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Recent Developments in European Support Systems for Renewable Power*

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1 Introduction

One of the central goals of the EU's energy and climate policy is to increase the share of renewable electricity provision. Since the installation of the first windmills and photovoltaic panels there has been a controversy about the ideal support scheme for promoting the further development of renewable power sources. Basically, the existing schemes can be characterized as either market-based (tradable quota) or tariff-based. Irrespective of academic discussion, we have observed that major countries are tending to move away from their current market-based support schemes and to gravitate towards tariff-based schemes. From a standard economic perspective this may initially seem surprising, because tariff-based schemes, as opposed to their market-based counterparts, have been assessed as too costly. To some extent, this discrepancy between standard economic assessment and real market development may perhaps be explained by the failure to attribute appropriate significance to the investor perspective.

The risk premiums demanded by an investor decrease with the stability of the revenue streams from the underlying investment. A market-based support scheme will add volatility to the revenue stream from renewable power projects so that in comparison with a fixed tariff, investors will require higher remuneration per unit of power fed in. Accordingly, for a given target share of renewable power generation agreed on politically, a tariff-based scheme will need less overall support in achieving this share due to the lower risk premiums. In this paper we emphasize the aspect of ex-post efficiency introduced by Schmalensee (2012) and present some arguments that indicate why acknowledging this particular aspect can enhance our understanding of the discrepancy between theoretical economic advice and practical application. We review the development of current renewable power markets in Europe and underpin the practical evidence with a theoretical option value approach. Our discussions below focus on a particular aspect of the problem. Naturally, we are fully aware that the design of an appropriate supporting scheme requires consideration of many other aspects as well. But the fact remains that a number of policy-relevant implications for the design of support schemes derive from factoring the investor perspective into the overall debate.

* We would like to thank Andrew Jenkins and Henning Klodt for helpful comments and useful suggestions. The usual caveats apply.

2 An Introduction to Renewable Energy Support

The EU Emission Trading Scheme (ETS) has established a price for carbon emissions and has therefore provided an incentive to invest in a carbon-free energy system. If this price signal is sufficiently high, then we can expect corresponding investments in renewable energy. In the presence of such a cap on CO_2 emissions, additional support for renewable power technologies will not result in further emission reductions (e.g., Reichenbach and Requate, 2012; Schmalensee, 2012).[1] However, bearing in mind the long investment cycles in the energy sector and the various market imperfections that exist there, the incumbent technology could still prevail for several decades (Arthur, 1989; Acemoglu et al., 2012; Kalkuhl et al., 2012). As a way of achieving a faster transition to a more sustainable growth path, a system combining a price for carbon emissions with subsidies for the introduction of renewables might be the better option (e.g., Acemoglu et al., 2012). Additionally, the presence of learning spillovers may lead to an underprovision of technology development, since inventors are unable to obtain the entire rent generated, losing some of it to their competitors (e.g., Jaffe et al., 2005). Taking this line of argument, Finon and Perez (2007) state that it might make better economic sense to provide generous support for renewable electricity technologies in the first place and thus quickly reduce their costs.[2] As pointed out by Reichenbach and Requate (2012) and Acemoglu et al. (2012), it would also be ideal to promote research connected with renewable electricity technologies, for example by subsidizing the firms and scientists involved in the development and production of these technologies.

Instead of this first-best policy, the European countries have chosen a second-best policy: they directly support the producers of renewable power, not the producers of renewable power technologies. However, as indicated by Kalkuhl et al. (2012), the difference between a subsidy for the power-producing sector and the technology-producing sector is small, and in the second-best policy there is no delay in carbon-free energy deployment. Besides, this paper does not set out to discuss the overall efficiency or distributional implications of EU energy and climate policy. Instead, it focuses on potentially appropriate instruments for achieving certain goals like the 20 percent share of renewable energy provision by 2020. This aim can be operationalized with the notion of ex-post efficiency, which addresses the question whether certain given goals are likely to be achieved at minimum cost (Schmalensee, 2012).

[1] Additionally, for any uni- or minilateral demand-side emission control measures like the EU ETS or the support for renewable energy the corresponding decrease in fossil fuel prices implies higher demand for fossil fuels by other countries so that the related emissions of these countries increase (e.g., Markusen 1975; Sinn 2008; Frankel 2009; Eichner and Pethig 2011). This international carbon leakage is defined as the ratio between carbon emission increase of countries without emission control and the carbon emission reduction of countries with emission control (Barker et al. 2007).

