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Willingness to pay for green electricity: a review of the contingent valuation literature and its sources of error"

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Leon A.G. Oerlemans[a,b], Kai-Ying A. Chan[a,*], and Jako Volschenk[c]

[a] Department of Engineering and Technology Management, Graduate School of Technology Management, University of Pretoria, Lynnwood Road, Pretoria 0002, RSA.

[b] Department of Organisation Studies and Center for Innovation Research, Tilburg University, 2 Warandelaan, 5037 AB Tilburg, The Netherlands.

[c] University of Stellenbosch Business School, Carl Cronjé Drive, Bellville, Cape Town 7530, RSA.

Abstract

Contingent valuation is widely used due to its flexibility in valuing a wide variety of non-market goods. Although this method has important benefits, its validity and reliability are often criticised. This paper reviews the literature on the use of contingent valuation for measuring willingness to pay (WTP) for electricity generated from renewable energy sources (green electricity). A literature review, conducted on a sample of 51 peer-reviewed studies, shows that the vast majority of contingent evaluation studies stems from developed economies. Furthermore, most frequently used WTP elicitation techniques are open-ended and dichotomous choice approaches, which tend to produce varying levels of WTP. Studies dealing with the antecedents of WTP are predominantly inspired by the theory of reasoned action or by its extension, the theory of planned behaviour. This paper identifies five common errors in contingent valuation methods and discusses a number of remedies to deal with these errors in WTP research.

Keywords: Contingent valuation method; willingness to pay; green electricity; elicitation techniques

[*] Corresponding author: Department of Engineering and Technology Management, Graduate School of Technology Management, University of Pretoria, Hatfield, Pretoria 0002, South Africa. Tel: +27 12 420 5070. Fax: +27 12 362 5307. Email address: alice.chan@up.ac.za.

1. Introduction

This paper provides the results of a literature review of the frequently used contingent valuation method and its sources of error in the context of willingness to pay (WTP) for green electricity. There is an increasing number of recently published studies that focus on people's WTP for certain (public) goods in general and for "green" goods in particular. For example, between 2000 and 2013[1], the number of studies with "willingness to pay" in the title increased by about 250%. A large proportion of WTP studies used the so-called contingent valuation method to determine certain economic characteristics of the goods or services under study. Sundt and Rehdanz [77], for instance, reported that almost two-third applied this valuation method in a sample of studies published between 2000 and 2011.

The contingent valuation method estimates standard economic values such as willingness to accept or to pay using responses to survey questions. The contingent valuation method is part of a wider family of approaches labelled as stated preference methods. The latter methods build on actors' responses to questions about changes in the quality of goods. Because a researcher designed the questions about the characteristics of the goods, the changes investigated are often hypothetical.

The contingent valuation method attracted lively academic debate between opponents and proponents. Some opposing scholars [1] even argued that the contingent valuation method developed from "dubious to hopeless". They conclude (also see: [2]) that the contingent valuation method has a number of serious problems, making "the resulting data useless for serious analysis" [1]: pp.43. In this debate, the focus is predominantly on three problems. The first is hypothetical bias, where what people say is different to what they do. Consequently, WTP values are often (very) different from what is called the "true" economic price. The second problem is the gap between what actors are willing to pay and what they are willing to accept. It is argued that economic theory predicts that both values should be the same. Because many empirical studies find differing values, this is regarded as a serious flaw of the contingent valuation method. The third problem is the scope or embeddedness problem, which implies that WTP values for the same goods vary depending on whether the goods are valued separately or as a part of a more inclusive package.

This paper reviews the contingent valuation literature dealing with WTP for green electricity by sampling a number of studies, showing that the contingent valuation method is

[1] *Google Scholar reports (in July 2014) that in 2000, about 5 000 publications have "willingness to pay" in their title. In 2013, this number had grown to 17 600.*

plagued by a wider range of errors than merely the three identified above. These errors are identified and described and, where appropriate and possible, remedies are suggested. In this review, the focus is especially on elicitation techniques. These are an understudied potential source of error on the one hand, while they have high practical relevance on the other, as they are the actual means whereby WTP data is collected, thus informing policy makers and practitioners. Furthermore, the paper investigates what the contingent valuation literature regards as the main explanatory factors that influence WTP for green electricity. Combined, it provides the opportunity to reach the three main objectives of this paper. These objectives are to provide a state-of-the-art review of contingent valuation literature; an overview of the possible errors in contingent valuation studies, which result in varying WTP estimates, together with their remedies. Thirdly, it wishes to provide an overview of antecedents of WTP in contingent valuation studies, which helps one explore to what extent a general theoretical framework can be traced in these studies. More broadly, the researchers concur with Haab, Interis, Petrolia and Whitehead [3]: pp.608, who stated: "The time has come to move beyond endless debates that seek to discredit contingent valuation and to focus instead on making it better." This statement voices the overall aim of this study.

