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DOI

[10.1016/j.erss.2021.101965](https://doi.org/10.1016/j.erss.2021.101965)

Publication date

2021

Document Version

Final published version

Published in

Energy Research and Social Science

Citation (APA)

Mouter, N., Shortall, R. M., Spruit, S. L., & Itten, A. V. (2021). Including young people, cutting time and producing useful outcomes: Participatory value evaluation as a new practice of public participation in the Dutch energy transition. *Energy Research and Social Science*, 75, Article 101965. <https://doi.org/10.1016/j.erss.2021.101965>

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Original research article

Including young people, cutting time and producing useful outcomes: Participatory value evaluation as a new practice of public participation in the Dutch energy transition

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ARTICLE INFO

Keywords:

Participatory Value Evaluation

Energy transition

Effective participation

Digital participation

Citizen preferences

Real-world experiment

ABSTRACT

To achieve a successful energy transition, it is vital to integrate citizens' needs into government policies through participatory processes. However, offline participatory approaches can be overly intensive which leads to an over-representation of citizens who think that the issue is in their immediate interest. Hence, elected officials often question the extent to which participants' priorities are a good proxy to represent "the public". Participatory Value Evaluation (PVE) potentially circumvents this by allowing a large and diverse group of citizens to advise their government in an accessible manner. In an online environment, citizens step into the shoes of a policy maker and see which policy options the government considers, while being informed about the impacts. Next, they are asked to provide advice. Because PVE was originally designed as an economic evaluation method, it is unclear whether it can be deployed for effective participation. This study investigates how PVE could be deployed for effective participation of citizens in the energy transition through a real-world experiment in the Netherlands. We aimed to conduct the PVE in line with goals of stakeholders which is the most important requirement for effective participation. We fully achieved three goals that were defined by stakeholders: PVE enables participation of people that normally do not participate (particularly young people); low time investment of civil servants; outcomes of a PVE should be useful for decision-making. We partly achieved two goals: PVE raises awareness among citizens about decisions and implications of the energy transition; participation should be meaningful for citizens.

1. Introduction

Space heating, hot water and cooking represent fundamental aspects of social life (e.g. entertaining guests) and seasonal cultural practices (e.g. wintertime cosiness) [1]. Even though the transition of heating systems (also known as the 'thermal energy transition'¹) is widely seen as essential to attaining low carbon societies, change is difficult to achieve. Many people remain reluctant to introduce low carbon technologies into their lives and homes, even where measures are demonstrably economically effective [2].

Electricity and mobility systems have gained increased policy attention, but thermal energy is a different story. Policymakers hide

behind long term climate goals and are reluctant to act unless decarbonisation of heating and cooking becomes a broad public concern [3–4]). Unsurprisingly, countries that today have high shares of renewables in heat supply have had active heat policies [5]. The Netherlands is an example of a country that has had a passive renewable strategy in recent decades, as the process has largely been dominated by regime actors² [6] who frequently resist low carbon transitions [7]. Wider issues of societal concern and niche actors have been neglected [3]. The thermal energy transition has only recently gained broad public attention, which has partly been caused by the increase in earthquakes, and resulting damage to private property, due to natural gas extraction in the Province of Groningen [8]. The severity of protest, claims for

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E-mail addresses: n.mouter@tudelft.nl (N. Mouter), r.m.shortall@tudelft.nl (R.M. Shortall), s.l.spruit@tudelft.nl (S.L. Spruit), a.v.itten@tudelft.nl (A.V. Itten).¹ The energy that comes from the temperature of the heated substance is called thermal energy.² Regime actors in Dutch energy transition platforms heavily favoured established, incumbent and regulated actors, such as business and commercial entities, industry associations and lobby groups (for example, large corporations in the business of producing and distributing energy and the building sector).

financial compensation and reports of wider social costs (e.g. anxiety, powerlessness, mistrust) served as an exogenous shock at the political level, creating pressures on the regime; and opening a window of opportunity for the diffusion of innovations [7]. This pressure resulted in an ambitious national strategy for ending the use of natural gas in households. The government's plan is to phase out natural gas from 6 to 7 million houses between 2030 and 2050, i.e. around 90% of private houses that are connected to the gas grid [9]. The national government ordered lower-tier governments such as municipalities to make Heat Transition Plans in which they need to specify how the thermal energy transition should take place in their jurisdiction.

This is a huge task. In the Netherlands, natural gas is the dominant fuel providing around 84% of heat in the residential sector. Only 4% of Dutch houses are connected to a district heat network and only 0.5% have a heat pump [9]. Potential adopters of sustainable heating face barriers including high up-front costs, regulations or lack of information. Further social and behavioural barriers might occur due to low trust, risk averseness, social comparison, and opinion dynamics [10].

Jansma et al. [11] further show that Dutch citizen's needs in the thermal energy transition vary greatly. Dutch homeowners are less positive than tenants about becoming natural gas free and have a stronger wish to be engaged in the transition. Hence, integrating the needs of citizens and homeowners into policy plans, such as the required Heat Transition Plans of municipalities, plays a key role and requires complementing existing processes of representative democracy with public participation [8,12–13]. The field of science and technology studies (STS) broadly distinguishes three rationales for including citizens in the design and evaluation of public policies: instrumental, substantive and normative [14–16].

Public participation exercises can be said to be motivated by an instrumental rationale when they aim to achieve a particular predefined end, for instance, increasing public support for a specific energy policy option or to restore public trust [17]. Securing public support for energy projects has been an important topic in the literature as many energy projects suffer from severe social opposition [18–19] and the lack of public support can lead to delays, escalating costs, and risk of failure for energy cases [20]. The active and participatory incorporation of diverse local actors into the planning process is crucial for deep and rapid thermal energy transitions [21]. Stadelmann-Steffen and Dermont [22] investigate how varying modes of a local community's political participation in local infrastructure projects affects local acceptance of such initiatives. They find that if local communities' political participation in such projects is limited to public engagement, it may not be enough to specifically foster acceptance of renewable energy projects, but when citizens are allowed to decide on the project in a popular vote, the authors observe an increase in support.

The substantive rationale for public participation suggests that involving citizens will actually lead to (substantively) better results, e.g. it improves the quality of the outcome of a decision-making process [23]. Public participation is widely acknowledged as an important means for bringing forward perspectives other than those of incumbents with vested interests in the status quo [24]. Cuppen [25] observes that new knowledge can emerge from participation processes that are initiated by governments, but also from settings in which participation is initiated by citizens who contest energy plans of the government. A review of 239 published cases of environmental decision-making that involved citizens found overwhelming evidence of participants 'improving decisions over the status quo' and 'adding new information, ideas, and analysis' [26]. Unlike that of the instrumental rationale, the outcome here is not defined beforehand as it is precisely the point that a better result will emerge through the process of public participation.

When citizen participation is driven by a normative rationale, it is seen as 'the right thing to do' [14]. Calls for participation are often driven by 'the democratic ideal' that citizens should have a say in (governmental) decisions regarding energy policies, as it will affect their lives and society in significant ways. For instance, Burke and Stephens

[24] argue that energy regimes should be democratically restructured, meaning that decisions are made by communities and citizens rather than by a few large corporations. In this case, it is the process rather than the result that is the focus of the participation exercise).

In practical applications, the three rationales are often interlinked and can therefore be hard to distinguish explicitly. For instance, the design of energy projects and policies often requires decision-makers to trade-off (competing) public values such as autonomy, affordability, fairness, sustainability and privacy [27–28]. It has been argued [29] that citizen participation can be an effective means to identify, understand, and prioritize among (competing) public values (substantive rationale). Others argue that collective policy production has not only the potential to optimise the implementation of technology, but also to activate households to engage in behavioural change [30]. Finally, various scholars argue that when policy makers and other stakeholders successfully embed public values in the design of energy projects this may increase public support [28,31].

