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Linking renewable energy CDM projects and TGC schemes: An analysis of different options

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Abstract

Renewable energy CDM (RE-CDM) projects encourage cost-effective GHG mitigation and enhanced sustainable development opportunities for the host countries. CERs from CDM projects include the value of the former benefits (i.e., "climate change benefits"), whereas the second can be given value through the issuing and trading of tradable green certificates (TGCs). Countries could agree to trade these TGCs, leading to additional revenues for the investors in renewable energy projects and, therefore, further encouraging the deployment of CDM projects, currently facing significant barriers. However, the design of a combination of CDM projects and TGC schemes raises several conflicting issues and leads to trade-offs. This paper analyses these issues, identifies the alternatives that may exist to link TGC schemes with RE-CDM projects and analyses the impacts of those options on different variables and actors.

Keywords: Renewable energy; CDM projects; Tradable green certificates

1. Introduction

The substitution of electricity from renewable energy sources (RES-E) for fossil-fuel conventional electricity leads to significant socioeconomic and environmental benefits.[1] Therefore, the effective and cost-effective deployment of renewable energy is a major policy goal for many countries.[2] Several instruments can help countries achieve this goal, such as tradable green certificates (TGCs) and feed-in tariffs.

Reduction of GHG emissions is a major benefit of RES-E deployment. The international community has taken measures to reduce these emissions, signing the Kyoto Protocol, which sets targets for GHG emissions and envisages the use of the so-called "Kyoto Flexible Mechanisms". One of these mechanisms, the Clean Development Mechanism (CDM), would help Annex-I countries (AICs) comply cost-effectively with their GHG targets, while simultaneously contributing to the sustainable development of non-Annex I countries (NAICs).

However, the implementation of CDM renewable energy (RE-CDM) projects is fraught with difficulties. Renewable energy technologies are still costly compared to fossil fuel technologies and the investor faces different types of risks (economic, technical, political and otherwise).

Therefore, obtaining CERs from CDM projects may not be enough to make RES-E projects in NAICs attractive for investors, leading to their suboptimal implementation. CERs as a source of revenue may have to be supplemented by additional funds provided by the investor or the host country in support schemes specifically targeted at RES-E promotion. The former could be interested in providing this additional funding,

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[1]The focus of this paper will be on electricity from renewable energy sources (RES-E) and not on renewable energy sources in general.

[2]Public support also allows renewable energy technologies to experience long-term cost reductions, which is important to achieve long-term CO_2 and RES-E targets at lower costs.

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because RES-E helps the country comply with its Kyoto Protocol target and enter new markets abroad. An early involvement in CDM projects allows the investor country to have first-hand knowledge on the procedures and problems related to their realisation. Given their local benefits, the host country could also provide additional funding to these projects.

TGC schemes could provide this support.[3] Awarding TGCs to RE-CDM projects provides an additional incentive for their implementation. However, this raises a number of issues and has implications for different variables and actors. These issues are analysed in this paper, which tries to identify the different alternatives to combine RE-CDM projects and TGC schemes and analyses what is the best combination considering different variables and actors.

Accordingly, the paper is structured as follows. The next section justifies the aforementioned combination. The methodology and main assumptions are provided in Section 3, whereas Section 4 analyses the different alternatives for the linking and their impacts on different actors and criteria. The main limitations of the analysis are discussed in Section 5. The paper closes with some concluding remarks.

2. Combining CDM projects and TGC schemes: justification and links to the existing literature on interactions

If the additionality condition of the CDM project is achieved, then the project may generate CERs, tradeable in the international market. The amount of CERs the project generates is equal to its emissions reductions compared to the GHG emissions in the absence of the project (baseline). Selling these CERs contributes to the financial viability of the project.

However, RES-E deployment faces economic, technical and administrative barriers, even in developed countries. To these barriers, we have to add those which are specific to CDM projects. Although a CDM project may mitigate the economic barrier, other obstacles remain, such as risks and transaction costs for the investor.[4] These costs are proportionally higher for small RE-CDM projects.

