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Tradable Green Certificates as a Policy Instrument? A Discussion at the Case of Poland

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Abstract: Quota obligation schemes based on tradable green certificates have become a popular policy instrument to expand power generation from renewable energy sources (RES). Their application, however, can neither be justified as a first-best response to a market failure, nor, in a second-best sense, as an instrument mitigating distortionary effects of the emissions externality, if an emissions trading system exists that fully covers the energy industry. We study how ancillary reasons, in form of overcoming various barriers for RES use and establishing beneficial side-effects, such as industry development, energy security, and abatement of pollutants not covered under the ETS, apply to the scheme recently introduced in Poland. While setting substantial expansion incentives, an advantage for local industry or job-market development or energy security can hardly be seen. With rising power prices for end consumers and awareness that the extra rents from the schemes mostly accrue to foreign investors and renewable and polluting generators, we expect a negative impact on social acceptance for RES and RES deployment support policies.

Keywords: tradable green certificates, environmental policy, Poland

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1 Introduction

According to basic welfare economics, every policy intervention (unless directly enhancing social welfare) needs a market failure at its basis; and every market failure requires one policy instrument which should mitigate the distortion in question without increasing another distortion (Ng 2004, Stiglitz 2000). A prime example constitutes the release of greenhouse gases (GHG) into the atmosphere, which has been dubbed the "greatest externality ever" (Sinn 2008). It is a market failure because many are likely to suffer from the consequences of climate change, while, without regulation, emitters lack an economic incentive to reduce emissions. In an idealized world with perfect information, perfect competition, and no other market failure than the emissions externality, a cap-and-trade system for GHG emission permits or a GHG emission tax provide a first-best response of environmental policy allowing full internalization of the externality. If a first-best instrument, in this sense, is unavailable, second-best instruments may be used to mitigate the distortionary effect of a market failure.[1] Feed-in tariffs for green electricity, and quota obligation schemes based on tradable green certificates (TGC) are examples of *possible* second-best instruments of environmental policy: while not immediately responding to a market failure, the expanded use of renewable energy sources (RES) may, in the absence of other environmental policy, mitigate GHG emissions by substitution of conventional fossile energy sources. If, however, an emissions trading scheme (ETS) is in place that fully covers the energy industry, the emissions from the covered sectors are capped by the ETS irrespective of the generation portfolio, and expanded RES use can hardly further mitigate the related emissions externality. In this situation successful RES-support policies tend to lead to excessive power generation costs, power prices and rents to green-electricity generators.[2] Moreover, the carbon price will be negatively distorted, alleviating abatement pressure from polluting technologies. Thus, in the presence of an ETS, the application of a TGC-based quota obligation scheme (or of feed-in tariffs alike) can neither be justified in a first-best sense, nor in a second-best sense.[3]

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[1] Generally, the theoretical justification of policy interventions in a second-best world is subtle (see Cremer *et al.* 1998, Fullerton and Wolverton 2005, and the references therein for a useful discussion). Fullerton and West (2002), *e.g.*, study for car emissions (where, in contrast to the energy industry, a first-best response is actually unavailable) how other policy measures can mimic a direct emissions tax.

[2] See Pethig and Wittlich (2009), Traber and Kemfert (2009) for illustrations of these relationships. Frondel *et al.* (2008) calculate that due to the German feed-in-tariff scheme an average household has additional annual power costs of about €31.5. Subsidies for photovoltaics (PV) alone cumulated to about €26.5bn since the introduction of the scheme in 2000 until 2007, to which by 2010 another €27bn will add. The abatement of 1 tonne CO_2 through additional PV use costs about €760.

[3] This statement holds more generally than the discussion above suggests. As is well recognized, the innovation and diffusion of new technologies may be accompanied by further market failures, especially

In this paper, we analyze the Polish TGC scheme with regard to its economic functioning, and its justification with reference to *ancillary* reasons. By ancillary reasons, we understand reasons that may justify the application of a TGC scheme, beyond a first- or second-best reasoning, on politically-pragmatic grounds. These reasons comprise, for example, overcoming potential legal, institutional, infrastructure, funding, technological, and social barriers for renewable-technology deployment, and the establishment of beneficial side-effects. Beneficial side-effects may include stimulation of employment or industry development, technological diversification, and abatement of pollutants not covered under the ETS. Poland agreed in its EU accession treaty to an indicative target of 7.5% RES contribution to gross electricity consumption by 2010 (European Parliament 2003), which translates into a 10.4% RES quota of total electricity generation for that year. In 2006, when the TGC scheme was introduced, Poland generated 60.8% of its electricity from hard coal, 34.9% from brown coal, 2.6% from RES, and 1.7% from natural gas (Sejm 2006, URE 2008a).[4] EU member since 2004, the country has been part of the EU ETS since its start in 2005.

The literature on TGC-based quota obligation schemes has covered a range of issues.[5] Apart from numerous studies on regional systems, the effectiveness and efficiency of such schemes have been compared especially to those of feed-in tariffs (*e.g.*, Menanteau *et al.* 2003, Finon and Menanteau 2004, Palmer and Butraw 2005, Finon 2006, Finon and Perez 2007), and their interaction with emissions trading schemes (ETS) has been analyzed (*e.g.*, Morthorst 2001, Amundsen and Mortensen 2001, Jensen and Skytte 2003, Del Rio 2007, Gillenwater 2008b). Further contributions have focused on particular aspects, such as the relationship between wind supply volatility and TGC price (Lemming 2003), certificate banking and TGC price volatility (Amundsen *et al.* 2006), market power in TGC markets and power prices (Amundsen and Bergman 2008) and the role of long-term contracts for TGC-market efficiency (Kildegaard 2008). Surprising to us is that none of these contribution has raised the question of what the application of a TGC-based quota obligation scheme justifies as a fundamental issue.[6] The Polish TGC scheme has, to the

in form of knowledge spillovers as related to the public-good nature of new knowledge from R&D, learning by doing or learning by using (Jaffe *et al.* 2002, 2005). Typically, a Pigou subsidy or a respective credit, as first-best measures, can reward an RES technology producer for foregone rents which others appropriate when using the newly generated knowledge in their own production. Again, (implicit) subsidies for RES technology use can hardly internalize these externalities.

[4] 47.4% of its 4.3 terawatt hours (TWh) of green electricity in 2006 were generated from hydropower, 43% from biomass, 4.3% from wind, and 3.7% from biogas (GUS 2007).

[5] See, *e.g.*, Agnolucci (2007) for a survey, and Gillenwater (2008a,b), Wiser *et al.* (2005) for fairly encompassing discussions of definition and different aspects.

[6] This is not to say that critical concerns have not been mentioned in the literature. For example,

best of our knowledge, not been examined in the scientific literature yet.[7]

Section 2 describes the TGC scheme implemented in Poland in detail. Section 3 analyzes, based on a cash-flow model, the conditions for wind-power investments under this support scheme in Poland.[8] In section 4, we discuss how ancillary reasons justify the application of the Polish TGC scheme. Section 5 concludes.