This paper builds on and extends the work of other scholars who have assessed the contingent valuation method. In this regard, one can refer to studies by Diamond and Hausman [4], Hanemann [5], Carson, Flores and Meade [6] and Carson [7]. These studies are updated with the latest insights from literature, adding a special focus on elicitation issues. The results of this review of contingent valuation literature can be relevant to scholars and practitioners interested in WTP for green electricity, applying the contingent valuation method, as it helps them to quickly identify major caveats and ways to avoid or mitigate them.

The remainder of this paper is structured as follows: Section 2 briefly discusses a definition of green electricity and why it is an interesting good from an economic theory point of view. Furthermore, this section introduces the main methods used to economically value environmental (public) goods. Next, contingent valuation literature is reviewed and a number of its characteristics identified. Additionally, those antecedents are explored that are often used to explain or predict WTP value grounded in the contingent valuation approach. Section 4 discusses important errors of contingent valuation methods, as identified in the literature, and possible ways to avoid or mitigate them. In the last section of the paper, the main findings are briefly summarised and discussed.

2. Valuing willingness to pay: definitions and valuation methods

2.1 Green electricity and willingness to pay: definitions

From an economic theoretical point of view, green electricity is an interesting case because it is a so-called impure public good [8]. Impure public goods are characterised by the joint production of a private good and an environmental public good, the latter being a good that is non-rival and non-excludable. In the case of green electricity, the private good is the individual consumption of electricity. The public good is the reduction of greenhouse gas emissions, from which other consumers cannot be excluded and for which the utility for one person does not decrease the utilities for others.

Why do people voluntarily contribute to privately providing public goods? The answer to this question from the "classical" economic literature is pure altruism in private spending, because it is assumed that the preferences of each consumer depend on private consumption and accumulated voluntary contributions by other consumers [9]. Menges, Schroeder and Traub [10] argue that if individuals follow the Nash assumption and take the spending of other individuals as exogenous, the privately achieved level of the public good may be inefficient. Consequently, government spending is needed to increase public good levels. However, as Bergstrom, Stoll and Randall [9] show, under pure altruism, government grants funded by lump-sum taxes crowd out voluntary contributions completely. Andreoni [11] relaxed the pure altruism condition and introduced the concept of impure altruism, by assuming that consumers can get a direct, private benefit ("warm glow of giving") from contribution to a public good. He concluded that, under the assumption of impure altruism, private and public contributions are no longer perfect substitutes. As a result, crowding out effects are only partial, and subsequently, it can be concluded that different forms of altruism are relevant for the provision of public goods, such as green electricity.

Green electricity customers voluntarily pay an additional premium, which covers (part of) the additional production expenses of generating consumers' electricity from renewable energy sources. This additional premium is an expression of the consumer's WTP and is an expression of (choice) behaviour.

In a more formal sense, WTP is a Hicksian surplus measure [12]. This measure is divided into two different categories: compensation variation and equivalent variation. For an increase in welfare as a result of the provision of a public good, "the compensation variation refers to the amount of monetary income that has to be given up by the consumer to attain

increased level of utility" [13]: pp.91, which is the definition of WTP[2]. In an attempt to reconcile different definitions of WTP, also known as the reservation price, Wang, Venkatesh and Chatterjee [14] propose three types of WTP:

- Floor reservation price: the maximum price at or below which a consumer will definitely buy a product
- Indifference reservation price: the maximum price at which a consumer is indifferent about buying and not buying
- Ceiling reservation price: the minimum price at which a consumer will definitely not buy the product

2.2 *Measuring willingness to pay: valuation methods*

Methods to economically value the environment can be broadly classified into two groups [15]: approaches that value a good via a demand curve, and methods that do not. Examples of the latter are methods based on opportunity costs, dose response methods and the replacement cost approach.

Demand curve approaches are broadly divided into revealed preference and stated or expressed preference methods. The consumers' demand for a (public) good are *revealed* by examining the purchases of related goods in the private marketplace. Typical examples of revealed preference methods are the hedonic price method [16], experimental auctions [17], travel cost models, averting behaviour and the creation of simulated or actual markets [18].

As an alternative, the demand for public goods, and thus the WTP level, can be measured by investigating consumers' expressed or stated preferences for these goods relative to their demand for other goods. These techniques circumvent the requirement to find a complementary or substitute good to derive a demand curve and hence implicitly determine consumers' values for environmental goods. Stated preference methods ask actors explicitly how much they value environmental goods. Two types of stated preference methods (choice modelling and contingent valuation methods) can be distinguished [19,20].