[2] The example they draw upon is the wind energy industry in Germany and Denmark.

3 Current European Support Systems for Renewable Energy

The support schemes for producers of renewable power can be classified into two main types: i) Renewable Feed-in Tariff (REFIT) and ii) Renewable Portfolio Standard (RPS). REFIT means that the generator of renewable energy receives a fixed tariff per kWh for a certain period of time. RPS means that all energy generators are obliged to generate a certain share (quota) of renewable energy. For a certain period of time, producers of renewable energy receive *green certificates* for this energy. Producers that fail to deliver their obligatory share of renewable energy can offset their obligations with these certificates. Since these certificates are usually traded at a market place (a stock exchange), generators of renewable energy receive an additional cash-flow from these certificates. It should be noted that due to price volatility on the market place this additional income is uncertain and is also influenced by additional transaction costs. However, there is a cap on the price because producers that fail to meet their quota have to pay a fine for every kWh with which they fall short of their obligations. Often, RPS support schemes contain measures designed to prevent certificate prices from plummeting in the case of oversupply. Another instrument sometimes used is a feed-in premium (FiP) scheme. Here the supplier of renewable energy sells this power to the market and receives an additional fixed bonus as support.

Hence, RPS determines the quantity of renewable power provision and REFIT the price. Consequently, there are different implications for cost control of the support (e.g., Menanteau et al., 2003). Given the marginal cost function for renewable power is relatively flat, the limited quantity of certificates under RPS ensures an overall limit of support costs. For REFITs this is not the case. Here renewable power installations are built until the marginal cost equals the subsidy and therefore the effect on overall support costs may be drastic (e.g., Schmalensee, 2012). As already pointed out, several European countries have therefore adjusted their REFIT scheme by reducing the tariff. Another option, albeit hardly drawn upon as yet, is to combine REFIT with an auction process. Here REFITs for a certain amount of capacity are awarded to the developers who offer the lowest bid with regard to the REFIT. This so-called tender system also ensures control over support costs.

However, if we take a closer look at the practicalities of these apparently different support systems (REFIT and RPS) in their actual implementation, we find that they have much more in common than might be expected. And this is by no means accidental. In fact, it is the result of the investors' security requirements and the political necessity of setting specific capacity targets for renewable energy installations.

To shed light on this issue, we will discuss examples of both the REFIT and RPS support schemes and the market development. We also go into the German support system, which represents an archetypal REFIT scheme as also used, for example, in

France or Spain.[3] We restrict our analysis to one REFIT scheme since the essential design features of these systems are very similar. This is not true of the RPS schemes, which differ more substantially across Europe. Accordingly, we describe some of the most important ones, in the UK, Sweden, and Italy.

The German REFIT pays a fixed amount of money for a certain period of time. Different types of power receive different remunerations. For example, wind receives approx. 0.09 EUR per kWh. Ground-mounted photovoltaic (PV) installations currently receive about 0.19 EUR per kWh for installations below 10 kW. With increasing size, the remuneration is reduced up to about 0.13 per kWh for installations above 1 MW. Note that the wind REFIT has a whole range of particularities with regard to example location, grid issues, etc. We leave these out of account as they do not change the essential character of the support in REFIT form.

Due to the generous support for PV and the steep decline in costs over the last few years, we observe a dramatic increase in built PV capacity both in Germany and in many other European countries. Accordingly, to keep support costs in check, REFITs for PV have been cut substantially across Europe. In addition, very rigid restrictions have been imposed on ground-mounted photovoltaic installations; farm land, for example, can no longer be used for the purpose. In historical terms, the German market has been dominated by small-scale installations, in contrast, for example, to the Spanish market. The restrictions on ground-mounted systems have reinforced this tendency. Beside substantial discretionary cuts, an automatic mechanism has been implemented since 2009 to keep the dramatically increasing costs for the support of photovoltaic in check. REFITs are adjusted according to annual installations. However, these adjustments seem not to have been strong enough since in 2011 the German photovoltaic market still grew strongly with an additional installed capacity of about 7.5 GW (EPIA, 2012). Accordingly, an additional overall cap for PV installations in Germany was set at 52GW in July 2012, which is roughly twice the current capacity installed.