2 The Polish TGC scheme

The Polish TGC scheme, as is characteristic for such schemes, requires electricity distributors to prove that a certain proportion (quota) of their electricity sold is generated from RES.[9] The quota is defined by the Ministry of Economics and amounted to 3.6% in 2006, 5.1% in 2007, and 7% in 2008.[10] Retailers are obliged to grant grid access to RES producers. The fed-in green power is remunerated to producers at the average market price of conventionally generated power, the level of which is determined by the Polish energy regulatory office URE. Retailers prove quota fulfillment by submitting green certificates to URE. One certificate refers to one megawatt hour (MWh) of RES electricity, and has an indefinite maturity, so that they can be banked across trading periods. No distinction is made whether green electricity is generated from hydropower, wind, biomass, biogas, photovoltaics, solar, or geothermal energy. URE also issues the TGC and distributes them to generators according to their amount of RES electricity produced. Retailers may either buy electricity and green certificates at the Polish Power Exchange (POLPX), or receive them via bilateral long-term contracts with RES generators in which the two parties fix the prices of electricity and green certificates. There is no legally defined upper and lower price limit in certificate trading. Decisive for quota fulfillment is the number of TGC submitted, not whether RES electricity has actually been provided to consumers according to the quota. With its submission, a TGC vanishes. A retailer who fails to fulfill his RES quota is fined for the unfulfilled part. The fine is set annually by URE. In 2006, it was €61.60 (PLN 240) per missing

Sorrell and Sijm (2003), Frondel *et al.* (2008) have clearly pointed to the lack of additional emissions reductions below the ETS target if implemented in parallel. Policy documents, however, such as EU Commission (2008), follow the favorable arguments in the literature.

[7] A few (rather early or survey) papers or studies have covered aspects of RES policies in the region, *e.g.*, Barbu (2007), Hindsberger *et al.* (2003), Paska *et al.* (2009), OPTRES (2007), Reiche (2006).

[8] This working-paper version contains, moreover, a description of the Romanian TGC scheme, and an analogous analysis of conditions for wind-power investments for Romania in appendix.

[9] See Lemming (2003), Menanteau *et al.* (2003), *e.g.*, for general descriptions of TGC schemes.

[10] See Table 1 for the period 2009-2014.

green certificate,[11] in 2007 €64.06 (PLN 242.40), in 2008 €70.74 (PLN 248.46) (URE 2007a, 2008b). The level of the fine introduces an upper price limit in the TGC market, the so-called buy-out price.

2.1 Development of TGC prices and RES generation

In 2006, for a gross electricity consumption of 150.87 terawatt hours (TWh)[12] (Paska *et al.* 2009), 5.43 million green certificates would have been necessary to meet the RES quota of 3.6%; but RES power generation only reached 4.2 TWh, leading to the issuance of 4.2 million TGC. In 2007 and 2008, gross electricity consumption rose, respectively, to 154.17 TWh and 154.89 TWh (PSE Operator 2009), with corresponding TGC demands of 7.86 million and 10.84 million to satisfy the RES quotas of, respectively, 5.1% and 7%. To meet the 2007 TGC demand, as compared to 2006, an increase of electricity generation from RES by 87% would have been necessary, to meet the 2008 TGC demand another increase by 37%. That the realization of this development of production was not realistic can also be seen at the price trend for TGC, which touched the level of the fine for missing TGC of €61.60 (PLN 240) in mid-2006 (Figure 1). Beside TGC trading at POLPX,

Figure 1: OZEX (TGC-price index at POLPX) (data: POLPX 2008).

it is also possible to sell certificates directly to distributors via bilateral contracts. In

[11] The certificate trading is in Polish Zloty (PLN), as have been our calculations. To display, to some extent, the exchange-rate volatility to which actors are subject, we indicate prices in this section in nominal Euro and PLN values. The annual average exchange rate was PLN 3.8959/€ in 2006, PLN 3.7837/€ in 2007, PLN 3.5121/€ in 2008 (ECB 2009).

[12] A terawatt hour is 10^6 MWh.

2007, 74.4% of all certificates were traded this way (POLPX 2008). The price for these transactions ranged in a span of €39.64-63.43 (PLN 150-240). The remuneration for RES power fed into the grid, which is based on the price of conventionally produced power, amounted to €30.72 (PLN 119.7) in 2006 and to €34.04 (PLN 128.8) in 2007 (URE 2007b, 2008c). In 2007, RES producers could thus have realized a combined revenue from TGC and electricity of up to €97.47 (PLN 368.8) per MWh green electricity generated.

2.2 Development forecast for the Polish TGC market

For a judgment of the possible development of the Polish TGC market in the near future, it is first necessary to estimate the TGC demand. Table 1 lists the results, derived using the estimates of gross electricity consumption for the years 2009–2013 in URE (2009: 53).[13]

Table 1: TGC demand estimation.

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Power cons. (TWh)	158.1	159.9	162.8	165.7	168.5	171.1
RES quota (%)	8.7	10.4	10.4	10.4	10.4	10.4
TGC demand (million)	13.57	16.63	16.93	17.23	17.52	17.79

The development of hydropower is restricted by the government to avoid further intrusion into ecological systems by this technology. Therefore, only a slight increase in small hydropower has been expected (Paska *et al.* 2009), so that electricity generation from hydropower is unlikely to exceed 2.1 TWh in the near future.

Further available technologies to increase RES power generation in Poland include biomass and biogas. Power generation from these sources reached 1.9 TWh in 2006, 0.5 TWh more than in 2005 (Paska *et al.* 2009). The German Ministry of the Environment estimates a span of €80–210 for the power generation cost of biomass and biogas (BMU 2007). In view of the maximum revenue expectation from electricity generation and TGC for 2007 of about €97.47 per MWh, as calculated above, the development opportunities of biogas and biomass seem limited due to the high risk for such projects to become unprofitable when the TGC price decreases.

[13] The estimate for 2014 has been extrapolated using the average growth rate of gross electricity consumption between 2009 and 2013.

For a constant annual growth for biomass of 0.5 TWh until 2014 and a hydropower production in 2014 of 2.1 TWh, a production gap of 9.79 TWh remains to fulfill the RES quota shown in Table 1. This gap could possibly be filled by electricity from wind power plants. At the end of 2007, their capacity amounted to 267 MW (EWEA 2008a). PSEW (2008) estimates the load factor for wind energy plants in Poland in a range of 20–35%. It can be assumed that projects with the highest load factors will get realized first. An average load factor of 30% then implies the need of 3.725 MW of wind power capacity[14] to fulfill the RES quota of 10.4% in 2014. This value implies the need for an annual capacity growth of about 532 MW until 2014. In 2007 only wind power plants with a capacity of 123 MW have been erected. A rapid increase in the annually erected capacity will thus be required to fulfill the targets. EWEA (2008b) estimates that the Polish wind power production capacity will only meet 1,000 MW in 2010.

Because the RES quotas set by the Polish government will hardly be achieved, the TGC price is likely to remain high in the short and medium term. Whether the quota will be fulfilled until 2014 depends on further biomass and biogas growth and accelerated wind power plant construction. If the RES quota is not met in 2014, TGC demand will exceed TGC supply. This should lead to a TGC spot market price near the fine of €70.74 (PLN 248.46).

3 Conditions for wind-power investments

To evaluate the immediate incentives set for investors by the Polish TGC scheme, we analyze the profitability of a hypothetical 20-MW wind-farm project with a 20-year economic lifetime.[15] We compare two possible investor strategies: selling both TGC and electricity at the relevant exchanges (Option 1), and the conclusion of bilateral long-term contracts to sell TGC and electricity directly to distributors (Option 2).

3.1 Cash-flow model and framework data

A necessary condition for an investor to invest in a single project is that it has a positive internal rate of return (IRR).[16] A sufficient condition is, in general, that it yields a higher

[14] The figure derives as 9,790,000 MWh = 3.725 MW * 24 h * 365 days * 0.30 load factor.

[15] We stick to parameter values as typically used in practice. For example, 20 MW installed capacity of the wind farm constitutes a size big enough for delivery of plants by a technology producer and where financing is still available relatively conveniently. A 20-year economic lifetime is the standard value considered for a wind park; after that time operation-and-maintenance costs increase rapidly.

[16] The IRR is the rate of return for which a project's net present value is equal to zero.

return than a comparable investment on financial markets.[17] RES projects are typically realized by companies founded for a specific project only, so that granted loans have to be repaid by the cash flow of the specific project (Böttcher and Blattner 2006, Wiser and Pickle 1998). We determine the IRR of the reference project based on a standard cash-flow model (*e.g.*, Perridon and Steiner 2007). The IRR is calculated based on the dividends paid to shareholders. In Table 2 we indicate how the dividend payments are calculated.

