatives has received only little interest. This is an important area to be considered too. In this paper, we bring behavioural issues into the foreground by listing and discussing biases and heuristics which can arise in different stages of the policy generation process. It is noteworthy that behavioural issues have remained an understudied topic in the policy literature too (see, e.g., Howlett et al. 2020).

We also present results from a behavioural experiment, based on a climate change mitigation game. The model in this game and its data do not correctly represent the current climate mitigation challenges as reducing emissions is not enough to solve the problems. We chose to use it anyway because it allows a straightforward way to compare two bundling techniques in policy generation. There is a set of elements, and the task is to use them in the construction of a policy. The number of elements available is higher than the number of elements needed to meet the goals of the policy, so the final policy alternative consists of a subset of the elements available. Two bundling techniques are compared: selection and elimination. The selection process refers to adding elements one by one. In the elimination process, elements are removed one by one from the set of all possible elements. The techniques reflect two alternative choice architectures (Thaler et al. 2013).

We find that the technique can have an impact on the resulting policy. An analysis of the subjects' answers to the open-ended questions suggests that the heuristics and biases involved depend on the technique used. The results raises an interesting question. Could it be that the elimination technique triggers the person to apply holistic systems thinking, whereas the selection technique can activate myopic thinking? To our knowledge, this is the first behavioural experiment in the decision analysis literature related to the generation of policy alternatives based on a set of multiple elements.

2. Literature on the generation of policy alternatives

The generation of policies is discussed extensively in policy sciences (see, e.g., Howlett 2019), however, this essential stage has received little attention in the operations research and decision analysis literature (Colorni and Tsoukias 2020). The situation is symmetric as in the policy literature there is only little work on the use of modelling in the generation of alternatives (Cairney 2021). The reasons for the limited interest in the generation of alternatives in the mainstream decision analysis literature can possibly be due to the strong interest in the normative and descriptive approaches to decision making where the focus has been on the comparison of fixed alternatives.This can be one reason why policy problems have not received more attention in decision analysis. Policy generation and modelling processes are intertwined. The interests of stakeholders and overall goals drive the generation of actions. Modelling can be needed to evaluate the impacts and feasibility of an action before including the action as an element in the policy alternative.

There are many modelling approaches that can support policy decision making but, so far, the literature has focused mainly on the selection of the models and as well as on the steps in the implementation of the models. For related discussions see e.g. Pluchinotta et al. (2019) and Ferretti et al. (2019). Systems thinking is a natural perspective to be engaged in this kind of setting as it can help in the holistic understanding of the problem under consideration (Leong and Howlett, 2022). However, this can easily remain only on a general level where the possible impacts and stakeholders are described without extending the analysis to the phase of policy generation. Yet, decision problems cannot be solved without alternatives. The recent paper by Colorni and Tsoukias (2020) clearly points out that designing alternatives has remained an almost forgotten issue even in decision analysis. Problem structuring is seen as an important initial stage in the process of multi-criteria decision making. Belton and Stewart (2002) describe the process as an iterative one where the alternatives are specified along the model building, and they also briefly discuss the importance of the identification of alternatives. There is a wide literature on participatory modelling approaches in environmental management. The related process descriptions (see, e.g., Jakeman et al., 2006, Voinov and Bousquet 2010, Voinov et al. 2016, Basco-Carrera et al. 2017 and Moallemi et al. 2020) start from problem structuring by identifying goals and stakeholders and include iterative loops but the alternative generation stage is not considered explicitly. The focus remains on the modelling process and on aspects related to participation and communication. There is an implicit assumption that the policy alternatives are given. The same seems to be true for the group model building literature. For example, the review of the effectiveness of group model building by Scott et al. (2016) covers the literature widely but policy generation is not among the topics studied. Policy generation can also be seen as an additional component in participatory modelling competences (ElSawah et al. 2023). Pluchinotta et al. (2019) do present and test a design theory based process for generating alternatives in public policy and find that their tool helped stakeholders to work together.

In an early decision analysis paper, Arbel and Tong (1982) presented a two-stage process where the factors affecting the decision situation are evaluated which gives the setting to generate and evaluate decision options. Keller and Ho (1988) emphasise the need for a policy perspective and describe alternative generation processes which are based on different principles ranging from attribute based and option based to general brainstorming. They also briefly discuss judgemental effects such as the use of representativeness of availability heuristics . Keeney (1992, 2012) advocates the generation of alternatives based on the value-focused approach, where the generation of alternatives is guided by the objectives identified. Gregory and Keeney (1994) use this approach in a policy setting with multiple stakeholders. Siebert and Keeney (2015) illustrate the benefits of the value-focused approach using behavioural experiments. Montibeller et al. (2009) also include value focused thinking in the structuring of portfolios. The strategy generation table is an idea introduced early by Howard (1988) and it suggests one heuristic way of generating policy alternatives. The strategy generation table is a structured way of presenting the elements available in the policy generation problem, and the idea is that the policies are generated by selecting actions from this table. However, there still remains the difficult and generally unanswered question of how to carry out the process of selecting the elements from the table to be included in the strategy (see, e.g., Eisenführ et al. 2010, Gregory et al. 2012 and Tani and Parnell 2013). This can be a challenging task as there can be a high number of possible combinations of the elements in the table.

In the public policy literature, a policy alternative can be called a portfolio or a mix of instruments (Howlett and Rayner 2013). Also in this literature, there is interest in finding improved processes for the generation and design of policies (see, e.g., Howlett et al. 2015). Steinhilber et al. (2016) apply the so-called multiple streams approach for policy generation and combine it with the Promethee multi-criteria evaluation method. Ferretti et al. (2019) provide a comprehensive review of policy design approaches in different traditions and have identified possibilities for fruitful interaction and cross-fertilization between decision analysis and policy analysis approaches.

Scenario planning is an area which can lead into similar processes to those that we discuss here in the context of policy decision making. Generating a diverse set of initial scenario alternatives can be the starting point (Amer et al., 2013, Seeve and Vilkkumaa 2022). The early paper by Stewart and Scott (1995) presents a model for scenario-based policy planning and combines it with multiple criteria analysis in the context of water resources planning. The process has an emphasis on the

decision making stages. Further developments can be found in the papers by Stewart et al. (2013) and Wright et al. (2019). Witt et al. (2020) provide a process framework for using multi-criteria scenario planning in energy systems analysis.

Behavioural issues have received a lot of attention in decision analysis (for a review see Montibeller and von Winterfeldt 2015) and recently also in more general modelling contexts (see, e.g., Hämäläinen et al. 2013 and Hämäläinen 2015). More than ten years ago Fasolo and Winterfeldt (2011) noted that there were only a few studies trying to understand how people make resource allocation decisions, i.e., in solving portfolio problems in real life. The situation has not changed a lot over the years. Fasolo and Winterfeldt (2011) discuss a number of possible effects without setting the observations in a general model for the policy portfolio generation process. It is quite surprising that, so far, there has not been any newer analyses or experiments about these phenomena. The importance and impact of agent behaviour has been acknowledged in the policy design literature (Considine et al. 2014) but the related papers are not many. There is an interesting recent case study on large scale participation in policy design by Braiki et al. (2022). They report that the actions proposed by the stakeholders were not very innovative. This is a finding which emphasises the need for a structured process model such as the one presented in this paper. Today, the need for modern approaches to policy design where the human perspective is put in the foreground is finally gaining increasing attention (Cairney, 2021).

Different paths can be followed in the policy generation process and the risk of path dependence is naturally present (Hämäläinen and Lahtinen 2016; Lahtinen and Hämäläinen 2016; Lahtinen et al. 2017a; Lahtinen et al. 2020). The path followed in the policy generation process depends on the problem solving team and the participants. Different paths can trigger different behavioural effects and lead to differences in the results. Also, the processes and starting points used can impact the results. However, so far, there are no published studies on path dependence in policy generation in the modelling literature. Path dependence has been discussed a lot in policy sciences (see, e.g., Pierson 2000). It is seen as an important phenomenon affecting, e.g., climate policy processes (Rosenbloom et al. 2019) and energy transitions (see, e.g., Kotilainen et al. 2019). This literature discusses many lock-in phenomena but there is limited discussion on cognitive biases as a cause of path dependence.