Choice modelling is a modelling preference for goods, where goods are decomposed into their attributes and into the levels that these attributes can exhibit [19,21]. Choice

[2] "*The equivalent variation refers to the amount of compensation required to be provided to the individual so that she or he could attain an improved utility level in case the provision of the public good does not take place." [13]. This is known as willingness to accept.*

experiments, as one of the variants in choice modelling, are a popular WTP measurement approach that is frequently applied in marketing, transportation and environmental economics. In this approach, individuals are typically confronted with their most preferred choice between two or more products, which is defined by several attributes such as price, quality and quantity. Individuals are invited to decide which product they would purchase [12].

Contingent valuation is applied in environmental economics and in many other fields to estimate non-use values and/or non-market use values. According to Carson, Flores and Meade [6]: pp.173, "its flexibility facilitates valuation of a wide variety of non-market goods, including those not currently provided". It first defines the goods to be valued in detail. Listing their attributes and using different elicitation methods, consumers are asked about their WTP.

For two reasons, choice modelling is a further specification of the contingent valuation method [22]. First, whereas in contingent valuation, the product characteristics to be valuated are fixed across individuals, in choice modelling, these characteristics are experimentally varied. Second, in contrast to contingent valuation, in which information is collected about a product that is chosen, choice modelling generates information about the case where the product is not chosen.

3. Willingness to pay for green electricity: a review of the contingent valuation literature

3.1 General characteristics of the contingent valuation literature on WTP for green electricity

Given the prominence of the contingent valuation method, this section explores the academic contingent valuation literature with regard to WTP for green electricity. This literature search was conducted using Google Scholar, Science Direct, Swetwise and Proquest as search engines. Key words used were (combinations of) "willingness to pay", "green electricity", "renewable energy" and "sustainable energy". Studies had to be published in academic journals and should focus on WTP for (types of) green electricity from a consumer perspective. The main purpose of this literature review was to get an overview of the main characteristics of and methods used in recent contingent valuation studies on WTP for green electricity. The following criteria were included:

- Country and period: Where and when was the research conducted? In particular, the researchers wanted to know whether a study was conducted in a developed or in an emerging economy. The WTP might take different values and have different determinants because it can be assumed that consumers in developed economies are generally more environmentally conscious and maybe, more importantly, can afford the more expensive green alternatives to electricity purchasing more easily.

- Research focus: What were the researchers trying to explore with regard to WTP for green electricity? Is it valuing WTP and/or exploring antecedent of consumers' WTP for green electricity?

- Research methodology: How did the researchers gather their data and how was WTP measured? From these two criteria, it was explored which research methodology was commonly used so that researchers may consider using the same approach if applicable. An important aspect is the elicitation approach used.

- Type of renewable source: Which specific renewable energy source(s), if any, was/were indicated to the respondents in the application of the contingent valuation method? Examples could be wind, solar, waste, hydro or biomass. This criterion was included because research [23,24] has shown that, in some cases, consumers prefer one green source to another.

Table 1: Review of WTP for green electricity literature

Author(s) and year of publication	Country and year of survey	Research focus	Research method		Type of renewable source	Comment
			Data collection method	WTP elicitation		
Bang et al. (2000) [25]	USA, 2000	2	1	1	Wind	SBDC without bids using ordinal scale
Batley et al. (2000) [26]	UK, 1999	2	1	2	Wind, solar, waste	
Ethier et al. (2000) [27]	USA, year not specified	1	1 and 2	1	Land fill gas, wind	SBDC with FCQ
Roe et al. (2001) [28]	USA, 1991	2	3	3	Wind, solar, hydro	Choice experiment
Rowlands et al. (2003) [29]	Canada 2000, 2001	1 and 2	1	3	Wind, solar, waste	Payment card
Zarnikau (2003) [30]	USA, late 1990s	1 and 2	1	2	Wind, solar	