According to Michaelowa et al. (2004, p. 7), "the CER prices that can be achieved by renewable energy project developers under (…) CDM range from 2.5 to 12 € and depend on the buyer". This only makes viable those projects whose profitability is close to the market (wind and large hydro), whereas other technologies (PV) are still too expensive and it is unlikely that awarding CERs (with those prices) will make these projects attractive for investors.[5]

The CDM could contribute to RES-E deployment, although it will not provide a panacea for large-scale renewables promotion at currently low CER prices (5 €/t CO_2). Additional support for these projects is a necessary condition for their implementation, for example, by granting TGCs to RE-CDM projects. The justification for this additional support should lie in the "local sustainability benefits" of these projects.[6]

We focus on TGCs and not on other RES-E support schemes because it is a very innovative instrument which has been recently implemented in several countries. It is also a market-based instrument, having some resemblance with CDM (see Table 1), although TGCs only apply to the electricity sector, while CDM projects can be implemented in all energy-consuming and producing sectors.

If used together, both instruments interact. RE-CDM projects lead to two types of benefits: GHG mitigation and sustainability opportunities for NAICs. CERs monetise the former, whereas TGCs could monetise the latter. Two currencies from the RE-CDM project would then result. If countries agreed to trade these TGCs, additional revenues for RE-CDM project investors would result, further encouraging their deployment.

Michaelowa et al. (2004) propose that, in order to encourage the deployment of RES-E projects, these "achieve higher CER prices". However, due to the fungibility of CERs with other Kyoto currencies, CERs would be traded in the international market at the international price. The local sustainability benefits from the RE-CDM project cannot be easily included in the CER price and, thus, "higher CER prices" cannot be expected. The sustainability value should be incorporated in another currency, for example a TGC. Since, in their own realms (GHG mitigation and RES-E promotion) both instruments are theoretically cost-effective to achieve their respective goals, their combination may reach a cost-efficient outcome in terms of both goals, an issue to be discussed in the next section.

This paper can be included in the recent literature on the theoretical interactions between policies, instruments and four international markets (liberalised power, TGC, the CO_2 allowance and the global CDM/JI markets).

[3] By setting the quantity of RES-E generation (quota) and allowing the market to set the price, TGCs are a theoretically more cost-effective system than other systems (i.e., feed-in tariffs). This paper analyses the interaction between a renewable electricity promotion scheme (TGCs) and CDM projects, but, to a certain extent, the results would be similar if other support schemes had been used instead of a TGC scheme.

[4] See Janssen (2003) for further details.

[5] The incentive per kWh provided by the sales of CERs (0.3–0.8 €cents/kWh) is relatively low compared to current support levels in AICs using feed-in tariffs (Michaelowa et al., 2004, p. 12).

[6] This is in contrast to most other papers, which implicitly assume that RES-E has value only as long as it leads to CO_2 reduction.

Table 1
Comparing CDM and TGCs

Aspect	CDM	Quota with TGCs
Type of instrument	Market instrument. Project-based.	Market instrument. Quantity-based.
Aim	Cost-effective GHG mitigation and sustainability of NAICs.	Cost-effective deployment of RES-E.
Target sector	Projects in different sectors	Mainly electricity sector.
Relevant actors	Project proponent, investor Party, host country government, Designated Operational Entity and CDM Executive board.	Demand side. Obligated actors: consumers, suppliers or generators. Supply side. Generators. Public authority
Territorial scope	International. AIC investments in a NAIC. Beneficiaries: not only countries where the project is physically located.	National or international. Beneficiaries: Countries where the project is physically located (national scheme).
Unit	CER (1 ton of CO_2e)	TGC (1 MWh)

Source: Own elaboration.

Most papers in this literature have dealt with the interaction between the electricity and the TGC markets (Morthorst, 2003a; Jensen and Skytte, 2002) and between the CO_2 and the TGC markets (Morthorst, 2001, 2003b; Jensen and Skytte, 2003; Boots, 2003). However, the interaction between TGC schemes and CDM/JI projects has not been analysed.[7] This paper tries to fill this gap.