Notwithstanding the demand, the rationales and the calls for new practices of public (digital) participation in social transitions, it is quite rare to see those calls translate into practice. Moreover, closer empirical examination of existing participatory processes in government decision-making on energy policies often disproves their expected benefits [32–33]. For instance, with regard to representativeness, a great number of public perspectives are often not included in future energy scenarios [32,34]. And where public views are depicted, they tend to emerge as imagined publics with little grounding in empirical analysis [32], merged as homogeneous wholes, like the 'public opinion' [35]. Problematically, imagined publics are typically not only imagined, but imagined in ways that explicitly diminish the value of participation initiatives, for example by characterising people as self-interested, uninformed and unrepresentative, or that they are a potential risk [36]. Such attitudes often result in engagement with the public because it ought to be, not because it could be beneficial.

Moreover, participation is demanding for citizens and stakeholders in terms of knowledge, capability, time, and resources [37]. This has the potential to lead to overrepresentation of citizens who either think that the issue is in their immediate interest, have a lot to gain by influencing decisions, have a lot of expertise or have a lot of spare time and/or enjoy speaking in public [37]. For instance, Hartmann [38] identified an overrepresentation of environmentally concerned individuals in conventional participation approaches and Hendriks [6] observes that women and younger citizens are often underrepresented. As decisions related to the energy transition require discussions on both, technical, political and juridical dimensions, they tend to be dominated by individuals with a high level of expertise [39], neglecting the opposing or supporting opinion of lay people [40–41], which are not incorporated in a significant way in policy plans [42]. This poses a challenge to participatory processes as they can easily be labelled as not being inclusive enough or meaningful enough for citizens [43]. On the other end of the spectrum, elected officials might question the extent to which participants and their priorities are a good proxy to represent 'the public' or only a narrow cross-section of their communities.

Participation methods in the thermal energy transition in the Netherlands have tended to face similar problems. The majority of them being overly intensive and/or only able to reach a motivated sub-set of residents to participate. For instance, in a recent report the Natural Gas Free Districts Programme, it was emphasized that organizing the participation and communication with residents turned out to be much more intensive than expected, and raised the question whether the costs are still acceptable [44].

The recently proposed Participatory Value Evaluation (PVE) method potentially circumvents the issues addressed above [45–46]. PVE is a web-based evaluation method which was originally designed for assessing the societal value ('aggregate utility') of government policy options through the participation of a large and diverse group of citizens. PVE has been applied in the context of a transport investment

scheme and a flood protection scheme and in both cases more than 2,000 people participated. The essence of a PVE is that citizens advise on a specific decision-making problem of a government in an easy-to-access manner. Citizens are basically put into the shoes of a policy maker. In an online environment, they see: 1) which policy options the government is considering; 2) the impacts of the options among which the government can choose and; 3) the constraint(s) that the government faces. Subsequently, citizens are asked to provide a recommendation to the government in terms of the policy options the government should choose, considering the constraint(s). Citizens are also asked to provide written motivations for each of the choices they made.

The obvious advantage of online participation is the low barrier to participation and increased efficiency or cost-effectiveness due to the fact that digital tools can operate regardless of time, location, jurisdictional boundaries or physical presence [47]. This can promote greater inclusion of citizens that may otherwise not attend participatory events. The main reason PVE reaches a larger and more diverse group of citizens is precisely this low entry barrier. Participants generally spend 20 to 30 min to submit their choice(s), and they can choose themselves when and where they conduct the PVE. Greater possibilities for inclusion may lead to better representation. Young people are far more likely to be represented in this way [48–49], due to their capability and willingness to engage online. In the energy transition, the use of digital tools for participation can ensure a diversity of participants [50].

An interesting feature of previous PVEs is that all relevant segments of the population were represented to a substantial extent [45–46]. Consequently, policy makers who commissioned these studies recognized that PVE holds the promise to ensure that the preferences of participants are a better reflection of the preferences of the general public than the outcomes of conventional (offline) participation methods. Since household perceptions do not always align with policy design, resulting in high-emitting habits that receive low policy attention [51], a PVE could ideally result in a greater match of thermal energy policy with citizens preferences.

Because PVE was originally designed as an economic evaluation method providing a viable alternative for the Cost-Benefit Analysis (CBA), previous studies focused on the technical details of the economic and econometric analysis [52], the conceptual differences between CBA and PVE in terms of valuing the impacts of public projects [45] and analysing whether the two methods rank public projects differently in terms of their societal value [46]. At present, it is unclear whether PVE can currently be considered as an effective method for participation, in spite of its promising characteristics. Deploying PVE for public participation and economic evaluation is distinctly different because involving citizens in the design and evaluation of public policies is a goal in itself rather than a means to compute the societal value of government policies. When the goal is to deploy PVE for public participation a minimum criterion is that it should facilitate a two-way flow of information between policy makers and citizens [53]. That is, a PVE enables policy makers to communicate a choice dilemma on which they want the advice of their citizens whilst providing access to transparent and balanced information about the impact of each policy. Subsequently, citizens communicate their advice to the policy makers and finally, policy makers communicate to the citizens how they used the advice. A minimum criterion for *effective* participation is that it fulfils the goals of all involved parties [54] as a participation process can easily lead to dissatisfaction when it is not meaningful for either citizens or government officials [53].

Since no studies have empirically investigated how PVE could be deployed for effective participation of citizens in general, and the thermal energy transition in particular, we conducted a real-world experiment together with the municipality of Utrecht in which we involved citizens in the design of the Heat Transition Plan. The primary research question we aim to answer in this paper is: “how can PVE be deployed for effective participation of citizens in the thermal energy transition of Utrecht.” A secondary question we aim to answer is “what

are the differences between deploying PVE for economic evaluation and participation”.

In this paper, we primarily seek to address three process issues in participation (intensiveness, representation, inclusiveness) because these are major issues that digital participation holds promise to ameliorate. Our study did not attempt to ameliorate other critical issues of public participation in energy transitions (e.g. lack of control of agenda, lack of influence, political manipulation, decision quality or inequity), as they are not always within the scope of a digital tool to address, rather, they relate to the broader decision-making process. Hence, we do not discuss these issues in the results section of our paper, but merely reflect on the extent to which PVE could ameliorate some of these issues in the discussion section. We also acknowledge that public participation in energy transitions not only covers policy making, but also financial participation, participating in community energy collectives, etc. but these are out of the scope of this article.

To answer these questions, we determined the goals that the PVE should achieve according to the main stakeholders: civil servants, politicians and citizens. Secondly, we designed the PVE in line with these goals. Finally, after conducting the PVE, we assessed the extent to which the defined goals were met and we established the differences between this PVE and previous PVEs that were deployed for economic evaluation in terms of its design process, the nature of the outcomes and the communication of the outcomes. Section 2 surveys the challenges of deploying economic evaluation methods for effective participation, section 3 presents the results of our study and section 4 provides conclusions and a discussion.