Table 2: Dividend payment calculation.

	income from sales
+	interest received
-	operation&maintenance costs
-	depreciation
-	interest paid
-	corporate tax
=	**earnings after taxation**

	earnings after taxation
+	depreciation
-	loan redemption
-	dividend payout for previous period
=	**cash flow of the period**
+	cash on hand from previous period
-	debt service fund
=	**dividend payment of the period**

The model also accounts for the perspective of lenders, typically banks. Lenders expect a project cash flow sufficient to serve debt service and to handle risks, such as price volatility. We consider two instruments banks typically use to enforce a sufficient cash flow: the debt service fund, and the debt service cover ratio (DSCR). The debt service fund obliges the debtor to hold back a specific amount of cash for bad periods in which the cash flow is insufficient for debt service. (The debt service comprises the payments for interest and loan redemption of a period.) Dividend payments are only allowed, if the debt service fund contains cash. The $DSCR$ gives an indication of the project's capability of serving the debt service of the period. It is calculated as:[18]

$$\mathrm{DSCR} = \frac{\text{operating cash flow} + \text{debt service fund}}{\text{debt service of the period}}$$

$DSCR < 1$ implies the project lacks capability to serve debt service. Therefore, banks usually want a project to fulfill $DSCR$ >1. Wind farms are often required to fulfill $DSCR > 1.3$ (Böttcher and Blattner 2006: 104).

[17] In subsection 3.4, we compare the hypothetical wind-farm investment with an alternative financial-market investment.

[18] The operating cash flow is the cash flow directly generated by the operation of the wind farm. It comprises the earnings after taxation and depreciation, but not loan redemption or dividend payments.

In our model dividend payments are only possible, if the debt service fund reaches 50% of the debt service of the following period, a typical value in practice. As to the $DSCR$, we use 1.3 as the benchmark to balance debt and equity. In a projection for the whole of its duration, a project has to fulfill this $DSCR$ in every period. If the project fails to meet this requirement, the initial equity ratio of period 0, before the start of plant operation, has to be increased. If the project achieves $DSCR > 1.3$ in every period, the equity ratio has to be decreased until any period reaches $DSCR = 1.3$. This provides for the simultaneous integration of investor's and lenders' perspectives in the determination of the equity ratio in the model. We assume the redeemable loans to have a duration of 13 years, that they are free of redemption in the first year of operation, and have a fixed annual coupon of 7.4%.[19] The annual return on deposits is 3%. We adopt the Polish corporate tax rate of 19%.

As to further framework data, we assume an average load factor of 30%.[20] Thus, the 20-MW wind park will have an annual electricity output of 52,560 MWh. The total investment volume for the wind park amounts to €31.094m,[21] the operation and maintenance (O&M) costs in the first year of operation to €0.9m.[22] The annual O&M costs increase in years 1-10 by 3.5%, and in years 11-20 by 2%.[23] The wind farm starts to operate on 01/01/2009.

3.2 Option 1: market sale of TGC and electricity

The analysis of the market-sale option splits in two steps. In the *banking case*, we determine the minimum equity quota claimed, if a conservative lender assumes a worst-case scenario concerning the price development to secure his money. In the *base case*, we calculate the IRR of the project using the equity ratio of the banking case and a price development an investor could realistically assume.

Banking case. Banks want the project to be able to repay its debts even under the conditions of a worst-case scenario. Given the young markets for green electricity and

[19] Firms are required to save the debt service saved by the freedom from loan redemption in the first year in the debt service fund.

[20] The load factor of 30% is in the upper third of the ranges in the literature (PSEW 2008: 5, Barbu 2007: 300). Usually more favorable sites are developed first.

[21] The price indications in this section are in values of 2008.

[22] Investment volume and first-year O&M costs are based on ZSW (2008). They include a premium of 2.4% for exchange-rate risks, as the plants have to be imported from the Euro zone.

[23] The increase in O&M costs of 3.5% in the first ten years corresponds to the average inflation rate in Poland in the last years (it may then join the European Currency Union), the 2% increase to the ECB inflation target.

TGC, and that the project company sells both electricity and TGC at exchanges, the expected price variability is particularly high. We assume that the estimated electricity income will not be increased by the regulatory authority URE, but will remain at its 2007 level of €36.67/MWh (PLN 128.8/MWh) (URE 2008c) during the 20-year duration of the forecast. The demand for TGC is likely to exceed supply in Poland in the next years (subsection 2.2). This implies TGC prices at the upper limit of €68.34 (PLN 240) at least until 2014, where current regulation ends. Because the development of the Polish RES scheme past 2014 cannot be foreseen yet, we consider an income of €0 per TGC as the realistic assumption for a worst-case scenario for the period of 2015–2028. In Table 3, we also give the results for incomes of €59.45 (PLN 80) and €70.84 (PLN 120).[24] Within the bounds for TGC income after 2014 considered, the reference wind farm needs an equity ratio of between 70.1% and 23.2%, or €21.8 million to €7.2 million (PLN 76.5 million to 25.3 million) equity, to ensure a $DSCR > 1.3$ for the whole duration. The IRR amounts to between 0.51% and 10.51%. Note that, thus, even for the assumption of a zero income per TGC in 2015–2028, the IRR is positive.

Table 3: Results market sale of TGC and electricity.

Income per TGC 2015–2028 (€)	**0**	22.78	34.17
Combined income (€)	**36.67**	59.45	70.84
Equity quota banking case (%)	**70.1**	38.8	23.2
Equity required (million €)	**21.8**	12.1	7.2
IRR banking case (%)	**0.51**	6.61	10.51
IRR base case (%)	**9.49**	12.27	15.70

Base case. The base-case scenario uses the specified equity ratio of the banking case to calculate the project IRR under the assumptions of an investor. In this scenario the power income is increased with the inflation rate, as the regulatory authority URE links the RES-power remuneration determined to the average market price of conventionally generated power. Because of the expectation of increasing prices for fossil fuels, we increase the RES-power remuneration in the base case by 3.5% p.a. for the years 2009-2018 and by 2% p.a. beginning in 2019. The TGC price forecast is more difficult. In concordance with the banking case, we assume that until 2014 the TGC price will remain at its upper limit of €68.34 (PLN 240). Because we do not know, when the RES quota will be fulfilled we decrease the TGC income in the forecast annually by 20% beginning in 2015.

[24] The required equity quota reaches 0% at an assumed income per TGC in 2015–2028 of €66.06 (PLN 232).

Figure 2 illustrates the price development in the base case. Based on these assumptions

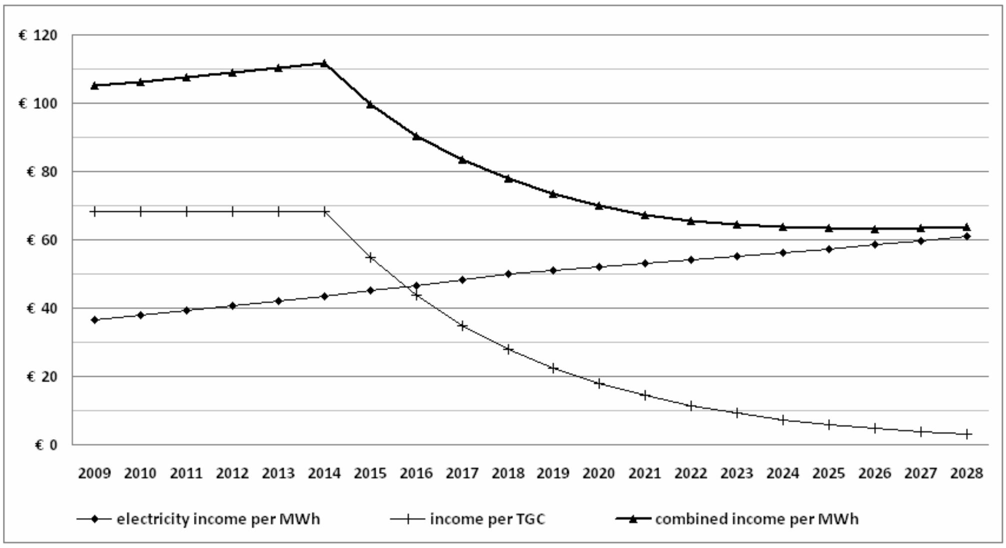

Figure 2: Illustration of price development in the base case.

and under consideration of an banking-case equity ratio of 70.1%, we calculate an IRR relevant for investors of 9.49% for a Polish 20-MW reference project (Table 3).