3. A process model for the generation of policy alternatives

In public policy problems, it is often necessary to generate alternative policies to give a comprehensive perspective of the decision situation at hand. This is the case especially in the area of environmental management. For example, Marttunen and Hämäläinen (2008) report an illustrative water course management case where the policy alternative includes the regulation scheme and over thirty other mitigation measures.

In this paper, we describe the process of generating alternative policies and consider potential behavioural issues in different stages of the process. We assume that there is a participative decision making context with the direct involvement of stakeholders. Even if the final aim is to find the most preferred policy alternative, it can be necessary to begin the process by deliberately generating a diverse set of alternatives. This helps the participants of the process to consider the problem from multiple perspectives and increase their understanding of the situation. Furthermore, stakeholders and the general public often expect that policy decisions are based on a thorough evaluation of the pros and cons of different alternatives. The explicit consideration of a diverse set of alternatives helps to build confidence in the process and to justify the final decision.

In the literature there are different ways of describing the contents of a policy. In this paper we use the following terminology. A policy consists of elements. An element can be e.g. an action to do something, a legal or practical mitigation measure, or instrument. In the case of water course management, elements could include e.g. hourly water flow rates from dams, flood protection measures, compensations for flood damages, and installing an information site for water level changes. A policy alternative or in short a policy is created by bundling i.e. collecting a set of elements together. This set / bundle of elements is called a policy. In this paper we are interested in generating different policies which represent policy alternatives.

Policies can also be seen as portfolios of actions (see e.g. Howlet and Rayner, 2013 and Howlett, M. and Del Rio, P. 2015). However, for clarity, we do not use the word portfolio in our model. Yet, in this context portfolio decision analysis literature is highly relevant as we note later in the paper.

We suggest a five-stage process model for the generation of policy alternatives outlined in Fig. 1. This is one structured approach but naturally others could be developed as well, see, e.g., Keller and Ho (1988).

In the problem definition stage, the problem solving team seeks to understand the broader context one is dealing with and to define the problem in a way that is mindful of the big picture. This stage usually involves the identification of the decision makers and the stakeholders as well as their key interests. Interaction with the decision makers and the stakeholders helps to ensure that an appropriate problem definition is reached. The problem definition can be expressed in various ways. One typical format is to define the overall goal together with the set of objectives, values, concerns and perspectives to be taken into account. The structuring of the problem by using a preliminary objectives hierarchy can be useful (for a review, see Marttunen et al. 2017). Quantitative target achievement levels and quantitative constraints such as a budget constraint can also be included. In complex problems the redefinition of the problem can be an essential step helping to go forward.

In the design of approaches stage, the aim is to ensure that a diverse set of policy elements will be generated. The term approach refers to the ways and principles which are used when looking for new elements to be considered in generating policy alternatives. Including the generation of approaches as an explicit stage directs the participants to view the situation in different ways and brainstorming new elements which can be relevant for some of the stakeholders. The idea is that considering different approaches will lead to different sets of elements. The principles followed in the approaches can be defined, e.g., in terms of perspectives and objectives. Also, different constraints and time perspectives can be used. One can start by considering the stakeholder dynamics (Eden and Ackermann, 2021) and identify the key players and create approaches which emphasise their individual interests. In this way, one can provide an understanding of the range of goals. To balance these one could consider approaches which include the interests in a balanced form. In Table 1, we give examples of perspectives and objectives that can be used in the design of the approaches. By using these kind of principles it is hoped that we can support creativity, find new elements and widen the range of alternatives to be considered. Naturally, other ways can be developed as well. Table 1 describes just one possibility but others can be generated by changing,e.g., the scopes and perspectives. Table 1 is naturally not a comprehensive list of all possibilities. These exemplary ideas can be combined and not all of them need to be used and some of them can also be overlapping. In practice, such lists can be valuable support tools for the process as they help reduce the risk that essential perspectives are omitted. In this stage, the explicit generation of objectives related to the stakeholder interests as a basis can be useful (Gregory and Keeney, 1994; Haag et al., 2019 and Marttunen et al., 2019). Table 2 demonstrates simple ways to design different approaches using the perspectives and objectives.

In the generation of elements stage, all parties involved in the problem solving process can participate in generating the elements which are the building blocks of policy alternatives. This creative process is guided and stimulated by the problem definition and by the

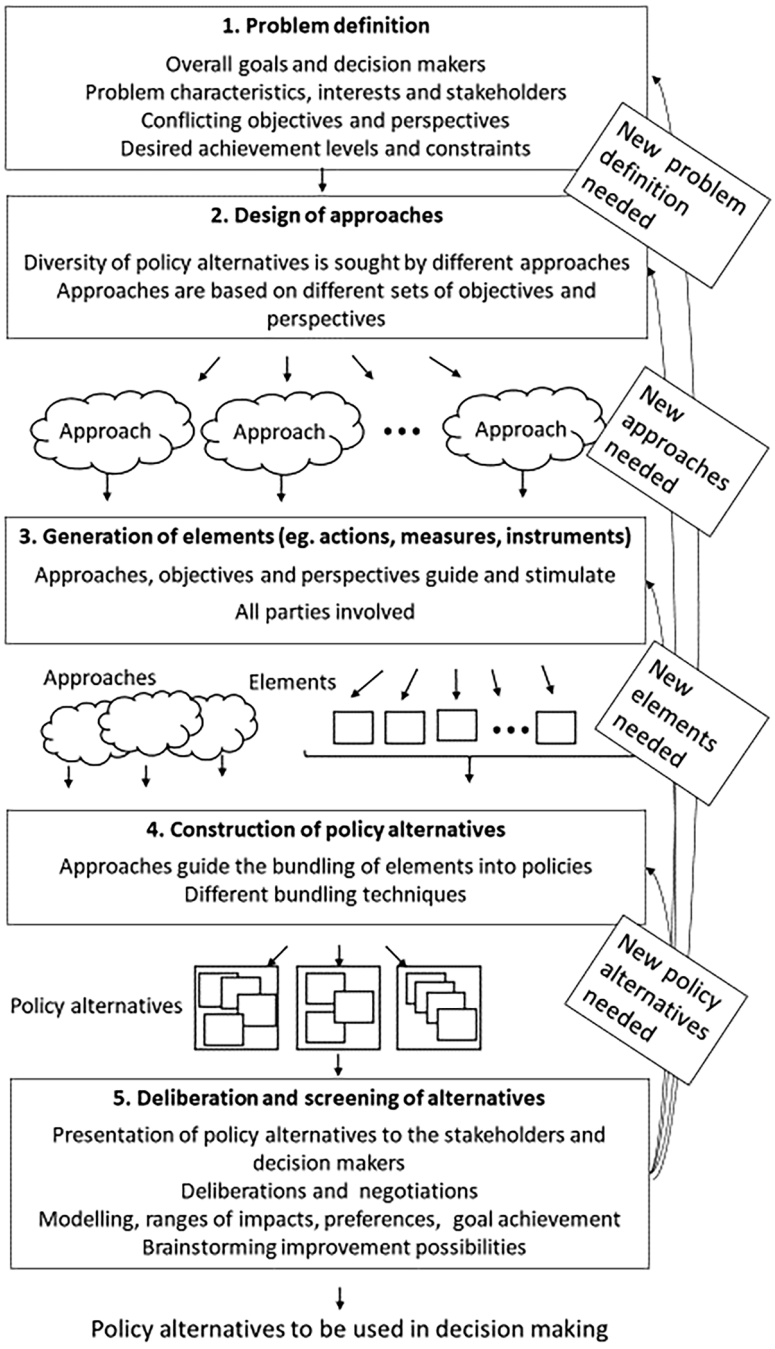

Fig. 1. A process model for the generation of policy alternatives.

approaches defined in the preceding stage. The elements can be, e.g. different measures and actions taken in different locations and at different times, monitoring rules, as well as possible compensations to stakeholders. Before proceeding to the next stage, the elements and the interactions among them need to be considered. Interactions can easily be present so that the same impacts can be produced by different actions. There can be synergies or the impacts of an action can depend on the inclusion of another action. However, one has to keep in mind that in this stage the goal is to generate different actions and it is not necessarily a problem if two different actions have the same impact. The attractiveness of the actions can still be different to different stakeholders. Interdependencies can be very challenging to tackle. In policy problems, substance area experts are usually part of the problem solving team and they are naturally expected to be able to point out possible interdependencies. There are no straightforward tools to help. Again the consideration of interactions becomes more important at a later stage when the final policy alternatives are being evaluated. A detailed quantitative impact analysis can be needed in high stake settings.

