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Investment barriers under a renewable-electricity support scheme: Differences across investor types

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ABSTRACT

In 2012, Norway and Sweden implemented a common market for tradable green certificates to achieve each country's renewable-energy target. This is the first example of a cooperation mechanism that the EU has suggested to improve the cost efficiency of its renewable-energy policies. We asked investors in 446 planned hydropower projects in Norway what type of barriers may prevent their project from being realized under this scheme, and how likely it is that their project will be realized. Based on a regression analysis we find that the responses to these questions vary systematically with investor, project and process characteristics. We find that investors are concerned with capacity barriers imposed on the market because of the short duration and abrupt termination of the subsidy scheme at the end of 2020. Consequently, the cost efficiency of this and similar schemes can be improved by choosing a better design. Moreover, experienced investors and local landowners without previous experience in the energy sector responded differently to these questions. Local landowners were more optimistic, less concerned with capacity barriers and more concerned with economic barriers than experienced investors were. These observations are interesting given the recent emergence of new investors in the renewable energy sector.

1. Introduction

In January 2012, Norway and Sweden implemented a common market for tradable green certificates[1] to achieve at the least cost for society each country's renewable-energy target by the end of 2020. This joint support scheme is the first example of a cooperation mechanism that the EU has opened up for in Directive 2009/28/EC on promoting use of energy from renewable sources [7]. Based on a survey among investors in 446 planned hydropower projects in Norway we use regression analysis to formally examine the perceived barriers against implementing cost-effective projects by the deadline set by this scheme. Special attention is paid to whether such perceptions varied systematically between experienced and inexperienced investors when we control for other project characteristics. Identifying perceived barriers can help policymakers improve the design of future joint support schemes and reduce the extent of other factors that reduce the cost effectiveness of the scheme.

The potential benefits from coordinating support for renewable energy stem from a more efficient localization and composition of renewable-energy investments, reflecting differences in costs and market conditions. Directive 2009/28/EC suggests joint support schemes between member states (and between member states and third countries) which allow two or more member states to decide, voluntarily, to join or partly coordinate their national support schemes. In such cases, a certain amount of energy from renewable sources produced in the territory of one participating member state may count towards the national target of another participating member state.[2] The Directive includes a plan for a continuous evaluation of the cooperation mechanisms, in order to ensure that, together with the possibility to use national support schemes,

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[1] Other terms for the same concept are “renewable portfolio standard” (United States) and “renewable obligation” (United Kingdom).

[2] See Article 9–11 in Directive 2009/28/EC [7].

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those mechanisms enable member states to achieve the national targets by the end of 2020 on the best cost-benefit basis.[3]

Cost efficiency requires that the support scheme be broadly applied (that is, that it covers all renewable-energy technologies in a wide geographic area), and that the support scheme not favor any particular technology or renewable source by differentiating the support payment solely on the basis of differences in costs.[4] The Swedish–Norwegian common market for tradable green certificates meets many of these requirements of cost efficiency. The common market was implemented in 2012 and shall by the end of 2020 contribute to an increase in renewable-electricity production of 26.4 TWh in Sweden and Norway combined, equivalent to a rise of approximately 14% in total electricity production. Each country can count half of total production towards its national renewable-electricity target. There is no restriction on in which country the new capacity is located or on which technology or renewable source that is used. Producers are, in a period of 15 years, entitled to sell one certificate for each MWh of electricity produced from a renewable source.[5] In this period, they receive two streams of revenue, one from the sale of electricity and one from the sale of certificates. Distributors of electricity are required to buy predetermined annual quotas of certificates for each MWh of electricity sold. The quotas vary over time and across countries to meet the two countries' joint target at the end of 2020. To balance supply of and demand for certificates, the sum of the electricity and certificate prices must equal the long-run marginal cost of the last producer to enter the market. Thus, in a perfect market, we would expect that the scheme stimulates investing in the least costly options first—including many hydropower projects.

However, market failure (for example, externalities, information asymmetry, transaction costs, non-competitive markets, time-inconsistent preferences and public good characteristics) may prevent cost-efficient renewable-electricity projects from being realized. Consequently, barrier removal includes "… correcting market failures directly or reducing the transactions costs in the public and private sectors by, for example, improving institutional capacity, reducing risk and uncertainty, facilitating market transactions, and enforcing regulatory policies" (IPCC WG III 2007, p. 810).

We examine whether a specific design feature, namely the way the scheme is terminated in Norway, contributes to or reinforces investors' perceptions of barriers and thus may reduce the cost efficiency of the Swedish–Norwegian joint support scheme. In Norway, the last plant to be entitled to sell green certificates must have started operation by the end of 2020; while, in Sweden, the number of years the generator could sell certificates is gradually reduced from 15 years in 2020 to 1 year in 2035. Because of the scheme's short duration in Norway (that is, 2012–2020), internal and external factors that delay the process (from license application until the power plant is operating) may prevent Norwegian hydropower projects from being realized within the scheme period. The short duration may also put pressure on limited resources like access to funding, transmission net and entrepreneurial services, regulator's handling of applications and capacity and competence within the firm to manage the projects. Last, but not least, as investors get closer to 2020, they may hesitate to invest because of the increasing risk of missing the operational deadline.

We also examine whether the emerging groups of new investors without experience in the energy sector form different perceptions of the potential for and barriers against their projects, all else being equal. In Europe, private individuals, farmers and community groups have invested in decentralized power production based on renewable energy. In Germany, more than half of all renewable-energy capacity installed in the electricity sector in 2010 was owned by private individuals and farmers [1]. In an empirical study [3], find that investors with no traditional background in electricity production have made the majority of renewable-electricity investments in Sweden. In Norway, local landowners (that is, farmers) have since 2000 invested in small-scale, run-of-the-river projects. As documented by Ref. [12]; differences in previous experience have affected actual investments in these projects; consequently, differences in previous experience may also affect perceived potential for and barriers against these projects.

Our case study can be compared and contrasted to a selection of studies on investment barriers to renewable-energy development. While our case study takes place in a well-organized and liberalized electricity market with a long history of using renewable sources for production of electricity, other case studies take place in countries in which little previous experience with renewable-electricity production, and inadequate organization of the marketplace may be the main source of many barriers against renewable-electricity projects (for example, [13,16,18,20–22,26]). While this literature points out how policy intervention can reduce market failure by providing adequate education, institutions and regulations, our study illustrates how policy intervention can sometimes increase market failure by contributing to additional risk and transaction costs.

While our case study focuses on cost-effective deployment of mature technologies, a major part of the literature on investment barriers has been devoted to emerging technologies and identifies policies, institutional factors, lack of information and knowledge and behavioral constraints that prevent adequate investment in the early stages of the technology innovation cycle (for example, [5,11,15,23,24]). This literature therefore concludes that using differentiated feed-in tariffs is the preferred support scheme (for example, [4,10,25]; while our focus on cost efficiency results in a preference for technology neutral support schemes and the use of cooperation mechanisms. Like Refs. [2,9] and [6]; we argue that there are considerable benefits from cooperation among member states on meeting the 2020 renewable-energy targets, and that countries that are not coordinating support for renewable energy might induce inefficient investment.

While we take the perspective of an investor and use regression analysis to formally examine the relative importance of different investment barriers, most of the studies mentioned above take a stakeholder perspective and use a qualitative approach to identify barriers. For instance [16], use stakeholder theory and a qualitative approach to examine the barriers identified by firms and stakeholder organizations in the renewable-energy sector in Queensland, Australia. They find that finance-related issues provided the most prominent barrier to the growth of renewable-energy supply, although access to infrastructure, technical issues and the regulation process were also important. Similar barriers are identified by Ozcan [20]; who assesses the effectiveness of the renewable-energy incentive system in Turkey based on interviews of 18 investors; the most important barriers are difficulties related to the permission and license processes and to connection to the grid. Ozcan [20] examines the relative importance of the barriers using frequency tables, cross-tables and a summary of Likert-scale

[3] See Article 23 on monitoring and reporting by the Commission in Directive 2009/28/EC [7].