3.3 Option 2: bilateral contracts

Bilateral contracts constitute an opportunity to avoid price variability, as RES power producer and retailer agree to trade electricity and certificates at fixed prices during the time of the contract. Because banks accept the incomes of the project as secured by the contract, a banking case is no longer necessary. As a consequence, the price agreed in the bilateral contract has a direct influence on the level of the equity ratio. The hypothetical bilateral contract for this project shall comprise agreed prices for electricity and TGC. The benchmark for the power-price component is the 2007 RES remuneration of €36.67 (PLN 128.8) set by URE (URE 2008c). To simplify we use a value of 130 PLN/MWh in the contract. TGC prices in contracts ranged between €42.71 (PLN 150) and €68.34 (PLN 240) in 2008 (POLPX 2008). With €55.52 (PLN 195) per TGC the average of this range shall be used for the TGC component of the contract. This implies the project facing a combined income of €92.54 (PLN 325) per MWh of power generated and leads to an annual project income of €4.9 million (PLN 17.1 million).

Under consideration of the bilateral contract above the project requires an equity ratio of 11.4% or €3.6 million (PLN 12.5 million) to fulfill the requirement of $DSCR > 1.3$.

Table 4: Sensitivity analysis bilateral contracts.

Combined income (€)	75.45	79.72	84.00	88.27	**92.54**	96.81	101.08
Combined income (PLN)	265	280	295	310	**325**	340	355
Equity ratio (%)	30.0	25.4	20.7	16.1	**11.4**	6.9	2.2
IRR (%)	5.10	6.78	8.70	11.02	**14.07**	18.64	29.25

The IRR of Option 2 is 14.07%. A sensitivity analysis shows how tightly IRR, equity ratio and negotiated prices are linked (Table 4).

3.4 Comparison with financial-market investment

The two investor strategies considered above lead to positive IRR. For the figures we consider as most realistic (columns in bold in Tables 3 and 4), the IRR is higher in the case of a bilateral contract than in the market-trading option. Under the bilateral-contract option, the IRR strongly depends on the prices negotiated for electricity and TGC (Table 4). For example, if an investor faces a bad negotiating position and the IRR threatens to be under the IRR of Option 1 of 9.49%, the investor should consider selling electricity and TGC on the free market. Even in the worst-case-scenario considered in Option 1 the IRR remains positive and the project is not in danger of illiquidity.

To evaluate the attractiveness of the reference project for an investor, it is necessary to account, in addition, for the opportunity of an alternative financial-market investment. For this comparison, typically the capital-asset-pricing model (CAPM) is used (Böttcher and Blattner 2006, Perridon and Steiner 2007). If the expected return of the CAPM exceeds the IRR of the real investment project, the project should be abandoned. We derive a CAPM reward-to-risk ratio for wind-farm projects in Poland of 9.84%.[25] This value exceeds the IRR of 9.49% calculated for Option 1, meaning that trading TGC and power on the free market is not interesting under the Polish TGC scheme. Under Option 2, the conclusion of a bilateral contract with a combined income of over €86.20 (PLN 303) is necessary (see also Table 4).

Our analysis shows the bilateral-contract option to be more profitable than direct reliance on TGC and electricity markets alone. As a consequence, TGC trading at the local certificate exchange would be expected to dry up, a tendency which can be seen

[25] The figure is calculated as 5.7%+0.66·6.25%, where 5.7% is the risk-free rate of interest (corresponding to a similar state bond; Comdirect 2008), 0.66 the beta coefficient (calculated based on the indications of a self-compiled wind power peer group), and 6.25% the risk premium (Damodaran 1999: 72).

(subsection 2.1).[26] This weakens the TGC market as the central element suggesting the efficiency of such schemes. The high quota requirements in Poland are likely to imply persistently high TGC prices, making these prices *de facto* better predictable. This moves the scheme effectively close to one with feed-in tariffs, with guaranteed prices for green electricity.[27] At the same time, the high quotas enhance the uncertainty as to how the system will develop in the next decade. Given the favorable investment conditions found in this section, we conclude that in Poland indeed a relatively fast RES expansion pace can be expected, mostly based on wind power.

4 Ancillary reasons to justify the Polish TGC scheme

In this section, we study how the application of a TGC scheme in Poland can be justified with reference to ancillary reasons. As set out in the introduction, only these additional reasons may justify support policies for RES technology deployment, if, as is the case in Poland, an ETS is present that fully covers the energy industry. We wish to emphasize that neither the concept of "ancillary reasons," nor a methodology for their assessment are established in the literature. Closest to our analysis is OPTRES (2007: ch. 12), which focuses on administrative, grid, social, and financial barriers. We adopt a categorization of barriers, and side-effects, that is more adapted to the situation in Poland, as a new EU member state with few previous experience with the installation of renewable generation technology.[28] Part of the character of ancillary reasons is that their net social benefits are hard to quantify. As a consequence, the assessment is mostly qualitative.

We distinguish two categories of ancillary reasons:

(1) *barriers* for the deployment of additional RES technologies that may be inherent in the economy;

(2) *side-effects* that may be associated with an expansion of the use of renewable generation technologies.

We consider five kinds of barriers and four possible side-effects. The first two kinds of barriers, (B1) legal and (B2) institutional, pertain, respectively, to the legal structures

[26] This is in line with Kildegaard's (2008) prediction that capital-intensive technologies with low operational costs – such as wind power – will typically find a more profitable financing via contracts than by way of the TGC exchange trading.

[27] Of course, feed-in-tariff schemes do not implement a particular RES quota.

[28] Similar aspects have been studied, *e.g.*, in Neuhoff (2005), Neuhoff and Twomey (2008), Sorrell (2003) and Sorrell and Sijm (2003). We are grateful to Paul Twomey for his input on this section.

and efficient regulatory institutions to enable or facilitate the integration of renewable generation capacity into power supply; they are located in the legal system of an economy. Further preconditions for additional RES technology deployment include (B3) the available infrastructure, and (B4) the availability of funding and the technologies in question. The fifth aspect is (B5) the social acceptance of RES technologies. As side-effects, we consider (S1) the expansion of local job markets, (S2) domestic industry development, (S3) the diversification of the national generation portfolio, and (S4) the abatement of pollutants not covered by the (current) ETS.

It is characteristic for these barriers or side-effects that none of them constitutes a market failure to which subsidies to RES power producers would constitute the corresponding first-best policy response, or a indirect substitute for a first-best measure. The barriers will tend to lock in energy systems with the previously implemented technologies. Moreover, the barriers hamper the carbon-price signal (as generated by an ETS or an emissions tax) to become fully effective. The side-effects constitute possible additional effects of RES support policies. Side-effects may be considered as desirable from a social-policy (S1, S2), an energy-policy (S3), or an environmental-policy (S4) perspective. Though, such as stimulation of local job market and industry development, routinely emphasized in the policy debate, side-effects cannot be recognized as the primary purpose of RES-deployment support. On politically-pragmatic grounds, these barriers and side-effects may be referred to as *ancillary* reasons to justify RES support policies as temporary measures. We consider barriers as more important for a possible ancillary policy justification than side effects because of their general importance for the energy system and the effectiveness of the carbon-price signal. Our discussion will mostly focus on wind power, as the most important RES in Poland in the near future (section 2).