2. The challenges of deploying economic evaluation methods for effective participation

Until now, PVE has only been deployed as an economic evaluation method which aims to measure the social welfare effects of public projects. The theoretical foundations of PVE are rooted in welfare economics which is a branch of economics that investigates the social desirability of alternative economic outcomes [55]. In a PVE, participants are offered several possible public projects, information about the impacts of these projects and a constrained public budget in an (online) experiment [46]. Participants are asked to choose (a portfolio of) public projects they would like to see implemented while respecting the budget constraint. Participants also have the option to advise the government against implementing any of the projects and instead shift the budget to the next year. The choices of the participants in the PVE are analysed using the multiple discrete continuous extreme value (MDCEV) model [52] which estimates individuals' preferences for (the impacts of) government projects and the extent to which participants think that the earmarked public budget should be allocated to the proposed projects in the PVE. This information can be fed into a Cost-Benefit Analysis (CBA). However, the choices of participants in a PVE can also be directly used to estimate the social welfare effect of government projects and rank public projects in terms of their social desirability [50]. One reason why the two approaches to economic evaluation might provide different outcomes is that CBAs value impacts of government projects through observing people's past consumer choices (e.g. behavior in the housing market or choices regarding energy consumption), whereas PVE allows individuals to include normative ideas regarding their preferred *future* urban energy system [46]. In addition, PVE facilitates the participation of large groups of citizens in the design of public policies [46] which might raise participants' awareness concerning the dilemmas policy makers are faced with in making complex decisions, [45] and other skills and actions associated with energy citizenship such as the formation of new knowledge and literacy [56].

The design of a PVE to be deployed for economic evaluation is optimized for the purpose of measuring the social welfare effect of public policies. For instance, PVEs are designed using statistical techniques to ensure that choices of participants contain a maximum amount

of information on the weights assigned by participants to different policy impacts. A so-called ‘experimental design’ is generated by repeatedly drawing random values for each impact of the projects that are part of the PVE from a distribution [46]. The benefit of such an experimental design is that it allows the analyst to determine people’s sensitivity for impacts [45].

Public participation is generally considered as effective when it fulfils the goals of all involved parties [54]. To successfully achieve this objective, it is important to engage stakeholders to ensure that their goals are known, and the content of the economic evaluation aligns with their goals [57]. However, the literature suggests that it is not trivial to deploy economic evaluation methods such as CBA in a way that this minimum criterion for effective participation is satisfied. A CBA is generally not designed together with various stakeholders to meet their goals as the method adopts a technically-rational model which promises to produce value-free knowledge, and assumes a process in which scientific advice, grounded in a positivist epistemology, translates straightforwardly into the substance of policy [58]. Moreover, a separation of power is deemed to exist between neutral, authoritative experts and the decision makers they advise [59–60]. Haezendonck [61] also observes that CBAs are generally not designed in line with needs of stakeholders.

Several researchers investigated the extent to which CBA actually affects decision-making on transport projects by investigating the statistical relationship between results of CBA studies and political decisions on investments in transport infrastructure [62]. The broad picture is that these studies show that there is no significant statistical relation between CBA outcomes and political decisions. Furthermore, studies which interviewed politicians about how they use CBA establish that politicians tend to use CBA in an opportunistic or symbolic way and only in rare cases the outcomes of a CBA affect their judgments [63–64]. To circumvent the issues with regard to the effectiveness and meaningfulness of economic evaluation studies addressed above we substantially include stakeholders in the design of the PVE for the thermal energy transition of Utrecht and carefully check whether the process and the content of the PVE satisfied their goals.

3. Deploying PVE for effective participation in practice: The case of the thermal energy transition of Utrecht

To answer our research questions, we needed to find a municipality that wanted to host an experiment. It was not easy to convince a municipality to host such a real-life experiment, as conducting a PVE was seen as a political risk because it holds the promise to mobilize a large group of citizens which might curb the degree of policy discretion for elected officials. Hence, the only reason for our decision to conduct an experiment in Utrecht (and not in another city) was that this was the

only municipality that was interested in being the first municipality to apply PVE for consulting citizens on strategic choices in the thermal energy transition. In Utrecht, 110,000 homes are connected to natural gas, which have to be disconnected by 2050. The municipality has the ambitious goal of disconnecting 40,000 homes by 2030, with one neighbourhood (Overvecht-Noord) already chosen to be the first area to be free of natural gas.

The municipality facilitated the case study for three reasons. First, previous participation exercises were criticised by the municipal council for only facilitating the participation of ‘usual suspects’ and under-representing other segments of the population, especially young people. Second, civil servants found previous participation processes so time consuming that they resulted in participation fatigue. Third, civil servants wanted to raise awareness among citizens about the major decisions and implications of the thermal energy transition in their city. Because a PVE aims to mimic the real choice situation of a policy maker, which is informed by the impacts of the different options and the limitations that exist (e.g. limited budget or a binding target) participants can be made more aware of such issues as scarcity of public resources (not everything is possible) and difficult trade-offs within the alternative policy options. In this respect, a PVE differs greatly from a regular policy survey where participants usually respond to black and white propositions (do you agree with this proposition, yes or no), while having very little information on the impact of these choice options.

3.1. Designing the PVE together with stakeholders

To ensure that the PVE would satisfy the goals in terms of participation in the thermal energy transition we aimed to involve all important stakeholders in the design of the PVE through various workshops. The process is summarized in Table 1 and Fig. 1.

3.1.1. Kick-off meeting:

The essence of a PVE is to put citizens into the shoes of a policy maker. In a PVE, citizens are asked to provide a recommendation to the government in terms of the policy options the government should choose subject to the constraint(s) it faces. Hence, we started the design process by consulting policy makers about the policy options that the municipality was considering regarding the thermal energy transition. Participation goals were discussed and two additional goals were added, namely ‘participation in the PVE should be meaningful for participating citizens’ and ‘the PVE should provide useful information for decision-making on the thermal energy transition of Utrecht’. To ensure that the results of the PVE could be used for economic evaluation of policy options, two constraints that citizens should face when choosing between policy options were also defined as: 1) the sustainability goal of 22,000 households getting rid of gas by 2030; 2) choices must not

Table 1
Overview of the design process.

Date	Description	Stakeholder type (number)	Outcome
13-06-2019.	Kick-off meeting.	Civil servants [8]	- 5 goals of participation identified. - Decision problem defined. - 2 constraints identified. - 4 policy strategies identified.
02-07-2019.	Meeting with Alderman.	Alderman [1]	- Budget constraint removed from PVE. - PVE no longer suitable to measure societal value of policies.
17-07-2019.	Workshop.	Experts and stakeholders (e.g. energy companies, private consultants, representatives of non-profit housing association) [25]	- Visual design improvements to PVE tool. - ‘Custom strategy’ option added to PVE.
18-09-2019.	Workshop	Civil servants [20]	- PVE tool modified to provide varying levels of complexity of information to citizens.
04-10-2019 and 09-10-2019.	Workshops	Citizens [7]	- Improvements to instruction video. - More detail about consequence of individual options added to PVE tool.