[4] Differentiating the support across technologies or renewable sources may be consistent with cost efficiency under some circumstances, for example, if there are positive externalities like knowledge spillover from investing in innovative technologies.

[5] If the electricity is produced partly by renewable energy sources and partly by nonrenewable energy sources, the subsidy is adjusted to reflect the relative amount of renewable energy.

questions. Our research method is more similar to that of Masini and Menichetti (2012) [17]; who use a regression model to determine which structural and behavioral factors, including investors' experience, affect renewable-energy investment decisions. However, while Masini and Menichetti (2012) [17] examine how investors' prior beliefs and attitudes affect their willingness to invest in a broad range of renewables under different market and policy conditions, our study is tailored to examine investment barriers for two investor types under a specific market-oriented renewable support scheme.

In the next section, we present the empirical context for our case and the methods we have used for data collection and statistical analysis. In the third section, we present and discuss the result of our data analysis. We discuss policy implications in the final section.

2. Method

2.1. Empirical context

Norway produces approximately 130 TWh electricity of which 95% is generated by hydropower plants.[6] The Norwegian power market was deregulated in 1991. Physical power contracts are traded at the leading power market in Europe, Nord Pool Spot. Financial power contracts, as well as green certificates, are traded at the world's largest power derivatives exchange, NASDAQ OMX Commodities. The Norwegian part of the Nord Pool Spot market is divided into five geographical price-bidding areas, named Elspot price areas, reflecting differences in supply and demand conditions and transmission net capacities.

The Norwegian hydropower plants are typically owned by traditional vertically integrated utilities owned by the state (that is, Statkraft) or by a group of municipalities. The recent focus on small-scale, decentralized power plants with installed capacity below 10 MW has resulted in new investors entering this market, that is, corporations specializing in small hydropower and local landowners, without any previous experience with energy projects, who form a privately owned company, sole trader or partnership.[7]

To construct a hydropower plant in Norway, an investor must have regulatory approval. After a license is granted, the licensee (1) updates the cost estimate to reflect any changes in license conditions and results of any new water-flow measurements; (2) obtains tender offers for turbines, generators, penstock, and construction, so that a major part of the total costs is identified; (3) secures project funding and make sales agreements for delivering the power to the electricity transmission grid and revises the investment budget accordingly; (4) acquires the regulatory authority's approval for the detailed plans for plant development; (5) decides whether to invest; (6) enters into a contract with the main entrepreneur; and (7) starts constructing the plant.

2.2. Variables

Based on a survey of 446 planned hydropower projects in Norway, we examine the potential for and barriers against Norwegian hydropower within the common Swedish–Norwegian market for green certificates. The survey reveals investors' expectations about whether their individual projects will be operating within the deadline set by the green certificate scheme. In the survey, we ask: 1) Which barriers, if any, may prevent your project from being realized by the end of 2020? 2) How likely or unlikely is it that your project will be realized by the end of 2020? We use a multinomial logistic regression model to examine the responses to each of these questions. The independent variables are investor, project and process characteristics. The dependent and independent variables are described in Table 1.

We have selected the barriers to be examined based on a review of relevant literature mentioned in Section 1 and based on an examination of the empirical context in Subsection 2.1. The potential barriers have been discussed with different types of investors, energy authorities, energy associations and academics in the energy field. The list of barriers in our survey are factors affecting the cash flow of the project (that is, electricity price, certificate price, taxes and fees and investment costs); capacity constraints created by the short duration and the abrupt termination of the green certificate scheme in Norway (that is, access to the transmission net, access to entrepreneurial and other services and access to components for construction); factors relating to the progress and outcome of the licensing process (that is, external stakeholders and the process itself); overall risk related to uncertain policy, market and technological conditions; access to adequate funding; and internal factors like capacity or knowledge constraints within the firm.

2.3. Data

The survey was sent in June 2012 to investors in Norway who were considering constructing a new hydropower plant or updating or extending an existing hydropower plant.[8] Some months earlier, the energy minister of Norway stated that all license applications submitted to the regulator by the end of 2012 would be handled in time for investors to be able to realize their project within the deadline set by the scheme, that is, the end of 2020.

The survey was pre-tested by the regulatory authority, the energy associations and a selected sample of energy investors. The regulatory authority and energy associations helped us produce an address list that included all potential investors in hydropower projects in Norway, ranging from small farmers to the biggest hydropower company, Statkraft. The list of investors was controlled against the regulator's database on submitted license applications.

The survey was carried out by a professional marketing firm in close cooperation with us. The data was collected through a combination of internet and postal surveys. Respondents were asked to answer the survey for all their hydropower projects that were under planning or construction. A total of 387 investors in our target group received the questionnaire, of which 172 investors (44%) responded.

The responses covered 446 single hydropower projects with a total planned production of 7.3 TWh, equal to 40% of the planned production volume registered in the regulator's database.[9]

[6] Source: Facts 2013 Energy and water resources in Norway, Ministry of Petroleum and Energy, Norway. [Published 18 June 2013 at https://www.regjeringen.no/en/dokumenter/facts-2013-energy-and-water-resources-/id712168/].

[7] For most small hydropower projects, the river is fully controlled by a group of local landowners (that is, farmers). They can choose between two principally different ways of organizing the ownership and operation of the power plant [19]: (1) form a privately owned company, sole trader or partnership, which applies for a license, makes the decisions whether and when to invest, gains access to funding, takes the investment risk, and operates the plant; or (2) ask a professional firm to take these responsibilities and to operate the power plant for a fixed number of years, after which the plant is sold back to the landowners at an agreed upon price. The choice of organizational model may depend on characteristics of the project (for example, profitability, risk and size) and/or of the group of local landowners (for example, risk preference and access to funding).

[8] A detailed description of the survey, the data collection process and the data is given in the technical report HSF notat N-NR 3/2013.

[9] The sum of applications for a license to construct a hydropower plant (including those that are exempt from the requirement of a license) totaled 18 TWh as of 28 February 2013. Source: http://www.nve.no/no/Konsesjoner/Konsesjonssaker/Vannkraft/ and http://www.nve.no/no/Konesjonspliktvurdering/Konsesjonspliktvurdering-oversikt-over-saker.

Table 1
Dependent and independent variables.

Variable	Question	Response type
Dependent variables		
Type of barrier	Which barriers, if any, may prevent your project from being realized by the end of 2020?	Categorical scale. Multiple responses, that is, a respondent may tick one or several barriers or the response 'no barrier'.
Degree of optimism	How likely or unlikely is it that your project will be realized by the end of 2020?	Ordinal scale. 1: very unlikely; 2: more unlikely than likely; 3: equally likely; 4: more likely than unlikely; 5: very likely.
Independent variables		
Experience	Do you/your firm have previous experience from the energy sector?	Categorical scale. Dichotomous variable. 1 = yes and 0 = no.
Elspot price area	In which municipality is your planned project located?	Categorical scale. We define a new variable for the five bidding areas in the Norwegian Elspot market based on the municipality number for each project 1: east (reference); 2: south; 3: central; 4: west; 5: north.
Project type	What kind of project are you considering?	Categorical scale. 1: micro power plant, ≤1 MW (reference); 2: small power plant (1–10 MW); 3: big power plant (≥10 MW); and 4: upgrading and extension of existing power plant.
Production	What is the expected annual production volume?	Continuous variable. Measurement unit is GWh.
Investment cost	What is the expected investment cost per annual production volume?	Ordinal scale. 1: 0–12.5 EURc/kWh; 2: 12.5–25.0 EURc/kWh; 3: 25.0–37.5 EURc/kWh; 4: 37.5–50.0 EURc/kWh; 5: 50.0–62.5 EURc/kWh; 6: ≥62.5 EURc/kWh. The intervals were expressed in NOK/kWh in the survey, but here translated to EURc/kWh using an exchange rate of 8 NOK = 1 EUR.
Process stage	At what stage from planning to implementing is your project?	Categorical scale. Seven response categories are coded into 4. 1: preliminary: preliminary planning/notification submitted to authorities (reference); 2: application: application for license submitted to authorities; 3: answer: received a positive answer from authorities; 4: contract: entered into contract with entrepreneur/work in progress

Comparison of our sample data and the regulator's data on planned hydropower projects shows similar distributions of projects across project type, process stage and Elspot price area.

