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Trading off visual disamenity for renewable energy: willingness to pay for seaweed farming for energy production

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35 **Abstract**

36 We studied people's preferences to support a renewable energy programme to grow seaweed
 37 for biogas production, using a choice experiment. Participants had to choose one among three
 38 alternatives, two of which were variations of a seaweed programme and the third was the
 39 status quo. The two alternatives were defined in terms of four attributes: the number of
 40 households powered, the percentage of coastline used to farm seaweed, the additional cost
 41 they would incur and perks, which were added to encourage people to participate in the
 42 programme. The choice experiment was conducted online in England, Scotland and Northern
 43 Ireland among 2016 respondents. The compensating variation from a renewable energy
 44 programme from seaweed that powers 85,000 households and covers 20% of the UK
 45 coastline is £16 per year in England, £16 per year in Scotland and £14 per year in Northern
 46 Ireland, respectively. We find that people are willing to use more coastline to farm seaweed
 47 in order to power more households. That is, they are willing to make a trade-off between the
 48 visual disamenity caused by the seaweed farms and producing more green energy. Lastly,
 49 both perks have negative effects on people's preferences for using seaweed as biogas.

50

51 **Keywords:** choice experiment, random parameter logit, seaweed, biogas, coastline, visual
 52 disamenity

53 **JEL classification:** Q51, C35, Q42

54

55 Declarations of interest: none

56 **1 Introduction**

One of the main challenges that societies and economies will be facing in the coming years is adapting to and mitigating climate change. The threat imposed by this phenomenon is becoming more prevalent due to our dependence on fossil fuels, the main cause of current global warming (IPCC, 2014). Increasing the production of renewable energy is seen by governments as one of the means to reduce anthropogenic greenhouse gas emissions. The UK government set a target to produce 20% of electricity by 2020 from renewable sources (Department of Trade and Industry, 2006), and, more recently, launched a bioeconomy strategy to harness renewable biological resources to replace fossil resources in innovative products, processes and services (HM Government, 2018). Whilst first generation biogas from crops are controversial for their possible impact on the supply of food (Gallagher, 2008), second generation biogas from solid waste and food waste appears more promising (Naik et al, 2010). Within this policy framework, seaweed, and in particular sugar kelp (*Saccharina latissima*), being rich in sugar content and not requiring land or freshwater, has the potential to be an important source for biogas production, also thanks to the extensive UK coastline suitable for commercial seaweed farming and harvesting (van der Molen et al, 2018).

No commercial seaweed farm exists in the UK that grows seaweed to produce biogas. To understand the challenges in this venture, the UK Biotechnology and Biological Sciences Research Council (BBSRC) funded the SeaGas project to develop a study site in Strangford Lough, Northern Ireland, where researchers were able to grow 20 tons of seaweed per year (www.seagas.co.uk), enough to power about 12 households per year, by placing 24 longlines along 300 metres of coastline. The study found that the cost of growing and harvesting one ton of seaweed is about £2,000. These costs translate to about £3,300/year for powering one household and include the seeding and deployment of the baby seaweed, and then harvesting

the algae at maturity and transporting it to an anaerobic digestion plant suitable to receive marine biomass rich in salt. This cost can be compared with the annual household electricity bill in the UK, which is about £700 (Department for Business, Energy & Industrial Strategy, 2019). The research team concluded that these production costs are prohibitively high, and that if seaweed should be used for energy generation, its production cost should be reduced to £23/ton to be competitive with alternative biomass sources, such as corn and grass silage. Whilst it is possible to cut costs through technological developments in the harvesting of seaweed, and with economies of scale using larger farming areas, it is unlikely that this activity be sustainable without the support of subsidies.

In this study, therefore, we explore society's willingness to pay (WTP) for supporting the use of seaweed for energy production, in the form of an additional cost on top of households' electricity bills, using a discrete choice experiment (CE) method. This is the first study to explore society's price premium for growing seaweed for energy production. In addition, we explore how to mitigate free-riding behaviour in CEs, which is quite common when participation in environmentally-friendly programmes is voluntary. To overcome this, we offer some perks to our participants to recognize people's contribution to the public good programme. The first perk is a Facebook profile picture overlay with an eco-friendly stamp, whilst the second perk is a letter to the participant certifying the positive effect their contribution would have in supporting the seaweed programme.

The rest of the article is structured as follows. The next section reviews the literature on the use of CEs for renewable energy production and for reducing free-riding behaviour. In the following section, the methodology of the CE is detailed and then the design of the CE is described. Next we present our results, before discussing the implications of our findings in the final section of the paper.

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106 **2 Literature Review**

107 Some CEs have been conducted studying people's preferences for using biomass as
 108 a source of energy. Borchers, Duke and Parsons (2007) conducted a CE to elicit people's
 109 preferences for participation in green electricity programmes. They find that there is a
 110 positive WTP for green electricity, but that biomass and farm methane are the least preferred
 111 sources. Susaeta, Lal, Alavalapati and Mercer (2011) analysed people's preferences for
 112 woody biomass, and they found that the levels of the two attributes - reduction of CO₂
 113 emissions and improvement of forest habitat - were not statistically significant. Three other
 114 articles focus on people's preferences for using forest biomass as a source of electricity in
 115 Spain (Soliño, 2010; Soliño et al, 2012; Soliño, Prada and Vázquez, 2010). They find that
 116 people value a decrease in pressure on non-renewable sources and lower risk of forest fires
 117 the most. Moving away from woody biomass, Lim, Lim and Yoo (2014) studied respondents'
 118 WTP for converting waste to energy, and found a positive WTP. Using a similar biogas
 119 production process, Zemo and Termansen (2018) researched farmers' willingness to
 120 participate in a partnership-based biogas investment in order to increase farmers' low
 121 engagement. The collective investment had the desired effect even among farmers who had
 122 never considered investing in biogas before. Lastly, Solomon and Johnson (2009) used the
 123 contingent valuation method and fair share format question to analyse the public's valuation
 124 of mitigating global climate change through its WTP for biomass or "cellulosic" ethanol.
 125 They found that a larger proportion of respondents were willing to pay extra for cellulosic
 126 ethanol in the contingent valuation than in the fair share scenario.

127 Few studies have looked at people's preferences for seaweed farming. For example,
 128 Kosenius (2010) studied the general public's water quality preferences in the Gulf of Finland.

Four attributes were used to describe the possible improvement in the water quality: water clarity, abundance of non-attractive fish, status of a type of seaweed, and mass occurrences of blue-green algae blooms. She found that the most important attribute was water clarity, followed by a preference for fewer blue-green algae blooms. However, to the best of our knowledge, no CE has been conducted on the preferences of using seaweed as a source of biogas. Given that this is a fairly recent development in renewable energy, it is not very surprising.