3. Theoretical framework, methodology and major assumptions

The above-mentioned literature uses graphical and incentive analysis. An incentive analysis is also the approach followed in this paper. The analysis is based on the following assumptions:

- Effective and cost-effective GHG emissions mitigation and RES-E deployment are the major goals of energy and environmental policy. RES-E has many socioeconomic and environmental advantages, but other alternatives may lead to cheaper GHG emissions reductions.[8]
- To reach those goals, and assuming that deployment of RES-E projects is cheaper in NAICs, two instruments are considered: CDM projects and quotas with TGCs. No international TGC scheme is considered because this would be a highly unrealistic situation and also because, when complete separation between the GHG target and the TGC is considered (as we do in this paper), the incentives for international TGC trade are minimal since the TGC only carries the local RES-E value (see below and Morthorst, 2001).
- The quotas for TGCs are implemented through an obligation on electricity suppliers. The GHG obligation falls on power producers, who pass the additional compliance costs to consumers.
- The TGC and CER markets are separated (i.e., it is not possible for power companies to fulfil the CO_2 target by buying TGCs and viceversa). There are at least four possibilities to link TGCs and CO_2 allowances (Sorrell et al., 2003): Full fungibility, one-way fungibility and complete separation. Under full fungibility the CO_2 emissions reduction caused by the displacement of conventional electricity by RES-E is calculated and included in the TGC, which then represents a CO_2 emissions reduction value. Therefore, TGCs can be used to comply with CO_2 quotas and viceversa. While this provides flexibility in compliance with the respective quotas, there would be a problem to comply with the RES-E quota (since RES-E are more expensive as a CO_2 emissions reduction alternative). In addition, this approach does not consider the local benefits of RES-E and it may involve significant transaction costs.

One-way fungibility allows those overcomplying with the RES-E quota to convert the surplus of TGCs into CO_2 allowances (i.e., the UK system) providing additional revenues for renewable generators and encouraging the achievement of the RES-E quota. But it also presents practical problems of carbon accounting and it may lead to double crediting (since the increase in RES-E generation is awarded TGCs and also leads to the creation of new CO_2 allowances) (Sorrell et al., 2003).

Separation means that the CO_2 value and the non-CO_2 value of RES-E are independently traded in the CO_2 market and the TGC market, respectively, with

[7] Boots et al. (2001), del Río et al. (2002) and del Río et al. (2005) are exceptions.

[8] We assume that targets in both cases are relatively ambitious. However, the GHG target is not enough to achieve significant RES-E deployment and the RES-E target is not enough to achieve the GHG target.

actors having to comply with quotas in both markets but being unable to use one of the currencies to comply with the other quota[9]. Since separation allows the values of RES-E to be included in different currencies (the CO_2 value included in the CER price and the non-CO_2 RES-E benefits included in the TGC) it is probably the best option in the context of this paper[10]

- When separation is chosen, two options remain: either GHG credits are attached to TGCs or they are not (Morthorst, 2001), depending on whether a GHG credit is generated or exchange when TGCs are generated or exchanged. Potential problems exist in both cases. In the first case (attachment), a renewable generator in a RE-CDM project in a NAIC would receive the CERs in addition to the TGCs and it would not make sense to generate GHG credits attached to the TGCs in addition to the CERs, because the CER already carry the GHG reduction value. When credits are not attached the problem is that there are limited or no incentives for a permanent trade in TGCs (see Morthorst, 2001). In the context of this paper, the problems related to having GHG credits attached to TGCs are more serious because it would question the feasibility of the system itself. Therefore, we assume that no GHG credits are attached to TGCs.
- In the following section we consider the implications of having a TGC attached to RE-CDM projects.
- For simplicity of exposition, constant and inelastic electricity demand and no physical transmission of electricity between AICs and NAICs are assumed.

4. Linking the CDM with TGC schemes: options, scenarios and results

4.1. What is traded?

The difference between the emissions from the RE-CDM project and the baseline lead to the issuance of CERs, helping companies comply with their GHG targets. Although the goal of CDM projects is two-fold (low-cost emissions reductions and contribution to host country sustainability), the CERs are rather an expression of the former.

In contrast, quotas with TGC schemes aim at cost-effective promotion of RES-E deployment. TGCs are thus an expression of, both, the local values achieved through RES-E generation and GHG emissions reductions. However, since we have assumed separation of currencies, when a RE-CDM project is undertaken, the GHG value is included in the CERs, whereas the TGCs only represent the local RES-E value of RES-E. Otherwise, double counting would result.

If TGCs only include the "local value" of RES-E, what is the incentive for countries to trade TGCs? The countries importing TGCs would only be promoting the local value of RES-E in other countries, but not CO_2 emissions reductions. This will be discussed in the following subsection by considering alternative design options.