2.4. Regression model

To formally examine the influence of investor, project, and process characteristics on the outcome of the two dependent variables in Table 1, we use a multinomial logistic regression model (see Refs. [8] and [14]). It is the most frequently used nominal regression model. This model is non-linear, and consequently the simple interpretations that is possible in a linear model are no longer appropriate. In a non-linear model, the effect of each variable on the outcome depends on the level of all variables in the model. Thus, we will accompany the estimated regression models, using Equation (2) below, with post-estimations showing the predicted probabilities of given responses for a set of values on the independent variables, using Equation (3).

The dependent variable "degree of optimism" in Table 1 can be formally investigated using a multinomial logistic regression model.[10] The dependent variable "type of barrier" in Table 1 can also be investigated by estimating a logistic version of a multinomial regression model. However, when we analyze the distribution of responses, we must take into consideration that one respondent can answer yes on more than one alternative. One alternative is to estimate a binary regression model for each response category. The disadvantage with this approach is that we do not consider how the responses are distributed in relation to each other. What is the probability of agreeing that "capacity" is an important barrier relative to agreeing that "economic" is an important barrier? This question can be answered by employing a multinomial regression model in which the number of responses, not the number of respondents, is the basis for the analysis of the response distribution.

The principles for the multinomial regression model are the same as for a binary regression model. The dependent variable is the logarithm of the odds ratio for agreeing with one statement relative to agreeing with another. The difference is that we must choose one of the categories as a base category. First, we define the odds that an outcome is equal to m relative to a base category b for a given vector of independent variables $\mathbf{x}$:

$$\Omega_{m|b}(\mathbf{x}) = \frac{\Pr(y = m|\mathbf{x})}{\Pr(y = b|\mathbf{x})}. \quad (1)$$

The odds are calculated for $m = 1$ to $J - 1$, in which J is the number of response categories. The log of the odds is assumed to equal:

$$\ln \Omega_{m|b}(\mathbf{x}) = \beta^T_{m|b}\mathbf{x} \quad (2)$$

in which $\mathbf{x}$ is a row vector augmented by one and $\beta^T_{m|b}$ is the corresponding column vector of estimated parameters for an outcome equal to m relative to a base case category b. Consequently, we estimate $J - 1$ regression models. The probability that an outcome is equal to m is computed as

$$\Pr(y = m|\mathbf{x}) = \frac{\exp\left(\beta^T_{m|b}\mathbf{x}\right)}{\sum_{j=1}^{J}\exp\left(\beta^T_{j|b}\mathbf{x}\right)} \quad (3)$$

in which $\beta_{b|b} = 0$ because $\ln \Omega_{b|b} = \ln 1 = 0$.

[10] Because the responses are ordered, we tried estimate a logit and a probit version of the ordinal regression model. However, these models are based on a parallel regression assumption which is not satisfied by our data. Therefore, we had to use the multinomial logistic regression model that relies on fewer assumptions. In this model, we are essentially estimating a separate binary logistic regression for each pair of responses.

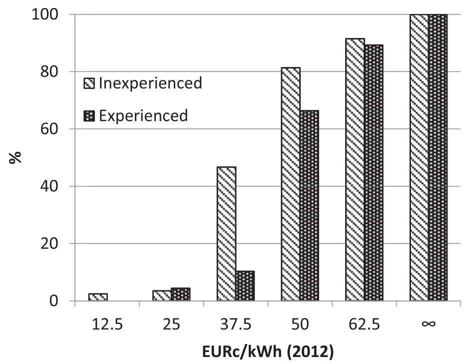

Fig. 1. Expected investment cost. Cumulative percentage of planned production.

3. Results and discussion

3.1. Descriptive data

Our sample covers 446 hydropower projects with a total planned production of 7.3 TWh. The distributions of these projects on investor, project and process characteristics are as follows (percentages of production volume are given in parentheses): 30% (20%) of the projects are controlled by inexperienced investors and 70% (80%) by experienced investors; 18% (3%) of the projects are micro power plants, 70% (47%) small power plants, 7% (39%) big power plants and 5% (11%) upgrading and extending existing power plants; 10% (12%) of the projects are in the east Elspot area, 21% (19%) in the south, 19% (17%) in the central part, 21% (19%) in the west and 28% (33%) in the north; and, 23% (23%) of the projects are in the preliminary process stage, 50% (55%) in the application stage, 19% (15%) in the answer stage and 8% (6%) in the contract stage.

Fig. 1 shows the cumulative percentage of planned production for different investment cost levels. We see that inexperienced investors believe their projects to be less expensive than experienced investors believe theirs to be. When the survey was conducted, the electricity and certificate prices were around 3.8 and 2.0 EURc/kWh, respectively.[11] At these price levels, projects with a maximum investment cost of between 37.5 EURc/kWh (18% of total planned production) and 50 EURc/kWh (69% of total planned production) were profitable according to a traditional net-present-value investment rule, depending on investor's tax position, the share of debt funding and other assumptions made when calculating the discounted cash flows.[12] However, because the tradable green certificate scheme causes the least expensive projects to be realized first, we would expect the sum of these prices to increase over time, thereby rendering a higher share of these hydropower projects profitable. On the other hand, uncertain market, policy and technology conditions could make investors require a higher rate of return, and thereby reduce the willingness to invest (see for example, [12]).

Tables 2 and 3 show investors' responses to questions on expected barriers and expected realization by the end of 2020, respectively. In Table 2 we see that investors representing 36% of planned projects expect “no barrier” to prevent their project from being realized by the end of 2020. Investors in big power plants are the most optimistic, and 45% of these projects are not expected to be exposed to any barrier. Similar numbers for the other project types are 39% of small hydropower projects, 29% of upgrading and extension projects and 23% of micro power projects.

However, investors representing 64% of the planned projects expect that one or more barriers could prevent their project from being realized by the end of 2020. In Table 2, we have marked the barriers with an asterisk when the responses exceed 10% of the number of projects or of the planned production volume for that kind of project. We find that electricity price, certificate price, investment cost, access to transmission net, external stakeholders and process are the most frequently chosen barriers and also the ones that represent the greatest production volume. It should be noted that investors do not seem to worry about getting access to funding or that internal conflicts or lack of competence or capacity might reduce the probability of realizing the project by the end of 2020. Again, there are differences across project types. Investors in big power plants seem to be less concerned that barriers related to market prices, external stakeholders, process and access to the transmission net may prevent their projects from being realized by the end of 2020. On the other hand, these investors seem more concerned about access to entrepreneurial and other services. Investors in micro power plants and in upgrading and extending existing plants are more concerned with the overall risk of the projects.