Turning to the RPS support schemes, we begin with Sweden. Sweden's support scheme for renewable power generation currently comes closest to the ideal type of an RPS support scheme. There is only small discrimination between energy types: producers of renewable power receive the same amount of certificates irrespective of the renewable power source. There is a small bias towards wind energy in two respects: lump-sum payments for major wind projects and a specific political goal set for wind energy, accompanied by plans to facilitate the permit process for wind projects. Currently, there is no tangible pressure to attain the target set, but this may change given that the development of installations is lagging behind target. Sweden has adjusted the prescribed RPS to avoid an oversupply of green certificates, so up to 2020 there will be a steady increase in the prescribed renewable quota. The fine for non-compliance with the RPS is 150 percent of the average price of a green certificate from the former year,

[3] Spain offers both, a FiP and a REFIT supporting scheme. Here, renewable power suppliers may choose once every year which scheme of support they prefer.

so there is an incentive to actually build renewable energy installations instead of paying the fine for non-compliance. Given the large stretches of land and the abundant wind resources in the north of the country, Sweden has installed comparably few wind farms producing approx. 3GW at the end of 2011 (GWEC, 2012).

Italy has both RPS and REFIT. Except for PV, all renewable power technologies are supported by RPS. The amounts of certificates granted differ depending on the renewable energy technology. Non-compliance is sanctioned. However, fines are not proportional to the shortfall in renewable energy but are imposed as lump-sum payments. Since there was an oversupply of green certificates in the past, the Italian regulator decided to buy green certificates at a fixed price. This price is set so that the sum of the average power price in the last year and the certificate price at present amounts to 0.18 EUR per kWh. Currently, draft legislation replacing RPS by REFIT is under review and is envisaged for application in 2013. The value of the REFIT is determined via a tender. Italian photovoltaic projects are supported via a REFIT scheme. Unlike most other countries with quite high support for PV, Italy has only moderately reduced this support, and planned reductions for the next years are also moderate. As a result, over 9GW of additional capacity was installed in 2011 (EPIA, 2012). To stop this excessive growth, the installed capacity of ground-mounted systems has been restricted to 1MW from 2011 on, and the REFIT has been reduced further. To further limit market growth, a cap has been placed on overall annual installations.

The UK has an RPS that differentiates the amount of certificates issued depending on the technology. Offshore wind farms receive two certificates per kWh, while onshore wind farms receive only one certificate per kWh. In addition, there is a REFIT system for small-scale generators (smaller than 5 MW). Especially for photovoltaic, 5 MW is no more than a medium size for projects. The tariff set was generous, and it spurred a short-lived boom that was terminated in summer 2011 for ground-mounted projects. In the UK, a fixed fine is incurred in the case of a shortfall in certificates. So it is not necessarily true to say that actually building a renewable energy installation may be more profitable than paying the fine. Currently, legislation to introduce a REFIT is under review and is to be implemented by spring 2013. REFITs are planned for inclusion in a tender system.

4 Financing Renewable Energy

Global investments in renewable energy rose to a record high of USD b211 in 2010 (UNEP and Bloomberg 2011). Of this amount, b187 went into new installations. The rest was spent on technology development and equipment manufacture. Investment in new installations was split into USD b127.8 for larger projects and 59.6b for small-scale projects such as domestic rooftop solar and farm biogas projects. The b100.9 for larger projects mainly consisted of investment for balance-sheet finance (USD b87.6) and

project finance (USD b37.9). Only a very small fraction went into bonds and other financing options. In 2008, before the financial crises, the split between balance sheet and project finance was more even, USD b67.9 for the former and USD b45.7 for the latter. The financial crisis made it increasingly difficult for project developers to find banks willing to lend them any money at all and thus had a negative effect on project finance. To shed more light on the underlying mechanisms for financing (and hence realizing) new renewable energy projects, we next provide a brief description of the two most important ways of financing renewable energy projects: balance sheet finance and project finance (based on Böttcher and Blattner, 2010).

Balance sheet finance means that the company operating the project borrows money in the name of the whole enterprise. The project remains a dependent part of the company, and the company itself is liable for debts and cash-flow payments. All assets of the company are used as collateral, and the rating of the company is relevant for its credit rating and hence affects the conditions under which the company can borrow money.

Structurally, *project finance* is differently. Here the initiator of the project (the sponsor) establishes a special-purpose vehicle (SPV). The assets of this SPV are the collateral for the credit, and there is no (or only limited) recourse to the sponsor. Accordingly, the debt is served exclusively by the project cash-flows. The amount and stability of the cash-flow is crucial for the credit rating and the debt-financing options. This has important implications for the project structure. Banks will only be willing to finance projects with very limited risk of cash-flow fluctuations. That means that only experienced developers (the project initiators) will receive loans and only technology with a long, successful track record will be accepted by lenders. Also, the expected cash-flow has to fulfil certain criteria ensuring that the debt can be served even in adverse scenarios.