In the construction of policy alternatives stage, the chosen approaches guide the bundling of elements into policy alternatives. During bundling one works with the "basket" which represents the unfinished alternative being constructed. One can start with an empty basket or with a basket which already includes elements. More elements can be added into the basket, and elements can be removed from the basket. Modifications in the basket are made until one is satisfied with the basket, or until one feels that the basket cannot be improved anymore. Table 3 describes techniques and heuristics that can be used in the bundling. These are basic examples and depending on the case one or

Table 1
Different perspectives and objectives that can be used when generating elements and policy alternatives.

Perspectives and objectives	Description
Interests and objectives of a single actor	Reflect the interests and values of a single actor such as a stakeholder group or a party involved in the decision process. Objectives can be elicited separately.
Multiple interests and objectives with different prioritisations	Reflect the interests and values of multiple actors. Objectives can be elicited separately. The priorities assigned to the objectives of the actors can vary.
Consider the fundamental objectives	Discuss and elicit stakeholders' fundamental objectives and generate policy alternatives reflecting the fundamental objectives rather than only means-ends objectives
Include core elements	Stakeholders can agree on including certain important core elements which are initially found essential.
Resource efficiency	Trying to meet the overall policy goals with minimal resources.
Short term / long-term	Address an urgent problem quickly, or to approach the problem with a long-term perspective.
Risk	Discuss the stakeholders' risk attitudes. Consider high risk or low risk alternatives.
Precautionary	Follow the precautionary principle. The resulting alternatives must not leave room for undesired risks.
Feasibility and flexibility	The policy alternatives must be feasible and easily modifiable in the future if the situation evolves due to new information or changing circumstances.
Conflict minimisation	Minimise risks of conflict among the stakeholders and decision makers when selecting the elements.
Acceptability	Policy alternatives must be acceptable to all stakeholders.
Fairness	Aim at generating non-discriminating alternatives.

more of these techniques can be used together. Furthermore, in this stage, it can sometimes be helpful to use the strategy generation table to describe the possible elements in a structured way (see, e.g., Howard 1988). The outcome of this stage is a set of policy alternatives to be submitted to the decision makers.

In the deliberation and screening of alternatives stage, the decision makers evaluate and compare the policy alternatives generated in the previous stage. This discussion can lead to requests to improve the suggested policy alternatives or it can lead directly to the final decision making stage with the current set of alternatives. Refinements can be requested on the elements in the alternatives. A broader set of elements may be needed so that a compromise or win-win solution can be more easily reached. The deliberations can also result in the design of a new approach, which is then used to create a new policy alternative Sometimes there can also emerge a need to redefine the problem and even reconsider who are the stakeholders. The final decision making stage would be typically supported by decision analytic modelling tools (Salo et al. 2021). This remains, however, out of the scope of this paper.

Overall, in the process of generating policy alternatives, it is important that there are possibilities to go back to the earlier stages of the process. Besides the iterative loops described in Fig. 1, there can be more such loops, as well as screening and review steps between the stages, for example. General reasons to go back to an earlier stage in the alternative generation processes include learning, the acquisition of new data, changes in the problem environment, and the construction of preferences (see, e.g., Marttunen and Hämäläinen 2008, Gregory et al. 2012, Lahtinen et al. 2017a). During the process the group can even realise that the original problem description and composition of stakeholders needs to be re-evaluated. In environmental management, the decision making process can take long, even years, as stakeholder input can reveal needs to consider additional perspectives and gather new data.

The suggested process reflects several ideas presented in the earlier decision analysis literature related to the generation of alternatives. The

Table 2
An illustration of ways to design approaches. Three different approaches are found by using different scopes and time perspectives and emphasising different stakeholder interests. Public acceptance is taken into account in two and core elements are included in one approach. The target achievement levels and resource constraints specified are expected to be met.

Designing approaches by using different constraints, interests, scopes and time perspectives	Approach emphasizing local scope and stakeholder 1 interests with a short-term perspective	Approach emphasizing regional scope and stakeholder 2 interests with a short-term perspective	Approach emphasizing stakeholders in a balanced way with a long-term perspective
Achievement levels and constraints			
Target achievement level	X	X	X
Resource constraint 1	X	X	X
Resource constraint 2	X	X	X
Emphasising the interests and objectives of stakeholders			
Stakeholder 1	X		X
Stakeholder 2		X	X
Stakeholder 3			X
Scope			
Local	X		X
Regional Government		X	X
Time perspective			
Short-term	X	X	
Long-term			X
Other			
Public acceptance	X		X
Core element		X	

Table 3
Different techniques and heuristics to bundle elements into policy alternatives.

Bundling technique	Description
Add-the-best	One starts with an "empty basket" and then adds elements into the basket one by one selecting the best first. The element to be added in each step can be the best in an objective criterion or one that is subjectively perceived to produce the best increase in the overall value.
Elimination method	One starts with a basket including all the elements. Elements are removed from the basket one at a time until the stakeholders are satisfied or a desirable outcome is reached. The criterion of elimination can be, e.g., the subjectively perceived lowest decrease in the overall value.
Look for synergies	The goal is to find elements with positive synergies in some criteria and to avoid sets of elements with negative synergies. For example, one can search for synergistic sets of elements and add them into the basket together.
Benefit-cost ratio	Elements are added into the basket in the order of the benefit-cost ratio until a budget limit is reached. When quantitative models are not available, this is done based on subjective judgement.
Core elements first	One starts by including the elements which are the most essential ones as seen by all the decision makers and/or by the key stakeholders. After the inclusion of the core elements, the process can be continued by following any other bundling technique.
Rotate the perspective	One periodically rotates the perspective taken and selects elements based on the perspective.
Joint gains	One constructs the policy alternative incrementally such that every modification in the basket under construction is beneficial to all stakeholder groups.

value focused thinking approach (Keeney 1992) is incorporated in the explication of values and concerns in the initial stage which guides all the subsequent generation stages. The idea of first considering the fundamental objectives and creating alternatives from different perspectives and then proceeding to create improved alternatives representing a broader set of perspectives (see, e.g., Keeney 1992) is also included in the proposed process model. Moreover, the process distinguishes element generation and policy alternative construction as distinct phases as in Gregory et al. (2012). Uncertainty is always present in policy problems. Uncertainty can relate to the data available but also to changes in the problem context e.g. due to environmental, economic or political reasons. For clarity, we have not included uncertainty explicitly in the model. However, in the present framework consideration of uncertainty can naturally be included in all the stages and when thinking of the perspectives and objectives. Uncertainty can create the need to consider alternative actions and it can affect the feasibility of actions. Naturally, uncertainties in the actions and alternatives need to be included in their description. In the deliberation phase the decision makers can also give feedback and request that certain new uncertainties need to be considered too. It is a possibility that when the decision makers start reflecting on the relevant uncertainties they lean on scenario analysis (see Section 2). The literature on uncertainty in decision making is vast. For example, Moallemi et al. (2020) provide an uncertainty focused description of decision support processes in human-natural systems which relates to the scope of this paper.

4. Behavioural issues in policy generation

In the following discussion, the word process is used as a general term referring to decision processes in general and not only to the one described in this paper. Behavioural issues can have a strong impact on the outcome in the process of generating policy alternatives. The impacts can relate both to the behaviour of individuals and to the social system formed by the process. In participatory approaches, the process goals can also include learning and socio-emotional goals such as building positive relationships between the stakeholders (Kenny et al. 2022). This is an important topic which has received only limited attention in the literature. The tasks encountered in the process can be complex, so the participants may rely on cognitive heuristics. The use of heuristics can be useful or lead to undesirable effects depending on the situation. There is a high number of decision making and judgement related biases originating from, e.g., cognitive, and motivational effects, which may impact the process (Montibeller and Winterfeldt 2015; Hämäläinen 2015). Montibeller (2018) has discussed some group related biases in a value focused approach to policy generation.