Free-riding can be quite common in environmentally-friendly behaviour since the impact of one person making some sort of contribution towards improving the environment, such as recycling or buying “green” energy, may seem negligible. Furthermore, if a person does not contribute, he/she still receives the benefits of others contributing, thus people are incentivised to free-ride. Bartlett and DeSteno (2006) and Falk (2007) show that when there is some reciprocity for a public good contribution, the level of the provision of the public good increases.

In this article, respondents are presented with a CE that entails three options – the current situation, and two alternative hypothetical programmes which use seaweed for energy production. Respondents choose whether or not to opt into one of the seaweed programmes, which can be interpreted as contributing to a public good. We explore the trade-offs that people are prepared to make to increase the production of renewable energy from seaweed and the area of coastline affected by seaweed farms. We further investigate how two different perks affect free-riding behaviour by providing respondents with some reciprocity for their willingness to contribute to the public programme in the form of (i) a Facebook profile picture overlay with an eco-friendly stamp, and (ii) a personal letter from the electricity supplier to

the participant with a recognition of the respondent's role in supporting the seaweed programme.

3 Methodology: choice experiments

A CE, a non-market valuation method, is commonly used when eliciting people's preferences for environmental goods or services whose prices are not determined by the market (Tait et al, 2017; Chaikaew, Hodges and Grunwald, 2017). CEs have been widely used not only in environmental (Hoyos, 2010; Mariel et al, 2013; Taylor and Longo, 2010), and energy economics (Abdullah and Mariel, 2010; Boeri and Longo, 2017; Longo et al, 2008), but also in the fields of health (Ryan et al, 2007; Boeri et al, 2013; Grisolia et al, 2013, 2018; Morgan et al, 2017; Veldwijk et al, 2017), transportation (Bahamonde-Birke et al, 2017; Higgins, Mohamed and Ferguson, 2017), and marketing (Farsky et al, 2017; Mahadevan and Chang, 2017), among others. Participants have to choose one hypothetical alternative, among various, which describe different scenarios, each composed of the same attributes, but differ in levels. One of the advantages of this methodology is that since it forces people to make trade-offs, it reveals how they value the goods or services (Freeman III, 2003). One of the attributes is usually price or cost, which allows a monetary value to be assigned to people's preferences, or their WTP.

The utility function for a person choosing a hypothetical alternative on a choice occasion is given by:

$$(1) \quad U_{nt,j} = \beta_n' x_{nt,j} + \varepsilon_{nt,j},$$

where β_n' is a vector for the individual specific utility weights for respondent n , $x_{nt,j}$ a vector of attribute levels for alternative j on choice occasion t , and the error term, $\varepsilon_{nt,j}$, which is independently and identically distributed as extreme value type I and unobserved

by the researcher. This utility function is for a random parameter (RPL) model, which assumes people have heterogeneous preferences. Therefore, the parameters are random variables assumed to have a specific distribution.

It is assumed that when comparing the hypothetical alternatives, the respondent will choose the alternative i that gives him/her the highest utility, such that $U_{nt,i} > U_{nt,j}, \forall j \neq i$ (McFadden, 1974). Thus, the probability of respondent n choosing alternative j on choice occasion t is:

$$(2) \quad P_{nt,j} = \frac{\exp(x'_{nt,j}\beta_n)}{\sum_{j=1}^J \exp(x'_{nt,j}\beta_n)}.$$

Since respondents in our questionnaire are asked to pick one option in each of 10 choice occasions, the conditional probability of respondent n choosing the sequence of 10 choices is given by:

$$(3) \quad P_n|\beta_n = \prod_{t=1}^{10} P_{nt,j}|\beta_n.$$

Since β_n is unknown, it must be integrated out of the conditional probability. We assume that it is a random variable with density function $f(\cdot)$ that depends on a set of parameters Ω . The log likelihood function of the conditional logit model is defined as:

$$(4) \quad \log L = \sum_{n=1}^N \ln \int_{\beta_n} \prod_{t=1}^T P_{nt,j}|\beta_n f(\beta, \Omega) d\beta_n.$$

Lastly, the WTP for a good or service is the marginal rate of substitution between a non-monetary attribute and cost. In the RPL model, it is a random variable defined as a negative ratio of a non-monetary and a monetary coefficient.

The analysis can also include socio-demographic variables, such as age, gender, education level, etc. This is done by interacting the socio-demographic variables with the attributes in the utility function.

4 Design of the questionnaire

The objective of the questionnaire was to determine people's preferences for using seaweed as a source for renewable energy. The questionnaire was developed as part of the SeaGas project, in which biologists, engineers and economists explored the potential of extracting biogas from seaweed using a 7.5-hectare seaweed site situated in Strangford Lough, Northern Ireland, as a case study. After initial focus groups and piloting, an online questionnaire was developed and then administered through the Qualtrics platform by the marketing research company Netigate in England, Scotland and Northern Ireland from October 2017 to January 2018; they were instructed to collect a representative sample of the population in terms of age and gender.

The questionnaire was divided into three parts. First, respondents were asked about their attitudes regarding climate change and the environment in general using a set of questions from two Eurobarometer surveys: the first on climate change (EB 87.1), the second focusing on the attitudes towards the environment (EB 81.3); both were conducted by the European Commission. Participants were then informed about the possibility of growing seaweed as a new source of renewable energy, and the resulting advantages and disadvantages, along with a couple of pictures. They were specifically told:

“Recently, scientists have studied using seaweed as a source of renewable energy. Seaweed farms can be grown in salt water, from long lines supported by buoys and are harvested once a year. The seaweed is treated through a biological process, which generates methane gas. The methane can be passed through an engine to produce renewable energy. The potential benefit of seaweed farming is that there is no competition with land resources to grow the crop, therefore no chemical fertilizers and there is improved waste

processing. However, seaweed farms may hinder recreational use at a specific site, might affect the local fishermen and the view of the buoys might bother some people.”

This led into the second part of the questionnaire: the CE. Before being presented with ten choice sets, the four attributes were presented, along with their corresponding levels. As can be seen in Table 1, the four attributes in the choice sets were: (1) the number of households powered using seaweed as the source of renewable energy, representing the scale of the project, with three levels: 45,000 households, 85,000 households and 130,000 households; (2) the percent of coastline used for seaweed farms, its levels being 10%, 20% and 30% of the coastline; (3) an increase in electricity bill per year, with five levels ranging from £10 to £150; and (4) perks: receiving a letter detailing their contribution, in terms of how many households they helped power, receiving a certified eco-friendly overlay for their Facebook profile picture, or nothing. The attributes were described one at a time, with a question about the amount respondents pay on their electricity bill after the price attribute description, and a Likert scale question after each of the other attributes on the importance of that particular attribute to the respondents. These questions aimed at breaking the monotonicity of the attributes description and maintain the focus of the respondent on our survey.