4.2. Policy scenarios

Several possible alternatives to link RE-CDM projects and TGC schemes exist. A reference scenario will help us compare the results of the other scenarios:

I. *Ex-ante situation* (ETS in Annex-I, no CDM). An emissions trading scheme (ETS) exists in the AIC. However, CERs cannot be used to comply with the GHG targets. RES-E promotion in the AIC is based on an effective support scheme (feed-in tariffs), but not on a TGC scheme. The cost-effectiveness in attaining RES-E targets could be improved, however, if a TGC scheme was implemented. No RES-E support scheme is implemented in the NAIC.
II. *Reference case* (CDM, ETS, no TGC scheme). In this case, CERs can be used to comply with the AIC GHG targets.
III. *AIC coexistence* (CDM, ETS, TGC scheme in AIC). CERs from RE-CDM projects can be used to comply with the ETS in the AIC. A cost-effective TGC scheme substitutes the former support scheme in AIC. However, no TGCs are attached to RE-CDM projects (i.e., RE-CDM projects lead to the issuance of CERs but not of TGCs).
IV. *AIC attachment* (CDM, ETS, TGC scheme in AIC). Contrary to the previous cases, TGCs are attached to CDM projects, i.e. RE-CDM projects generate CERs and TGCs. The TGCs would accrue to the investor, who could use them to comply with the AIC RES-E quota. There is no quota with TGC scheme in the NAIC. If the AIC investor was not subject to a RES-E quota obligation, then he could sell the TGCs to obligated parties, receiving an additional incentive to invest in RE-CDM projects. He would benefit from three sources of revenues: sales of electricity, CERs and TGCs.

Electric utilities in AICs would invest in RES-E in NAICs in order to receive TGCs and CERs, allowing them to comply with their respective RES-E and GHG obligations. The costs for AIC consumers would be reduced since, by assumption, a RES-E support scheme

[9]This separation approach was followed in the Netherlands in 2001, as described by Boots (2003), and in the CO_2 emissions Directive.

[10]Separation also has some negative features. Double crediting is the most important drawback, according to Sorrell et al. (2003).

Table 2
Summary of the options considered in each scenario

Scenario	ETS in AIC	CDM	AIC TGCs scheme	
			TGC not attached to CDM projects	TGC attached to CDM projects
I	✓			
II	✓	✓		
III	✓	✓	✓	
IV	✓	✓		✓

was in place before the implementation of the TGC scheme and TGCs are, theoretically, a cost-efficient instrument. The next section provides a more detailed discussion of this issue.

In principle, the TGC includes the local value of RES-E, whereas the CERs would include the CO_2 value, which is traded in the international market.

CER and TGC prices would be mutually affected in the case TGCs are attached to RE-CDM projects. Generally, attachment would reduce CER and TGC prices compared to complete separation (i.e., when no attachment occurs) because in the case of attachment each currency carries a clear value (GHG emissions reductions or local RES-E value). In contrast, with non-attachment the separation of the respective values is not so clear and the TGCs may carry (part of) the GHG emissions reductions value.

Of course, other unrealistic cases could be considered, such as having a TGC scheme implemented in the NAIC.

Table 2 summarises the main options in each scenario.

4.3. Main variables and actors considered

The impact of the previous scenarios on several variables and actors in both countries will be compared:

- *Incentives for the implementation of RE-CDM projects*. Does the implementation of a TGC scheme lead to an increased incentive to carry out RE-CDM projects? Does awarding TGCs to RE-CDM projects increase the incentive to implement these projects?
- *RES-E deployment and sustainability benefits*. Does the scenario lead to an increase in RES-E deployment with respect to other scenarios? RES-E deployment brings significant local sustainable development benefits with it, especially for the country where RES-E plants are located.
- *Conventional electricity deployment*. Does the scenario change conventional electricity deployment?
- *Final consumer costs*. Two contradictory impacts are at play here. The use of CERs and TGCs may lead to a reduction in the electricity price at the spot market, but the costs of RES-E promotion (TGC) policy fall on the consumer.
- *TGC and CO_2 allowance prices*. Awarding TGCs to RE-CDM projects can have price effects. By encouraging the realisation of these projects and creating TGCs and CERs, a reduction of the price of GHG allowances and TGCs can be expected. However, the quantity of the CERs and TGCs created would be small compared to the volume of TGCs and GHG allowances in the markets and, thus, price effects are negligible.
- *Welfare of electricity generators*. The impact on three types of electricity generators is considered: "conventional" (using fossil fuels to generate electricity), "renewable" energy generators and "mixed" generators (producing both renewable and conventional electricity).
- *GHG emissions*. What is the impact of the combination on GHG emissions?