In Table 3 we see that investors representing 39% of the projects think that it is “very likely” that their project will be realized by the end of 2020. Investors in upgrading and extending existing projects are the most optimistic (43%), followed by investors in small hydropower plants (42%), big power plants (36%) and micro power plants (28%). Table 3 shows that expected investment cost will not negatively affect the probability that projects will be realized.

These relations between dependent and independent variables in our sample can be examined more formally using a multinomial logistic regression model. This model allows us to investigate the partial impact on investors' responses of one investor, project and process characteristic at a time, while controlling for other characteristics. Furthermore, we can test whether these relations are statistically significant or are merely due to a sampling error.

3.2. Regression analysis. Type of barrier

We asked: “Which barriers, if any, may prevent your project from being realized by the end of 2020?” The respondents could tick one or several barriers or “no barrier” (see Table 1). We examine the relative importance of all the response categories by using Equation (2) to estimate a multinomial regression model in which the response category “no barrier” is the base outcome or reference. Other references are an unexperienced investor (for the independent variable “experience”), a micro power plant with installed capacity ≤1 MW (for the independent variable “project type”), east (for the independent variable “Elspot price area”) and preliminary planning/notification submitted to authorities (for the independent variable “process stage”).

To keep the analysis simple and tractable, we group some of the fourteen individual response categories shown in Table 1 into more aggregated response categories. This is done when a group of response categories give more detailed information about one

[11] In 2011 and 2012 physical power contracts in Norway were traded for on average 4.6 EURc/kWh and 3.0 EURc/kWh, respectively (Source: Nord pool [http://www.nordpoolspot.com/]). In 2011 and 2012 green certificates were traded for on average 180 SEK/MWh and 180 SEK/MWh, respectively (Sources: historical prices from ICAP Energy and Cleanworld).

[12] Standard assumptions for hydropower project appraisal calculations are a project life of 40 years, annual operation and maintenance costs of 1.25 EURc/kWh, 5% depreciation for tax purposes and a real after-tax discount interest rate on equity of 6%. Investors can sell certificates for 15 years. The debt ratio in Norwegian power companies was about 60% and the interest rate on debt funding was about 3% in 2012. Company tax was 28% and resource tax on extraordinary profit was 30% in 2012. If the project is subject to resource tax, a project with a maximum investment cost of 32 EURc/kWh would be profitable under these assumptions; if the project is not entitled to resource tax, a project with a maximum investment cost of 44 EURc/kWh would be profitable under these assumptions.

Table 2
Type of barrier. Descriptive statistics.

Category	Sum		Project type								Experience			
			Micro ≤1 MW		Small 1–10 MW		Big ≥10 MW		Upgrading/extension		Yes		No	
	N[a,b]	GWh[b]	N[a,b]	GWh[b]	N[a,b]	GWh[b]	N[a,b]	GWh[b]	N[a,b]	GWh[b]	N[a,b]	GWh[b]	N[a,b]	GWh[b]
No barrier	159*	3094*	18*	47*	121*	1318*	15*	1600*	6*	128*	126*	2603*	32*	477*
Electricity price	68*	857*	16*	32*	44*	426*	3	255	6*	145*	41*	684*	27*	173*
Certificate price	53*	601	12*	27*	35*	305	2	165	4*	105*	28	483	25*	118
Taxes/fees	35	455	6	13	24	233	2	165	3*	45	15	340	20*	116
Investment costs	113*	1405*	34*	72*	66*	664*	7*	535*	7*	134*	62*	1037*	50*	369*
Access to services	10	485	–	–	5	65	3	377*	2	44	8	467	2	18
Access to components	7	233	–	–	4	55	1	135	2	44	6	225	1	8
Access to transmission net	65*	834*	12*	39*	47*	498*	2	86	4*	207*	56*	763*	10	71
External stakeholders	66*	1100*	17*	46*	39*	411*	4*	205	6*	439*	30	813*	36*	287*
Process	73*	1234*	10*	25*	56*	664*	3	292*	4*	254*	56*	1093*	17*	141*
Risk	31	377	12*	28*	14	146	1	90	4*	114*	17	326	14*	51
Funding	13	84	5	17	7	66	–	–	1	1	4	17	9	67
Internal aspects	15	136	4	6	10	127	–	–	1	4	7	79	8	57
Other aspects	39	620	5	10	19	236	5*	330*	3*	45	23	579*	6	41
Don't know	10	232	3	15	4	46	3	171	–	–	3	38	7	194*
Sum survey	446	7251	79	205	311	3412	33	2799	21	827	306	5759	128	1261

[a] *N* is the number of projects in which respondents have ticked for the answer corresponding to the row in the table and GWh is the corresponding production volume that these projects represent. Note that the respondent can tick one or more answers for each project, thus the sum in the last row is not equal to the sum of the above numbers. The respondents may not have answered all questions, thus the sum of responses *N* and the sum of production GWh for project type, investment costs, and experience will not always be equal to the total number of projects and production volume in the survey; that is, 446 projects and 7251 GWh.
[b] We have marked with an * barriers in which the number of projects (*N*) and the production volume (GWh) exceeds 10% of the total (that is, the last row) for that type of project.

major barrier to investment, as explained in Section 2.2. The dichotomous variable "economic" is equal to one if the respondent has chosen at least one of the individual barriers: electricity price, certificate price, investment cost and taxes/fees; the dichotomous variable "capacity" is equal to one if the respondent has chosen at least one of the individual barriers: access to services, access to components and access to transmission net; and, the dichotomous variable "process" is equal to one if the respondent has chosen at least one of the two individual barriers: process and external stakeholders. The remaining individual response categories (no barrier, risk, funding, internal aspects and other aspects) are included one by one in the regression model.

The estimated coefficients in Table 4 can be interpreted as follows. Consider the regression model "Economic." The coefficient for the independent variable "experience" is −1.301. If we replace an inexperienced with an experienced investor, the natural logarithm to the odds ratio of economic barriers relative to no barriers will decrease by 1.301. Since the coefficient is negative, the probability of assessing economic barriers as more important than no barriers is lower for an experienced investor than for an inexperienced investor. The constant is 4.526. This includes the effect for the reference respondent—who is an unexperienced investor, considering a project with an installed capacity below 1 MW, located in Elspot area east and where the project has only just started. Since the constant is positive, this respondent is more likely to consider economic barriers as more important than no barriers. Table 5 shows predicted probabilities for specified values of one or more independent variables, assuming mean values for the variables not

Table 3
Degree of optimism. Descriptive statistics.

		Sum[a]	Project type				Investment cost				Experience	
			Micro ≤1 MW	Small 1–10 MW	Big ≥10 MW	Upgrading/ extension	0–25 EURc/ kWh	25–50 EURc/ kWh	≥50 EURc/ kWh	Don't know	Yes	No
1: Very unlikely	N	36	5	29	1	1	–	17	18	–	35	1
	GWh	450	12	392	45	2	–	254	194	–	447	3
2: More unlikely	N	52	8	43	–	1	4	42	6	1	42	10
than likely	GWh	614	23	564	–	27	50	535	18	0	548	66
3: Equally likely	N	64	23	32	5	4	3	34	27	–	34	30
	GWh	951	54	354	399	144	171	424	354	–	713	238
4: More likely	N	115	20	74	15	6	2	80	29	5	74	40
than unlikely	GWh	2369	66	749	1312	243	31	1449	854	35	1883	486
5: Very likely	N[b]	175	22	131	12	9	4	97	71	4	125	50
	GWh	2853	48	1347	1043	411	43	1834	678	299	2211	642
6: Don't know	N	4	1	2	–	–	–	3	3	1	1	3
	GWh	11	2	8	–	–	–	9	4	0	2	9
Sum survey	N	446	79	311	33	21	13	273	153	11	311	134
	GWh	7251	205	3412	2799	827	295	4505	2112	355	5806	1443

[a] The respondents may not have answered all questions in the project specific part, thus the sum of responses *N* and the sum of production GWh for project type, investment costs, and experience will not always be equal to the total number of projects and production volume in the survey; that is, 446 projects and 7251 GWh.

explicitly mentioned. We have chosen to focus on the most frequently mentioned barriers in Table 2 when estimating predicted probabilities, that is, the response categories “economic”, “capacity”, “process” and “risk”.