Table 1. Attributes and their Levels

Attributes	Levels
Number of households powered	45,000; 85,000; 130,000
Percent of coastline used for seaweed farms	10%, 20%, 30%
Increase in electricity bill per year	£10, £20, £50, £100, £150
Perks	Facebook profile picture overlay, A letter with your contribution, Nothing

In each choice set, respondents had to choose one among two hypothetical seaweed projects and a “neither” scenario, which meant that there would be no change to their current situation. A full factorial was not possible since the four attributes and their levels resulted in a large number of combinations ($3^3 \times 5^1 = 135$). Thus, a D-efficient design for random parameter models was generated, using only a subset of the full factorial, in Ngene (ChoiceMetrics, 2012). Some restrictions were made to the design in order to avoid one alternative dominating another. For example, if an alternative was better in terms of the number of households powered (the more the better) or the percentage of the coastline used (the smaller the better), then it had to cost more than the other alternative.² The experimental design comprised of three blocks, with 10 rows in each block. The order of the choice sets was randomized to avoid an ordering effect. Figure 1 presents a sample choice set used in the online questionnaire.

Characteristics	Alternative 1	Alternative 2	Neither
Number of households powered	85,000 households	45,000 households	No change from your current situation
% of coastline used for seaweed farming	30% of coastline	10% of coastline	
Increase in electricity bill per year	£ 10	£ 10	
Perks	A letter with your contribution	Facebook profile picture overlay	

	Alternative 1	Alternative 2	Neither
I would choose:	☐	☐	☐

Figure 1. Sample choice set

² The specific case of 130,000 households powered using 10% of the coastline was not excluded as the seaweed site could extend further out into the sea, all the while only using 10% of the coastline.

After choosing an alternative in each of the 10 choice sets, respondents were debriefed with some basic socio-demographic questions, which included a question that asked respondents if they had a Facebook account.

5 Results

The results are examined in terms of three subsections: the choice experiment results, the willingness to pay results, and the compensating variation measures.

5.1 Choice experiment results

The sample of respondents for England (1,089 respondents), Scotland (537 respondents) and Northern Ireland (390 respondents) do not differ greatly in most socio-demographic variables as can be seen in Table A4 in the Appendix, which presents the descriptive statistics of the main variables. The samples are representative in terms of age and gender as according to the 2011 census results for England, Scotland and Northern Ireland, the mean age of the population was 39.3, 40.3 and 37.6, respectively (Office for National Statistics, 2018; National Records of Scotland, 2018; Northern Ireland Statistics and Research Agency, 2018). With respect to gender, slightly more than half of the population was female in 2011 (50.8% of the English population, 51.5% of the Scottish population and 51% of the Northern Irish population) (Office for National Statistics, 2018; National Records of Scotland, 2018; Northern Ireland Statistics and Research Agency, 2018).

The RPL models were estimated using PythonBiogeme version 2.4 (Bierlaire, 2008). Tables 2-4 present the RPL model results for each of the three countries. Two alternative-specific constants in the utility functions for alternatives 1 and 3 were included in the models. The alternative-specific constant included in the utility for alternative 3 represents the

“neither” alternative, or the status quo option. All variables except for price were coded as dummy variables. One random parameter is assumed to have a log-normal distribution with a negative sign (price), while the others were assumed to have normal distributions.

As can be seen from Tables 2-4, the first alternative-specific constant is not statistically significant, but the second is statistically significant at the 1% significance level and negative, indicating that people are more likely to choose either the first or the second alternative more than the status quo. This means that people prefer to opt into a seaweed project rather than not. The estimated coefficient for the price attribute is statistically significant at the 1% significance level and negative. Since the mean for the price coefficient is assumed to be log-normally distributed, its median for the English sample, for example, is $-\exp(-3.470) = -0.031$, and the mean is $-\exp\left(-3.470 + \frac{1.760^2}{2}\right) = -0.146$. The dummy variables representing the number of households being powered are both positive and statistically significant at the 1% significance level, with the magnitude of the second dummy variable always larger than the first. Therefore, people prefer a larger scale seaweed project. The percentage of the coastline used for seaweed farming is negative and statistically significant at the 10% significance level or better, with an increasing magnitude, in line with our expectations. Thus, people prefer a smaller percentage of the coastline being used to farm seaweed.

Moving on to the first perk, receiving a letter detailing the respondent’s contribution, the estimated mean of the random parameter is not statistically significant for the English respondents, but is negative and statistically significant at the 5% level for Scotland and Northern Ireland. Regarding the Facebook profile picture overlay, for all three countries, the estimated coefficient is negative and statistically significant at the 1% significance level. Therefore, neither of the two perks have a positive impact on encouraging more people to

306 **Table 2. RPL Results for England**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	0.042	(0.035)		
ASC3 (Status Quo)	-2.920***	(0.114)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.470***	(0.066)	1.760***	(0.064)
<i>Normal distribution</i>				
Number of households powered (<i>baseline = 45,000 households</i>):				
85,000 households	0.664***	(0.056)	0.537***	(0.106)
130,000 households	0.994***	(0.080)	1.280***	(0.100)
% of coastline used for seaweed farming (<i>baseline = 10%</i>):				
20% of the coastline	-0.173***	(0.051)	0.771***	(0.081)
30% of the coastline	-0.408***	(0.063)	1.150***	(0.083)
Perks:				
Letter with contribution	-0.042	(0.048)	0.305**	(0.140)
Facebook profile pic. overlay	-0.270***	(0.059)	0.661***	(0.085)
Number of observations		10890		
Number of estimated parameters		16		
Log-likelihood		-8043.658		
AIC		16119.316		
BIC		16236.046		
McFadden's Pseudo R-squared		0.325		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively.

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314 **Table 3. RPL Results for Scotland**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	-0.034	(0.052)		
ASC3 (Status Quo)	-3.200***	(0.164)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.200***	(0.101)	1.660***	(0.096)
<i>Normal distribution</i>				
Number of households powered (baseline = 45,000 households):				
85,000 households	0.751***	(0.076)	0.121	(0.130)
130,000 households	1.020***	(0.111)	1.140***	(0.117)
% of coastline used for seaweed farming (baseline = 10%):				
20% of the coastline	-0.117*	(0.070)	0.647***	(0.133)
30% of the coastline	-0.377***	(0.092)	1.280***	(0.126)
Perks:				
Letter with contribution	-0.144**	(0.073)	0.393***	(0.151)
Facebook profile pic. overlay	-0.421***	(0.094)	0.766***	(0.124)
Number of observations		5,370		
Number of estimated parameters		16		
Log-likelihood		-3800.249		
AIC		7632.498		
BIC		7737.915		
McFadden's Pseudo R-squared		0.354		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively.