Author(s) and year of publication	Country and year of survey	Research focus	Research method		Type of renewable source	Comment
			Data collection method	WTP elicitation		
Vossler et al. (2003) [31]	USA, 1996	1	1 and 2	1	Wind, gas	MBDC, SBDC with FCQ
Nomura & Akai (2004) [32]	Japan, 2000	1	1	1	Wind, solar	DBDC
Arkesteijn & Oerlemans (2005) [33]	Netherlands, 2001	1 and 2	2	2	Not specified	
Ladenburg & Dubgaard (2007) [34]	Denmark, 2004	1	1	3	Wind	Choice experiment
Borchers et al. (2007) [24]	USA, 2006	1	3	3	Solar, wind, biomass	Choice experiment
Duffy et al. (2007) [35]	USA, 2005	1 and 2	3	1 and 2	Biomass	SBDC
Navrud & Bråten (2007) [36]	Norway, 2005	1	3	3	Wind, hydro, natural gas	Choice experiment
Whitehead & Cherry (2007) [37]	USA, 2002	1	2	1	Not specified	SBDC
Wiser (2007) [38]	USA	1	1	1	Not specified	SBDC
Hite et al. (2008) [39]	USA, 2005	1 and 2	3	1 and 2	Biomass	OE for pre-group; SBDC for post-group
Longo et al. (2008) [40]	UK, 2005	3	3	3	Not specified	Choice experiment
Diaz-Rainey & Ashton (2008) [41]	UK, 2003	1	2	1	Not specified	DC with ordinal scale
Hansla et al. (2008) [42]	Sweden, not known	2	1	3	Solar, wind, hydro, bio-fuel	Payment card
Bollino (2009) [43]	Italy, 2006	1	1	3	Not specified	Payment card
Koundouri et al. (2009) [44]	Greece, 2007	1	2	1	Wind	DBDC
Soliño et al. (2009) [45]	Spain, 2006	2	3	1	Biomass	SBDC
Yoo & Kwak (2009) [46]	Korea, 2006	1	3	1	Solar, wind, hydro, biomass	DBDC
Gerpott & Mahmudova (2010) [47]	Germany, 2008	2	2	1 and 2	Not specified	
Ku & Yoo (2010) [48]	Korea, 2006	3	3	3	Not specified	Choice experiment
Oliver et al. (2011) [49]	South Africa, 2008	2	2	1 and 2	Wind, solar	
Scarpa & Willis (2010) [50]	UK, 2007	1	3	3	Wind, solar	Choice experiment
Zografakis et al. (2010) [51]	Greece, 2007	1 and 2	3	1	Wind, solar, hydro	DBDC
Abdullah & Jeanty (2011) [52]	Kenya, 2007	1	3	1 and 2	Solar	DBDC then OE
Cicia et al. (2012) [53]	Italy, 2009	1	2	3	Solar, wind, biomass	Choice experiment
Claudy et al. (2011) [54]	Ireland, 2009	1 and 2	1	1	Micro generation	DBDC

Author(s) and year of publication	Country and year of survey	Research focus	Research method		Type of renewable source	Comment
			Data collection method	WTP elicitation		
Grösche & Schröder (2011) [55]	Germany, 2008	1 and 2	1	2	Wind, solar, hydro	OE with a random scenario
Hanemann et al. (2011) [56]	Spain, 2009	1	2	1	Not specified	SBDC
Komarek et al. (2011) [57]	USA, 2009	1	1	3	Biomass, wind, solar	Choice experiment
Mozumder, et al. (2011) [58]	USA, 2010	1 and 2	1	2	Wind	A second follow-up OE question
Susaeta et al. (2011) [59]	USA, 2008	1	1	3	Biomass	Choice experiment
Aldy et al. (2012) [60]	USA, 2011	1	Not specified	1	Solar, wind	SBDC
Aravena et al. (2012) [61]	Chile, 2008	1	3	1	Wind, biomass, solar, geothermal	SBDC and DBDC
Gracia et al. (2012) [62]	Spain,	1	3	3	Wind, solar , biomass	Choice experiment
Ivanova (2012) [63]	Australia	1 and 2	1	2	Not specified	
Kim et al. (2012) [64]	Korea, 2010	1	3	1	Wind, solar, hydro	DBDC
Kosenius & Ollikainen (2013) [65]	Finland, 2008	1	1	3	Wind, hydro, biomass	Choice experiment
Kostakis & Sardianou (2012) [66]	Greece, 2009	2	3	1	Not specified	SBDC without bids
Zhang & Wu (2012) [67]	China, 2010	1	1	3	Not specified	Payment card
Zorić & Hrovatin (2012) [68]	Slovenia, 2008	1 and 2	1	2	Hydro	
Amador et al. (2013) [69]	Spain, 2010	1	3	3	Wind, solar	Choice experiment
Kaenzig et al. (2013) [70]	Germany, 2009	1	3	3	Wind, biomass, hydro	Choice experiment
Kontogianni et al. (2013) [71]	Greece, 2010	1 and 2	3	2	Wind, solar, geothermal	
Liu et al. (2013) [72]	China, 2011	1 and 2	3	1	Wind, solar	SBDC
Bigerna & Polinori (2014) [73]	Italy, 2007	1	1	2	Not specified	
Guo et al. (2014) [74]	China, 2010	1 and 2	2	1	Solar, wind, biomass, hydro	SBDC

Research focus: 1 = Valuation WTP; 2 = Antecedents; 3 = Other
Data-collection method: 1 = Mail/web survey; 2 = Telephone survey; 3 = Face-to-face
WTP elicitation: 1 = Dichotomous choice (DC); 2 = Open-ended (OE); 3 = Other

DBDC: Double-bounded dichotomous choice
SBDC: Single-bounded dichotomous choice
MBDC: Multiple-bounded discrete choice
FCQ: Follow-up certainty question

A sample of 51 studies relating to WTP for green electricity was found through the literature review process described above. Table 1 summarised the main findings of this review. It was found that 41 studies were conducted in developed countries. Of the 51 studies, a majority of studies were conducted in the USA (14 studies) and in countries in Europe (24 studies). Only two studies were performed in Africa (South Africa and Kenya). From these findings, it can be concluded that there seems to be a lack of studies conducted in emerging economies. This may be due to the fact that the use of green electricity for domestic purposes is not yet widespread in these countries.