As mentioned earlier, project finance requires a high degree of stability with regard to cash-flows. Balance sheet finance is not as strict as project finance because here the expected overall future cash-flow matters more than security. But internal accounting systems usually require projects to sustain themselves, so these systems also pay close attention to cash-flow security and not only to expected value.

REFIT systems guarantee a high degree of security with regard to cash-flow. In general, RPS countries are inherently more variable with regard to cash-flows since neither power prices nor certificate prices are stable.[4] In order to control for this variation in time, developers usually conclude long-term contracts with utilities to generate the necessary stability in cash-flows. That means the utilities buy the power and the green certificates for a specific period at a fixed price. As compensation for risk-assumption, such long-term prices are usually lower than average long-term prices. However, this approach to risk handling has its drawbacks. It requires utilities that are

[4] However, in some countries like Belgium and the UK, certificate prices have been relatively stable. The reason is that the fine for failure to comply with the given quota has not been set high enough, so it now functions as an upper boundary and stabilizes the price for certificates. Accordingly, it is attractive for energy suppliers to pay the fine instead of buying certificates.

willing to accept such long-term contracts, and this is not the case in all countries. Since such contracts are negotiated individually and subject to confidentiality agreements, there is less transparency than on spot-markets. This may lead to potentially adverse market power effects for the developers, as they only have a small number of buyers to negotiate with. Also, depending on the utilities rating, such long-term contracts imply a merchant risk in the case of bankruptcy. This in its turn is a problem when seeking loans from banks.

In general, derivatives can be used to manage the volatility of cash-flows and are important instruments in generating security for, say, a bank. Without these derivatives, banks would not be willing to give loans to project investors. The most important derivatives for project finance are swaps. Swaps (hence the name) usually imply the exchange of cash-flows. For example, an interest-rate swap entails a cash-flow stream where one of the partners pays the price for the current EURIBOR plus a spread. This stream varies with the EURIBOR, which is usually floating. In exchange, the partner pays a fixed interest rate through time. Such swaps are used to create payment stability. Similar swaps can be used to deal with the inflation risk in project finance. In Spain, France, and the UK, for example, support for PV projects is (partly) inflation-indexed. Since future inflation is uncertain and periods of 20 years are by no means unusual in financing PV installations, etc., this inflation indexation becomes an important financing aspect, especially in the latter years, which are prone to the compound interest effect. Inflation swaps are used to offset this insecurity. In theory, swaps could also be used to manage the volatility in cash-flows resulting from fluctuation in energy and certificate prices. However, up to now there have been hardly any power exchanges trading hedges that last longer than 5 years. It seems that financial institutions consider it too risky to commit to long-lasting contracts of this kind.

5 Insights from a Real Option Model

These discussions highlight two key elements in project appraisals by renewable investors: the baseline level of cash-flows and the risk in cash-flows. They also suggest that the choice of supporting schemes has a critical significance for the latter.

A simple theoretical illustration based on a real-option (RO) framework[5] will help us to see how the different ways in which support schemes address risk in cash-flows determines the effectiveness of those schemes. For a risk-neutral investor, risk in the returns from a renewable project has two ramifications. First, it generates an incentive for the firm to delay the onset of a project until prospects of high returns materialize. Second, the firm may need to pay a high interest rate to finance a risky renewable project, or worse, it may not obtain any external loans at all for a high-risk project.

[5] RO is a modeling approach used to apply the concept of financial options to problems of “real” investments that are subject to risk. For general descriptions of this approach, see e.g. Dixit and Pindyck (1994).

While in practice the second factor (project risk and access to loans) is related to various aspects of project financing, some of which have been discussed above, the first factor (risk and delay) allows for a straightforward theoretical interpretation. Here we describe a simple RO model based on the framework proposed by Dixit and Pindyck (1994). The basic idea behind the model is that the net present value of a project starting operations immediately has to be greater not only than zero (i.e. above the break-even point) but also than the value of not starting the project now and reserving the option to start it later. The value of operation and the value of waiting differ when risk is involved in project payoffs, because by waiting a firm can obtain additional information about the prospects of project returns. Note that this effect is independent of the firm's risk aversion.