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322 **Table 4. RPL Results for Northern Ireland**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	-0.057	(0.054)		
ASC3 (Status Quo)	-2.890***	(0.182)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.520***	(0.104)	1.620***	(0.097)
<i>Normal distribution</i>				
Number of households powered (baseline = 45,000 households):				
85,000 households	0.608***	(0.084)	0.313	(0.213)
130,000 households	0.908***	(0.123)	1.100***	(0.149)
% of coastline used for seaweed farming (baseline = 10%):				
20% of the coastline	-0.200**	(0.082)	0.617***	(0.137)
30% of the coastline	-0.385***	(0.096)	0.893***	(0.130)
Perks:				
Letter with contribution	-0.165**	(0.082)	0.561***	(0.144)
Facebook profile pic. overlay	-0.524***	(0.103)	0.733***	(0.136)
Number of observations		3,900		
Number of estimated parameters		16		
Log-likelihood		-2943.082		
AIC		5918.164		
BIC		6018.464		
McFadden's Pseudo R-squared		0.309		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively.

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opt into one of the seaweed projects.

To investigate this strong negative result of the Facebook overlay picture, we re-ran our models excluding respondents without a Facebook profile. However, limiting the sample to only respondents with Facebook accounts does not affect the results, as can be seen in Tables A1-A3 in the Appendix. Next, we postulate that a Facebook profile picture overlay might sway young participants, but not older participants, with the effect remaining hidden when analysing the full sample. However, re-estimating the RPL models with a dummy variable representing participants aged 18-25 interacted with the Facebook attribute shows there is no age effect on this perk. To further test the appeal of the two perks, we report in Figure 2, the bar plots of the responses, divided for individuals with and without Facebook accounts, to the Likert scale question “How much are these perks likely to affect your participation?”, with possible answers being “None”, “Very little”, “Some”, “A lot”, “Don’t know”. A visual interpretation of the graphs indicates that only for a minority of respondents, receiving either perks would affect their likelihood to support the renewable energy programme a lot. As the graphs show, there is strong dependence between the two variables. A χ^2 test rejects the null hypothesis of independence, in all six cases, concluding that people with and without Facebook have different preferences for the two perks.

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351 **Figure 2: Responses to the question “Is the *perk* likely to affect your decision to opt into**352 **the seaweed project scheme?”**

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354 **5.2 Willingness to pay results**

355 The simulated WTP distributions derived from the RPL model estimates presented in

356 Tables 2-4 allow for a relative comparison between the three countries. Table 5 presents the

357 WTP results for each country and shows that the only attribute levels with a positive WTP

358 range shown in the table are the number of households powered, with respect to the baseline

level of 45,000 households powered. The median value is similar for both dummy variables across the three countries, but the dummy variable that represents 130,000 households being powered has the largest dispersion.

Table 5. WTP results by country

	England			Scotland			Northern Ireland		
	25 th percentile	Median	75 th percentile	25 th percentile	Median	75 th percentile	25 th percentile	Median	75 th percentile
85,000 households	£2.70	£14.00	£59.10	£6.10	£18.80	£59.30	£5.20	£17.70	£59.00
130,000 households	£0.70	£17.30	£87.80	£1.60	£15.70	£70.30	£1.60	£19.50	£82.30
20% coastline	-£20.80	-£1.60	£7.10	-£13.10	-£0.80	£6.13	-£29.00	-£6.00	£4.00
30% coastline	-£43.00	-£4.50	£5.50	-£33.00	-£3.80	£7.40	-£43.00	-£6.50	£3.40
Letter	-£7.50	-£0.40	£3.30	-£11.60	-£1.50	£1.60	-£19.70	-£2.30	£4.30
Facebook	-£27.50	-£3.50	£2.60	-£30.80	-£5.40	£0.90	-£48.50	-£10.30	-£0.20

Both WTP measures for the percentage of coastline used are negative across all three countries. Although the median values are similar for both dummy variables, the larger percentage has a slightly more negative median than the middle value of 20% of coastline used, meaning they are increasingly less desirable than the smallest value of 10%. The WTP for 30% coastline used also has a large dispersion, which means there is a larger heterogeneity among respondents, with some respondents having a stronger aversion to using 30% of the coastline for growing seaweed than others.

Lastly, the median value corresponding to the first perk, the letter detailing the participant's contribution in terms of the number of households powered, is close to zero for all countries. Moving on to the second perk, the Facebook profile picture overlay with an eco-friendly stamp, the median value for all three countries is negative. This perk also has a

much larger dispersion than the first perk, meaning that there are people who strongly dislike the idea of using a Facebook profile picture overlay as an incentive to opt-in.

5.3 Compensating variation measures

Using the RPL model estimated coefficients in Tables 2-4, compensating variation (CV) measures are estimated for each of the three countries. In order to calculate the CV measures, we assume different increases or decreases in attributes from the baseline scenario of 45,000 households powered, 10% of coastline used to farm seaweed and no perks, represented by one of the seven scenarios listed in Table 6. Since there is still no consensus on whether or not to include the constants (Adamowicz et al, 2011; Oehlmann et al, 2017), and the main objective of the CV measures is a relative comparison, the constants are left out for simplification purposes. Nevertheless, the inclusion of the constant in our case does not change the outcome significantly because our CV measures represent changes from the baseline scenario that corresponds to one of the non-SQ alternatives. As can be seen in the output of Tables 2, 3 and 4, these constants (ASC1) are small (in absolute) values and statistically not significant at 5%.

The first column in Table 6 presents the different scenarios for which we calculated the CV measures, the second, third and fourth columns display the CV measures for England, Scotland and Northern Ireland, respectively, with the standard errors in brackets below. The values are in British Pounds per year.

The first three scenarios include the middle levels of both the number of households powered attribute as well as the percentage of coastline used to farm seaweed, i.e., 85,000 households and 20% of coastline used. What varies between the three scenarios are the perks offered. It is clear that, among the first three scenarios, the first scenario has the highest CV

400 **Table 6. Compensating Variation Measures in £ per Year**

Scenarios		England	Scotland	Northern Ireland
1	85,000 households, 20% of coastline, no perks	15.78*** (2.573)	15.55*** (2.874)	13.78*** (4.124)
2	85,000 households, 20% of coastline, letter	14.44*** (2.885)	12.02*** (3.163)	8.21* (4.671)
3	85,000 households, 20% of coastline, Facebook	7.10** (3.025)	5.23 (3.378)	-3.92 (5.156)
4	130,000 households, 30% of coastline, no perks	18.83*** (3.194)	15.77*** (3.490)	17.67*** (5.033)
5	130,000 households, 30% of coastline, letter	17.50*** (3.514)	12.24*** (3.807)	12.09** (5.591)
6	130,000 households, 30% of coastline, Facebook	10.16*** (3.598)	5.45 (4.006)	-0.034 (5.911)
7	130,000 households, 10% of coastline, no perks	31.94*** (3.049)	25.02*** (3.430)	30.68*** (4.793)

Note: (i) Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively; (ii) standard errors were calculated using the delta method.