The focus research areas of these studies were threefold. Firstly, they aimed to provide valuations of green electricity by using WTP (27 studies); secondly, they explored factors, barriers, predictors or determinants for consumers' WTP for green electricity (eight studies); and thirdly, they had other foci, such as identifying consumers' preferences for policy (two studies). Focus areas 1 and 2 are the main areas and some 14 studies (e.g. [29,55]) have even focused on both areas.

Predominantly, three methods of data gathering are used in the studies: mail and internet surveys (19 studies), telephone surveys (nine studies) and face-to-face interviews (19 studies). Two studies used both mail/internet and telephone surveys. The study of Ethier, Poe, Schulze and Clark [27] reported that neither telephone nor mail surveys appear to dominate from the perspective of providing more valid estimates of actual participation decisions.

An important part of any contingent valuation method is the elicitation technique used, that is, the format in which the WTP question is stated to respondents. Four WTP elicitation formats are currently in use [75]:

- Bidding or bargaining format: A researcher proposes WTP values that a respondent accepts or rejects, and continues to make higher or lower bids depending on the decision of the respondent.
- Payment scale format (payment card): Respondents choose (different) values from a predefined and ordered list and all individuals use the same list.
- Open-ended format: Each respondent is asked to choose her or his own WTP valuation, unbounded and unprompted.
- Dichotomous choice format: Each respondent receives a randomly assigned bid and is invited to accept or reject this bid (single-bounded version). In the so-called double-

bounded version, the respondent gets a second bid and its value depends on the first answer of the subject.

In 19 studies, the researchers chose the dichotomous choice option. Some examples of studies applying single dichotomous choice questions are Ethier et al. [27], Whitehead and Cherry [37], Hansla, Gamble, Juliusson and Gärling [42], Yoo and Kwak [46] and Kostakis and Sardianou [66]. Although it is customary to combine dichotomous choice with randomised bids, this is not necessarily the case. Some scholars use ordinal scales [25,41] or interval scales [42] to indicate the extent to which consumers are willing to pay (extra). Some studies (for example: [32,54]) use a double-bounded version of the dichotomous choice model. In eight studies, open-ended questions were used to measure WTP (for example: [33,39,64]). Five studies used both dichotomous choice and open-ended elicitation methods (for example: [49,52]). A limited number of papers (14) applied choice experiment [28,34,50]. This review shows that in consumer studies on WTP, predominantly two types of elicitation questions are used: dichotomous choice and open-ended questions.

The last topic addressed in Table 1 regards the question whether or not (and if so which one) the respondents were informed about the type(s) of energy source that they had to take into consideration when indicating their WTP. One out of four (13/51) studies in the review did not specify the renewable energy source for the generation of green electricity. In these cases, consumers were asked to value "green electricity" or "electricity from renewable sources". In the majority of cases, green electricity from wind or solar energy sources are explicitly mentioned, mostly because consumers are familiar with these sources. Familiarity and experience with these sources tends to impact on the level of WTP indicated by consumers.

3.2 ***Antecedents of WTP for green electricity in contingent valuation studies***

A second part of the literature review focused on the identification and classification of antecedents of WTP for green electricity. Table 2 presents the results of this review. All studies were scanned for factors impacting on WTP for green electricity. Only those factors were included for which a statistically significant relationship with WTP was reported. These factors are categorised into seven groups. These groups are attitude (towards the environment in general or towards renewable energy sources in particular), social norms, knowledge about

renewable energy sources, prior actual experience with renewable energy sources, socio-economic characteristics, actor characteristics and technical aspects.