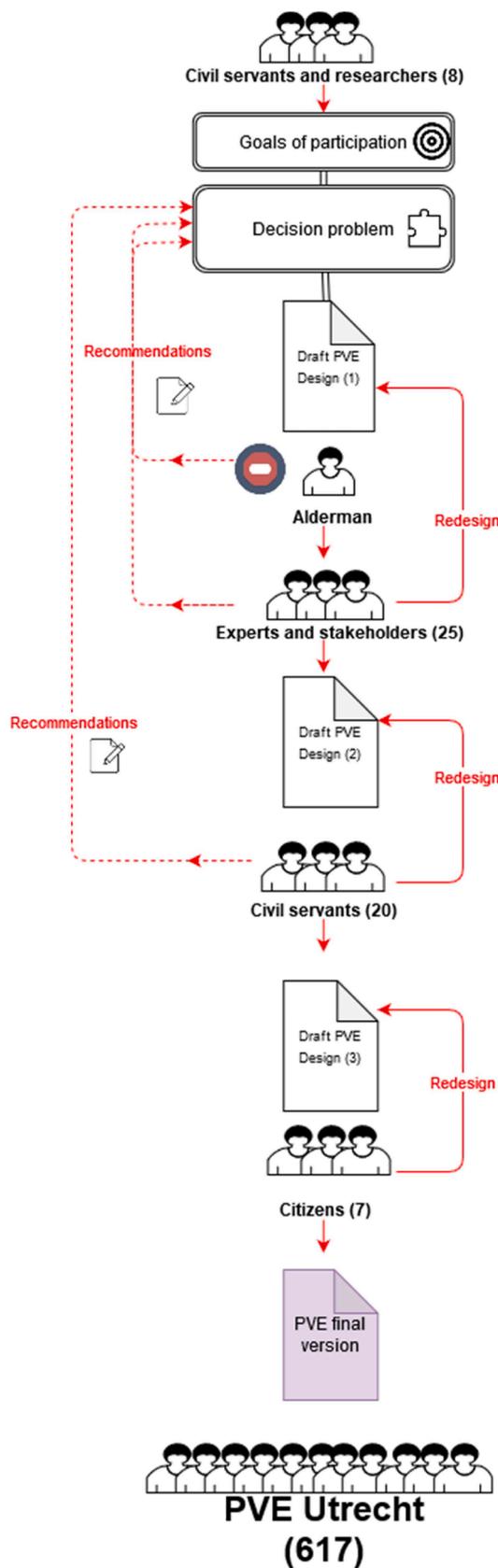


Fig. 1. Stages of the design process.

overshoot the government budget. The decision problem on which citizens should provide advice was defined as a strategic policy dilemma concerning the selection of areas which need to get rid of natural gas before 2030 and the government’s role in this process (e.g. top-down or laissez faire). The civil servants translated this decision-problem into a number of concrete policy options from which citizens could choose. Choice options ranged from highly expensive (allocation of entire budget) to cheaper options with the option to spend remaining budget on other policies (e.g. bike paths). Four possible strategies were proposed: 1) low cost strategy; 2) laissez faire strategy; 3) strategy that maximizes CO₂ reduction; 4) strategy which starts the thermal energy transition in the more affluent areas³ (henceforth we label these as strategies 1–4). After the workshop it was concluded that the proposed strategies could be seen as representations of four important values: affordability, freedom of choice, sustainability and fairness. A draft version of the webtool was drawn up based on these proposals.

3.1.2. Meeting with Alderman:

The draft PVE was discussed with the Alderman (the elected official responsible for political decision-making on the thermal energy strategy). The Alderman expressed concern that this draft PVE did not satisfy the goal *Usefulness*, and requested some changes. Her objections were as follows: 1) Giving citizens the option to spend the remaining budget on other public projects would create the expectation that the thermal energy transition would be entirely financed by public budget, leading to disappointment if citizens were required to partially finance their own installations; 2) Allowing citizens to allocate budget to other public policy projects unrelated to the energy transition was not appropriate when the main goal was to involve citizens in decision-making about the energy transition, and could eventually lead to biased choices by citizens.

The research team decided that citizens could no longer allocate public budget directly in the experiment, making the PVE results unsuitable for computing the societal value of public policies. Instead, participants would be informed that the government would allocate an earmarked public budget to ensure that 22,000 households get rid of natural gas before 2030. Next, participants would be presented with the four strategies that we determined in the kick-off meeting and would see that the public budget was sufficient to finance the low-cost option but insufficient to finance the other strategies. If participants, for instance, were to choose a more expensive strategy, they would see the private costs borne by citizens in the selected neighbourhoods, as well as other impacts (e.g. CO₂, nuisance, etc). Finally, participants in the PVE would be asked to express their preferences for the four strategies by allocating 100 points between them. This is the main difference from the previous PVEs that were deployed for economic evaluation in which participants expressed their preferences through the allocation of a constrained public budget.

3.1.3. Expert and stakeholder meeting:

We invited stakeholders who had an affinity with the thermal energy transition of Utrecht or a comparable city in the Netherlands. Experts completed the draft PVE and gave feedback. The majority of the feedback related to the *Goal Meaningfulness*. Stakeholders critiqued: 1) The visual design of the draft PVE and suggested it be improved to ensure ease of use for the citizens; 2) The absence of an option for citizens to suggest strategies themselves. Based on this feedback, it was decided to add a second part to the PVE with a ‘custom strategy’ option for citizens, once they had allocated the 100 points. Here citizens could create their own custom strategy by selecting neighbourhoods that should get rid of

³ The last strategy was added because an initial idea of the municipality regarding the thermal energy transition started in a relatively poor area (Overvecht-Noord) which was criticized for being unfair by inhabitants of this neighbourhood.

Box 1

. Goals agreed upon by stakeholders.

Stakeholder goals of facilitating participation through a PVE

1. *Goal Representation*: Better representation of people that normally do not participate (e.g. young people)
2. *Goal Lower Fatigue*: Lower participation fatigue policy makers
3. *Goal Awareness*: Awareness raising for citizens
4. *Goal Meaningfulness*: Meaningful participation for citizens
5. *Goal Usefulness*: Useful information for decision-making produced

natural gas and fulfil the sustainability goal as well as choosing whether the government would enforce a collective (often cheaper) strategy or allow a more costly but laissez faire approach in each of the neighbourhoods they selected.

3.1.4. Civil servant workshop:

We invited a wider variety of civil servants from the participation and energy department, the communication department and other domains. Workshop participants completed the draft PVE and provided feedback. Their critiques related to the *Goal Meaningfulness* and *Goal Usefulness*. The critiques were as follows: 1) The decision problem was too complex and should be simplified to ensure it was accessible to citizens of various education levels; 2) The decision problem should accurately grasp the complexity of the government's decision-making process in order to be useful.

This revealed two conflicting design requirements that we coined as the 'inclusiveness vs. complexity dilemma'. To alleviate this, we decided to communicate the information about the consequences of the four strategies in multiple layers. When participants click on a strategy, they would first see the most important information about the consequences of the strategy in the webtool. They could then click through if they wanted more detailed information. Hence, the experiment catered to both citizens that want to participate and receive simplified information and citizens that want information about the real-world complexity of the decision problem.

3.1.5. Citizen workshops:

Two workshops were held where a new version of the PVE, now including an instruction video, was discussed with seven residents of the municipality of Utrecht. The instruction video explained the exact goal and all the features of the PVE to participants. We started the workshops with a presentation of the design process so far including a discussion of the goals of the PVE. We asked citizens to provide feedback on the content of the PVE and we particularly asked them to reflect on our solutions for ameliorating the 'inclusiveness vs. complexity dilemma'. Participants in the first workshop critiqued the clarity of the instruction video and we adjusted the video accordingly. Moreover, these participants – who were all already actively involved in offline participation processes regarding the thermal energy transition of Utrecht – expressed concern about the extent to which the outcomes of the PVE would marginalize the importance of the outcomes of existing offline participation processes. In their view, the Alderman should not attach more importance to the input of layman citizens who would participate in the PVE than to the input of expert citizens who were involved in the offline processes. Civil servants that were present during this workshop reassured that this was not the purpose of the PVE. Based on this discussion we decided to ask participants in the PVE what the politicians should do with the results of the PVE compared with the advice that politicians received from experts in the thermal energy transition.

Participants in the second workshop were much more satisfied. They were pleased with the multi-layered way of presenting information in the PVE, but desired more detailed information about the consequences of different strategies.