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402 measure at an average of £15.78 per year in England, £15.55 per year in Scotland and £13.78
 403 per year in Northern Ireland. These measures decrease if a letter is offered as a perk, by as
 404 much as £5.57 per year (for Northern Ireland). If instead of a letter, the Facebook profile
 405 picture overlay is offered as a perk, the CV measures decrease even more, with the measures
 406 not statistically significantly different from zero for Scotland and Northern Ireland. Thus,
 407 simply adding this perk to a scenario where people were willing to pay a positive amount can
 408 take away people's WTP altogether.

409 Scenarios 4-6 have the highest levels of the number of households powered (130,000)
 410 and the percentage of coastline used (30%), and, once again, only vary by the type of perk
 411 offered. In scenario 4, where no perk is offered, the CV measures are higher than in scenario
 412 1, but the difference is not statistically significant at the 5% level for any of the three
 413 countries. Nevertheless, this means that they are indifferent between scenario 1, which
 414 powers 85,000 households and uses 20% of the coastline, and scenario 4, which powers
 415 130,000 households and uses 30% of the coastline. In other words, people are willing to

relinquish more of the coastline to seaweed farming as long as more households are powered. Similar to scenarios 1-3, the CV measures decrease if a letter is added to scenario 4, and decrease even more if a Facebook profile picture overlay is offered. Once again, the CV measures for Scotland and Northern Ireland cease to be statistically significant, as can be seen in scenario 6.

Lastly, the highest CV measure is scenario 7, powering 130,000 households, only using 10% of the coastline for farming seaweed, and not offering any perks. The highest value is for England at £31.94 per year, followed by Northern Ireland with a value of £30.68 per year, and Scotland with £25.02 per year. This would be the most expensive scenario, if the seaweed project were to be implemented.

6 Discussion and conclusion

To the best of our knowledge, this is the first study of people's WTP for the use of seaweed as a source of biogas. This environmentally-friendly programme does not compete for land, a common problem for land biomass sites, and therefore, could offer a sustainable solution for increasing energy demand. However, the cost of implementing this type of energy project may be high at first. As a result, a CE is conducted to elicit people's preferences for this new source of biogas, which allows for the simulation of people's WTP as well as the analysis of CV measures for different scenarios.

Given that free-riding behaviour can be common when people are asked to be proactive with regards to helping the environment, two perks were introduced to provide respondents with some reciprocity for their willingness to support the public programme of renewable energy from seaweed farming. The first perk entails receiving a Facebook profile picture overlay of an eco-friendly stamp certified by the electricity provider. The second perk

is a letter the respondent would receive if they were to opt into a seaweed project, detailing the participant's contribution, in terms of the number of households powered.

We found that neither of the two perks had a positive impact on encouraging people to opt into one of the seaweed projects. In fact, both decreased the CV measures, with the Facebook profile picture overlay decreasing it the most. The preferences for the Facebook profile picture were more heterogeneous than for the letter, indicating that people differ in preferences for the former, but not as much for the latter. One possible interpretation of this result is that participants did not like the perks that were offered and simply did not want their profile picture to be altered, nor were they keen to receive a small gift – the letter – in recognition for their support of the public programme. Thus, if this project were to be implemented, it would be advisable to leave out the perks.

When deriving the policy recommendations from our results, policy makers may want to focus on scenarios 1, 4, and 7 of Table 6 to consider the impact of different attribute-level combinations on the support of renewable energy projects based on seaweed farming. The difference in compensating variation between scenarios 1 and 4 is quite small, and a convolution method test (Poe et al, 2005) finds that there is no statistically significant difference at the 5% level between the CV of these two scenarios. For example, in Scotland, at a price of about £15 per year in both scenarios, respondents are indifferent between supporting a programme that powers 130,000 households with renewable energy and requires the use of 30% of the coastline, and a programme that powers 85,000 households requiring the use of 20% of the coastline. In other words, our respondents are willing to accept that a larger area of the coast needs to be used if more households can be powered by renewable energy from seaweed. Scenario 7 then shows that respondents are willing to pay almost twice as much as for scenarios 1 or 4, about £25 per year in Scotland, £32 in England and £31 in

Northern Ireland, to support a programme able to power 130,000 households, using only 10% of the coastline. Aggregating this to the total households in each country, these values correspond to £705 million in England, £59 million in Scotland and £21.6 million in Northern Ireland.³ Whilst this might be the most profitable scenario for the policy maker, and the one disrupting the beauty of the seascape the least, it would require considerable investments to increase the productivity of seaweed farms, which could be achieved, for example, selecting seaweed species that can be harvested more than once a year, and less likely to suffer from disease.

What perhaps is the most interesting result of this choice experiment is that people are willing to make a trade-off between their visual disamenity and powering more households, suggesting that the visual disamenity caused by seaweed farms is not very strong. Wind farms, on the other hand, have encountered a lot of public opposition due to visual intrusion (Soerensen et al, 2001). Even building wind farms offshore does not eliminate the visual disamenity they cause (Ladenburg and Dubgaard, 2007). This is understandable since seaweed farms are mostly underwater and not as visible as wind farms. Perhaps due to this difference in visual intrusion, we find a strong preference for larger seaweed farms, while this is not the case for offshore wind farms (Ek, 2006; Ladenburg and Dubgaard, 2007). Although a cost-benefit analysis comparing the two types of renewable energies is needed, our findings suggest that seaweed farming could provide several advantages. Firstly, it appears to be generally acceptable by the public; the strong preference for larger seaweed farms could allow this green energy to reach more households. Furthermore, while a larger

³ This is based on the number of households in 2011. For England, this was 22,063,368, for Scotland it was 2,372,780 and for Northern Ireland it was 703,275 (Office for National Statistics, 2011).

485 wind farm would mean more visual intrusion and, perhaps, more noise, a seaweed farm could
486 simply be extended further out into the sea, leaving the seascape unaffected.

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References

Abdullah, S., and P. Mariel. 2010. "Choice experiment study on the willingness to pay to improve electricity services." *Energy Policy*, 38(8): 4570-4581.

<https://doi.org/10.1016/j.enpol.2010.04.012>

Adamowicz, W., D. Dupont, A. Krupnick, and J. Zhang. 2011. "Valuation of Cancer and Microbial Disease Risk Reductions in Municipal Drinking Water: An Analysis of Risk Context Using Multiple Valuation Methods." *Journal of Environmental Economics and Management*, 61(2): 213-226.

