Value-based heuristics in policy analysis of renewable energy pricing and its incentives

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Abstract
Renewable energy (RE) prices studied in this research are in the form of carbon prices as green taxes and electricity tariffs. Its incentives may seem to depend on technologies employed and the willingness of the electricity customers to pay for this premium energy. However it is a complex process and many researchers that have arrived at RE prices use econometric approaches which do not factor in values of people. This study explored a new value-based method that might lead to a socially acceptable RE pricing. A linear model of social judgment or heuristics with uncertain cues of incentives was developed using a multi-level perspective (MLP) transition energy analysis framework. The results show the uniqueness of the value-based social judgment model. One unique policy outcome for carbon price as green tax is of wise-choice heuristics in character but with large variations. In contrast though, small variations are found for carbon prices as electricity tariffs which is another unique policy outcome with notions of availability heuristics or biases. In both models, the indication is that under certainty, people's values could possibly trade-off with marginal increases in RE prices.

Keywords: renewable energy, values, heuristics, carbon pricing

1.Introduction

Renewable energy (RE) can reduce carbon and this may possibly make RE more important to ensure low-carbon electricity generation. In an ideal world, we are looking to ensure that price signals from carbon reduction can be translated fully to equivalent RE investment signals. The problem is in the regulation which does not allow for RE to get the appropriate carbon prices [1]. The ability for society to price carbon may allow the society or market to price RE tariffs as RE may be seen to mitigate carbon. The question is how do people decide on carbon prices? Do people's values become the proxy between carbon pricing and RE technology? In this study for a proxy of carbon price, social judgment approach is used to price carbon. In social judgment is the integrated information from a number of uncertain cues about some distal state of the world [2] [3]. The policy outcome is the summation of all these cues and its dependency on how it is used [4] with possible biases [5]. In operations research this could be the problems of developing meta-decisions and heuristics in uncertainty [6] [7]. This paper will deliberate on how this analysis would generate general decision rules or heuristics in searching possible solutions for RE pricing and incentives which could lead to the much debated common carbon price.

2. Literature review

Social judgments inherently use heuristics [5] or the "rule-of-thumb" with which people make real world judgments through complex world of uncertainty [7]. In operations research (OR), under uncertainty, meta-heuristics are used such as hybridizing single (SNS) and the variable neighborhood search (VNS) algorithms for nurse rooster problem [8]. This include combining global and local heuristics for team orienteering problem [6], and self-adapting heuristic rules for optimization[9] and scoring decision for forecast of future economies [10]. In OR heuristics seemed dominant for solving real-world problems. Since social judgment contains elements of biases [5] and context effects [3], the heuristics to be studied are of two models; the biased judgment or availability heuristics [10] and other is the sensible estimation or 'wise-choice' heuristics [7].

Carbon pricing through tax, trading or regulation, is critical for climate-change policy. Regulatory structures however may prevent the pass through of marginal carbon prices to final electricity prices for RE. The present imperfect structure of financial cost-benefit method pinned down on high investment costs for RE technology and highly econometric [1]. Current studies on meeting carbon reduction targets in transitional economies in electric power supply view the impact of RE pricing and incentives from the multi-level perspective (MLP) sustainable transition framework [11]. This include the perspectives of globalization and social metabolic transformations. In globalization, free trade would have its impact to real income and welfare in meeting CO2 emission reduction targets [12]. Renewable energy (RE) pricing incentives that are associated with carbon prices also reflect their sensitivity to societal and environmental factors. In this study carbon reduction targets may also be influenced by local socio-political landscapes (with values and worldviews) [13] that may be the proxy between incentives and acceptable carbon pricing.

Carbon price is judgmental in a sense that it is also dependent on the nation's willingness to pay. This is evident in poor countries to have less money to pay for costs of carbon reduction [14]. "Willingness-to-pay" (WTP) for carbon price is chosen because the price of carbon alone may not lead to an efficient climate change mitigation in the distant future. Willingness-to-pay (WTP) is defined as "the reciprocal of the marginal rate of substitution between one's income and other's income. WTP has a societal notion. In contrast, is the altruistic need-to-pay (NTP) which is defined as the marginal rate of transformation of one's own income into other's income.

Carbon price as a wholesale electricity price (p/KWh) is also judgmental because from 2010 to 2020 it would stabilize with gradual but uncertain shift from technology-specific support to industry support for renewable energy. For example, a pricing heuristic (subjective rule-of-thumb) in UK would be the £15/tCO_2 carbon price that would add to about 1p/kWh to the cost of coal power generation [15].