Decision making heuristics and biases impact the generation of alternatives (see, e.g., Read et al. 1999, Fasolo et al. 2011, Schiffels et al. 2018, Durbach et al. 2020). Heuristics (Tversky and Kahneman 1974; Gigerenzer and Todd 1999) are cognitive processes people use to "reduce the complex tasks to simpler judgmental operations" (Tversky and Kahneman 1974). Depending on the situation, heuristics can be useful, e.g., by helping to achieve results quickly, or they can lead to undesirable outcomes when the heuristics do not fit the situation at hand. For example, heuristics can have an impact on whether actions are considered in groups or one-by-one which, e.g., increases the risk of double counting benefits or costs (Read et al. 1999). Generally, biases and heuristics refer to human judgement related tendencies that may distort judgements, and in a problem solving context they may work in favour of some alternatives. The origins can be, e.g., cognitive, or motivational. There are biases related to the identification of the actions which are well recognized and discussed in the decision analysis literature (see, e.g., Montibeller and von Winterfeldt 2015). These include anchoring, myopic problem representation and availability bias. However, there are also biases related to the alternative generation process, which have received little attention in the decision analysis literature, such as the equal allocation of resources to categories (see, e.g., Fasolo et al. 2011). Different processes used in the generation of policy alternatives can trigger different heuristics and biases. Alternatives are often generated in a step-by-step manner, e.g., by adding actions into the bundle one at a time. This can give rise to path dependence, i.e., the order in which one proceeds in a process can influence the resulting policy alternative (Hämäläinen and Lahtinen 2016; Lahtinen and Hämäläinen 2016; Lahtinen et a. 2017a). In general, there are many processes that could be considered. New processes can be created, e.g., by varying the starting point, the order of the steps, or some other features. The process followed can trigger different behavioural phenomena, and the phenomena can have an impact on the outcome of the process. It is possible that the process causes biases which counteract each other during the process leading to a reduced overall bias (Lahtinen et al. 2020). The process used can also influence whether one adopts a systemic perspective or considers individual actions in isolation of the big picture.

4.1. Behavioural issues in different stages of the policy generation process

In the following, we discuss the challenges and behavioural phenomena that can impact the policy alternative generation in the stages of the process model suggested in Fig. 1.

Stage 1. Problem definition is the first and most important stage where the main risk is narrow thinking and engaging an insufficiently representative group of stakeholders. Some essential groups could be forgotten or overrepresented and some could have a dominating role due to overrepresentation. Narrow thinking can lead to focusing on a limited scope of the problem and set of objectives. Here, project leadership is essential (Hämäläinen et al., 2020). The group can also set overly optimistic goals considering the available resources. It can also be that some initial assumptions will be redefined during the process. This can have an effect on the problem scope and goals so that returning to the problem definition one can become necessary at a later stage. It can happen that the stakeholders are not able to identify their objectives comprehensively (Bond et al. 2008, 2010; Haag et al. 2019).

Stage 2. Design of approaches can be cognitively challenging without a structured process help such as the one provided by Table 1. In earlier practice, this stage might have been embedded in the facilitated stakeholder engagements. If this stage is not considered explicitly there is a risk of ending up with narrow thinking which does not widen the perspectives and scope sufficiently.

Stage 3. Generation of elements requires creativity and an open mind. There can be a strong tendency to focus only on actions, measures and instruments which the stakeholders had initially been thinking of. The risk of a strong starting point effect is high. The initial elements considered can drive the thinking towards looking for similar elements. The group can also introduce a high number of elements in categories considered important as such elements are typically easily available in the thinking process of the stakeholders. This can result in a narrow set of elements and the overweighting of those categories in the later evaluation stage. The omission of elements is a general issue which can be the result of multiple different causes. There can be a premature conclusion of infeasibility of elements considered. For example, one can perceive some elements too radical when compared with the status quo, or one's thinking can be limited by illusory constraints. The set of elements generated is also likely to reflect the experience of the participants involved. Moreover, there can be intentional or unintentional strategic behaviour, e.g., to omit elements which compete with the elements preferred by some stakeholder.

Stage 4. Construction of policy alternatives is the core of the whole process. It can be cognitively challenging and again requires creativity and a wide perspective. Bundling of elements into policies poses a number of problems. The number of possible combinations of the elements available is typically high. The order of steps can influence the outcome of the sequential process of generating a policy alternative based on the elements. For example, one may look for synergies with the

elements that are first included in the policy draft. This may cause the process to get stuck on a certain path. Adding elements to a draft policy alternative may lead to different cognitive processes than paths that involve removing elements from a draft alternative. For example, one can perceive costs of elements as losses when the elements are added into a policy, and as gains when the elements are removed from a policy. A major problem in policy generation is the insufficient consideration of synergies or interactions. Not paying attention to the possibility that elements can compensate for weaknesses of other elements can lead to missing the opportunity to identify good alternatives. Creativity is also needed. Sometimes an element which seems insignificant or irrelevant on a general level can make the alternative look attractive for a particular stakeholder. This can be the case, e.g., when this new element acknowledges the concerns of this stakeholder.

Stage 5 Deliberation and screening of alternatives can incur many well-known behavioural challenges in decision making (Hämäläinen 2015; Montibeller 2018; Montibeller and Winterfeldt 2015). Here, we do not, however, go into the details of these well documented behavioural phenomena. Naturally, there are also challenges in the ways communication is carried out in the deliberation and screening stage. Depending on the case, this stage can represent the final decision making stage or it can be a stage where the policy alternatives are evaluated and screened before they are taken to the final decision makers.

4.2. Heuristics and biases

Below we describe heuristics and biases which can be present and can represent risks in the generation process.

4.2.1. Heuristics

Add-the-best heuristic refers to a strategy where actions or other elements are included in the basket one by one in a sequence where the best is always taken next. A related heuristic is the **benefit-cost ratio heuristic**, which refers to adding actions into the bundle in the order of benefit-cost ratios until a budget limit is reached (see, e.g., Schiffels et al. 2018). Both add-the-best and benefit-cost ratio heuristic can lead to poor outcomes if there are strong synergies. Furthermore, there can be **premature commitment** to the actions that are first selected or to the alternative that is first formed. The **elimination by aspects** is a heuristic, whereby elements or actions are eliminated which are below a threshold in a criterion (Tversky 1972). In the generation of policy alternatives, there is a risk that this heuristic leads to myopic decision making where one does not pay attention to the fact that actions can complement each other. **Naive diversification**, which is also known as the 1/n heuristic, refers to a tendency to allocate resources equally to different categories (see, e.g., Benartzi and Thaler 2001). In policy generation, this heuristic could manifest as the desire to select an even number of elements or actions from each category considered . This is related to **the splitting bias** which refers to the tendency to give the same weighs to split attributes as was given to the original unsplit attribute (see, e.g., Hämäläinen and Alaja 2008). **Recognition heuristic** (Gigerenzer and Goldstein 2011) can lead the group to prefer elements which are easily recognized and understood by the participants. The paper by Durbach et al. (2020) discusses a family of **fast and frugal heuristics** for portfolio selection which are relevant in the policy context as well.

4.2.2. Biases and other behavioural phenomena

Loss aversion (Tversky and Kahneman 1991) can affect policy generation as the perceived value of an element could depend on whether it is selected into the basket or eliminated from the basket. **Ambiguity aversion** (Frisch and Baron 1988) in policy generation is likely to manifest as avoidance of elements that one does not understand sufficiently well. **Omission bias** refers to a tendency whereby "people judge acts to be worse than omissions with the same consequences" (Baron and Ritov 1994). For example, including poor actions in the policy alternative can be perceived as a worse mistake than not including a very good action. **Status quo bias** (Samuelson and Zeckhauser 1988) could have an effect, e.g., if the starting point is, e.g., a pre-existing policy which needs to be renewed.