We study in subsection 4.1 whether the introduction of the TGC scheme has been a necessary requirement, or at least helpful, for overcoming the barriers. In subsection 4.2, we consider how the TGC scheme has been able to establish the mentioned side-effects. Subsection 4.3 briefly evaluates the findings.

4.1 Overcoming barriers

(B1, B2) *Legal and institutional barriers.* The importance of the legal framework and functional regulatory institutions for economic development in general, and the integration of new technologies in the energy sector in particular, is well established (*e.g.*, Golini 2005, OPTRES 2007, Williamson 2000). Given the state monopoly for power generation, transmission and distribution in Poland until 1991, a quick rise of the supply of renewable electricity from, typically, decentralized sources was neither obvious, nor did it happen after the fall of the Iron Curtain (URE 2008a). The question here is how the establishment of a TGC scheme has been necessary, or helpful, for overcoming legal and institutional barriers for additional deployment of renewable technologies.

The two major regulatory elements supporting the use of renewable generation technology and the TGC scheme in Poland today are the 1997 energy law act, and the energy regulatory office URE established in the same year (ERRA 2009, Sejm 2006). The adoption of the energy law act was the decisive step towards a liberalized and more decentralized national power generation system with unbundled generation, transmission and distribution (Szwagrun 2004, URE 2008a). The reforms of the Polish energy sector were especially made in view of the Polish EU accession. This meant to comply with the requirements of the internal EU electricity market and the EU expansion target for renewable electricity (Ministry of Economy and Labour 2005).[29] The national decision to set up a TGC scheme was made in response to EU (2001) aiming to achieve the desired renewables expansion. At the concrete administrative level, today four kinds of permissions are necessary to establish a new RES plant: an environmental approval from local authorities, the grid connection agreement with the local grid operator, the construction permission from local authorities, and the power supply license from URE (PAIiIZ 2009a,b). In a detailed study of the investment conditions in practice, the imprecise nature of the regulations to obtain these permissions has been described as the biggest barrier for wind-power expansion in Poland (PAIiIZ 2009a).[30] As a result, the project development phase, preceding construction works, has been taking between one and five years, and thus the time to complete an investment project ranges between four and seven years.

As a consequence, first, the developments on EU level, not the national set-up of the TGC scheme, occur as decisive for overcoming legal and institutional barriers for an expanded RES use since Poland's democratic turn. Second, the problem of imprecise rules to obtain permissions is with the Polish legislator; to overcome it, the TGC scheme may, at best, be helpful due to additional applications, but is not necessary.

(B3) *Infrastructure.* Infrastructure problems are relevant in Poland in relation to the grid access of decentralized suppliers, and plant construction (PAIiIZ 2009a).[31] For wind-

[29] The internal EU electricity market requires that decentralized generators are able to supply electricity from arbitrary sources (within the established safety bounds) to the national grids (EU 2003); the renewables expansion targets are described, in particular for the single member states, in EU (2001).

[30] See BSJP and Taylor Wessling (2009) for further illustration.

[31] OPTRES (2007) discusses in addition the transparency, objectiveness, and length of the grid connection process, it omits issues related to plant construction. The study emphasizes that the set of

power plants, grid access often is a typical issue, as their location does not necessarily fit well with the national grid (Paska *et al.* 2009, URE 2008a).[32] For project developers, another issue is the suitability of local transport infrastructure (especially, the roads) to bring plants and necessary machinery to the construction sites (PAIiIZ 2008, 2009a). Improvement of transport infrastructure is often part of the licensing agreement with local authorities. To realize a project, investors may need to pay the additional costs of both grid connection and infrastructure improvement.[33]

While the TGC scheme clearly helps to finance the additional costs in relation to grid connection and infrastructure improvement and, thus, to overcome infrastructure barriers, one may question the extent to which these investments are among the tasks of a renewable-technology investor.

(B4) *Funding and technological barriers.* The availability of funds for the deployment of renewable generation technology constitutes another typical issue (*e.g.*, Kann 2009, OPTRES 2007). We discuss in addition the availability of the technologies themselves and of the necessary knowledge for their erection and operation. Funding barriers have especially been described for potential domestic investors and operators, who often lack equity or sufficient credit from Polish banks (BSJP and Taylor Wessling 2009, PAIiIZ 2009a).[34] Attracted by the high expected rentability, major investors have thus been coming from abroad, including Germany, Portugal, Spain, and Switzerland. Part of the Polish situation is, moreover, that until recently technology for commercial renewable electricity generation has not been nationally produced (Ministry of Economy and Labour 2005, PSEW 2010).[35] The availability of generation equipment constituted a significant barrier, with delivery delays for wind turbines of over two years (PAIiIZ 2009a). Due to the abandonment of orders outside of Poland, and, to some extent, also from Poland, the problem has practically faded away during the world financial crisis.

The TGC scheme has certainly been helpful for these barriers not to block the development of renewable technology deployment, and necessary for the relatively fast recent expansion pace. At the same time, it is to be noted that most of the payments associ-

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relevant problems tends to be highly country-specific.

[32] While the location of these power plants is determined by the availability of favorable conditions of nature, the national grid is optimized for the transmission and distribution of electricity from large conventional power plants (IAEA 2002, PAIiIZ 2009a).

[33] PAIiIZ (2009a) estimates an average cost of €1.6 million per MW of wind power installed. It indicates the grid connection costs for a project with €0.5–0.8 million, and the additional expenses related to auxiliary and road infrastructure (net of transport of equipment) with about €0.5 million per MW.

[34] The variety of regional, national and EU RES investment-support programs has thus far not fully been exploited due to issues with obtaining investment-related permissions (see also PAIiIZ 2009b).

[35] In 2009, a Danish turbine-blade manufacturer opened a first plant in Poland (PAIiIZ 2009a).

ated with investments, apart, *e.g.*, from payments for grid connection and infrastructure improvement, have been received by foreign plant producers and project developers.[36]

(B5) *Social acceptance.* A further set of possible barriers for the additional deployment of renewable technologies pertains to their social acceptance. Social barriers may become manifest, for example, in low specific demand for renewable electricity by consumers, or in opposition from local public or local authorities (OPTRES 2007). A particularity of the Polish electricity market is that the prices for domestic consumers are still fully regulated by the energy regulatory office (URE 2009).[37] Moreover, the fraction of renewable electricity provided is fixed under the TGC scheme, and its supply has still been relatively small. Hence, the possibilities for consumers both to reveal their preferences on the power market, and to perceive the market development have remained limited. If, in the future, electricity prices are further liberalized and the generation of renewable electricity increases, the situation can be expected to change. In particular, social acceptance might further decrease, when consumers realize that the extra rents generated by higher power prices (compared to a fully competitive system with environmental policy) will particularly be received by the foreign wind-turbine industry, investors, renewable plant operators, as well as by domestic polluting conventional generators, for the by RES use avoided emissions. With continued deployment also a stronger reaction – negative or positive – of the local public will be induced; possible opposition of local authorities is closely linked to the imprecise formulation of regulation, discussed under points (B1, B2).

Hence, in the likely scenario of rising power prices after their liberalization, due to expanded RES use, and free generation-mix choice by consumers, social acceptance could rather decrease, and the TGC scheme may be counterproductive.