<https://doi.org/10.1016/j.jeem.2010.10.003>

Bahamonde-Birke, F.J., U. Kunert, H. Link, and J. de Dios Ortúzar. 2017. "About Attitudes and Perceptions: Finding the Proper Way to Consider Latent Variables in Discrete Choice Models." *Transportation*, 44(3): 475-493.

<https://doi.org/10.1007/s11116-015-9663-5>

Bartlett, M. Y., & DeSteno, D. 2006. "Gratitude and prosocial behavior: Helping when it costs you." *Psychological Science*, 17(4): 319-325.

<https://doi.org/10.1111/j.1467-9280.2006.01705.x>

Bierlaire, M. 2008. An Introduction to BIOGEME Version 1.7, available at: biogeme.epfl.ch.

Boeri, M., and A. Longo. 2017. "The importance of regret minimization in the choice for renewable energy programmes: Evidence from a discrete choice experiment." *Energy*

- 542 *Economics*, 63: 253-260. <https://doi.org/10.1016/j.eneco.2017.03.005>
- 543
- 544 Boeri, M., Longo, A., Grisolia, J. M., Hutchinson, W. G., and F. Kee. 2013. “The role of
- 545 regret minimisation in lifestyle choices affecting the risk of coronary heart disease.”
- 546 *Journal of Health Economics*, 32(1): 253-260.
- 547 <https://doi.org/10.1016/j.jhealeco.2012.10.007>
- 548
- 549 Borchers, A.M., J.M. Duke, and G.R. Parsons. 2007. “Does Willingness to Pay for Green
- 550 Energy Differ by Source?” *Energy Policy*, 35(6): 3327-3334.
- 551 <https://doi.org/10.1016/j.enpol.2006.12.009>
- 552
- 553 Chaikaew, P., A.W. Hodges, and S. Grunwald. 2017. “Estimating the Value of Ecosystem
- 554 Services in a Mixed-Use Watershed: A Choice Experiment Approach.” *Ecosystem*
- 555 *Services*, 23: 228-237. <https://doi.org/10.1016/j.ecoser.2016.12.015>
- 556
- 557 ChoiceMetrics. 2012. Ngene 1.1.1 User Manual & Reference Guide, Australia.
- 558
- 559 Department for Business, Energy & Industrial Strategy. 2019. “Annual Domestic Energy
- 560 Bills.” Retrieved from [https://www.gov.uk/government/statistical-data-sets/annual-](https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics)
- 561 [domestic-energy-price-statistics](https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics) Accessed: 9 November 2019.
- 562
- 563 Department of Trade and Industry, 2006. The Energy Challenge. Available online:
- 564 [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attach](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/272376/6887.pdf)
- 565 [ment_data/file/272376/6887.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/272376/6887.pdf) Accessed: 8 November 2019.

566

567 Ek, K., 2006. Quantifying the environmental impacts of renewable energy: the case of
 568 Swedish wind power. In ed. D. Pearce, *Environmental valuation in Developed*
 569 *Countries: Case Studies*. Cheltenham, pp.181-210.

570

571 European Commission. 2014. *Special Eurobarometer 416/Wave EB 81.3: Attitudes Of*
 572 *European Citizens Towards The Environment*. Brussels.

573 http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_416_en.pdf

574 Accessed: 8 April 2017.

575

576 European Commission. 2017. *Special Eurobarometer 459/Wave EB 87.1: Climate Change*.
 577 Brussels.

578 https://ec.europa.eu/clima/sites/clima/files/support/docs/report_2017_en.pdf

579 Accessed: 8 April 2017.

580

581 Falk, A. 2007. "Gift exchange in the field." *Econometrica*, 75(5): 1501-1511.

582 <https://doi.org/10.1111/j.1468-0262.2007.00800.x>

583

584 Farsky, M., O. Schnittka, H. Sattler, B. Höfer, and C. Lorth. 2017. "Brand-Anchored Discrete
 585 Choice Experiment (BDCE) vs. Direct Attribute Rating (DAR): An Empirical
 586 Comparison of Predictive Validity." *Marketing Letters*, 28(2): 231-240.

587 <https://doi.org/10.1007/s11002-016-9402-5>

588

589 Freeman III, A.M. 2003. "Economic Valuation: What And Why." In P.A. Champ PA, K.J.

Boyle, and T.C. Brown, eds. *A Primer On Nonmarket Valuation, Vol. 3*. Dordrecht: Kluwer Academic Publishers, pp. 1-25. <https://doi.org/10.1007/978-94-007-7104-8>

Gallagher, E., 2008. The Gallagher Review of the Indirect Effects of Biofuels Production. https://www.unido.org/sites/default/files/2009-11/Gallagher_Report_0.pdf, Accessed: 8 November 2019.

Grisolía, J. M., Longo, A., Boeri, M., Hutchinson, G., and F. Kee. 2013. “Trading off dietary choices, physical exercise and cardiovascular disease risks.” *Social Science & Medicine*, 93: 130-138. <https://doi.org/10.1016/j.socscimed.2013.05.031>

Grisolía, J. M., Longo, A., Hutchinson, G., and F. Kee. 2018. “Comparing mortality risk reduction, life expectancy gains, and probability of achieving full life span, as alternatives for presenting CVD mortality risk reduction: A discrete choice study of framing risk and health behaviour change.” *Social Science & Medicine*, 211: 164-174. <https://doi.org/10.1016/j.socscimed.2018.06.011>

Higgins, C.D., M. Mohamed, and M.R. Ferguson. 2017. “Size Matters: How Vehicle Body Type Affects Consumer Preferences for Electric Vehicles.” *Transportation Research Part A: Policy and Practice*, 100: 182-201.

<https://doi.org/10.1016/j.tra.2017.04.014>

HM Government, 2018. Growing the Bioeconomy. Improving Lives and Strengthening Our Economy: A National Bioeconomy Strategy to 2030.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy_Web_SP_.pdf,

Accessed: 8 November 2019.

Hoyos, D., 2010. "The state of the art of environmental valuation with discrete choice experiments." *Ecological Economics*, 69(8): 1595-1603.

<https://doi.org/10.1016/j.ecolecon.2010.04.011>

IPCC, 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp.151.

Kosenius, A.K. 2010. "Heterogeneous preferences for water quality attributes: The case of eutrophication in the Gulf of Finland, the Baltic Sea." *Ecological Economics*, 69(3): 528-538. <https://doi.org/10.1016/j.ecolecon.2009.08.030>

Ladenburg, J. and Dubgaard, A., 2007. "Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark." *Energy Policy*, 35(8): 4059-4071.