3. Methodology

Step1: Initially the input are structured based on the MLP sustainable transition framework [10]. Real-world data from actors (N=30) were measured between April-May 2010. For small-sized instances (N<20) the hybrid heuristics could be a highly effective approach [12].These actors are the risk-exposed engineers working with the electricity supply industry.
Step 2: The next step is to develop an algorithm with weights to the cues in the linear mathematical model of social judgment as shown in Chart 1 below;

Chart 1. Mathematical model of social judgment for RE pricing policy

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Socio-political landscapes cues;Worldviews (WV) Intrinsic Values IV); u(WVV)= [u(WV)+u(IV)]/2

Environmental governance: Benefit, Risks ;
***Perceived Risks (PR(t)) and Benefits (PB(t)) for transition energy technology (t); Green RE (Renewable Energy) technology (Solar, Energy, Wind, Conservation, MiniHydro, Bio-Mass, Geothermal); u(EGV(t))= ABS(PR(t)-PB(t))*u(WVV)**

Carbon pricing incentives; [XCCLEVY]=Climate Change Levy, (Longtprice)= Long-Term Purchase Price gfreetrade=Green Trading Off-sets, (Greentx*) = Green Tax
u(EGVp)= u(WVV).*f* {CCLEVY, ROC, CGF}, incentives with pass-over effects to electricity tariffs
u(EGVn)=*f* {GTX, GTQ, LTP, QOC}, incentives with national implications
u(EGVg)=*f* {GTV, GTH, GTO, ITG, LGC, IOS}, incentives with international

Linkages: Policy outcomes
Minimization willingness to pay (WTP) for carbon price in terms of Carbon Tax and Electricity Tariffs.
(WTP) cp = GTxS*[u(EGVn)*u(EGVg) + u(EGV(t))] + GTx*C, GTx=Green Tax Scale up to 2012 as per Kyoto Protocol
(WTP)cp = GES*[u(EGVp)+u(EGV(t)) + GES*C, Green Electricity Tariff based on 2010 domestic tariff

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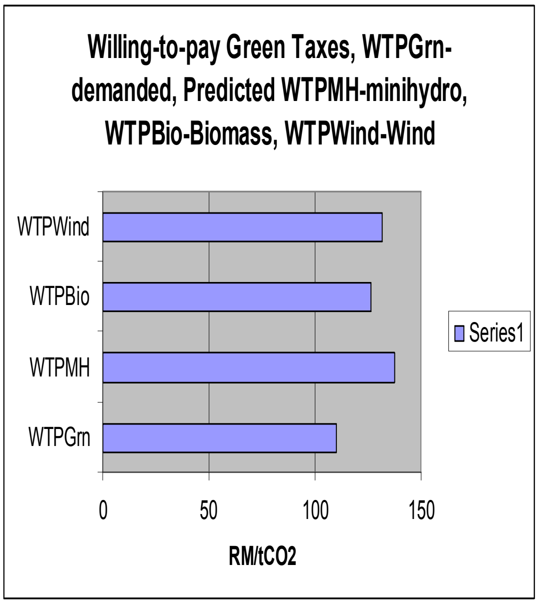
The weights would create the algorithm that could be used to compute the policy outcomes in the model. From the findings in Step1 above the relationships in the Berkhout's transition MLP model [10], show that value weights u(WVV) would be factored into the weights of environmental governance u(EGV) perspective with respect to perceived risks PR(t) and perceived benefits PB(t) for a specific RE technology (t). Value weights u(WVV) also have relations to weights of environmental governance u(EGVi) as u(EGVp), u(EGVn), u(EGVg) that are based on incentives with pass-over effects to electricity, national and international implications respectively. Climate Change Levy (CCLEVY), Renewable Obligation Certificate (ROC), Capital Grant Fund (CGF) are incentives with pass-over effects to electricity tariffs. Green Tax (GTX), Green Tradable Quotas (GTQ), Long-Term Purchase price (LTP) and Quota Off-Set Credits (QOC) are incentives with national implications. Green Tax Variations (GTV), Green Trade Harmonization (GTH), Green Trading Off-sets (GTO), Inter-changeable Green trading schemes (ITG), Long-Term Global Contracts (LGC) and International Off-Sets (IOS) are incentives with international implications [1]. The Willingness to Pay (WTP)cp for carbon price (marginal price over and above the baseline carbon price); the sum of weights of incentive related environmental governance ∑u(EGVi) are computed with CPS the carbon price scale (CPS=GTxS, Green Tax Scale based on 2012 Accord in Kyoto Protocol, CPS=GES, Green Electricity Scale based on domestic tariff 21.8sen/KWh), and C the societal constant in response to carbon price.