Suppose a renewable operator is considering an investment in a new project. The investment incurs an initial fixed cost I, and it receives profits in accordance with the sales price of power P, the public support of renewables (e.g., REFIT net of the market sales price of power) S, and the running cost of facilities c. In a power market in which the renewable operator is only a small player and other fossil-based power producers are dominant, P can be regarded as given (exogenous). The net present value of project operation starting immediately, V^o, is given by

$$V^o = E\int_0^T (P+S-c)e^{-\delta t}dt \tag{1}$$

where T is the term of the project and δ is the discount rate. E is the operator signifying expectation.

The temporal trends of P and S may show fluctuations and thus not be fully known at the beginning of operation (this is why the expectation operator E is needed for the formulation). The choice of renewable supporting schemes would determine whether P and S exhibit fluctuations in the operator's financial evaluation. With an RPS system, the renewable operator would be subject to fluctuations of both P and S.[6] By contrast, a REFIT scheme does not generate fluctuations of S and also removes fluctuations of P from the operator's financial evaluation. The other conceivable combination is a fluctuating P and a flat S, which might materialize under a feed-in premium (FIP) system. In this theoretical illustration, we use simple representations of these fluctuations, i.e. geometric Brownian motions whose drift terms for P and S are denoted by σ_P and σ_S (we assume no baseline growth in P and S).

[6] One might argue that an RPS system could be designed in such a way as to cancel out fluctuations of P and S. For example, the government could constantly intervene in the certificate market to manipulate the price of certificates by buying and selling excess certificates in the market (akin to the role of a central bank in a currency system). The above discussion of the practices of RPS schemes suggests, however, that current RPS schemes do in fact pose comparatively large investment risks for renewable operators and do not offset the volatility of power sales prices. In the following discussion, we examine a simple case in which an RPS system generates fluctuations of S that are exogenous to the operator.

Under *P* and *S* risk (i.e., their future levels are unknown at the time of project evaluation), the firm might be able to increase project payoff by delaying the beginning of operations until either *P* or *S* becomes substantial. This means that there is some value in reserving the option to start a project at a later point in time. Here we use V^w to denote this "value of waiting." V^w can be estimated from model conditions[7] and depends on σ_P and σ_S. The firm only has an incentive to start a project immediately when $0 \le V^w \le V^o - I$.

Figure 1 is a schematic diagram of the relationship between V^o and V^w. Both V^o-I and V^w increase with the current level of *S* (i.e., *S* at the time of evaluation), but V^w dominates V^o-I when *S* is low. The expected net present return from a project is positive if the current *S* is high enough to bring about a positive V^o-I (i.e., S≤S** on the graph). But in fact if S<S*, the firm is better off not starting a project immediately (i.e., "waiting"), because waiting brings the firm a higher expected return. Only when S≥S* does the firm have an incentive to start a project immediately.

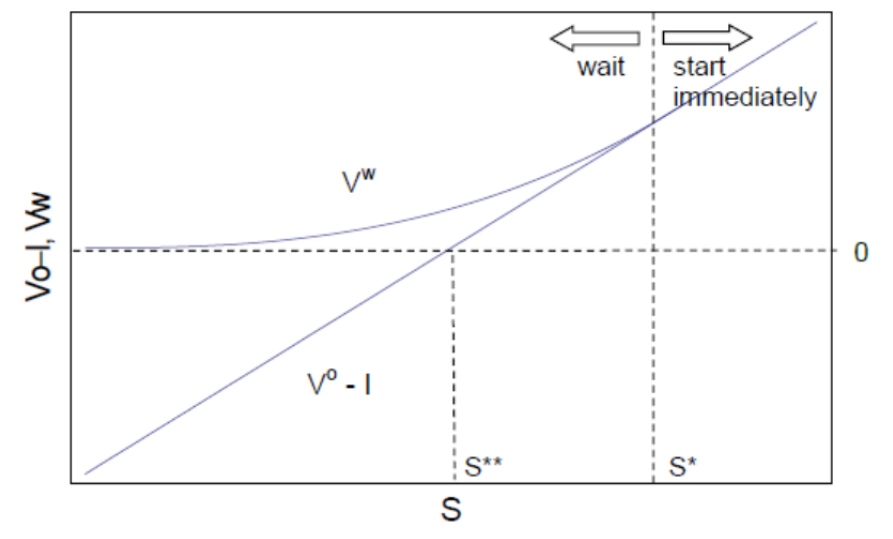

Figure 1: Schematic diagram of the value of operation (V^o) and the value of waiting (V^w). The expected net present return from a project is positive if the current *S* is high enough to bring about a positive V^o-I (i.e., $S \ge S^{**}$ on the graph). But in fact if $S^{**} < S < S^*$, the firm is better off not starting a project immediately (i.e., "waiting"), because waiting brings the firm a higher expected return. When $S \ge S^*$, the firm has an incentive to start a project immediately.