4.2 Establishment of beneficial side effects

(S1, S2) *Local labor-market and industry stimulation.* Stimulation of local job markets and national industry development through RES support policies are often mentioned as side-effects in policy debates. These arguments have also been made in relation to the creation of the Polish TGC scheme (Ministry of Economy and Labour 2005). From a welfare-economics perspective, they are unrelated to the environmental externality, and can hardly be related to technology-related market failures, even in a second-best sense

[36] The costs for the generator make up about 75-85% (€1.2-1.32 million per MW) of the average cost of a usual wind-power investment (PAIiIZ 2009a).

[37] In 2008, the prices for industrial consumers and small and medium businesses were liberalized.

(see footnote 3). From an economics point of view, these arguments need to be judged in a general-equilibrium perspective. General equilibrium models show the economy-wide implications of an intervention in the economy, thus, of a reallocation of scarce resources. The additional generation costs through the implicit subsidies for renewable power producers, which TGC schemes generate, are ultimately passed through to consumers and drag their purchasing power for other products.[38] As a consequence, employment that is won in the renewable-energy sector will come at the cost of job losses in other sectors of the economy; the question is whether the net employment effect is positive.[39] It is currently too early for a quantitative analysis of net employment effects. A certain expectation can be derived by considering that crucial equipment and much human capital for the planning, construction, financing and operation of the new plants has been coming from abroad (EWEA 2009, PAIiIZ 2009a, PSEW 2010). Only recently firms have started to develop local staff for monitoring sales and installation activities, and a first plant for manufacturing turbine blades was set up (SGS 2009, Vestas 2009, footnote 35). Thus, the Polish TGC scheme stimulates job creation and industry development in Poland and abroad. Whether the overall effect is beneficial for Poland is not clear.

(S3) *Generation-mix diversification.* The diversification of a country's generation portfolio is another frequently quoted side-effect of RES support policies. The positive connotation of diversification is related to the possibly induced reduction of risk exposure of the power-generation industry (Neuhoff and Twomey 2008).[40] A higher RES use in Poland has been expected to increase both the security of electricity supply, pollution abatement, and competition among generation technologies (Ministry of Economy and Labour 2005). Part of the particular Polish situation is the historically very high (over 95%) fraction of power generation from coal, coming mostly from domestic sources (Eurostat 2008, URE 2008a).[41] Thus, an effective support policy for RES technology deployment will rebalance the generation mix towards RES. It is currently too early for an empirical analysis. The following arguments suggest some caution as to whether this diversification effect will increase supply security, and whether the increased competition among generation technologies is clearly desirable. First, because the expanded use of

[38] Traber and Kemfert (2009) illustrate this point in an electricity-market model with conventional generators with market power, international feedback, and a focus on the (for the mechanism equivalent) German feed-in-tariff scheme.

[39] The general prediction is that a distortionary intervention in the economy entails a negative employment effect. However, the relationships are complex and need a detailed analysis.

[40] See Roques (2008) for a critical discussion of the concept of diversity in a power-generation system and the measurement of the costs and benefits of diversification.

[41] For example, in 2006 94.9% of the gross hard-coal supply was of domestic origin (63.2% of the imported fraction came from Russia), 46% of the gross supply was burned in electricity plants (Eurostat 2008).

RES will particularly be based on wind power, the issue of supply intermittency will become more important, making supply management in the grid rather more challenging. Second, while competitive pressure on conventional energy sources increases with their lower market share, they are stabilized by the decreased need for abatement due to the emissions reductions achieved by higher RES use. Moreover, the conventional technologies continue to be needed for backup purposes. Third, with investors and technology in the Polish RES sector especially coming from abroad, in the short term the technological dependence on other countries will rather rise.

(S4) *Abatement of pollutants not covered by EU ETS.* As a further side-effect, the increased use of RES may, by substitution of conventional energy carriers, reduce the emission of additional pollutants, beyond carbon dioxide, that are not covered by the current emissions trading scheme (*e.g.*, OPTRES 2007). A respective assessment should be based on a life-cycle assessment of technologies (Pehnt 2006, Sovacool 2008). The potential for abatement of additional pollutants from power generation is particularly high if, as is the case in Poland, especially coal is replaced. Additional pollutants from coal combustion may include carbon monoxide, sulfur dioxide, nitrogen oxides, particulate matter, heavy metals (including mercury), and radioactive trace elements (EIA 2001, IAEA 2002, USGS 1997). Note that many of these pollutants are subject to a particular environmental regulation on international or EU level, to which Poland complies or is bound.[42]

4.3 Evaluation

The qualitative consideration in this section provides mixed findings as to how the TGC scheme contributes to overcoming barriers for, or establishing beneficial side-effects associated with the deployment of additional renewable generation technology in Poland. The major inducement to overcome legal and institutional barriers has come from EU legislation and policies; the TGC scheme has been an outcome of this, not a cause. Unclear administrative rules still constitute a major obstacle for technology deployment, to overcome them the TGC scheme is not necessary. The TGC scheme helps to alleviate infrastructure barriers and funding and technological barriers. A caveat is that the high rents under the scheme are in part due to its non-differentiation among renewable generation technologies and accrue to plant producers, investors and operators, many of whom come from abroad, and also to conventional generators. Consumer reaction to RES

[42] In particular, Poland is signatory of the protocols on nitrogen oxides, sulphur emissions, and heavy metals of the Convention on Long-range Transboundary Air Pollution (UNECE 2010).

support has thus far been low, but power prices are still regulated, and thus the market revelation of consumer preferences is limited. Social barriers may increase with rising power prices and when consumers learn about the distribution of extra rents generated by the subsidy. The side-effects regarding stimulation of local job market and national industry, as well as technological diversification and its desirability are generally hard to determine. While jobs are being created for the operation of wind farms, the national production of equipment for commercial plants is not yet in view. Diversification effects have been limited by the *de-facto* support focus of the TGC scheme on wind power. The argument regarding abatement of pollutants not covered by an ETS should compare technologies on a life-cycle basis and needs to take into account the other regulation which is in place; generally, substitution of coal by wind power has a high potential for reducing additional pollutants.

We conclude that based on the acillary reasons considered no clear case can be made for the advantageousness of the application of a TGC scheme in Poland. In particular, from the consideration of these reasons no guidance arises as to what the RES-electricity quota, and, thus, the level of investment subsidies, should be in Poland.

5 Conclusion

Policies for the promotion of the deployment of renewable-energy technologies, including feed-in tariffs for green electricity and quota obligation schemes based on tradable green certificates (TGC), are today applied in a majority of OECD countries (*e.g.*, Australian Government 2009, EU Commission 2008, Wiser *et al.* 2007). Interestingly, also in the scientific literature the justification of such policies has hardly been discussed. In this paper, we provide an early analysis of the Polish TGC scheme, introduced in 2006 to contribute the country's part to the EU expansion target for RES use. From a welfare-economics perspective, support policies for renewable-technology deployment can neither be justified in a first-best, nor in a second-best sense (section 1). In particular, if an emissions trading scheme (ETS) is in place that fully covers the energy industry, deployment support for renewable generation technology cannot provide additional reductions of emissions capped by the ETS. We discuss how ancillary reasons, in form of overcoming deployment barriers and the establishment of beneficial side-effects, can provide a justification for the application of a TGC scheme in Poland. With high investment incentives, especially for wind power (section 3), the scheme helps to alleviate deployment barriers related to infrastructure, funding, and technology availability. But the scheme is not necessary to overcome barriers on legal and institutional level, and may rather decrease social acceptance when, after their liberalization, power prices for consumers start to rise. Benefits with respect to job-market and industry stimulation and as related to technological diversification are generally hard to establish. At least, there is a clear potential that the substitution of coal by wind power abates pollutants that are only insufficently regulated otherwise. The consideration of these ancillary reasons, however, gives no guidance as to what the RES-electricity quota should be.