Results & Analysis

Carbon pricing in green tax mode

The results of computations from the algorithm (Chart 1 above) for willingness to pay for two modes of carbon pricing , one being the green taxes and the other in the form of electricity tariffs for RE power plants. As shown in Figure 1(a) below, carbon pricing in the mode of green tax was found to be 'selective' for specifically preferred RE power technology namely the mini-hydro (WTPMH), bio-mass (WTPBio) and wind (WTPWind) power technology. Green tax was predicted to be higher for both mini-hydro and wind probably because of their 'stand-alone' characteristics. Green tax for bio-mass was rated relatively lower probably due to its 'neutral' carbon in nature and also their closer proximity to local power grid. This is the case for palm-oil and rice mills that are powered by local distribution grid while at the same time produce power using local biomass resources.

WTP green taxes range from the base-line 110 RM/tonneCO2 to 140 RM/toneeCO2 which is a difference of about 27 percent. This may indicate uncertainty because green taxes were never being introduced in Malaysia. Another reason for the uncertainty is the unknown impact of large deployment of RE power technology in the electrical system.



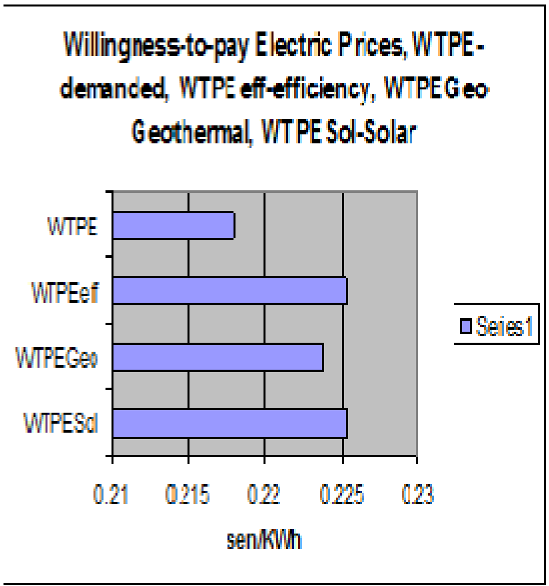


Fig 1(a) Willingness-to-pay for green tax and (b) RE electricity tariffs

Carbon pricing in electricity tariff mode

A more stable mode of carbon pricing could be explored. The mode in this study is electricity tariff with pass-over effect of costs of RE power technology. The following

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results in Fig.1 indicates this possibility because the range between maximum WTP for RE electricity tariff and base-line tariff is small. The 'selective' RE power technologies namely negative energy (i.e, energy conservation (WTPEeff), geothermal (WTPEGeo) and solar (WTPESol) are favored for carbon price in the mode of electricity tariff as shown in Fig.1(b) above.

Both Figures 1 (a) and 1(b) show deviations between predicted and actual demand for willingness-to-pay prices. In green taxes, the variation of 27% as shown earlier indicated uncertainty in actors' choices. On the other hand in the willingness-to-pay the variation for electricity tariffs was 3% between base-line tariff (WPE) of 21.8 sen/KWh and 22.5sen/KWh for both efficiency (WTPEff) and solar electricity (WTPESol) tariffs.

Discussion

The large variation between actual and predicted carbon price in terms of green tax shown in Fig. 1(a) reflects the uncertainty in its debut as a carbon pricing mode. This fact revolves around the difficulty of determining the marginal social damage for an extra ton of carbon released now would impose on current and future society. This argument is augmented by the ineffectiveness in some countries to pass through the marginal carbon prices to final electricity prices. This follows the Kyoto Protocol and seemingly the Copenhagen Accord, which defined quantified goals for carbon reductions, but left the choice of implementation of carbon reduction targets to national-level decision making. Predicted carbon price in the modes of solar, efficient power and geothermal electricity tariffs in Fig.1(b) are comparable to cost-risk tariff estimates for UK electricity generation [1].

The value-based heuristics indicated an RE policy instrument of implementing exemption from climate change levy for solar and biomass RE technology to achieve carbon prices similar to the RE tariffs that are in the industrial support scenario for UK electricity industry. This inter-regional consistencies however do not necessarily validate the value-based heuristics as a policy instrument for carbon pricing because the true outcome in Malaysia has yet to known. On a hind sight though, the Malaysian Government decided to incorporate one percent Fixed-in-Tariff into the consumers' electricity tariff for the 2011-2015 Tenth Malaysia Plan period. This is one third of the three percentage variation of RE tariff predicted from the value-based heuristics in this study. In other words, the heuristic prediction is only 30 percent accurate.

Conclusion

This study showed a method of developing heuristics from transition energy policy analysis algorithm involving local values and multi-level perspectives. However the results are only indicative because of the need for further improvement in the algorithms and more synthetic rules based on biases to be generated by data mining. It is possible that with more bias data the stabilized estimations of willingness-to-pay may be achieved. Finally, another criticism of this study is the selective method used in the choice for RE power technology and their respective carbon pricing modes either in the form of green taxes or electricity tariffs. Further analysis on carbon pricing modes should be for all types of RE power technology.

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