Based on an investigation of the sign and significance of coefficients in Table 4 and on the predicted probabilities in Table 5, we draw the following conclusions. The most frequently chosen response categories are economic barriers (29%), no barriers (27%) and process barriers (26%), followed by capacity barriers (12%) and overall project risk (4%). However, the relative importance of these responses depends on investor, project and process characteristics, as shown below.

If we replace an inexperienced investor with an experienced investor, the relative importance of economic barriers to no barriers decreases. The predicted probability of responding that economic barriers are important is 23% for experienced and 41% for inexperienced investors, while the predicted probability of responding that no barriers are important is 32% for experienced and 16% for inexperienced investors. Thus, in this case, both the *relative* and the *absolute* importance of the barrier decrease when we replace an inexperienced investor with an experienced investor. Recall that these predicted probabilities are calculated using Equation (3), setting all other independent variables but “experience” equal to mean values. Thus, we are comparing identical projects with, for instance, the same investment cost in the same Elspot area and at the same process stage. Consequently, we argue that differences in preferences and characteristics between these two investor groups explain the differences in assessment of relevant barriers.

Similar comparisons show that inexperienced investors are less concerned with capacity barriers but more concerned with economic, process and risk barriers than experienced investors are. For instance, the predicted probability of responding that capacity barriers are important is more than three times as high for experienced than for inexperienced investors ($0.17/0.05 = 3.4$) while the predicted probability of responding that economic barriers are important is almost twice as high for inexperienced than for experienced investors ($0.41/0.23 = 1.8$). Plausible, yet speculative, explanations for these differences are as follow. On one side, the lack of previous experience with energy projects may lead investors to underestimate the role of capacity constraints in delaying the progress of the project. On the other, inexperienced investors may be more concerned with price and cost development because they have a less diversified portfolio of assets and/or they have more restricted access to additional funding than professional investors do.

Although many investors are concerned with economic barriers, we find no evidence that expected investment costs are too high to render their project unprofitable. On the contrary, the more costly

Table 4
Type of barrier. Multinomial logistic regression model.

Response categories (Base outcome: No barriers[a])	Economic[a]		Capacity[a]		Process[a]		Risk[a]	
	β[b]	p	β[b]	p	β[b]	p	β[b]	p
Experience (D = 1)	−1.301**	0.000	0.568*	0.021	−0.989**	0.004	−1.123*	0.033
Production (GWh)	−0.018*	0.048	−0.005	0.626	−0.005	0.546	−0.009	0.558
Project type: small power plant (D = 1)	−0.127	0.755	0.005	0.993	0.140	0.741	−0.539	0.356
Project type: big power plant (D = 1)	0.708	0.428	−0.463	0.667	−0.391	0.686	−0.629	0.735
Project type: upgrading (D = 1)	0.717	0.333	−0.523	0.611	0.531	0.507	0.552	0.587
Investment cost (ordinal scale)	−0.249	0.133	−0.730**	0.000	−0.308	0.072	−0.510*	0.050
Elspot price area: south (D = 1)	−1.619**	0.004	−0.571	0.395	−1.023	0.066	−2.382**	0.001
Elspot price area: central (D = 1)	−1.697**	0.002	−0.837	0.230	−1.471*	0.011	−3.266**	0.000
Elspot price area: north (D = 1)	−1.940**	0.000	−0.957	0.152	−1.802**	0.001	−3.395**	0.000
Elspot price area: west (D = 1)	−1.260*	0.015	−0.408	0.525	−1.223*	0.023	−3.163**	0.000
Process stage: application (D = 1)	−1.519**	0.000	−1.335**	0.003	−1.833**	0.000	−1.754**	0.008
Process stage: answer (D = 1)	0.125	0.802	−2.142*	0.014	−0.254	0.615	1.312	0.055
Process stage: contract (D = 1)	−2.209**	0.000	−1.105	0.093	−2.856**	0.000	−1.635	0.074
Constant	4.526**	0.000	3.657**	0.002	4.225**	0.000	4.875**	0.000
N[e]	517		517		517		517	
LR $\chi^2(12)$[b]	236.03**	0.000	236.03**	0.000	236.03**	0.000	236.03**	0.000
McFadden's R^2[c]	0.1302		0.1302		0.1302		0.1302	

Response categories (Base outcome: No barriers[a])	Funding[a]		Internal factors[a]		Other[a]	
	β[b]	p	β[b]	p	β[b]	p
Experience (D = 1)	−2.893**	0.001	−1.509*	0.045	−0.579	0.332
Production (GWh)	−0.048	0.439	−0.007	0.863	0.009	0.427
Project type: small power plant (D = 1)	0.021	0.982	0.670	0.477	0.037	0.958
Project type: big power plant (D = 1)	−10.825	0.991	−13.149	0.990	−1.816	0.369
Project type: upgrading (D = 1)	1.731	0.243	1.675	0.268	0.328	0.807
Investment cost (ordinal scale)	−0.453	0.210	−0.801*	0.030	−0.416	0.158
Elspot price area: south (D = 1)	−1.559	0.180	−3.570**	0.003	−1.591*	0.044
Elspot price area: central (D = 1)	−1.552	0.165	−2.855**	0.005	−2.005*	0.022
Elspot price area: north (D = 1)	−2.196	0.116	−16.495	0.979	−1.916*	0.018
Elspot price area: west (D = 1)	−1.013	0.363	−2.534**	0.006	−2.486**	0.005
Process stage: application (D = 1)	−1.393	0.117	−2.181**	0.005	−2.069**	0.001
Process stage: answer (D = 1)	0.322	0.744	−0.439	0.662	0.091	0.901
Process stage: contract (D = 1)	−2.494	0.082	−16.687	0.986	−16.379	0.985
Constant	3.454	0.067	5.410**	0.002	3.268*	0.035
N[e]	517		517		517	
LR $\chi^2(12)$[b]	236.03**	0.000	236.03**	0.000	236.03**	0.000
McFadden's R^2[c]	0.1302		0.1302		0.1302	

[a] Coefficients marked with * and ** are significantly different from zero at the 5% and 1% significance levels, respectively.
[b] LR $\chi^2(12)$ test the null hypothesis that all coefficients except the intercept are zero.
[c] McFadden's R^2 compares a model with just the intercept to a model with all parameters.

Table 5
Type of barrier. Individual predicted probabilities.