[7] The solution of V^w could be obtained by using the following conditions: V^w satisfies the following Bellman equation $\delta V^w dt = (1/2)\left(\sigma_P^2 P^2 V_{PP}^w + 2\rho_{PS}\sigma_P\sigma_S PSV_{PS}^w + \sigma_S^2 S^2 V_{SS}^w\right)dt$, where ρ_{PS} is the correlation between *P* and *S*, and it also satisfies boundary conditions for threshold S^*, where both the values and the partial derivatives of V^w and V^o-I match with one another (value-matching and smooth-pasting conditions). For details about the solution method, see Dixit and Pindyck (1994).

A numerical example of the RO model suggests that differences in payoff risk could have significant impacts on the effectiveness of support schemes in the practical context of renewable power projects. Figure 2 shows the combinations of threshold *S* (*S**) and current *P* (*P* at the time of evaluation) with three supporting schemes associated with different risk patterns. Parameter values are set to reflect those patterns typical for an offshore wind power project. A lower *S** means that the operator has an incentive to start a renewable (offshore wind) project immediately at a lower expected level of policy support. The graph shows significant differences of *S** between schemes. It is at its lowest in connection with a REFIT-like system (with no associated risk for either *P* or *S*). In other words, REFIT requires lower remuneration than the two other schemes because of its risk-reducing quality.

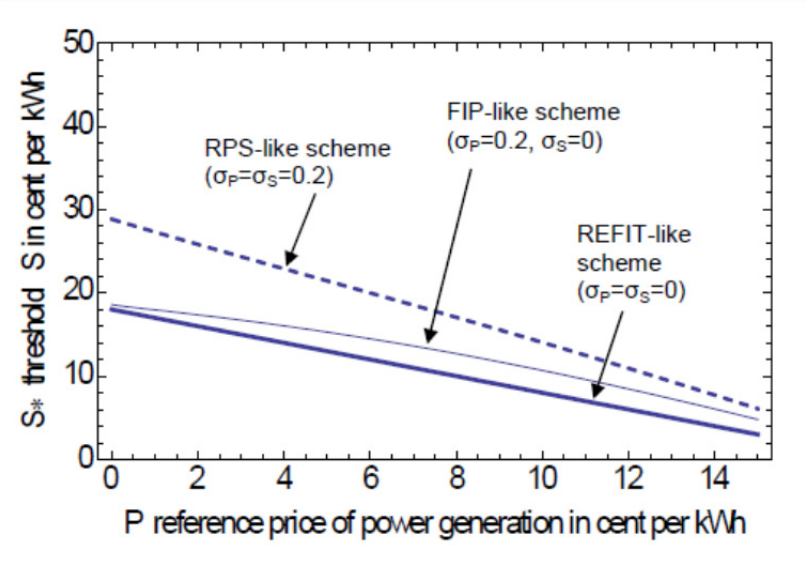

Figure 2: Combination of threshold *S* (*S**) and current *P* (*P* at the time of evaluation) with three support schemes associated with different risk reductions. Parameter values are set to reflect those patterns typical for an offshore wind power project: I=160, c=2, δ=0.1, and ρ_{PS}=0. For simplicity of computation, T is set at infinity. A lower *S** means that the operator has an incentive to start a renewable (offshore wind) project immediately at a lower expected level of policy support (for interpretation, see also Figure 1). The graph shows significant differences of *S** between schemes. It is at its lowest in connection with a REFIT-like system (with no associated risk for either *P* or *S*).