Insensitivity to scope (Fischer 1995) could lead one to prefer selecting a high number of elements with small scope rather than a small number of elements with a large scope. **Affective decision making** (see, e.g., Loewenstein and Lerner 2003) can affect portfolio choices too. In energy policy contexts, people's affective reactions to the names of technologies have been found to impact both choices and information search (Jobin and Siegrist 2018; Jobin et al. 2019). **The champion argument** is a motivational effect which relates to the relative position or strength of a member in a decision making group. If a high-level actor, i.e., a champion, expresses preference over a particular action this is likely to make others see it important too (see, e.g., Fasolo et al. 2011). **Groupthink** (Janis 1982) can lead participants to only pursue myopically the interest of the stakeholder groups they represent. **Premature commitment** refers to committing to elements that are selected early or to the policy alternative that is first formed without considering new perspectives or data that may come up later (see, e.g., Posavac et al. 2019).

4.3. Mitigation of behavioural impacts

There is likely to be interactions between the behavioural phenomena and approaches used. Awareness of the phenomena and risks is the key when trying to mitigate behavioural effects. In the policy setting, the main risks are typically group related such as groupthink, narrow thinking in general as well as strategic behaviour, where a participant mis-represents her goals or the perceived strength of the negative impacts of a policy (Hämäläinen 2015). Policy generation creates a problem solving path, and biases along the path can accumulate. The ideas for the mitigation of biases presented in Lahtinen et al. (2017a) are directly applicable here too. However, the mitigation of people's individual cognitive biases is challenging. Direct attempts to debias people have been shown to be difficult and often unsuccessful (Hämäläinen and Alaja 2008; Montibeller and Winterfeldt, 2015). Yet, mitigation efforts should not be abandoned. Raising the awareness of the risks of biases improves the transparency of policy processes. Behavioural effects need to be considered by project leadership and the mitigation of the risks of biases can be achieved by the active role of the leadership (Hämäläinen et al. 2020) . The appointment of a Devil's advocate to evaluate the project can also be an effective way to identify problems. Trying to bring all interests openly on the table can help to create a collaborative atmosphere and discourage group think and strategic behaviour.

5. Experiment

To study the emergence of behavioural effects, we carried out an experiment which compares two bundling techniques, selection and elimination, in the generation of the policy. The experimental task corresponds to the bundling of elements in Stage 4 of our process model. The experiment is based on the Stabilization Wedges Game of the Carbon Mitigation Initiative (Princeton University 2023), where the goal is to generate a stabilization policy for the mitigation of carbon emissions (Pacala and Socolow 2004). In the game, the problem and the possible solution elements are described qualitatively and there is no correct solution. The game is already old and its mitigation setting is outdated. However, it still attracts continuous interest (see, e.g., Nielsen et al., 2020, Johnson et al. 2021). For our purposes, the game provides a simple way to study behavioural effects in an easy-to- understand context. We do not aim to prove that certain behavioural effects are always present but rather to demonstrate what can happen and how people can think in portfolio decision processes. In the original game, the word strategy is used for the wedges, which represent alternative

ways of mitigating carbon emissions. These strategies correspond to elements in the terminology used in our process model. To follow the original terminology in the experiment, individual elements are called strategies and the resulting policy is the set of strategies selected. The task is to generate a policy consisting of a bundle of eight strategies, which is the needed number of strategies to meet the stabilization goal. This is an individual task and there is no game playing against others.

Subjects. The total number of subjects was 429 consisting of 372 students, 38 professional, and 19 other subjects of whom 352 were from Finland and 77 from other countries. The professional or study area was engineering for 242 subjects, business for 146 subjects, and other for 41 subjects. There were 283 male subjects, 137 female subjects, and 9 undefined. The subjects were on average 25 years old. The subjects participated in the experiment as a part of their courses on decision making or climate change during 2017–2021. The subjects were not compensated or paid to participate. Each participant completed the task independently using the web-application on a computer or on a mobile device.

Structure. First, the problem and the experiment were introduced to the subjects. Then, the subjects were asked to generate a policy with two techniques, selection and elimination. The order in which the techniques were used as randomly assigned to the subjects. Finally, there was a survey where the subjects were asked to reflect on their thoughts and feelings related to the policy generation task. The perceived difficulty of the techniques was evaluated by the subjects on a 1 to 5 scale, where 1 means very easy and 5 means very hard. The time spent was automatically measured by the web-application. The total duration of the experiment was about 30 min.

The policy generation task. To mitigate global carbon emissions and reach a target level of annual emissions, a policy consisting of eight strategies has to be created out of the fifteen strategies available. Each strategy has the same mitigation impact. The strategies are classified into four categories: Energy Efficiency and Conservation, Carbon Capture, and Storage Nuclear, and Renewables and Bio-storage. The policy generation task is stated in the following way:

"Create a basket of 8 mitigation strategies

How to make your decisions: Consider the impacts of the basket as a whole, follow your preferences and take into account the perspectives you find relevant, e.g., sustainability, economics, feasibility, social, political".

The participants followed two techniques in completing the task. In the selection technique, the subjects start with an empty basket and need to select eight strategies into the basket. In the elimination technique, the subjects start with a basket with fifteen strategies and need to eliminate seven. Backtracking is allowed in both techniques, i.e., it is possible to add eliminated strategies back into the basket, and to eliminate strategies already added into the basket.

Research questions. Are there differences in the baskets obtained, time spent and in the experienced difficulty when following the selection and the elimination techniques? If the baskets differ, it is a sign of path dependence. The secondary research question is do the participants' subjective comments reflect the presence of behavioural biases and heuristics used?

Web-implementation. The experiment was carried out fully on the web at the website http://carbcut.aalto.fi. This site contains an interactive implementation of the selection and elimination techniques and the final survey. For a description of the implementation, see Figs. A1-A4 in the Appendix A.

6. Results of the experiment

All subjects generated policy baskets with both techniques so there were two rounds for each subject. When the subjects do the tasks one after the other, learning can have an impact on the results. So, the differences in the baskets can be influenced by both learning and procedural path dependence. Another way to study path dependence is to compare group level results and compare if the techniques result in different baskets. Many of the subjects reported that they remembered the first-round result when determining the second-round baskets, so in the group level analysis, we use the first-round data only. The differences in the baskets obtained with the two techniques is compared. This way we can detect procedural path dependence.

6.1. Comparison of the results for the selection and elimination techniques

The individual level results show that the baskets obtained by the techniques do differ, see Fig. 2. The percentage of participants for whom there was no differences in the baskets is 35 %. When comparing the baskets for the two techniques we found that the average number of strategies which are same in the two baskets is 7.0 for those who started with the selection technique and correspondingly 6.8 for those who started with the elimination technique. As the baskets differ one can say that path dependence is present, e.g., because of the procedure used or because of learning.

In the group level analysis shown in Table 4, the comparison is based on the percentage of subjects whose policy baskets contains each of the strategies. If the results of the two techniques would not differ then the percentages should be the same for the group which started with selection (SEL) and the group which started with elimination (ELM). The statistical analysis is based on the two-sample t-test with unequal sample variances. The p-values are two-tailed p-values. The assumptions of the test hold since the subjects have been randomly assigned to the samples and thus the datasets are independent.

Most of the strategies are included equally often in the baskets of the SEL and ELM groups. There is one essential difference in Strategy 2 (Conservation – Transport). In group SEL, 63 percentage of the subjects has this strategy in their basket. In group ELM, 48 percentage of the subjects kept it in their basket. This 15-percentage point difference across the groups is statistically significant with $p < 0.002$. This suggests that procedure has an impact on the results.

The time spent on completing the policy generation task and subjects' perceptions on the difficulty of the task are shown in Table 5. It took on average 20 % longer to complete the task using the elimination technique compared to using the selection technique. The elimination technique was experienced to be, on average, more difficult than the selection technique. These results also suggest an impact of the procedure used.

6.2. Choice behaviour during the experiment

The survey question at the end of the experiment was: "Explain your thought process and feelings during the task". Table 6 presents an illustrative sample of the answers and their possible interpretations. Many of the behavioural phenomena discussed earlier in this paper did, indeed, emerge.

The elimination by aspects heuristic can be used by subjects who have first pruned the set of strategies, e.g., by eliminating strategies that they perceive to be infeasible or strategies that are poor in some criteria. Taking a holistic systems perspective can be reflected in the answers where the subjects say that they were paying attention to multiple criteria and to synergies among the strategies. Some answers indicate that subjects were concerned about the balance of the policy, e.g. "[I tried to] balance the different means for reducing emissions".