From the welfare-economics perspective, a well regulated market will pick the right technologies endogenously (see also Neuhoff and Twomey 2008). This requires especially an appropriate internalization of the emissions externality. In view of the justification question, the choice between emissions trading scheme and support policy for RES technology deployment is not arbitrary. It is hard not to conclude that such support policies tend to constitute a flawed policy instrument (*e.g.*, *contra* Gillenwater 2008b). The task is rather to improve existing emissions trading schemes and the mix of environmental and technology policies, to get appropriate incentives for renewable technology deployment.

Appendix

A.1 The Romanian TGC system

Romania became a full member of the European Union in 2007. In order to fulfill its obligations related to the EU Directive 2001/77/EC and the Kyoto Protocol, the Romanian parliament set up conditions for the RES support in 2003. The basis for RES promotion is the Electricity Law No. 13/2007 (Parliament of Romania 2007). In 2004, the government decided to introduce a TGC system for RES promotion (Government of Romania 2004). After a revision in 2005, its framework is as follows (Government of Romania 2005):

- Promotion is given to power generation from small hydropower (< 10 MW), wind, biomass, biogas, photovoltaics, solar and geothermal power.
- Energy distributors have to fulfill an RES quota defined by the government. In Table 5 it is shown for the years 2008-2012.[43] Note that the Romanian RES-support policies totally disregard the pre-installed hydropower plants with nominal production capacities above 10MW.
- RES electricity is traded with priority at the energy exchange OPCOM. For the years 2005-2012 there is an upper price limit of €42 and a lower price limit of €24 in certificate

[43] In 2005 the RES quota amounted to 0.7%, in 2006 to 2.22%, in 2007 to 3.74%.

trading defined by the national energy regulatory authority ANRE (ANRE 2007a).[44] Alternatively, an RES generator may sell TGC and electricity to a retailer at fixed prices via a bilateral contract.

- An energy distributor who fails to fulfill his RES quota is obliged to pay a penalty of twice the upper price limit for every missing green certificate. The penalty thus currently amounts to €84.

- The green certificates are issued by Transelectrica, the owner of the national transmission grid, not by ANRE. Unsold certificates are bought back by Transelectrica. The resulting price sets the effective lower price limit for TGC.

On 3 November 2008 the Romanian government amended the RES promotion scheme, extending it until 2030. The RES quotas were slightly decreased for the time until 2012. They increase thereafter. In order to create more equal deployment conditions for the different RES, the number of TGC per MWh is now technology-specific. As our analysis was done before the new legislation came into force and its consideration does not change our results in substance, we stick to the set out previous framework.

A.1.1 Development of prices and RES production in the Romanian TGC system

In 2007 46,299 TGC were issued to RES producers, 41,364 (89.34%) of them were traded at OPCOM (OPCOM 2008b). In order to fulfill the 2007 RES quota of 3.74%, given an electricity consumption of 58.49 million MWh (CIA 2008), the issuance of 2.187 million green certificates would have been necessary. This difference between supply and demand explains why the TGC price in Romania has been remaining at the upper price limit in the past (Figure 3). The reason

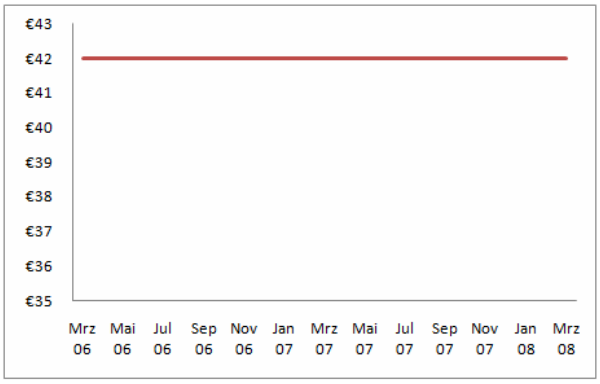

Figure 3: TGC price development – Romania (Source: OPCOM)

[44] Despite the Lei as local currency, the price limits are fixed in € and adjusted annually based on exchange rate developments.

for the weak emission of TGCs in 2007 were the missing RES capacities. Only 47 MW were registered, 40 MW of which were small hydropower and 7 MW wind energy (Transelectrica 2008a). To avoid high penalty payments of energy distributors, ANRE cut the RES quota in December 2007 from 3.74% to 0.098%. The new value represented 57,320 TGC. 2007 was the last year in which ANRE had the possibility to cut RES quotas (ANRE 2007b).

A.1.2 Development forecast for the Romanian TGC market

As shown in Table 5, the demand for TGC will rapidly increase in Romania in the next years. In the short term demand could be met by supply as RES capacities will remain low. At the end of April 2008 the registered RES production capacity was still at 47 MW. Because of the high TGC prices a rise in RES capacities can be expected in the mid and long term. The estimations for the Romanian RES potential range between 23–26.075 TWh for wind power and 3.08–3.6 TWh for small hydropower (Barbu 2007, Ministerul Economiei 2007). The implementation degree of this potential cannot be estimated at the moment. Transelectrica (2008b) reports that only wind farms with a nominal production capacity of 4,000 MW have been scheduled. It points out that due to a shortage of backup capacities only 1,000–1,500 MW of wind power can be connected to the grid in a first step.

Table 5: TGC demand estimation for Romania (Source energy consumption: Ministerul Economiei 2007)

	2008	**2009**	**2010**	**2011**	**2012**
Electricity demand (TWh)	62.5	64.2	66.1	67.7	69.5
RES quota (%)	5.2	6.78	8.3	8.3	8.3
TGC demand (million)	3.25	4.35	5.49	5.62	5.77

Barbu (2007) estimates the load factor to amount to 34% in the best wind regions in Romania. If new wind farms with an output of 1,500 MW are connected to the grid, given this load factor 4.476 million TGC would be issued.[45] This hypothetical TGC supply would only meet the 2009 demand (Table 5). When 1,500 MW of wind energy will be realized, cannot clearly be foreseen today. EWEA (2008b) assumes that only 50 MW of wind power will be erected in Romania until 2010. This estimation seems relatively low given the potential available in Romania. States in comparable situations have realized higher growth rates.[46] Even if wind farms with a cumulated capacity of 1,500 MW are built until 2012, the issued 4.5 million TGC would not meet the demand of 5.77 million certificates shown in Table 5. The remaining gap could

[45] This amount is calculated as: 4,467,600 MWh = 1,500 MW * 24 h * 365 days * 0.34 LF.

[46] For example, in 2007 in Bulgaria 34 MW, in Greece 125 MW, in Poland 123 MW and in Turkey 97 MW of new wind turbines have been erected (EWEA 2008a).

perhaps be closed by small hydropower plants, but this requires at least the realization of 41% or 320 MW of the estimated small hydro potential. Therefore Romania cannot be expected to fulfill its RES quota in the near future. Due to the excess demand for TGC their price should remain near its upper limit of €42 until 2012.

This reveals another issue of the Romanian TGC system. As the penalty payment for an electricity distributor is twice the upper trading limit of a TGC, the larger TGC amount can be expected to be traded in bilateral contracts, while their exchange trading will dry up. The reason for this development is the RES producers' possibility to sell certificates to distributors at a price above €42. As long as the price stays below €84, retailers will agree, as they can avoid the penalty payment of €84. ANRE tries to avoid these complications by getting informed of all bilateral contracts. But market actors should be able to use methods of "creative contract design" to overcome the restriction. The issue could be solved by equalizing buy-out price and upper price limit.

Besides selling certificates trading electricity is the second revenue source for RES producers. The average spot market price for power traded at the OPCOM day-ahead market was €47.89/MWh in 2007. There also exists an OPCOM platform for bilateral power contracts. The average price of these contracts was €48.35/MWh in 2007, the first contracts for 2008 reached prices up to €50/MWh (OPCOM 2008a). With an income from selling power with €48–50/MWh and €24–42 for TGC, an RES producer could receive €72–92/MWh. If market actors are able to bypass the upper price limit for TGC, a combined income of up to €134 may be expected.