3.1.6. PVE with citizens of Utrecht:

Based on the design process using the inputs of civil servants, experts, stakeholders and citizens, the PVE in its final version was launched online and conducted between November 2019 and March 2020. In total, 617 citizens of Utrecht took part. The data collection process is described in [Section 3.2](#).

3.2. Data collection

The PVE consisted of three steps. First, citizens were asked to allocate 100 points to the four strategies and to explain their choices. Second, they were asked whether or not they were willing to compose an 'own strategy'. Third, we asked follow-up questions regarding the socio-demographic characteristics, how they thought the government should use the results of the PVE and how they experienced participating in the PVE. A demonstration version of the PVE can be accessed via <https://burgerbegroting.tbm.tudelft.nl/onderzoek-utrecht-aardgasvrij> and an English language version can be accessed via <http://pve.splicedgene.com/onderzoek-utrecht-aardgasvrij-2>.

Participants of the PVE were recruited in three rounds. In the first round (November 2019) the residents' panel of Utrecht was invited to participate. In the second round (December 2019), residents were approached via social media (including a Facebook campaign) and advertisement on the website of the municipality. Participants could take part in the PVE via their desktop or smartphone. In the third round (March 2020) residents were approached via a panel bureau (Kantar Public). These residents received a small financial compensation for their participation. We asked Kantar Public to specifically approach low-educated Utrecht residents, because they were under-represented in the first two rounds and civil servants of the municipality found it important to have sufficient insights in the preferences of this part of the population. In the end, 617 participants fully completed the PVE.

3.3. Results

When PVE is deployed for economic evaluation the choices of participants are analysed using behavioural choice models which assume that participants aimed to select a portfolio of projects that in their view represents the portfolio which maximizes their 'utility' [46]. Preference parameters are estimated to determine the utility individuals derive from the impacts of the projects as well as utility individuals derive from a project irrespective of the level of the impacts included explicitly in the PVE. Based on this information the probability can be estimated that a project improves social welfare compared to shifting budget to the next

period and a second output of the welfare analysis in a PVE is the ranking of portfolios of projects in terms of their impact on social welfare [46].

As explained, we could not use the same econometric models for the analysis of the data of this PVE. Hence, we presented three types of results in a Dutch language report [65]: descriptive results, quantitative results and qualitative results. The main insight from the descriptive results was that the average age of the participants was relatively low. The number of respondents in the age group 26–35 years ($N = 88$) was higher than the number of respondents older than 65 years ($N = 55$). Moreover, we saw that the participants were relatively highly educated and people living in all neighbourhoods of Utrecht participated. More detail regarding the socio-demographics of the sample can be found in the Appendix.

We saw that participants allocated the most points (on average 35) to strategy 1: the ‘no increase in living costs’ approach and allocated approximately 20 points to the three strategies (in which they themselves would have to invest): 2) *laissez faire* strategy; 3) strategy that maximizes CO₂ reduction; 4) strategy which starts the thermal energy transition in the more affluent areas. We reweighed for the fact that some segments of the population were under-represented in our sample (older people and low-educated people), but this did not lead to different results. From the allocation of points, it appears that there are few participants who feel that just one of the approaches should be used. Most of the participants opt for a combination of the approaches because they feel that there are good elements in more than one of the approaches. This suggests that most of the participants feel that the four values that were integrated in the four strategies (affordability, freedom of choice, sustainability, and fairness) should be reflected to some extent in the Heat Transition Plan.

Through statistical analysis (ANOVA) we draw the following conclusions regarding the extent to which different sub-groups of the population differ in terms of their allocation of points (detailed results can be found in the Appendix): 1) no significant differences were found for income and gender; 2) Older individuals tend to allocate more points to strategy 1 and less to strategies 3 and 4. Supporters of globalist political parties (parties that have a relatively positive attitude towards supra national institutions such as the European Union) allocate significantly more points to strategy 3 and less points to strategies 1 and 4 than do supporters of the nationalist parties; 3) Right-wing voters allocate significantly more points to strategy 2 than left-wing voters; 4) Individuals with a higher education level tend to allocate less points to strategy 1 and more to strategy 3.

After allocating points to the four strategies, participants were asked to provide written explanations for the advice they gave in the experiment. Most of the arguments that residents mentioned can be labelled as substantive arguments (this is the best approach/most efficient approach), normative arguments (this is the fairest approach) and instrumental arguments (this approach can count on the most support). Moreover, our analysis revealed that participants had widely different perspectives about how the four strategies performed on these three dimensions. Firstly, participants had different views on the ‘efficiency’ of the different approaches. Some residents had high expectations about the efficiency of a communal approach by the municipality under ‘no increase in living costs’, while other participants thought that the ‘*laissez faire* strategy’ or the ‘start in the affluent areas strategy’ were the most efficient approaches. Secondly, we see that citizens of Utrecht have diverse perspectives and levels of support for the fairness of these three strategies. Some residents see the thermal energy transition as an exercise that will create a lot of stress and inconvenience, time-investment, and financial burdens. These residents think that the burdens of the heat transition will be greater than the benefits and think that “it would be fairer for residents in more prosperous neighbourhoods to bear these burdens” (strategy 4). Other residents see the thermal energy transition as a gift. According to them, the benefits are higher than the burdens. These residents feel that it would be more justifiable if the less well-off

residents can benefit from it first, and they propose that the heat transition should start in the less well-off neighbourhoods. These participants were very negative about strategy 4.

We verified whether some of the arguments listed above were mentioned predominantly by respondents with a specific set of characteristics. We found that the argument that the ‘start in the affluent areas strategy’ would be the most efficient approach for the thermal energy transition was particularly raised by females who voted on the Green Party or the Social Liberals (D66). These females are of the opinion that for these three reasons the heat transition can be started more quickly in well-off neighbourhoods. In their view, this can improve efficiency because a smooth start ensures that experiences can be gained quickly which can then be applied in the other (less well-off) neighbourhoods. They mention three reasons for why they think that starting in the affluent areas will safeguard a smooth start of the thermal energy transition: 1) affluent residents have a greater financial capacity and are better able to absorb any financial setbacks. Poorer residents who experience financial setbacks are more likely to show resistance; 2) affluent residents have a higher level of education and may be easier to convince of the usefulness of the heat transition and they are better able to make individual or collective choices for the long term. This is much more difficult for residents of poor neighbourhoods who are struggling to make ends meet. Even if the heat transition of their home provides clear financial benefits, people often cannot cope with the mental load (stress, hassle and regulation); 3) residents in well-off neighbourhoods have relatively sustainable attitudes and will therefore be more open to the heat transition.

As we observed that citizens agree that values such as affordability/efficiency and fairness should be embedded in the Heat Transition Plan, but have differing views in terms of how these values can be achieved, we recommended the municipality to adopt an adaptive approach to the heat transition project, by splitting the decision making into two or more phases. In the first phase, different approaches can be tested, providing more certainty on questions such as “which approach is the most efficient?” and “which approach has the most support?”. These experiences can then be used when making decisions in the second phase.

After allocating the points to the four strategies and explaining their choices, participants were enabled to put together their own strategy for the thermal energy transition. 67 participants (12%) used this option. We investigated whether the socio-demographic characteristics of the participants who decided to put together their own strategy for the thermal energy transition differed from the participants that decided not to use this option and found no significant differences. Half of the participants who composed an own strategy advised that their own neighbourhood should get rid of natural gas and the other half advised against phasing out of natural gas in their own neighbourhood.