Table 2: Antecedents of WTP for green electricity and examples of studies

Antecedents	Number of studies	Number of statistically significant positive relationships	Number of statistically significant negative relationships
Attitude towards the environment			
Arkesteijn & Oerlemans [33]; Mozumder et al. [58]; Amador et al. [69]	18	18	0
Attitude towards the renewable energy source (RES)			
Borchers et al. [24]; Duffy et al. [35]; Soliño et al. [45]; Gracia et al. [62]	9	9	0
Socials norms			
Rowlands et al. [29]; Gerpott & Mahmudova [47]	4	4	0
Knowledge about the RES			
Bang et al. [25]; Claudy et al. [54]; Kontogianni et al. [71]; Liu et al [72]	11	11	0
Prior experience with the RES			
Batley et al. [26]; Kim et al. [64]	8	6	2
Socio-economic characteristics			
Household income: Zarnikau [30]; Ladenburg & Dubgaard [34]; Zhang & Wu [67]	17	16	1
Electricity bill payer: Zarnikau [30]; Hite et al. [39]	4	2	2
Household size: Longo et al. [40]; Koundouri et al. [44]	5	3	2
Electricity price/bill: Hansla et al. [42]; Yoo & Kwak [46]; Kontogianni et al. [71]	4	2	2
Home owner: Bollino [43]; Abdullah & Jeanty [52]	2	2	0
Respondents' characteristics			
Age: Hite et al. [39]; Ivanova [63]; Kostakis & Sardianou [66]	12	3	9
Level of education: Rowlands et al. [29]; Longo et al. [40]	8	8	0
Gender (male = 1): Batley et al. [26]; Bollino [43]; Ivanova [63]	5	4	1
Technical aspects of energy systems			
Grösche & Schröder [55]; Soliño et al. [45]	3	3	0

The majority of antecedents reported in the literature that was reviewed for this study are attitudinal (beliefs and concerns about the environment or about renewable energy sources used to generate green electricity), socio-demographic characteristics (income, household size or size of the household electricity bill) and respondent characteristics. All studies in the

sample report that a positive attitude towards the environment or renewable energy sources is positively associated with WTP. Regarding the socio-economic characteristics, it is found that a vast majority of studies report a statistically significant relationship between income level (positive), size of the household electricity bill (negative), and being a homeowner (negative) on the one hand, and WTP on the other. Furthermore, most studies find a negative relationship between age and WTP, and report that respondents with a higher educational level, or who are male, are more willing to pay extra for green electricity.

The findings reported above are consistent with those found in a meta-regression analysis by Sundt and Rehdanz [76]:pp.7, who state that including "knowledge about renewables, household characteristics, income and education significantly influences WTP estimates. Ignoring these attributes in future WTP estimations might result in biased coefficients".

From a theoretical point of view, it seems that WTP researchers are predominantly inspired by the theory of reasoned action [77] or by its extension, the theory of planned behaviour [78] as "predictors" of WTP. Variables indicating attitudes and social norms (all positive relationships) are clearly part of these theories. The control beliefs, which are part of the theory of planned behaviour, are predominantly indirectly measured through prior experience with or knowledge about renewable energy sources. Both are positively related to WTP. Having experience and being knowledgeable about renewable energy sources increases the levels of perceived or actual behavioural control.

4. Possible errors in the contingent valuation method and their proposed solutions

One of the most important sources of error in the contingent valuation method is the embedding or scope effect. Although definitions of this effect differ, scholars agree on the fact that the scope effect can cause serious validity problems, because it is not clear which WTP value to select when comparing WTP for one or a combination of (energy) options. The majority of studies on the scope effect considers comparison of private goods, but several researchers maintain that it also applies to none-use values and use values for public goods. According to Venkatachalam ([13]:pp.102), this effect is amongst others caused by flaws in the design of a survey instrument, improper survey implementation and sampling procedures, inability of respondents to understand survey questions, and the properties attributed to standard value theory to substantiate the claims for embedding.

A second error source affecting WTP values is the sequencing effect, also known as the question order bias. Like the embedding effect, sequencing bias only occurs in multi-good valuation research. Researchers have identified several probable causes for this effect. Some point at the influence of substitution and income effects [6], where individuals replace the first good in a sequence for other goods, and because they already had expenses for the first good, they have less available for the second good in the sequence.

Table 3: Overview of possible errors in the contingent valuation method

Error type	Description of error	Example studies
Embedding/scope effect	A wide range of variation in WTP values for the same good is found, depending on whether it is valued separately or as a part of a more inclusive package.	Kahneman & Knetsch [79]
Sequencing effect	This occurs if WTP values for a particular good differ, depending on the order of the good in a sequence.	Hanemann [5]
Information effect	The level and nature of the information provided to the individual influences WTP values.	Blomquist & Whitehead [80]
Hypothetical bias effect	WTP values are biased because potential divergence between real and hypothetical payments occurs.	Champ & Bishop [81]
Strategic bias effect	WTP values are biased because of strategic behaviour on behalf of the respondent (free-riding and over-pledging).	Carson et al. [6]
Elicitation effect	This occurs if WTP values for a particular good differ, depending on the elicitation method used in a contingent valuation study.	Welsh & Poe [82]

The information effect is a third possible error influencing WTP values. It has been found that the nature of the information provided influences the WTP results. More precisely, studies report that the presence or absence of information about related environmental goods (substitutes) and budget constraints indeed influence stated WTP values, although not all studies, such as Loomis, Gonzalez-Caban and Gregory [83], find this effect. Venkatachalam [13] maintains that the influence of the additional information on the WTP value mainly depends on the amount of information already possessed by the respondents. The implication is that contingent valuation studies should address information asymmetry among individuals.