This simple RO model calculation clearly shows that for given levels of expected future power price and governmental support, a REFIT system is most effective in promoting implementation of renewable power generation because of its risk-reducing effect for renewable project operators. But such discussions of policy effectiveness are distinct from identification of the *social optimality* of policy schemes. While this RO model does not directly examine social optimality, it does provide some indications about the repercussions of those support schemes on social welfare. As Figure 1 shows, risk in project payoffs may justify waiting even when the expected net return for the operator from the

project is positive (the range between S^{**} and S^{*} on the graph). Differences in policy schemes could result in various impacts on social welfare if the external benefits of renewable power generation (future cost reduction in accordance with an increased installed capacity) happened to be a value S^{e} that satisfies $S^{**} < S^{e} < S^{*}$. With S^{e}, and if the payoff risk originates solely from the policy design (S randomness only), then society as a whole would be better off if the firm operated a renewable project. But the firm would refrain from running a project because of the policy risk. This mismatch might materialize under an RPS system. On the other hand, with the same S^{e} and if the payoff risk is natural and uncontrollable (P randomness only), society is somewhat better off if the firm does *not* operate a renewable project. Here a REFIT system removing randomness of P might prompt a firm to start a renewable project at a sub-optimally low level of S. These rankings concern the impact of policy choice on social welfare rather than the mere effectiveness of policy schemes. It should however be stressed that they are valid only under those limited circumstances in which external benefits happen to fall inside the range where running a renewable project would result in net positive expected social value but waiting is still favored because of the payoff risk.

6 Implications for an Optimal Renewable Power Support Scheme

In this paper we have emphasized the importance of reducing cash-flow volatility for the investors as one determinant in achieving ex-post efficiency. REFIT systems provide such cash-flow security and hence allow for a lower remuneration per unit of renewable power than RPS systems do. Under RPS systems, future cash-flows are less certain, and investors require additional risk premiums. While these aspects have been referred to and discussed in a number of papers and are also supported by market development, they are not yet sufficiently acknowledged in standard economic assessments.

Menanteau et al. (2003) explain the higher degree of success in terms of installed capacity by the reduction of risk due to feed-in tariffs, which makes it more attractive to raise capital. Comparing wind generation costs, they show that the UK, which uses RPS, has one of the highest generation costs within Europe, while for example costs in Denmark or Germany (two REFIT countries) are much lower. Mitchell (2006) and Lipp (2007) advance a similar argument, claiming that reducing risk lowers the cost of capital and hence makes more projects profitable. Lipp points out that to achieve a certain share of renewables a sufficient amount of investment is required in the energy sector, thus increasing the amount of debt finance or, more specifically, of project finance. Accordingly, using RPS with its inherent cash-flow uncertainty increases the costs for this capital. Haas et al. (2011) have calculated the levelized profits of wind projects for

a number of countries.[8] They show that all countries with RPS (UK, Italy, Belgium, Poland) have substantially higher levelized profits than REFIT countries, while growth is much smaller and conclude "[…] that certificate systems can lead to high producer profits resulting from high investment risks" (p. 1031).[9] Accordingly, Schmalensee (2012) points out that "[by] removing electricity market risks from investors… more capital can be raised per dollar of subsidy expense" (p. 50). We have also demonstrated this effect with the application of a real-option model where under REFIT an investor will require less support per unit of renewable power than under RPS.

This evidence from academic literature is backed by regulators in Europe. Both Italy and the UK plan to convert their RPS system to the REFIT mode. The main argument is the lower overall support cost required to achieve a specific capacity target. Italy expects a 3b EUR cost reduction per annum (about 25 %). One reason for the change-over referred to by the UK is the likely failure of the current system to achieve the desired capacity targets. The UK also anticipates lower overall costs for REFIT, notably in connection with the lower costs of capital due to increased investor security with regard to "stable and predictable revenue streams" (DECC, 2011). Surprisingly, these countries have not elected to increase the fine for non-compliance within their existing RPS, even though in theory such a step should be a sufficient incentive hike for investments. One explanation for choosing the option of introducing REFITs instead may be the high transaction costs resulting from RPS. As Schmalensee (2012) shows, the green certificate markets in the US are fragmented and thin, resulting in high bid-ask spreads to cover illiquidity risks and hence generating high transaction costs.

In designing renewable power support schemes one should ask oneself whether the support will add volatility to the cash-flows of a project. However, using a REFIT system does not imply that the overall risks are lower but only that the risks are taken away from the investors. Not surprisingly, fixing the price by a tariff-based system leaves the overall amount of renewable energy capacity to be determined by the market. Schmalensee (2012) shows that if the full incremental costs of renewable power are larger than those of fossil power, the variance of social costs could even be higher under REFIT than under RPS. Moreover, he shows that with REFIT a negative shock in the costs for renewable power will result in an increase in total social costs and that this effect is amplified, the flatter the supply curve for renewable power is. With RPS, on the other hand, a negative shock will result in lower overall social costs. In particular, the recent increase in installed PV capacity in many European countries with REFIT systems could be considered an instance of such a situation where a negative

[8] The levelized profits are calculated as the expected average annuity which corresponds to the sum of the discounted average returns per kWh over the entire lifetime of the technology, including therefore also initial investments and other expenditures (Haas et al., 2011).