The add-the-best and benefit-cost heuristics are present too. Schiffels et al. (2018) suggest that people use the benefit-cost heuristic in a context where the strategies have known quantitative benefits and costs. Interestingly, our finding is that some people think of benefit-cost ratios also in settings where the strategies have been described qualitatively. A statement like "[I] just added what felt good" refers to relying on emotions, which have, indeed, been shown to be important drivers in evaluating energy policies (Jobin and Siegrist 2018; Jobin et al. 2019).

Multiple subjects cite familiarity, understandability, and simplicity

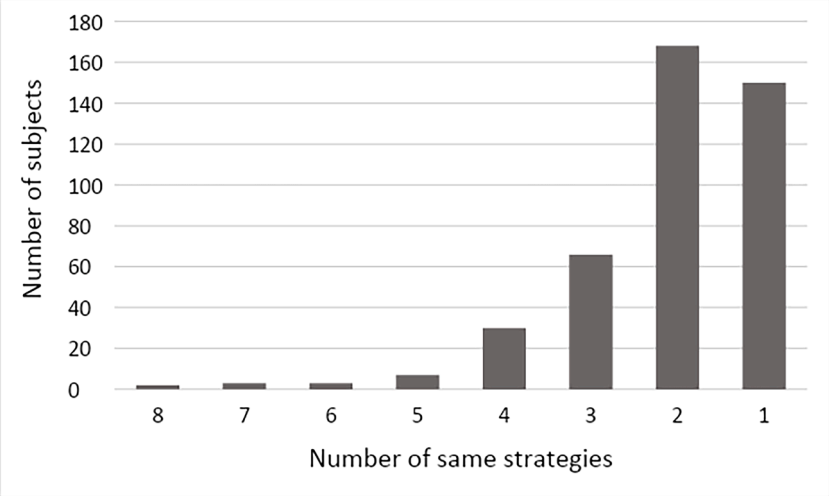

Fig. 2. The number of subjects versus the number of same strategies in baskets generated with the selection and elimination techniques. Identical baskets have 8 common strategies.

Table 4
Percentage of the subjects who had included the strategy in the basket. Group SEL ($N = 194$) includes the subjects who used the selection technique in the first round. Group ELM ($N = 235$) includes the subjects who used the elimination technique in the first round.

Strategy	SEL (%)	ELM (%)	Difference (%-pts)	p-value
1. Efficiency – Transport	75	68	7	0,100
2. Conservation - Transport	63	48	16	< 0,002
3. Efficiency – Buildings	77	73	4	0,324
4. Efficiency – Electricity	77	78	−1	0,793
5. CCS Electricity	27	27	0	0,984
6. CCS Hydrogen	19	23	−5	0,219
7. CCS Synfuels	11	17	−6	0,063
8. Fuel Switching - Electricity	38	42	−4	0,455
9. Nuclear Electricity	60	61	−1	0,824
10. Wind Electricity	71	78	−7	0,089
11. Solar Electricity	78	74	4	0,346
12. Wind Hydrogen	40	41	−1	0,808
13. Biofuels	47	50	−3	0,554
14. Forest Storage	70	77	−7	0,087
15. Soil Storage	47	43	4	0,368

Table 5
Comparison of the mean times spent and perceived difficulty in the selection (SEL) ($N = 194$) and elimination (ELM) ($N = 235$) techniques.

	SEL	ELM	p-value
Time spent (seconds)	210	250	<0.05
Perceived difficulty (1: very easy - 5: very hard)	2.05	3.02	<0.001

as rationales for their choice behaviour. We interpret these answers as signs of the recognition heuristic and ambiguity aversion, respectively. This might partly explain why Carbon Capture and Storage based strategies were generally the least preferred ones as they are likely to be difficult for non-experts to understand.

6.3. Discussion

The results of our experiment demonstrate that path dependence can, indeed, occur in policy generation. On the individual level only 150 subjects out of 429 ended up with the same basket and the difference in the baskets was typically only one or two strategies (Fig. 2). As noted earlier, the reason for the difference can be, e.g., learning or procedural path dependence. The group level results also show differences in the baskets as individual strategies are not equally often selected into baskets with the two techniques (Table 4). This suggests that the paths trigger different kinds of thinking and can end up in different results.

Interestingly, the time spent on generating the basket with the elimination technique was longer and the perceived difficulty was found to be higher than with the selection technique. A possible explanation for this is that the elimination technique, where one starts with all the elements in the basket, could prompt the subject to think of the situation as a whole and to think of the dependencies of the strategies. Naturally, it takes more time to complete the task if one thinks about dependencies more thoroughly. The observation that the selection technique is faster and is perceived less challenging can indicate that the subject is applying fast myopic thinking rather than thinking of the whole. This is something to be considered in practice as systems thinking would naturally be encouraged when dealing with real policy problems.

The experiment considered only one stage of the policy generation outlined in the process model in Fig. 1. If the overall process would be studied, path dependence could emerge in the other stages too.This remains an interesting topic for future research.

7. Conclusions

This paper complements the rapidly growing portfolio decision analysis literature (Liesiö et al. 2021) and the operational research papers on policy design (Ferretti et al. 2019) by proposing a structured process model for generating policy alternatives in real life settings. The stages in the model allow to take different perspectives and stakeholder interests into account.

The policy generation process creates a problem solving path and the relevance of considering path dependency is noted. We also discuss different behavioural issues including heuristics and biases and their possible impact on the policy generation process. Our experiment demonstrates the possibility of path dependence, and the participants feedback illustrates that a range of heuristics are used by the participants.

Our experiment is a simple start and there is clearly need for more experimental studies. From the methodological perspective the experiment has limitations in the sampling of the participants and in the fact that the impact of learning could not be eliminated. In the future, policy related behavioural experiments could possibly be carried out with existing portfolio modelling tools such as the one presented in Mayer et al. (2014). One of the main conclusions of this paper is that it is

Table 6
Thought processes and feelings of the subjects during the policy generation task and their possible behavioural interpretations.

Subjects' answers	Possible interpretation
"First, I picked the best strategy, then second, and third and so on." *"[I proceeded by] removing less important stuff first."*	Add-the-best heuristic
"I used a systematic strategy where the most efficient in terms of cost-base where chosen as solutions" *"How to get the best benefit for least cost. Starting from the best options until 8 was filled."*	Benefit-cost ratio heuristic
"First deleted the ones I don't support. Then thinking which are the most expensive ones, or has the smallest impact, or compete with the other strategies" *"I quickly checked costs and therefore excluded hydrogen things as I am not so sure how feasible such a transition would be. I kind of started with my most preferred one and then added less preferred ones until the basket was full."*	Elimination by aspect and add-the-best heuristic
"I tried to minimize costs and biomass- and land use. I wanted nuclear and wind energy for producing electricity." *"I considered which strategies are the most efficient and feasible as well as concentrated a lot to the costs, to minimize them."*	Paying attention to multiple criteria
"Tried to find positive synergies" *"[When eliminating] I wanted to take [out] the strategies that did not provide synergies with the strategies that I valued the most."*	Paying attention to synergies
"[I tried to] balance the different means for reducing emissions (colors)" *"Developing a little bit of everything, not just one area."*	Equal allocation heuristic
"Avoid strategies that are really bad in some attributes." *"Going through choices and thinking of which would or could be feasible yet not extremely expensive."*	Elimination by aspects
"The feeling [with elimination process] was like that first I have everything and I had to give up away some of the options." *"When you have already removed the "stupid" ones [with the elimination technique] it feels like a loss when you remove more strategies."*	Loss aversion
"I have a background of studying energy and environment technology, so I kept the strategies I was most familiar with." *"First I added those strategies which were familiar and sustainable."*	Recognition heuristic
"The most simple strategies that I understand well were my priorities" *"I'd start from most simple strategies such as increasing energy efficiency in existing houses, vehicles and energy generation."*	Recognition heuristic and ambiguity aversion
"[I] just added what felt good" *"Prioritization quite intuitively"*	Affective decision making / intuition

important to acknowledge the role of human behaviour in policy related decision support processes. This is the general message emphasised also in behavioural operations research (see, e.g., Hämäläinen et al. 2013, Hämäläinen 2015, Franco et al., 2021). New challenges are met when incomplete information and spatial modelling are also considered in the portfolio settings (Harju et al. 2019). The structured policy generation model and the behavioural considerations could also be of interest in scenario analysis studies related to climate problems (see, e.g., Demski et al. 2017, Elsawah et al. 2020)

The discussion in this paper can also be relevant for the general policy design literature, which has considered processes for the construction of policy mixes and discussed related behavioural issues (see, e.g., Howlett and Rayner 2013, Clarke and Craft 2019, Kuehnhanss 2019). In addition, this paper relates to the stream of research interested in crafting choice architecture and nudges to reduce the risks of biases and undesired behavioural effects (see, e.g., Thaler and Sunstein 2008, Thaler et al. 2013, Keeney 2020, Lahtinen et al. 2020).