A.2 Conditions for wind-power investments in Romania

This subsection studies the conditions for wind-power investments analogously to the Polish case in section 3. The framework data are adapted for the Romanian case in four respects: the investment volume is €30.36 million, the operational costs increase at the constant rate of 2% p.a., the coupon is 5.5%, the tax rate is 16%.

A.2.1 Option 1: market sale of TGC and electricity

Banking case. In 2007 electricity has been traded at the Romanian day-ahead market at an average price of €47.89/MWh (OPCOM 2008a). To simplify we assume a value of €48/MWh in the banking case. This price is not index-linked to the inflation rate for reasons of caution. The demand for TGC in Romania will exceed the supply at least until 2012 (subsection A.1.2). For this reason one can expect the price of a certificate to stay at the upper limit of €42, which we also assume here. In 2013-2020 the RES quota may be fulfilled. Hence, we assume a TGC price at the lower limit of €24 for this period. Past 2020 the promotion of TGC will become fully canceled in this scenario. The resulting price development of the banking-case is shown in Table 6:

Table 6: Income banking case – Romania.

	2009–2012	2013–2020	2021–2028
Power income (€/MWh)	48	48	48
Income per TGC (€)	42	24	0

Based on these assumptions the project requires an equity ratio of 31.3% or €9.5 million equity to fulfill the condition of $DSCR > 1.3$. The resulting IRR amounts to 6.02%.

Base case. In 2009 the basic value for the power income amounts to €48/MWh in this scenario. It is index-linked to the ECB inflation target of 2%. An adequate assumption for the TGC-price development is again more difficult. Although the upper price limit in 2008 was set at €42, we use a value of €46 to appoint the TGC income for the years 2009-2012. The reason for this is the announced increase of the upper price limit up to €50. As it is not fixed, we take a haircut on the assumed income. From 2010 the TGC income decreases annually by 10%. This rate is smaller than the one chosen for Poland, because one can expect it takes more time to fulfill the RES quota as the Romanian market is less developed. Nevertheless the lower price limit of €24 remains valid. As it is not clear how the Romanian RES scheme will develop past 2020 we assume from that year an annual TGC-price decrease of 20%. The lower price limit looses its validity. Figure 4 illustrates this development. Using the banking-case equity

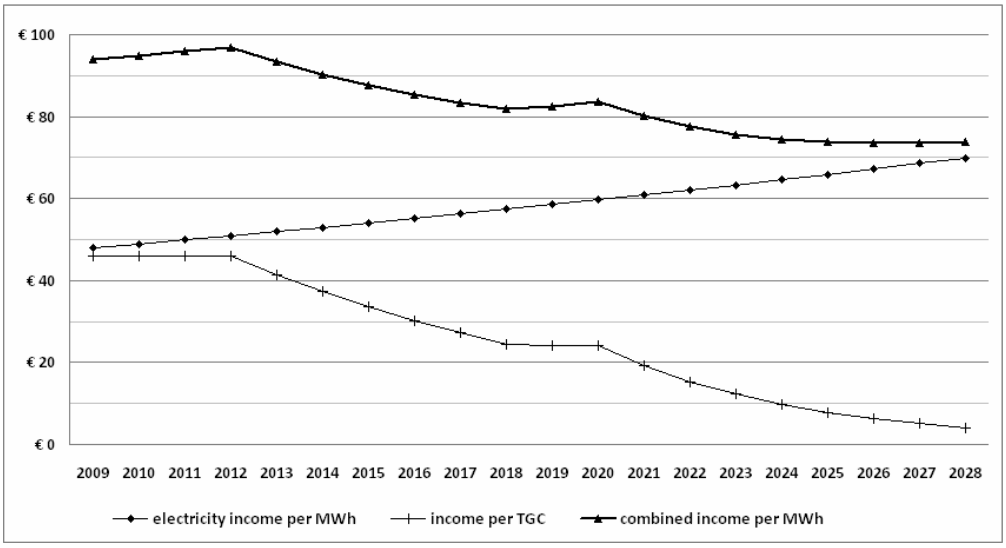

Figure 4: Illustration of price development in base case – Romania.

ratio of 31.3%, the base case leads to an IRR of 13.26% for a 20-MW reference project.

A.2.2 Option 2: bilateral contracts

The conclusion of bilateral contracts is especially interesting in Romania as the framework has an appeal to avoid market trading, which enables RES producers to achieve a TGC income beyond the upper price limit of €42 (subsection A.1.2). We first analyze which IRR are possible, when the actors respect the price limit. In a second step we have a closer look at the attractiveness of avoiding the price limit.

In 2007 the average power price at the Romanian day-ahead market was €47.89/MWh (OPCOM 2008a). We assume €48/MWh with regard to the agreed power component of the bilateral contract. For the TGC component of the contract, RES producers are in a favorable position to negotiate due to the high buy-out price of €84 a retailer has to pay for a missing certificate. We assume a price of €40 as TGC component, near the upper price limit. These values add up to a combined income of €88/MWh of RES power generated. Under consideration of this contract the cash-flow model gives an equity ratio of 2.7% (€0.81m) and an IRR of 25.47%. The sensitivity analysis shows again how tightly linked IRR, equity ratio and negotiated prices are (Table 7).

Table 7: Sensitivity analysis bilateral contracts – Romania.

Combined income (€)	70	73	76	79	82	85	**88**
Equity ratio (%)	26.0	22.1	18.1	14.5	10.5	6.6	**2.7**
IRR (%)	5.71	7.19	8.92	10.94	13.62	17.57	**25.47**

We now consider the case of certificate trading beyond the upper price limit of €42 in bilateral contracts. The power component remains at €48/MWh. For the TGC part, we distinguish two periods. The TGC price will reach €63 during 2009-2012. RES producer and retailer thereby share the advantage from the difference of bay-out payment and upper price limit of €42. Retailers suggest that the RES quota may be fulfilled after 2012. So they set a TGC price of €36 for the second period of 2013-2028. Table 8 summarizes these assumptions. This kind of contract enables investors to use 100% debt financing within the project and

Table 8: Income with bilateral contract and avoidance of upper price limit – Romania.

	2009–2012	**2013–2028**
Power income (€/MWh)	48	48
Income per TGC (€)	63	36
Combined income (€/MWh)	111	84

simultaneously fulfills $DSCR > 1.3$ during the whole project duration. As there is no equity in the project, the IRR calculation is not possible. This implies that the capital value is positive and the project is always justifiable. The capital value of the described 20-MW project based on dividends and a discount rate of 12% amounts to €5,714,662.

A.2.3 Evaluation

Also in Romania, the two considered investor strategies lead to positive IRR, and in the case of a bilateral contract the IRR is higher than in the market-trading option. The banking case in Option 1 leads to a relatively small equity ratio of 31.3% (compared to 70.1% in the Polish case). This divergence results from the lower price limit for TGC in Romania. This limit reduces volatility and price risks considered by banks, reducing the required equity ratios.

The CAPM reward-to-risk ratio for wind farm projects in Romania amounts to 12%.[47] Thus, the IRR exceeds the reward-to-risk ratio under both investor strategies, implying positive capital values and that the reference project is marketable in both cases. The bilateral-contract approach is, however, still more favorable. Hence a high share of bilateral contracts can be expected in the Romanian market. Moreover, due to the expected high investor returns further increases in the RES volume seem likely in the near future.

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[47] For Romania, a 6.7% risk-free rate (corresponding to the average return on time deposits in Romania in 2007; National Bank of Romania 2008: 17) and an 8% risk premium (Damodaran 1999: 72). Again, we take a 0.66 beta coefficient.

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