Finally, participants were asked what the politicians should do with the results of the PVE compared with the advice that politicians received from experts in the thermal energy transition. A minority of the participants (9%) thought that policy makers should only follow the advice given by local residents in the PVE and 10% thought that the outcomes of the PVE should have a heavier weighting in the municipality’s decision-making than the advice given by experts. Contrarily, 4% said of the participants said that the advice of citizens should have no role at all and 32% believe that the expert advice should weigh heavier than the advice of citizens. Finally, 45% of the participants felt that the municipality should give both types of advice equal weighting. Hence, a large share of the residents think that it is important to be involved in the municipality’s decision-making process, but at the same time they think that their opinion should only have a modest role in the final decision. People from Utrecht with a lower education thought that there should be a relatively higher value attached to the advice of the residents than the higher educated residents do.

Participants in favour of residents having a more important voice than experts in the municipality’s decision predominantly cited the substantive argument in their answers. Many citizens seem to believe

that experts can overlook important practical points as they take theory as a starting point. One participant clearly illustrates that he thought that adding knowledge of residents to the process adds value: “Experts don’t have parents of 90 years who already have hypertension at the idea of replacing single with double glazing. Even experts don’t know what the price of energy will be in 2030. Experts have their own preoccupations and don’t always agree with each other. They underestimate or overestimate technological developments and often ignore the soft side of the energy transition. Residents are more expert than often thought and often take a more holistic view”. The participants who suggested that experts should have a more important say in the decision than the residents used the argument that they, themselves, (or other residents who have participated) have insufficient knowledge to be able to give a well-informed opinion.

3.4. Communication of the outcomes of the PVE

As said, we aimed to design our PVE according to the principle of a two-way government citizen-communication. More specifically: PVE should enable policy makers to communicate a choice dilemma to their citizens. Citizens communicate their advice to the policy makers by giving their preferences and by providing written motivations. Moreover, citizens are asked how the results should be used alongside recommendations of experts. Finally, policy makers communicate to the citizens how they used the advice. The Alderman wrote a note to the citizens on what she had learned from the results. This note was sent to the PVE participants and also included in the Dutch language report (65, P. 80). First, the Alderman explained what she had learned with regard to the application of the methodology: 1) PVE has given the municipality an innovative way to consult more groups than before, i.e. particularly a younger target group 2) A benefit of the method is that participants have a lot of space for comments and explaining their answers; 3) PVE is not equally accessible to all target groups. Some residents prefer (offline) meetings in which they can ask questions and exchange knowledge. The municipality therefore continues to consult residents in various ways. Secondly, the Alderman reflected on substantive lessons that she learned: “The results of the experiment help to make a better Heat Transition Plan. Fairness and affordability have often been mentioned as arguments for determining where we start with the natural gas-free transition. Residents appear to think differently about what is fair. Affordability is and remains an important starting point for the transition plan. The various insights from the PVE confirm that we should not only look at the lowest social and individual costs, but also take other criteria into account in our considerations. In the Heat Transition Plan, we will clearly indicate how we arrived at choices and how we have taken various arguments into account. The researchers also note that the energy transition will involve many uncertainties. In their report, they therefore recommend that the choice of alternatives should remain flexible

Table 2
Overview of the design process.

Goal	Descriptive data of PVE	Questions in the PVE survey	Interviews with civil servants
1) Goal Representation: Allows participation of people that normally do not participate (particularly young people)	X		X
2) Goal Low Fatigue: Low time investment for civil servants			X
3) Goal Awareness: Raise awareness among citizens		X	
4) Goal Meaningfulness: Participation should be meaningful for citizens		X	
5) Goal Usefulness: PVE should provide useful information for decision-making			X

which endorses the approach adopted by the Municipality of Utrecht.” Apart from a note from the Alderman to the citizens, a presentation about the research project was given for the municipal council and interested citizens.

3.5. Experiences of citizens and policy makers

To establish whether PVE constitutes an effective participation exercise, we need to assess whether the five goals defined by the stakeholders were met. Table 2 shows which method we used to establish whether a certain goal was achieved. The descriptive data showed that young people were well represented in the PVE which suggests that the first goal was met.

To evaluate whether Goal Awareness and Goal Meaningfulness were met, we asked participants to respond to several propositions (see Fig. 2) and we asked open questions to reflect on the strengths and weaknesses of the method. Fig. 2 shows that 60% of the participants felt that they learned more about the choices the municipality has to make regarding the natural gas freeing of homes through participating in the experiment, whereas 20% disagreed with this proposition. Based on this result we can conclude that for most of the participants Goal Awareness was achieved.

Moreover, when we looked at qualitative statements of participants, we saw that there was a large group of participants who argued that their participation in the PVE has made them more aware of the complex choices the municipality has to make. Participants appreciate the fact that in the PVE, the municipality displays them the dilemmas it faces. Below we list illustrative quotes from particularly younger citizens of Utrecht:

“It’s great that you get a glimpse into all the considerations involved in the decision-making process! Gives a more nuanced picture, which is nevertheless communicated powerfully and concisely.” (Male, 26–35 years)

“It gives a good overview of the dilemmas the municipality faces and the scale of the challenge.” (Female, 26–35 years)

“The map and a lot of data make it clear and at the same time you can choose how much information you want. I’ve really learned something about the various options the municipality stands for, and it provides fruit for thought for me as a resident”. (Female, 36–45 years)

We included two propositions to assess whether participation in the PVE was meaningful for citizens. 55% of the participants thought that PVE is a good method for involving residents in this subject (16% thought that PVE is not a good method for this subject). 68% of the participants thought that the municipality should use PVE more often, and 10% thought that this is not a good idea. Participants who are not highly educated are generally more positive about using PVE for involving them in policy decisions. Based on this result we can conclude that for most of the participants Goal Meaningfulness was achieved.

Two key strengths of PVE that stand-out in the comments of the participants which relate to meaningfulness are the complexity of the choice situation and the possibility to express a nuanced opinion. See below several statements of participants that reflect their appreciation of the first two strengths.

“This was the first time that I was asked my opinion in a complex, interactive way and I really like this! I have the feeling that the subject matter is explained concisely and yet comprehensively”. (Male, 46–55 years)

“You have to think about it and by seeing the information in the film and answering the questions you become a bit more expert on a subject. I do feel like a “consulted citizen of Utrecht” now, because of this way of working.” (Male, 46–55 years)

“A lot of information was given on how each method would be set up. So you can give a more substantiated opinion. This is good because