Declaration of competing interest

None

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Appendix A

The web-application and the Questionnaire

The experimental task was carried out using an interactive web-application described in the following figures. Fig. A1 illustrates how the individual strategies were described.

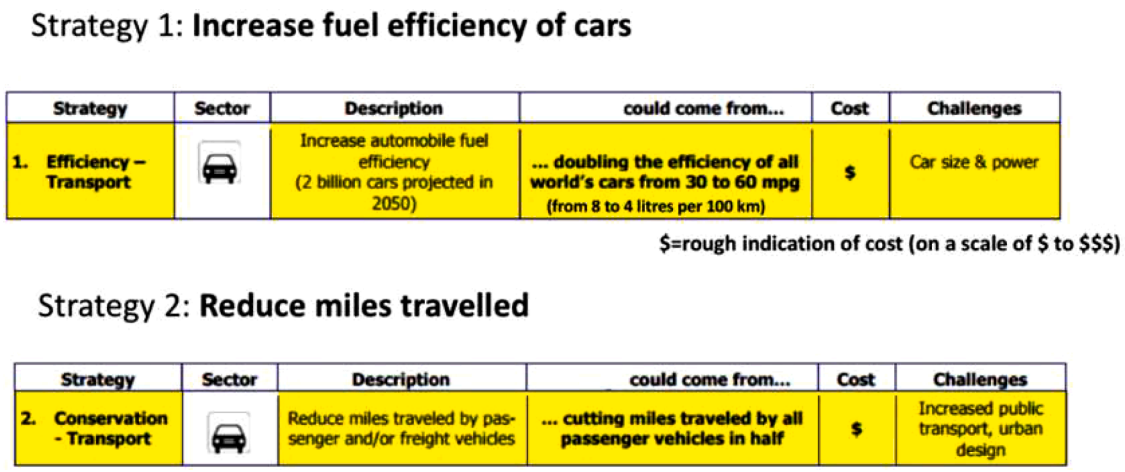

Fig. A1. Sample screenshots of the descriptions of the strategies.

Figs. A2 and A3 demonstrate the implementation of the selection and elimination techniques in the application. The order in which the strategies are displayed to the user is randomized when they enter the selection and elimination tasks. The current number of strategies in the basket is displayed to the user on the top of the page.

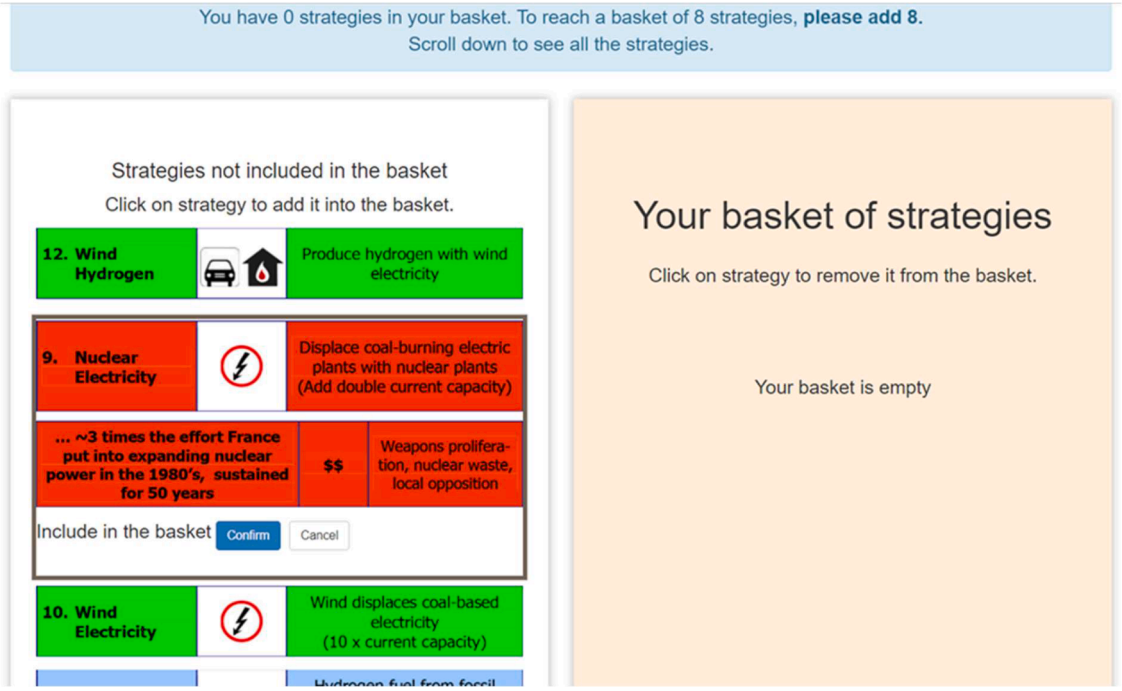

Fig. A2. In this screenshot, the user of the experimental application follows the selection technique The column in the left includes a list of strategies. The user has clicked "Nuclear Electricity" which has opened the box with grey outline containing information about the strategy. Next, the user needs to decide whether to include this strategy in the basket (the column on the right) or not.

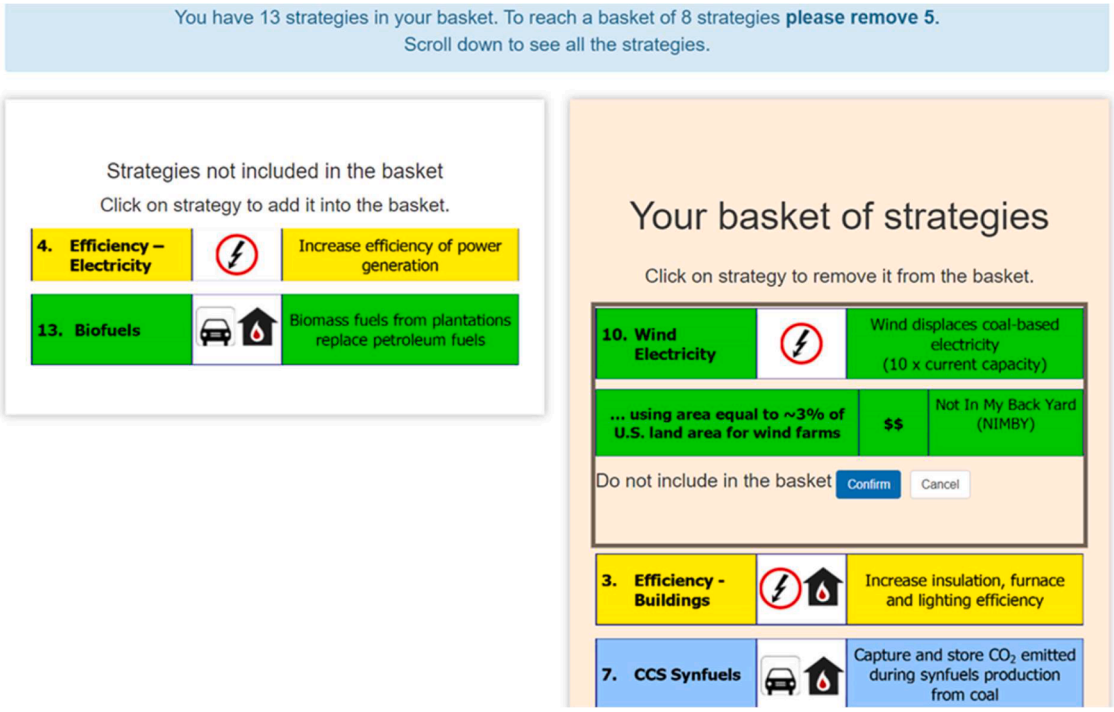

Fig. A3. Screenshot of the interface of a user following the elimination technique. The user has already eliminated two strategies from the basket and she still has to remove five more strategies to reach the desired number of eight strategies in her basket. On this screen the user is evaluating whether to eliminate the strategy "Wind Electricity".