The market for a (public) good used in a contingent valuation study is hypothetical. This could lead to a bias called “hypothetical bias”. Many contingent valuation studies have found that hypothetical contingent valuation values were larger than the real WTP values (for example: [84]:Table 1). Some studies, however, reported that stated WTP was an understatement of the actual WTP. Several scholars investigated solutions to the hypothetical bias problem. Aadland and Caplan [85], for example, employ a so-called cheap talk reminder

statement. Cheap talk is information provided prior to the WTP question, reminding respondents that they are valuing a hypothetical programme, and consequently, may misstate their real WTP value. Other research [37] shows that the more familiar an individual is with the good to be evaluated, the lower her or his level of hypothetical bias in a contingent valuation method.

The possibility of strategic behaviour by respondents causes strategic bias in WTP values. There are two types of strategic behaviour [86]. The first is free-riding, which would occur if a consumer understated her or his real WTP for a public good because he or she expects others to pay for that good, and therefore, she or he need not pay. The second type is over-pledging, which occurs when a consumer thinks her or his expressed WTP would influence the supply of a good, provided that the stated WTP would not be any basis for the future price of this good. Venkatachalam [13] states that there are not many studies that only deal with the strategic bias issue. Mitchell and Carson [87] maintain that strategic bias will probably not occur if there is much information needed, as well as if respondents think they have little influence due to the large number of survey participants involved, are aware of their budget constraints and assume that the good may not be provided.

The last main error source is the so-called elicitation effect. Contingent valuation studies predominantly use two formats: the open-ended and the dichotomous choice approach. The open-ended format has some obvious advantages [13]: 106–107. It is easy and convenient for respondents to answer, does not require an interviewer and does not result in any starting-point bias. A number of disadvantages is also identified. The approach tends to generate a large number of non-responses or protest (zero) bids because subjects find it too difficult to provide an answer or do not feel inclined to provide a true answer and they would rather indicate cost than true value.

The main advantage of the single-bounded dichotomous choice approach is that it supports the respondent to go through a complete valuation process. Furthermore, due to the fact that the approach is regarded as incentive-compatible, it runs a low risk of strategic bias. This approach is found to have a number of disadvantages as well. The approach derives the maximum WTP but not the actual willingness to pay amount. It is prone to starting-point bias and is sensitive to the extent to which individuals are already familiar with the (public) good. A large number of observations are needed for establishing the distribution of WTP values.

Several studies compared results generated by these two elicitation methods [12,75,82,84,88]. With a few exceptions (for example: Frykblom and Shogren [89], who find no differences), comparative studies reveal that WTP values elicited by the dichotomous

choice technique are systematically lower when compared to the open-ended technique. The findings of a meta-regression conducted by Soon and Ahmad [90] also confirm this. The literature suggests four possible explanations for this so-called elicitation effect. A first explanation is that the probability of strategic response bias is low in the dichotomous choice option. Consequently, individuals are less inclined to over- or understate their true WTP value. A second explanation relates to the cognitive complexity of OE WTP questions. Respondents just find it too difficult "to put a number on it" and often submit a zero value lowering the overall average value of this option. Preference uncertainty is a third explanation. Especially for complex and unfamiliar goods, individuals seem to miss the ability to submit a precise estimate of their WTP. "Yea-saying" is a reflection of this. In a dichotomous-choice format, respondents accept the proposed bid as a cue for a reasonable WTP amount. In an open-ended format, this cue is absent. A related phenomenon is anchoring or starting-point bias, which implies that different starting points (bids in dichotomous choice) produce different estimates, which are biased toward the initial value. Another explanation argues that individuals may have two aims when responding to WTP questions: they want to truthfully answer the question and they would like to express that they favour the good at issue.

Table 4 provides an overview of remedies for the possible errors in the contingent valuation method and the impact of these remedies.