<https://doi.org/10.1016/j.enpol.2007.01.023>

Lim, S.Y., K.M. Lim, and S.H. Yoo. 2014. "External Benefits of Waste-to-Energy in Korea: A Choice Experiment Study." *Renewable and Sustainable Energy Reviews*, 34: 588-595. <https://doi.org/10.1016/j.rser.2014.03.045>

638

639 Longo, A., Markandya, A., and M. Petrucci. 2008. "The internalization of externalities in the
640 production of electricity: willingness to pay for the attributes of a policy for renewable
641 energy." *Ecological Economics*, 67(1): 140-152.

642 <https://doi.org/10.1016/j.ecolecon.2007.12.006>

643

644 Mahadevan, R., and S. Chang. 2017. "Valuing Shipscape Influence to Maximise Cruise
645 Experience Using a Choice Experiment." *International Journal of Hospitality
646 Management* 67: 53-61. <https://doi.org/10.1016/j.ijhm.2017.08.002>

647

648 Mariel, P., De Ayala, A., Hoyos, D., and S. Abdullah. 2013. "Selecting random parameters
649 in discrete choice experiment for environmental valuation: a simulation experiment."
650 *Journal of Choice Modelling*, 7: 44-57.

651 <https://doi.org/10.1016/j.jocm.2013.04.008>

652

653 McFadden, D. 1974. "Conditional Logit Analysis of Qualitative Choice Behaviour." In P.
654 Zarembka, ed. *Frontiers in Econometrics*. New York: Academic Press, pp. 105-142.

655

656 Morgan, J.L., S.J. Walters, K. Collins, T.G. Robinson, K.L. Cheung, R. Audisio, M.W. Reed,
657 and L. Wyld. 2017. "What Influences Healthcare Professionals' Treatment
658 Preferences for Older Women with Operable Breast Cancer? An Application of the
659 Discrete Choice Experiment." *European Journal of Surgical Oncology (EJSO)*,
660 43(7): 1282-1287. <https://doi.org/10.1016/j.ejso.2017.01.012>

661

Naik, S.N., Goud, V.V., Rout, P.K., and A.K. Dalai. 2010. "Production of first and second generation biofuels: a comprehensive review." *Renewable and Sustainable Energy Reviews*, 14: 578-597. <https://doi.org/10.1016/j.rser.2009.10.003>

National Records of Scotland. 2018. "Scotland's Census 2011 - National Records of Scotland" [Table KS102SC - Age structure]. Retrieved from <http://www.scotlandscensus.gov.uk/ods-analyser/jsf/tableView/tableView.xhtml> Accessed: 15 May 2018.

Northern Ireland Statistics and Research Agency. 2018. "Census 2011: Key Statistics for Northern Ireland" Retrieved from <https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/2011-census-results-key-statistics-summary-report.pdf> Accessed: 15 May 2018.

Oehlmann, M., J. Meyerhoff, P. Mariel, and P. Weller. 2017. "Uncovering Context-Induced Status Quo Effects in Choice Experiments." *Journal of Environmental Economics and Management*, 81: 59-73. <https://doi.org/10.1016/j.jeem.2016.09.002>

Office for National Statistics. 2011. "Number of usual residents in households and number of households, with percentage change" [Data]. Retrieved from <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/populationandhouseholdestimatesfortheunitedkingdom/2011-03-21> Accessed: 16 May 2018.

- 686 Office for National Statistics. 2018. "Census 2011" [Table Links: Key Statistics]. Retrieved
 687 from http://www.nomisweb.co.uk/census/2011/key_statistics
 688 Accessed: 16 May 2018.
- 689
- 690 Poe, G.L., Giraud, K.L., Loomis, J.B., 2005. "Computational Methods for Measuring the
 691 Difference of Empirical Distributions." *American Journal of Agricultural*
 692 *Economics*, 87(2): 353-365.
 693 <https://doi.org/10.1111/j.1467-8276.2005.00727.x>
 694
- 695 Ryan, M., Gerard, K. and M. Amaya-Amaya. 2007. Using discrete choice experiments to
 696 value health and health care (Vol. 11). Springer Science & Business Media.
 697
- 698 Soerensen, H.C., Hansen, L.K., Hammarlund, K., 2001. Social acceptance, environmental
 699 impact and politics. Final Report WP2.5 Concerted Action on Offshore Wind Energy
 700 in Europe NNE5-1999-00562. EMU/SPOK Consult, and Hammarlund Consulting,
 701 Copenhagen. Available from: <http://www.emu-consult.dk/includes/c5report.pdf>.
 702
- 703 Soliño, M. 2010. "External Benefits of Biomass-e in Spain: An Economic Valuation."
 704 *Bioresource Technology*, 101(6): 1992-1997.
 705 <https://doi.org/10.1016/j.biortech.2009.09.086>
 706
- 707 Soliño, M., B.A. Farizo, M.X. Vázquez, and A. Prada. 2012. "Generating Electricity with
 708 Forest Biomass: Consistency and Payment Timeframe Effects in Choice
 709 Experiments." *Energy Policy*, 41: 798-806.

<https://doi.org/10.1016/j.enpol.2011.11.048>

Soliño, M., A. Prada, and M.X. Vázquez. 2010. “Designing a Forest-Energy Policy to Reduce Forest Fires in Galicia (Spain): A Contingent Valuation Application.” *Journal of Forest Economics*, 16(3): 217-233. <https://doi.org/10.1016/j.jfe.2009.11.006>

Solomon, B.D., and N.H. Johnson. 2009. “Valuing Climate Protection through Willingness to Pay for Biomass Ethanol. *Ecological Economics*, 68(7): 2137-2144.

<https://doi.org/10.1016/j.ecolecon.2009.02.010>

Susaeta, A., P. Lal, J. Alavalapati, and E. Mercer. 2011. “Random Preferences towards Bioenergy Environmental Externalities: A Case Study of Woody Biomass Based Electricity in the Southern United States.” *Energy Economics*, 33(6): 1111-1118.

<https://doi.org/10.1016/j.eneco.2011.05.015>

Tait, P., C. Saunders, G. Nugent, and P. Rutherford. 2017. “Valuing Conservation Benefits of Disease Control in Wildlife: A Choice Experiment Approach to Bovine Tuberculosis Management in New Zealand's Native Forests.” *Journal of Environmental Management*, 189: 142-149.