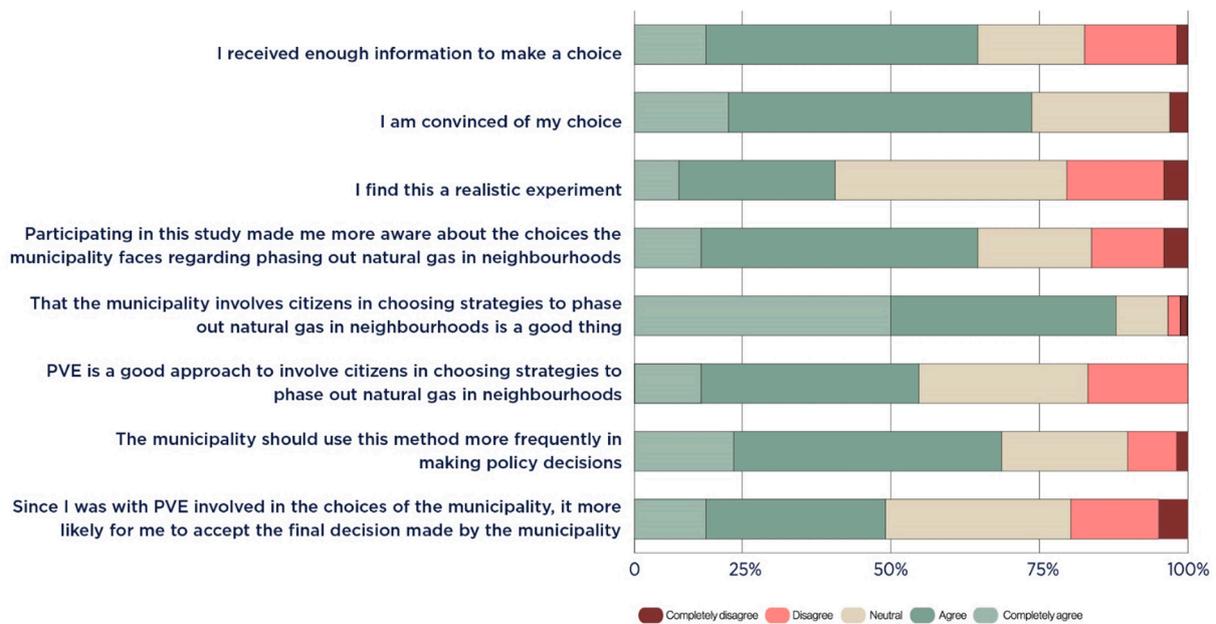


Fig. 2. Responses of 617 participants to different propositions.

only responding with your 'gut feeling' has, in my opinion, very limited value." (Male 36–45 years)

"This approach can collect good ideas as it contains a lot of open questions, which makes it possible to really measure what our motives and preferences are, without being oversimplified in multiple choice questions". (Male 26–35 years).

Moreover, Fig. 2 shows that most of the respondents were convinced of their choice and found that they received enough information to make a choice. Finally, Fig. 2 reveals that half of the respondents thought that it was more likely for them to accept the final decision made by the municipality due to the possibility to participate in the PVE. Increasing acceptance of the final decision was not explicitly mentioned by participants in the design process as a goal of the PVE, but we included this proposition as it relates to the instrumental rationale of organizing public participation.

We also checked the comments of participants that were negative about the experiment. The lion's share of negative comments concerns the following: participants find it problematic that in the PVE it is assumed that the heat transition will take place via the freeing of neighbourhoods from natural gas, yet they cannot indicate a disagreement with this approach. Hence, the experiment was not meaningful for citizens that contest the plan of the municipality to make 22,000 homes natural gas-free before 2030. A relatively small number of participants thought that the experiment was too complex, but on the other hand there were participants who thought that the experiment did not sufficiently grasp the complexity of the thermal energy transition. Apart from heterogeneity with regard to the desired complexity of the choice task, we also saw heterogeneity with regard to participating online and offline. Particularly, older participants seemed to have a strong preference for participating offline or complementing online and offline approaches.

To check whether *Goals Representation*, *Lower Fatigue* and *Usefulness* were achieved we interviewed two civil servants of the municipality that were involved in the design of the PVE and communication with the Alderman and one member of the municipal council. Both the member of the municipal council and the civil servants endorsed that the PVE allowed citizens to participate that normally do not attend offline participatory approaches such as town-hall meetings. All three respondents recognized that a PVE rectified the problem that offline participation approaches can easily be dominated by noisy individuals.

The council member perceived that 4 out of 5 citizens who attend town-hall meetings are protesters. In his view, supporters do not have a lot to gain from attending these meetings because for them, the proposed policies are already heading in the right direction. Protesters on the other hand see these occasions as a last chance to urge the council to steer into a different direction. The council member observes that only outspoken supporters dare to attend these meetings and raise their voices. In his view, a positive feature of PVE is its anonymity which provides a safe environment for supporters as well as people with a nuanced opinion to transmit their preferences to the council. The civil servants stated that noisy individuals can intimidate other citizens and they stressed that this problem is absent in a PVE.

In the interview with the civil servants, we asked them to compare their time investment in the PVE with that of conventional participation approaches. The civil servants asserted that time investments per participant were extremely low in a PVE compared to conventional participation processes. They argued that organizing an offline meeting is very time intensive as a team of several people is generally charged with multiple tasks: coordinating with the location, preparing a program, briefing the moderators, moderating the meeting and writing down the minutes of the meeting. These are all activities that are not needed in the preparation of the PVE. We also asked the civil servants about their time investments of the PVE, since they had to gather information for each strategy (e.g. the CO₂ reductions for the strategies presented to the participants). The civil servants emphasized that these are all activities they had to do anyhow; hence little extra time investment was needed.

Thirdly, we asked the respondents whether the PVE provided useful information for decision-making. The civil servants said that the most relevant insight for them was that preferences of the large group of participants in the PVE aligned well with the (heterogeneity of) preferences of the citizens that were already in contact with the municipality prior to the PVE. The council member said that the outcomes of the PVE confirmed his prior beliefs. He also found it useful that the PVE produced a lot of qualitative information which allowed him to gain insights into the underlying motivations of citizens that drive their preferences. Moreover, the civil servants argued that one of the most important insights from the PVE was that various participants contested the plan of the municipality to make 22,000 homes natural gas-free before 2030. They learned that it is important to start with explaining the underlying

rationale of this ambition in the communication with citizens that are not yet well-acquainted with it, instead of directly jumping into a discussion about different alternatives to implement the ambition. One of the civil servants said that as a policy maker one can get easily locked into a sort of tunnel vision and due to the PVE they realized that it was important to start the narrative to the citizens with explaining the merits of the thermal energy transition as well as the broader policy context (e.g. the thermal energy transition takes place alongside the energy transition in electricity, industry and mobility systems). At the end of the interview, the civil servants emphasized that they liked the fact that designing the PVE forced them to think in terms of trade-offs that have to be made in the thermal energy transition, whereas prior to the PVE they were more prone to think about criteria that all have to be satisfied. In their view, it was good to make the trade-offs that eventually have to be made explicit in an earlier stage of the planning process.

4. Conclusions and discussion

The key purpose of our paper was to investigate how PVE can be deployed for effective participation in the thermal energy transition of Utrecht. To achieve this goal we aimed to design and conduct the PVE in line with the two minimum requirements for effective participation: 1) PVE should facilitate a two-way flow of information between policy makers and citizens; 2) PVE fulfils the goals of stakeholders.

A first conclusion we can draw is that we successfully designed our PVE according to the principle of a two-way government citizen-communication. More specifically, PVE enabled policy makers to communicate a choice dilemma to their citizens. Subsequently, citizens communicated their advice to the policy makers by expressing their preferences and by providing written motivations. Moreover, citizens were asked how the results should be used alongside recommendations of experts. Finally, the Alderman communicated to the citizens how the advice was used and the municipality organized a session in which citizens could reflect on the results of the PVE and the conclusions of the Alderman. We found it interesting that a minority of the participants thought that the advice of citizens should receive higher weight in the decision-making process than the advice of experts. Apparently, many citizens want a type of participation which is somewhere between pure forms of direct democracy (citizens directly choose the policy and the government executes it) and representative democracy (citizens elect representatives of the people and these representatives choose the policy). These citizens would like to be involved in specific subjects but wish for other sources (such as experts) to be taken into account in the final choice of the elected officials.