Response categories[a]	Economic	Capacity	Process	Risk	No barriers
At means	0.29	0.12	0.26	0.04	0.27
Experience					
Experienced	0.23	0.17	0.24	0.03	0.32
Inexperienced	0.41	0.05	0.30	0.05	0.16
Process stage					
Preliminary	0.29	0.15	0.34	0.04	0.11
Application	0.23	0.14	0.19	0.02	0.39
Contract	0.15	0.22	0.09	0.03	0.50
Process stage: Prelemenary					
Experienced, micro power plant, 2.58 GWh[b]	0.27	0.22	0.27	0.05	0.12
Inexperienced, micro power plant, 2.58 GWh	0.42	0.05	0.31	0.06	0.05
Experienced, small power plant, 9.281 GWh[b]	0.22	0.23	0.32	0.03	0.13
Inexperienced, small power plant, 9.28 GWh	0.37	0.06	0.38	0.04	0.06
Experienced, big power plant, 84.82 GWh[b]	0.25	0.19	0.24	0.02	0.25
Experienced, upgrading, 41.28 GWh[b]	0.26	0.10	0.35	0.05	0.11
Process stage: Application					
Experienced, micro power plant, 2.58 GWh	0.20	0.19	0.14	0.03	0.41
Inexperienced, micro power plant, 2.58 GWh	0.39	0.06	0.21	0.04	0.22
Experienced, small power plant, 9.28 GWh	0.16	0.20	0.17	0.02	0.43
Inexperienced, small power plant, 9.28 GWh	0.34	0.06	0.25	0.03	0.24
Experienced, big power plant, 84.82 GWh	0.14	0.13	0.10	0.01	0.61
Experienced, upgrading, 41.28 GWh	0.20	0.10	0.20	0.03	0.41
Process stage: Contract					
Experienced, micro power plant, 2.58 GWh	0.12	0.29	0.06	0.04	0.49
Inexperienced, micro power plant, 2.581 GWh	0.31	0.12	0.12	0.08	0.35
Experienced, small power plant, 9.28 GWh	0.10	0.30	0.07	0.02	0.51
Inexperienced, small power plant, 9.28 GWh	0.27	0.13	0.15	0.05	0.38
Experienced, big power plant, 84.82 GWh	0.08	0.18	0.04	0.01	0.69
Experienced, upgrading, 41.28 GWh	0.14	0.16	0.10	0.05	0.55
Elspot price area					
East	0.36	0.07	0.26	0.17	0.09
South	0.23	0.12	0.30	0.05	0.28
Central	0.26	0.11	0.24	0.03	0.34
North	0.24	0.11	0.20	0.03	0.40
West	0.32	0.13	0.24	0.02	0.27

[a] Predictions for only the most frequently chosen response categories are presented.
[b] The annual production volume is set equal to the average level in our sample for each project type; that is, 2.58 GWh for micro power plants, 9.28 GWh for small power plants, 84.82 GWh for big power plants and 41.28 for upgrading existing power plants.

the project is, the more likely it seems that it will be realized. If we replace a less expensive project with a more expensive project, the relative importance of capacity, risk and internal barriers to no barriers decreases significantly. For instance, the predicted probability of capacity barriers being important decreases from 20% for projects with an investment cost of 25–37.5 EURc/kWh to 5% for projects with an investment cost of more than 62.5 EURc/kWh, while the predicted probability of no barriers being important increases from 19% for projects with an investment cost of 25–37.5 EURc/kWh to 40% for projects with an investment cost of more than 62.5 EURc/kWh. A possible explanation is that investors are less likely to pursue a costly project if they do also expect to encounter other barriers like overall project risk, access to transmission net or internal capacity or competence problems. Also, investment cost may serve as a proxy for project properties that are not adequately captured by our independent variables and that reduce the extent of other barriers; for instance, investing in a reservoir to regulate production will reduce the overall project risk.

The location of the project significantly affects what barriers are perceived as important. If we replace a project in Elspot area east with a project in one of the other Elspot areas, the relative importance of economic, process, internal and other barriers to no barriers decreases significantly. This does not imply, however, that the absolute importance of each of these barriers is highest in Elspot area east. Table 5 shows that although projects in Elspot area east have the highest probability of economic (36%) and risk barriers (17%), projects in Elspot area west have the highest probability of capacity barriers (13%) and projects in Elspot area south have the highest probability of process barriers (30%). Projects in Elspot area north have the highest probability of facing no barriers (40%).

Although the importance of most barriers is reduced throughout the process, capacity barriers remain important. If we replace a project in the preliminary stage of the process with a project in the later stages of the process, the relative importance of most barriers to no barriers decreases significantly. The predicted probability of no barriers increases from 11% in the preliminary stage to 50% in the contract stage while the predicted probability of economic barriers being important decreases from 29% in the preliminary stage to 15% in the contract stage and the predicted probability of process barriers being important decreases from 34% in the preliminary stage to 9% in the contract stage. Obviously, process barriers will be dealt with as the project proceeds through the different stages of the process. And, projects that encounter economic or project risk barriers, for instance, may not be given a license for construction, and will therefore not reach the later stages of the process. Capacity barriers, however, remain important. In fact, for projects reaching the contract stage, the predicted probability of capacity barriers being important is 22%. Thus, although the relative importance of capacity barriers to no barriers has decreased throughout the process, capacity barriers are the most important obstacle to realization at the contract stage.

From the perspective of this paper, the existence of capacity barriers is of special interest because the short duration and the abrupt termination of the Norwegian support scheme are expected

Table 6
Degree of optimism. Multinomial logistic regression model.

Response categories (Base outcome: VUL/MUL[a])	EL[a]		ML[a]		VL[a]	
	β^b	p	β^b	p	β^b	p
Experience (D = 1)	−1.895**	0.000	−1.743**	0.000	−1.460**	0.002
Production (GWh)	−0.130	0.382	−0.006	0.610	−0.008	0.482
Project type: small power plant (D = 1)	−0.685	0.187	−0.330	0.510	−0.250	0.620
Project type: big power plant (D = 1)	2.690	0.151	3.107	0.076	2.966	0.093
Project type: upgrading (D = 1)	16.127	0.990	16.534	0.990	15.856	0.990
Investment cost (ordinal scale)	0.139	0.558	−0.176	0.936	0.298	0.177
Elspot price area: south (D = 1)	−0.409	0.600	−0.873	0.241	0.110	0.886
Elspot price area: central (D = 1)	−0.833	0.283	−1.263	0.086	−0.747	0.332
Elspot price area: north (D = 1)	−0.320	0.700	−0.550	0.464	0.488	0.525
Elspot price area: west (D = 1)	−1.446	0.066	−1.138	0.103	−0.790	0.177
Process stage: application (D = 1)	0.186	0.702	1.993**	0.000	3.118**	0.000
Process stage: answer (D = 1)	−1.172*	0.036	0.233	0.635	1.138*	0.032
Process stage: contract (D = 1)	13.690	0.990	14.182	0.989	18.472	0.986
Constant	1.746	0.175	1.674	0.168	−1.150	0.378
N[e]	399		399		399	
LR $\chi^2(12)$[c]	213.34	0.000	213.34	0.000	213.34	0.000
McFadden's R^2[d]	0.2042		0.2042		0.2042	

[a] The abbreviations VUL, MUL, EL, ML and VL refer to 'very unlikely', 'more unlikely than likely', 'equally likely', 'more likely than likely' and 'very likely', respectively.
[b] Coefficients marked with * and ** are significantly different from zero at the 5% and 1% significance levels, respectively.
[c] LR $\chi^2(12)$ test the null hypothesis that all coefficients except the intercept are zero.
[d] McFadden's R^2 compares a model with just the intercept to a model with all parameters.

to create problems with access to infrastructure, products and services. Thus, it should be noted that for projects where the investor is experienced and the expected investment cost is relatively low (that is, 12.5−25.0 EURc/kWh), the predicted probability of expecting one or more capacity barriers is as high as 39%. For these projects, economic barriers and process risk are much less important (18% and 20%, respectively). This finding is of special importance since it indicates that many cost-effective projects may not be realized because of the way the scheme is terminated.

3.3. Regression analysis. Degree of optimism

We asked: "How likely or unlikely is it that your hydropower project will be realized by the end of 2020?" The respondents could choose one response from the ordinal scale 1: very unlikely to 5: very likely (see Table 1). We examine the relative importance of all the response categories by using Equation (2) to estimate a multinomial regression model in which the response categories "more unlikely than likely" and "very unlikely" are merged (because there are few responses in the last category) and used as the base outcome or reference. Other references are an unexperienced investor (for the independent variable "experience"), a micro power plant with installed capacity ≤1 MW (for the independent variable "project type"), east (for the independent variable "Elspot price area") and preliminary planning/notification submitted to authorities (for the independent variable "process stage"). Table 6 gives the estimated regression model and Table 7 gives the predicted probabilities for projects with particular sets of characteristics assuming mean values for the independent variables not explicitly mentioned.