[9] One exception, however, is Sweden. Despite its RPS system, the support costs for renewable energy are very low. According to Haas et al. (2011) this can be explained by Sweden's country-specific characteristics: an abundance of water and biomass power plus lump-sum payments for wind-power projects that are not included in the calculation of the levelized costs.

shock in costs has resulted in high social costs. Accordingly, several of those countries have adjusted or modified their support schemes so as to keep support costs down to a reasonable level. Consequently, choosing a REFIT system over an RPS system implies that some risks are shifted from the investor level to the society level. Taking into account that renewable power provision does also entail external benefits for the society one could argue that the risk-adverse perspective of investors could result in a too low level of renewable power investment compared to the socially optimal level derived from a risk-neutral perspective. The question on the optimal distribution of risks from a welfare perspective is beyond the scope of this paper but would be a highly desirable issue for further research from our point of view.

Returning to the implications from factoring in the investors' perspective, one way of incorporating the benefits from lower capital costs (and therefore lower levelized costs) for renewable energy in REFIT systems, while at the same time keeping the quantity risk resulting from negative cost shocks down to a manageable level, would be to restrict the tariffs for a certain amount of capacity. This involves using so-called tenders, where tariffs are awarded to the developers who offer the lowest bids with regard to the REFIT. Both Italy and the UK are planning to use tenders within the conversion of their support systems from RPS to REFIT. This however entails one problem that has already reared its head in the past. In the UK, the non-fossil-fuel obligation (NFFO) scheme actually meant that in the 1990s renewable energy capacity was tendered via long-term contracts. The snag here was that contracts for roughly 3GW of capacity were concluded between 1990 and 1998 but by September 2003 less than one GW had actually been delivered. This mismatch between prospective and actual capacity can be partially explained by the "winner's curse," i.e. the winning bids turned out to be too low to be sustainable. Thus we see that one of the problems besetting tender systems is that they may attract speculative and partly inexperienced investors who underestimate the costs and often go bankrupt as a result. This means that the project does not come to fruition and additional transaction costs accrue as a result. However, it should be noted that at the time, failing to install an awarded project was not subject to any penalties. Turkey used a tendering system for wind projects and also ran into this problem. One measure for coping with such difficulties could be sufficient penalties imposed in the case of failure to deliver the capacity awarded and a due diligence provision on the project's financial viability. However, the latter measure would of course generate administrative costs and thus reduce the benefits of a REFIT scheme in combination with tenders over and against RPS.

The various support schemes across Europe vary not only with respect to the volatility of the cash-flows generated but also with respect to the level of remuneration for the various technologies. This regionalized technology-specific support landscape prevents equalization of marginal costs for renewable electricity across technologies and countries and violates one of the core conditions for optimal support systems: letting the market choose the efficient technology and location. Equalization of marginal costs

across technologies might be justified to some extent because the various technologies differ in their external costs and their potential for learning effects. Schmalensee (2012) suggests using "[t]echnology-specific multipliers … to penalize some [variable energy sources] for the costs they impose on the electric power system or, perhaps, to reward some technologies because of the perceived external effect of induced learning by doing if their production is increased" (p. 61). Equalization of marginal costs across countries by using a uniform REFIT system or European trading in green certificates would be beneficial because it would allow the market to develop the most efficient locations with the most efficient technologies. Additionally, a large European green-certificate market would also significantly reduce bid-ask spreads and illiquidity risks and hence cut down on transaction costs. Nevertheless, as long as European countries stick to their country-specific support schemes, the path taken by Italy and the UK to combine REFITs with tenders might also be a suitable instrument for other countries, for example Germany. Tenders provide constant payment for energy and hence the requisite cash-flow security. In addition, in the case of competitive, well-designed bidding, the competition for licences should ensure support that does not grant excessive rents. For practical reasons, small-scale PV cannot be part of a tender mechanism. These small-scale systems play an important—in Germany a dominant—role, which has consequences for potential support schemes. For small-scale systems, one approach to coping with excessive markets is automatic discounting with reference to market development, a system that has already been introduced. Reasonably designed, this may be a good mechanism for ensuring a market that grows as politically desired. However, up to now this system of automatically discounted tariffs has not been tremendously successful in Germany because the discounts have been set too low.

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