Table 4: Overview of possible errors in the contingent valuation method and their remedies

Error type	Proposed remedies	Impact of remedy
Embedding/scope effect	1. Use labels under which a good is sold. 2. Take into account the cognitive ability of respondents. 3. Control for perception and experience in the sample.	1. The use of labels leads to significant increase in scope sensitivity [91]. 2. Respondents with higher cognitive abilities have a smaller scope effect [92]. 3. Once controlled for attitude and experience, scope effects disappeared [93].
Sequencing effect	1. Use subsamples that do not offer the goods in a sequence, but as a package. 2. Use a design in which subgroups are presented in different sequences as a control. 3. Avoid multiple valuations using a stepwise approach in one research design.	1. This mitigates the sequencing effect [6]. 2. Research found no differences among respondents [92]. 3. Simple valuations do not produce a sequencing effect [94].
Information effect	1. Provide a combination of perspective, relative expenditure and provision cost information. 2. Provide information about the actual costs or quality of goods. 3. Avoid cognitively challenging information about the goods.	1. The combined effect of the three information types increases bids [9]. 2. This reduces the number of zero bids, protest bids and "don't know" responses [80]. 3. This prevents information being ignored due to it being too cognitively demanding [95].
Hypothetical bias effect	1. Only use this for goods that have characteristics close to existing goods. 2. Use a consequential survey design in which respondents believe their responses will affect something that they care about.	1. There is a smaller correlation between purchase intentions and actual sales of goods [96]. 2. For consequential surveys with well-defined incentives, stated values are closer to revealed

Error type	Proposed remedies	Impact of remedy
	3. Use a "cheap talk" survey design. 4. Use oath design. 5. Use certainty scales. 6. Apply dissonance minimisation.	WTP values [97]. 3. Meta-analyses show that cheap talk reduces this type of bias [98]. 4. An oath-only design results in more sincere bidding behaviour [99]. 5. Well-designed certainty scales mitigate hypothetical bias [100]. 6. The use of dissonance minimisation is effective in mitigating hypothetical bias, but it cannot be used with open-ended responses [100].
Strategic bias effect	1. Use incentive-compatible elicitation techniques. 2. Use and make known that the sample size is large. 3. Design the payment vehicle in such a way that it is clear that there is a budget constraint. 4. Ask for a compulsory contribution (for example, tax percentage). 5. Use scenarios with background information describing the type of management strategy, its risks and benefits. In addition, ask behavioural or experience questions specific to each scenario before the WTP question is introduced. 6. Use in-person surveys for direct contact with the respondent.	1. The use of reservation price and undisclosed price setting lowered this effect [14]. 2. Through a large sample size, the impact of the individual respondent is (perceived as) low, which reduces strategic bias [13]. 3. The presence of a budget constraint lowers the probability of overstated WTP [87]. 4. A scenario with a compulsory (tax) contribution lowers the probability of free-riding behaviour [101]. 5. This allows the researcher to capture strategic bias with a distinct variable and provide a better model for WTP estimation [102]. 6. In-person surveys make the act of being dishonest a much harder task and are less prone to strategic bias [103].
Elicitation effect	1. Use payment card. 2. Use a multiple-bounded discrete choice approach.	1. Payment card responses are not sensitive to range effects as long as the card includes values that are large relative to the respondent's value [104]. 2. This allows the respondents to vote on a wide range of referendum thresholds and provides a higher level of precision [82].

5. Conclusions and future study

The contingent valuation method is widely used in valuing public goods, such as green electricity. Recently, there have been more published studies of estimating WTP value for green electricity using the CV method, despite its criticism of errors due to various elicitation techniques. This paper provides a review of the CV literature published in the area of WTP for electricity generated from renewable sources with the aim of exploring the antecedents of WTP, the different elicitation techniques used, as well as possible errors and their remedies.

Two main conclusions can be derived from this literature review. Firstly, from a sample of 51 studies, there are predominantly two elicitation approaches used to measure WTP for green electricity: the dichotomous choice and the open-ended approach. These approaches are often used separately and independently. Moreover, empirical studies comparing WTP measures across approaches are limited [13]. The second conclusion relates to the identification of the factors impacting on WTP for green electricity. One cannot ignore these attributes when estimating WTP because these might result in biased coefficients [76].

From the factors empirically identified by the other researchers, it follows that they are informed by the theory of reasoned action/planned behaviour.

This study contributes to the field of contingent valuation in two ways. Firstly, the literature review conducted in this study pointed out the issues of the various elicitation techniques used in WTP for green electricity, and suggested remedies for the six main types of errors. Future scholars and practitioners will be able to design their WTP estimation models better by identifying the possible errors and applying the suggested remedies. Second, one of the main criticisms of the CV method is its lack of construct validity, which includes convergent and theoretical validity [13]. This literature review reveals that there is a need to test the convergent validity of the two most commonly used elicitation techniques, namely DC and OE approaches, when estimating WTP for green electricity. This is most applicable to policy makers as they need to know to what extent there exist any differences in WTP estimations when using the dichotomous choice and open-ended approach for decision making in any renewable energy investments. Moreover, this paper provides an overview of the antecedents, which can be used to test the theoretical validity in future studies by including these factors in the WTP estimation models. This may result in a more accurate WTP estimation, which will provide a better index of consumers' relative preferences [105].

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