<https://doi.org/10.1016/j.jenvman.2016.12.045>

Taylor, T., and A. Longo. 2010. “Valuing algal bloom in the Black Sea Coast of Bulgaria: A choice experiments approach.” *Journal of Environmental Management*, 91(10): 1963-1971. <https://doi.org/10.1016/j.jenvman.2010.04.007>

734

735 van der Molen, J., Ruardij, P., Mooney, K., Kerrison, P., O'Connor, N. E., Gorman, E., ... ,
736 and E. Capuzzo. (2018). "Modelling potential production of macroalgae farms in UK
737 and Dutch coastal waters." *Biogeosciences*, 15(4): 1123-1147.
738 <https://doi.org/10.5194/bg-15-1123-2018>

739

740 Veldwijk, J., J.V. Johansson, B. Donkers, and E. de Bekker-Grob. 2017. "Mimicking Real
741 Life Decision-Making in Health: Allowing Respondents Time-to-Think in a Discrete
742 Choice Experiment." *Value Health*, 20(9): A406.
743 <https://doi.org/10.1016/j.jval.2017.08.049>

744

745 Zemo, K.H., and M. Termansen. 2018. "Farmers' Willingness to Participate in Collective
746 Biogas Investment: A Discrete Choice Experiment Study." *Resource and Energy*
747 *Economics*, 52: 87-101. <https://doi.org/10.1016/j.reseneeco.2017.12.001>

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758 **Appendix**759 **Table A1. RPL Results Limited to Sample with a Facebook Account for England**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	0.068*	(0.039)		
ASC3 (Status Quo)	-3.000***	(0.130)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.500***	(0.079)	1.680***	(0.079)
<i>Normal distribution</i>				
Number of households powered (baseline = 45,000 households):				
85,000 households	0.676***	(0.060)	0.240	(0.261)
130,000 households	1.080***	(0.093)	1.230***	(0.117)
% of coastline used for seaweed farming (baseline = 10%):				
20% of the coastline	-0.183***	(0.055)	0.658***	(0.106)
30% of the coastline	-0.394***	(0.072)	1.140***	(0.097)
Perks:				
Letter with contribution	-0.012	(0.055)	0.398***	(0.121)
Facebook profile pic. overlay	-0.162***	(0.061)	0.435***	(0.110)
Number of observations		8200		
Number of estimated parameters		16		
Log-likelihood		-6011.083		
AIC		12054.166		
BIC		12166.356		
McFadden's Pseudo R-squared		0.326		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively.

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766 **Table A2. RPL Results Limited to Sample with a Facebook Account for Scotland**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	-0.011	(0.062)		
ASC3 (Status Quo)	-3.260***	(0.205)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.280***	(0.103)	1.500***	(0.084)
<i>Normal distribution</i>				
Number of households powered (baseline = 45,000 households):				
85,000 households	0.816***	(0.091)	0.347*	(0.196)
130,000 households	1.190***	(0.136)	1.240***	(0.153)
% of coastline used for seaweed farming (baseline = 10%):				
20% of the coastline	-0.171**	(0.086)	0.729***	(0.149)
30% of the coastline	-0.440***	(0.108)	1.320***	(0.147)
Perks:				
Letter with contribution	-0.120	(0.086)	0.425***	(0.161)
Facebook profile pic. overlay	-0.335***	(0.110)	0.807***	(0.152)
Number of observations		3930		
Number of estimated parameters		16		
Log-likelihood		-2802.035		
AIC		5636.070		
BIC		5736.492		
McFadden's Pseudo R-squared		0.346		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%, and 10% level, respectively.

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774 **Table A3. RPL Results Limited to Sample with a Facebook Account for Northern**
775 **Ireland**

	Est. Coefficient	St. Err.	St. Dev.	St. Err.
ASC1	-0.013	(0.064)		
ASC3 (Status Quo)	-3.060***	(0.226)		
Random Parameters				
<i>Log-normal distribution</i>				
Price	-3.410***	(0.118)	1.650***	(0.117)
<i>Normal distribution</i>				
Number of households powered (baseline = 45,000 households):				
85,000 households	0.760***	(0.102)	0.092	(0.143)
130,000 households	1.150***	(0.154)	1.190***	(0.166)
% of coastline used for seaweed farming (baseline = 10%):				
20% of the coastline	-0.153	(0.097)	0.554***	(0.186)
30% of the coastline	-0.389***	(0.119)	0.915***	(0.179)
Perks:				
Letter with contribution	-0.184*	(0.098)	0.515***	(0.192)
Facebook profile pic. overlay	-0.475***	(0.120)	0.757***	(0.149)
Number of observations		2760		
Number of estimated parameters		16		
Log-likelihood		-2026.300		
AIC		4084.600		
BIC		4179.368		
McFadden's Pseudo R-squared		0.327		

Note: Triple asterisk (***), double asterisk (**) and asterisk (*) denote significance at the 1%, 5%,
and 10% level, respectively.

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782 Table A4. Descriptive statistics

	England		Scotland		Northern Ireland	
Variable	Num. of indiv.	1,089	Num. of indiv.	537	Num. of indiv.	390
Age	Mean	40.7	Mean	41.2	Mean	40.9
	St. Dev.	12.9	St. Dev.	13.1	St. Dev.	12.8
	Min	18	Min	18	Min	18
	Max	65	Max	65	Max	65
	Frequency		Frequency		Frequency	
Female		52.5%		50.6%		52.3%
<i>Marital status</i>						
Single		30.1%		35.5%		32.0%
Married		43.4%		39.9%		48.5%
Cohabiting partnership		6.4%		5.1%		6.7%
Divorced/Separated		1.4%		0.7%		2.2%
Widowed		18.7%		18.6%		10.6%
<i>Education</i>						
Primary or less than primary		1.6%		1.6%		1.1%
Secondary		76.3%		71.1%		71.0%
University and higher		22.1%		27.3%		27.9%
<i>Job status</i>						
Employed (full- or part-time)		60.6%		61.5%		60.5%
Self employed		9.0%		7.3%		6.4%
Retired		5.4%		4.9%		7.5%
Unemployed		7.6%		9.0%		8.6%
Other		17.4%		17.3%		17.0%
<i>Income</i>						
< £ 15,000		18.4%		19.8%		19.8%
£ 15,000- £ 23,500		18.5%		17.7%		19.5%
£ 23,501- £ 33,800		20.3%		22.0%		21.5%
£ 33,801- £ 48,000		19.8%		18.7%		16.1%
£ 48,001- £87,500		18.1%		18.1%		20.0%
£87,501+		4.9%		3.7%		3.1%

Facebook account	80.9%	77.2%	76.9%
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How much are these perks likely to affect your decision to opt into the seaweed project scheme?

Facebook overlay

None	57.4%	62.2%	58.7%
Very little	18.4%	17.1%	17.7%
Some	11.8%	11.9%	11.0%
A lot	6.7%	5.1%	6.4%
Don't know	5.7%	3.7%	6.1%

Letter

None	37.3%	47.3%	36.4%
Very little	21.4%	18.4%	23.6%
Some	25.5%	22.7%	21.5%
A lot	9.8%	7.1%	12.8%
Don't know	6.0%	4.5%	5.6%