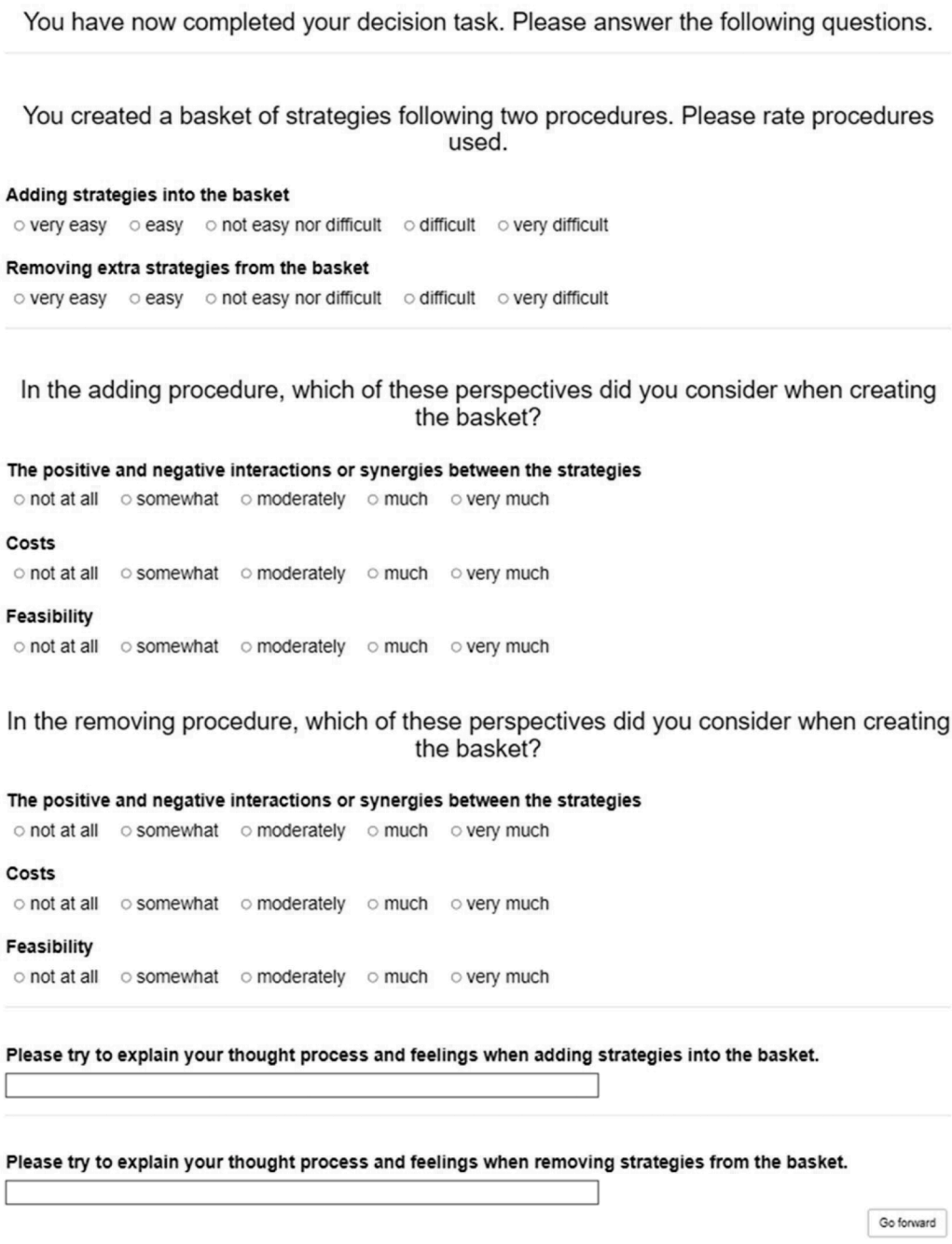

Fig. A4. Screenshot of the Questionnaire.

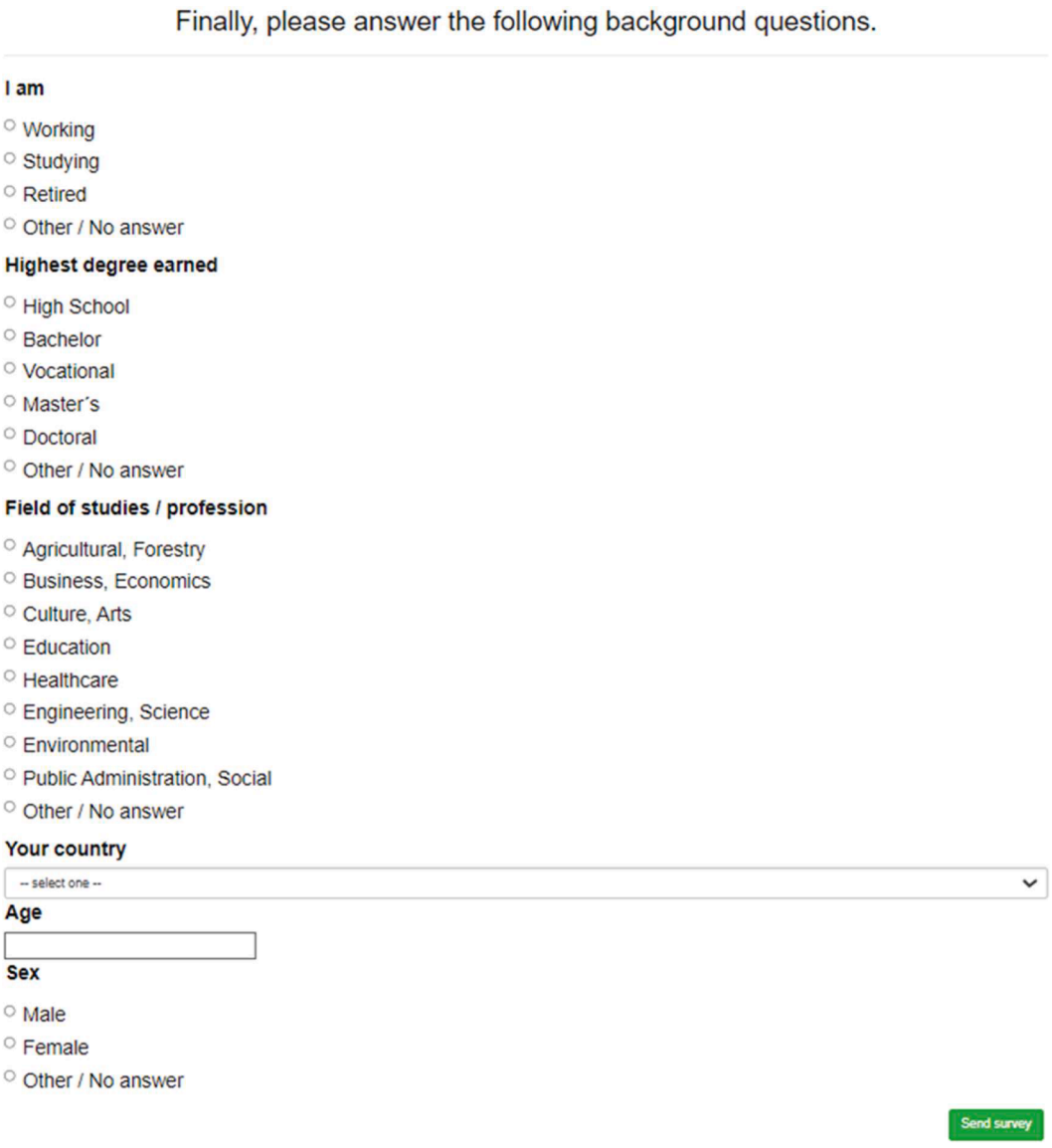

Fig. A4. (*continued*).

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