We find that the answer to this question is significantly influenced by what process stage the project is in. Naturally, optimism increases significantly as the projects move forward through the process stages. The predicted probability of responding that it is very likely that the project will be realized increases from only 13% in the preliminary stage to 53% when the license application is submitted to the authorities, and finally to 95% when the contract with the entrepreneur is signed and/or the construction work has started, all else being equal.

We notice the great increase in optimism at the time the application for a license is submitted to the authorities. The substantial change in attitude is at least partly due to the short duration of the Norwegian support scheme and to the way the scheme is terminated.[13] In fact, the energy minister did in 2012 promise that all applications received by the end of that year would be handled by the authorities by the end of 2016, giving investors sufficient time to construct and start operating the plant within the deadline set by the support scheme. As discussed in Section 3.1, most of the planned projects would not be profitable at the prevailing electricity prices if they did not get additional revenues from selling certificates. Thus, the scheme design will likely prevent many cost-effective projects from being realized.

Experienced and inexperienced investors respond significantly different to this question. Experienced investors are on average six time more likely to choose the response category "very unlikely/more unlikely than likely" than inexperienced investors are. This difference in response is particularly prominent in the earliest parts of the process. For experienced investors, the predicted probability is 58% for choosing the response category "very unlikely/more unlikely than likely" for small power plants in the preliminary process stage, while for inexperienced investors it is only 19%.

As the projects proceed from the preliminary process stage to the contract process stage, the difference in response between inexperienced and experienced investors is reduced. For experienced investors, the predicted probability is 79% for choosing one of the response categories "very likely" and "more likely than unlikely" for small power plants in the application stage, while for inexperienced investors the predicted probability is only slightly higher, 84%. In fact, in this process stage, experienced investors are more likely to choose the response category "very likely" for small power plants than inexperienced investors are (50% vs. 47%).

We believe that these differences in responses mainly reflect differences in preferences and characteristics between the two investor groups. Recall that the predicted probabilities discussed above are calculated using Equation (3) setting all other independent variables but "experience" equal to the same values. Thus, we are comparing projects of the same type and size, with the same

[13] Even without a scheme, there would be a rise in optimism as the project entered the application stage. This is because investors will rule out the least promising projects before they enter this stage.

Table 7
Degree of optimism. Individual predicted probabilities.

Response categories	VUL/MUL[a]	EL[a]	ML[a]	VL[a]
At means				
	0.04	0.14	0.33	0.49
Experience				
Experienced	0.06	0.12	0.31	0.51
Inexperienced	0.01	0.17	0.37	0.45
Process stage				
Preliminary	0.25	0.36	0.26	0.13
Application	0.05	0.08	0.34	0.53
Contract	0.00	0.02	0.03	0.95
Process stage: Prelimenary				
Experienced, micro power plant, 2.58 GWh	0.44	0.32	0.16	0.09
Inexperienced, micro power plant, 2.58 GWh	0.11	0.55	0.24	0.10
Experienced, small power plant, 9.28 GWh	0.58	0.19	0.14	0.09
Inexperienced, small power plant, 9.28 GWh	0.19	0.42	0.27	0.12
Experienced, big power plant, 84.82 GWh	0.09	0.32	0.43	0.17
Experienced, upgrading, 41.28 GWh	0.00	0.45	0.44	0.11
Process stage: Application				
Experienced, micro power plant, 2.58 GWh	0.11	0.10	0.29	0.50
Inexperienced, micro power plant, 2.58 GWh	0.02	0.14	0.37	0.47
Experienced, small power plant, 9.28 GWh	0.15	0.06	0.28	0.51
Inexperienced, small power plant, 9.28 GWh	0.04	0.09	0.37	0.50
Experienced, big power plant, 84.82 GWh	0.01	0.05	0.42	0.51
Experienced, upgrading, 41.28 GWh	0.00	0.08	0.51	0.40
Process stage: Contract				
Experienced, micro power plant, 2.58 GWh	0.00	0.03	0.02	0.95
Inexperienced, micro power plant, 2.58 GWh	0.00	0.04	0.03	0.93
Experienced, small power plant, 9.28 GWh	0.00	0.02	0.02	0.96
Inexperienced, small power plant, 9.28 GWh	0.00	0.03	0.03	0.94
Experienced, big power plant, 84.82 GWh	0.00	0.01	0.03	0.95
Experienced, upgrading, 41.28 GWh	0.00	0.03	0.05	0.92
Elspot price area				
East	0.02	0.16	0.45	0.36
South	0.03	0.15	0.26	0.56
Central	0.05	0.18	0.33	0.44
North	0.02	0.12	0.26	0.59
West	0.06	0.10	0.39	0.44

[a] The abbreviations VUL, MUL, EL, ML and VL refer to 'very unlikely', 'more unlikely than likely', 'equally likely', 'more likely than likely' and 'very likely', respectively.

expected investment cost, in the same Elspot area and in the same process stage.

It seems that although inexperienced investors are aware of many investment barriers, they are less likely to draw the conclusion that these barriers will reduce the probability of their project being realized. In fact, for inexperienced investors, the predicted probability of choosing the response 'no barrier' to the question on barriers is only 16%, while for experienced investors it is 32%, all else equal (Table 5).

A plausible, yet speculative, explanation for the differences in responses is that previous experience with hydropower projects make it easier to more accurately assess the probability of succeeding with new projects; therefore, experienced investors are more prone to choose the extreme response categories than inexperienced investors are. Especially, having experienced that not all planned hydropower projects are realized, experienced investors may be more inclined to expect such a negative outcome of the process. Additional research, including qualitative research methods, is required to more fully examine the mechanisms behind this result.

The great optimism among inexperienced investors being in the early phase of planning micro and small hydropower projects is particularly interesting because these investors represents a new and emerging group of investors in the renewable electricity market in Norway, and elsewhere. In Norway, micro and small hydropower projects account for more than half of the planned production volume, of which almost 40% is owned by inexperienced investors (see Section 3.1). Therefore, inexperienced investors' attitudes and subsequently ability to succeed will have a great effect on the extent of small-scale hydropower projects in Norway under the Swedish–Norwegian scheme of tradable green certificates.

4. Conclusions and policy implications

In January 2012, Norway and Sweden implemented a common market for tradable green certificates to achieve each country's renewable-energy target by the end of 2020. This is the first example of a cooperation mechanism that the EU has suggested to improve the cost efficiency of its renewable-energy policies. Six months after the scheme was implemented, we asked potential investors in hydropower projects in Norway how certain they were that their project would be realized and which investment barrier(s), if any, would prevent this from happening. We formally investigated their responses using multinomial logistic regression analysis. Based on this we draw two main lessons.

First, differences in the way this scheme is implemented in Norway and Sweden may prevent the most cost-efficient projects from being realized first. That is, we find that investors in Norwegian hydropower projects are concerned with capacity barriers like access to transmission net, access to entrepreneurial services and access to components. We argue that because project profitability depends to a great extent on revenues from sale of certificates, the short duration and the abrupt termination of the certificate scheme in Norway is expected to contribute to a scarcity of such resources. Consequently, our study illustrates how policy intervention can sometimes increase market failure by contributing to additional risk and transaction costs. The cost efficiency of this and similar schemes can be improved, by for example choosing the Swedish design with a long scheme duration and a gradual reduction in the number of years investor can sell certificates.