We partly succeeded in deploying PVE for *effective* participation as we met most of the goals of stakeholders. In five workshops with citizens, civil servants and experts, we identified that the PVE should meet five goals: 1) it should enable participation of citizens that normally do not participate (e.g. young people); 2) time investment of civil servants should be lower than in offline participation approaches; 3) it should raise awareness among citizens about the major decisions and implications of the thermal energy transition; 4) participation should be meaningful for citizens; 5) outcomes of a PVE should be useful for decision-making on thermal energy transition. We conclude that *Goals Representation*, *Low Fatigue* and *Usefulness* were fully met, whereas *Goals Awareness* and *Meaningfulness* only partially. We see that 60% of participants felt that they learned more about the choices the municipality has to make regarding the natural gas-freeing of homes through participating in the experiment (*Goal Awareness*) and 55% of the participants thought that PVE is a good method for involving residents on this subject (*Goal Meaningfulness*). However, 20% of the participants said that they did not learn from participating in the experiment and 16% thought that PVE was not a good method for participation in the thermal energy transition. It is noteworthy to highlight that in the workshops in which the PVE was designed, the *Goal Meaningfulness* was not only

mentioned by citizens, but also by various civil servants. This suggests that in this context civil servants were genuinely attempting to allow citizens to express their preference instead of merely consulting citizens to push through existing ideas.

We learned that those citizens who negatively evaluated meaningfulness of the PVE disliked the assumption that it was taken for granted that the heat transition will take place via the natural gas-freeing of 22,000 homes before 2030. Hence, the PVE did not enable these residents to express a different opinion. With the benefit of hindsight, we could have made the PVE more meaningful for this group of participants by integrating a strategy in which carbonisation reduction would be realized through a different strategy or a status quo option. However, this design adjustment would conflict with *Goal Usefulness*. The Dutch national government ordered the city of Utrecht to make a Heat Transition Plan resulting in gas-freeing of 22,000 homes by 2030 and allowing citizens to express preferences that are not aligned with this goal might make the PVE less relevant for the municipality. Palett et al. [66] observed a similar tension between tight framing of government-led participatory processes which stems in part from participatory processes feeding into a clear and specific governmental decision and the desire of some part of the citizenry to propose alternative solutions that are deemed by policy makers as 'out of scope'. For instance, they survey a case where participating citizens do not find the process meaningful as they reject the government's set target or argue that setting targets is not a useful course of action whatsoever. One thing that could be improved in further applications of PVE for public participation is to include a more heterogeneous group of citizens in the design process of the PVE to ensure that the researchers who design the PVE are aware of alternative framings or understandings of the issue [66]. The citizens involved in the workshops all had a positive attitude towards the thermal energy transition and the above-mentioned tension would then be illuminated at an early stage when also citizens with a negative attitude toward government ambitions participated in the design workshops. In addition, it would have been better to conduct a PVE at an even earlier stage of the policy cycle before the fundamental decisions concerning the thermal energy transition were made at a national level.

The PVE that was conducted in this study perhaps best aligns with the public debate model introduced by Callon [67] in the sense that academics structure the problem together with civil servants leaving ample room for citizens to bring in new arguments, to introduce new policy options (citizens had the opportunity to create a custom strategy), to weigh policy options and to recommend on the extent to which citizen input should be weighed against the input of experts. An avenue for further research would be to explore the merits of pushing PVE more towards the co-production of knowledge model [67] by giving citizens a prominent role in the first stages of the design process of a PVE where the discussion takes place about which policy options should be included in the experiment. Perhaps, mobilizing the creative potential of citizens in this stage will result in the addition of policy options to a PVE that are conceived as meaningful by both citizens and policy makers. Indeed, Schot et al. [68] illustrate that citizens, can come-up with innovative solutions that are not on the radar of policy makers. We hypothesize that involving citizens in the early stages of the design process of a PVE also improves the extent to which PVE irons out other issues of public participation in energy transitions examples being lack of control of the political agenda and lack of influence.

Another issue that we faced during the design of the PVE – also reflected in the comments of the participants – is heterogeneity in preferences toward the complexity of the experiment. Some participants were happy with the relatively high complexity compared to conventional opinion polls, some participants found it too complex and others found that the PVE did not do justice to the complexity of the thermal energy transition. We saw that presenting information in a multi-layered way might alleviate the issue and recommend further research to ensure that the design of PVEs is tailored to the needs of citizens that either wish only to receive simplified information or want to give advice while being

informed about the real-world complexity of the thermal energy transition. Furthermore, integrating opportunities for deliberation into the PVE webtool could help deal with the above-mentioned issues since it lends itself well to complex policy environments where taking a societal rather than individual perspective is required [69], allowing diverse viewpoints to be exchanged and encouraging citizen learning on complex issues [70]. A key limitation of our study is that we investigated how PVE can be deployed for effective participation in the energy transition through a single case study. The same question should be studied in other contexts (e.g. other countries other policies) to determine the generalizability of our results [71]. We hope that our research inspires others to replicate our study in other contexts or to conduct more refined and more ambitious projects.

A secondary question that we aimed to answer was “what are the differences between deploying PVE for economic evaluation and participation”. Unlike using it for an economic valuation, a PVE deployed for effective participation should satisfy goals of a broad range of stakeholders. When PVE is deployed for economic evaluation, it produces information about individuals’ preferences for (the impacts of) government policies which can be used to rank government projects in terms of their desirability. Such information could not be obtained from the current PVE due to amendments that were made in the design of the PVE to ensure that it aligned with goals of stakeholders. A downside of deploying PVE for participation is that the researchers need to invest additional time in the design process to elicit the goals of stakeholders and align the PVE with these goals. However, our research suggests that the PVE deployed for the thermal energy transition of Utrecht had several benefits and further research may investigate whether similar benefits are realized when stakeholders’ goals are not considered in the design of the PVE. A first benefit of the PVE was that the Alderman learned via outcomes that there is heterogeneity among residents concerning the perceived fairness of strategies for the thermal energy transition. Moreover, civil servants learned that it is important to start with explaining the underlying rationale of the Heat Transition Plan in the communication with citizens that are not yet well-acquainted with it. In addition, civil servants emphasized that designing the PVE forced them to think about the trade-offs that eventually have to be made early on in the planning process of the thermal energy transition. Both the Alderman and the civil servants agreed that the greatest virtue of PVE was that it allowed the municipality to include a more diverse range of citizens than before, especially younger citizens. In the context of this study, policy-makers were reassured to discover that preferences of the large group of citizens who participated in the PVE seemed well aligned with the preferences of citizens with whom the municipality had already spoken offline prior to the PVE. This gave policy makers a comfortable feeling as the PVE seemed to provide an affirmative answer to the question of whether the small group of citizens who already participated in conventional (offline) processes represents ‘the general public’.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank two anonymous reviewers for their valuable comments. Niek Mouter and Ruth Shortall acknowledge funding from the Netherlands Organisation For Scientific Research (NWO) Grant “Participatory Value Evaluation: a new assessment model for promoting social acceptance of sustainable energy project” (313-99-333). Researcher Spruit acknowledges funding from the Netherlands Organisation For Scientific Research (NWO) Grant RESponsible innovation: linking formal and informal assessment in decisionmaking on Energy projects (RESPONSE) (313-99-303). Anatol Itten and Niek Mouter

acknowledge funding from the Interreg 2 Seas Sustainable Heating: implementation of fossil-free technologies (SHIFT) program. We acknowledge the contribution of the civil servants, experts and citizens who participated in the workshop in which we designed the PVE as well as the politicians and civil servants who facilitated this real-life experiment. We would like to thank Marion Collewet, Jose Ignacio Hernandez, Annie Chen and Paul Koster for their assistance during the design of the experiment and the analysis of the results. We would like to thank Perry Borst for the development of the software.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.erss.2021.101965>.

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