Second, local landowners with no experience from the energy sector were less concerned with capacity barriers and more optimistic with respect to realizing their project than experienced investors were, all else being equal. These differences in expectations may be due to differences in experience, preferences and other characteristics between these two investor groups. If difference in experience is the most important explanation, we would expect local landowners to become less optimistic as they gain more experience with the investment barriers under the current renewable-electricity support schemes. We leave this question open for further research. Empirical investigation of whether and why such differences in expectations exist across investor types is interesting given the distributed nature of many renewable energy technologies. Solar and wind power, for example, can be installed by small land and homeowners as well as by large corporations. Thus, our study has important implications beyond the narrow case of hydropower investments in Norway and can help planners and policymakers better understand the forces shaping the future market for electricity.

Three years after the Swedish–Norwegian tradable green certificate scheme was implemented, it is on its way to delivering the promised 26.4 TWh by the end of 2020. As of 1 October 2014, 9.0 TWh is installed in Norway and Sweden, thus, the scheme has reached one third of the total target in slightly less than one third of the time. However, while as much as 7.5 TWh are installed in Sweden (mostly wind power), only 1.5 TWh is installed in Norway (mostly hydropower). Two reasons are mentioned to explain the big difference between Norwegian and Swedish investments; differences in taxation and differences in how the scheme is ended. On 3 December 2014, the Norwegian government suggested amendments in the law regulating green certificates, amendments that included an extension of the deadline by which a plant must be operating in order to be entitled to sell certificates. This suggestion is based on the understanding that a design feature in the current scheme is preventing the best projects in the two countries from being realized.

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References

[1] AEE. Kraftwerke fur jederman. Chancen und herausforderungen einer dezentralen erneuerbaren energieversorgung [Opportunities and challenges of a decentralized renewable energy supply]. Agentur fur Erneuerbare Energien; 2010. Tech. rep.

[2] Al-Mansour F, Sucic B, Pusnik M. Challenges and prospects of electricity production from renewable energy sources in slovenia. Energy 2014;77:73–811. http://www.sciencedirect.com/science/article/pii/S0360544214005374.

[3] Bergek A, Mignon I, Sundberg G. Who invests in renewable electricity production? empirical evidence and suggestions for further research. Energy Policy 2013;56:568–81. http://www.sciencedirect.com/science/article/pii/S0301421513000645.

[4] Burer MJ, Wustenhagen R. Which renewable energy policy is a venture capitalist's best friend? empirical evidence from a survey of international cleantech investors. Energy Policy 2009;37(12):4997–5006. http://www.sciencedirect.com/science/article/pii/S0301421509004807.

[5] Byrnes L, Brown C, Foster J, Wagner LD. Australian renewable energy policy: barriers and challenges. Renew Energy 2013;60:711–21. http://www.sciencedirect.com/science/article/pii/S0960148113003170.

[6] Creutzig F, Goldschmidt JC, Lehmann P, Schmid E, von Blücher F, Breyer C, et al. Catching two European birds with one renewable stone: mitigating climate change and eurozone crisis by an energy transition. Renew Sustain Energy Rev 2014;38:1015–28. http://www.sciencedirect.com/science/article/pii/S1364032114004808.

[7] Directive. Directive 2009/28/ec of the European parliament and the council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing directives 2001/77/ec and 2003/30/ec. l140/16. 2009.

[8] Greene WH. Econometric analysis. 7th ed., vol. 5; 2011 [Prentice hall].

[9] Jacobsen HK, Pade LL, Schröder ST, Kitzing L. Cooperation mechanisms to achieve {EU} renewable targets. Renew Energy 2014;63(0):345–52. http://www.sciencedirect.com/science/article/pii/S0960148113005144.

[10] Jacobsson S, Bergek A, Finon D, Lauber V, Mitchell C, Toke D, et al. {EU} renewable energy support policy: faith or facts? Energy Policy 2009;37(6): 2143–6. China Energy Efficiency, http://www.sciencedirect.com/science/article/pii/S0301421509001347.

[11] Leete S, Xu J, Wheeler D. Investment barriers and incentives for marine renewable energy in the UK: an analysis of investor preferences. Energy Policy 2013;60:866–75. http://www.sciencedirect.com/science/article/pii/S0301421513003431.

[12] Linnerud K, Andersson AM, Fleten S-E. Investment timing under uncertain renewable energy policy: an empirical study of small hydropower projects. Energy 2014;78:154–64.

[13] Lo K. A critical review of China's rapidly developing renewable energy and energy efficiency policies. Renew Sustain Energy Rev 2014;29:508–16. http://www.sciencedirect.com/science/article/pii/S1364032113006655.

[14] Long JS, Freese J. Regression models for categorical dependent variables using stata. StataCorp LP; 2006.

[15] Lund H. The implementation of renewable energy systems. Lessons learned from the Danish case. Energy 2010;35(10):4003–9. http://www.sciencedirect.com/science/article/pii/S0360544210000472.

[16] Martin NJ, Rice JL. Developing renewable energy supply in Queensland, Australia: a study of the barriers, targets, policies and actions. Renew Energy 2012;44:119–27. http://www.sciencedirect.com/science/article/pii/S0960148112000171.

[17] Masini A, Menichetti E. The impact of behavioural factors in the renewable energy investment decision making process: conceptual framework and empirical findings. Energy Policy 2012;40:28–38. Strategic Choices for Renewable Energy Investment, http://www.sciencedirect.com/science/article/pii/S030142151000532X.

[18] Mondal MAH, Kamp LM, Pachova NI. Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—an innovation system analysis. Energy Policy 2010;38(8):4626–34. http://www.sciencedirect.com/science/article/pii/S0301421510002922.

[19] NVE. Veileder i planlegging, bygging og drift av småkraftverk [Guide to planning, construction and operation of small hydropower plants]. Norwegian Water Resources and Energy Directorate; 2010. Tech. Rep. 1/2010.

[20] Ozcan M. Assessment of renewable energy incentive system from investors' perspective. Renew Energy 2014;71:425–32. http://www.sciencedirect.com/science/article/pii/S0960148114003140.

[21] Pegels A. Renewable energy in South Africa: potentials, barriers and options for support. Energy Policy 2010;38(9):4945–54. Special Section on Carbon Emissions and Carbon Management in Cities with Regular Papers, http://www.sciencedirect.com/science/article/pii/S0301421510002673.

[22] Peidong Z, Yanli Y, Jin S, Yonghong Z, Lisheng W, Xinrong L. Opportunities and challenges for renewable energy policy in china. Renew Sustain Energy Rev 2009;13(2):439–49. http://www.sciencedirect.com/science/article/pii/S1364032107001542.

[23] Richards G, Noble B, Belcher K. Barriers to renewable energy development: a case study of large-scale wind energy in Saskatchewan, Canada. Energy Policy 2012;42:691–8. http://www.sciencedirect.com/science/article/pii/S030142151101055X.

[24] Shum KL, Watanabe C. An innovation management approach for renewable energy deployment—the case of solar photovoltaic (PV) technology. Energy Policy 2009;37(9):3535–44. New Zealand Energy Strategy, http://www.sciencedirect.com/science/article/pii/S030142150900233X.

[25] Sovacool BK. A comparative analysis of renewable electricity support mechanisms for southeast asia. Energy 2010;35(4):1779–93. Demand Response Resources: the {US} and International Experience Demand Response Resources: the {US} and International Experience, http://www.sciencedirect.com/science/article/pii/S0360544209005507.

[26] Xu J, He D, Zhao X. Status and prospects of Chinese wind energy. Energy 2010;35(11):4439–44. Energy and Its Sustainable Development for China, http://www.sciencedirect.com/science/article/pii/S0360544209002746.