4.4. Main results

In order to identify the most accurate combination of both instruments, scenarios will be compared to the reference case and to other scenarios.

4.4.1. Comparing scenarios I and II

Compared to the ex ante situation, an increase of RES-E deployment in the NAIC can be expected in the reference scenario, since the CDM provides an additional incentive to undertake these projects.[11] The increased RES-E fed into the grid in the NAIC displaces conventional electricity, lowering the electricity price at the spot market.[12] The overall costs for NAIC electricity consumers (addition of changes in the spot power price and in the RES-E specific support, which remains constant) are reduced. The AIC electricity price would also be reduced, because the use of CERs allows utilities to reduce their GHG compliance costs.

Consumers in both countries would unambiguously benefit and they would not have to pay for the additional RES-E deployment because there is not an increase in RES-E support. The additional RES-E deployment is a consequence of cheaper locations being exploited, and not of a more supportive RES-E policy.[13]

[11]The better the conditions to undertake CDM projects (the more RES-E potentials and the lower risks and transaction costs), the greater the number of projects undertaken and the more CERs, lower CO_2 prices and lower spot power prices in AIC. I thank an anonymous referee for this remark.

[12]See Jensen and Skytte (2002, 2003) for details on the relationship between an increase in RES-E deployment and the electricity price at the spot market.

[13]If the increased RES-E deployment was the result of more support being granted to RES-E technologies, then the reduction in the price of electricity should be compared to the additional charges for the consumer from the financing of the RES-E policy.

Table 3
Comparing scenarios I and II

	AIC	NAIC	TOTAL
RES-E production	=	↑	↑
Conventional power production	=	↓	↓
Spot price of power	↓[a]	—	
Final consumer costs	Lower costs	Lower costs	Lower costs
Welfare conventional generators	Lower costs, higher sales	Lower sales	
Welfare independent RES-E generators	↓	=[b]	
Welfare mixed generators	Lower costs	=	
Sustainability benefits	=	↑	↑
GHG emissions	=	↓	↓
Other impacts	Increased revenues for RES-E technology suppliers		

[a]Depending on several variables, including the price of tradable GHG emissions permits.
[b]RES-E generators unrelated to the RE-CDM project.

A lower RES-E deployment could in principle be expected in the AIC, because the realisation of CDM projects entails the use of CERs to comply with the GHG target, reducing the incentive to substitute RES-E for conventional electricity.[14] However, this effect is really marginal, since RES-E deployment in the AIC is mainly determined by the existing support schemes.

Emissions in the AIC would remain constant (constant RES-E deployment). Emissions in NAIC would be lower (due to the implementation of the RE-CDM project).

To sum up, moving from scenario I to scenario II is an unambiguous improvement. GHG emissions and costs for the consumers in both countries are reduced. The only caveat is that RES-E deployment would be reduced in the AIC (Table 3).

4.4.2. Comparing scenarios II and III

Moving from scenario II to scenario III allows us to know what a TGC scheme adds to CDM projects. The major difference between both scenarios is that, as a result of the substitution of the existing support scheme by the TGC in the AIC, the same RES-E target is achieved at lower consumer costs in scenario III. No change in RES-E deployment can be expected in NAIC, which is unaffected by the system substitution in the AIC. Therefore, introducing a TGC scheme in this context does not lead to conflicts with respect to CDM projects. On the contrary, it has positive synergistic effects with respect to the reduction in consumer costs. Lower CO_2 emissions at lower cost would result. Moving from II to III also represents an unambiguous improvement (Table 4).

Table 4
Comparing scenarios II and III

	AIC	NAIC	Total
RES-E production	=	=	=
Conventional power production	=	=	=
Spot price of power	=	=	=
Final consumer costs	↓	=	↓
Welfare conventional generators	=	=	=
Welfare independent RES-E generators	↓	=	↓ (small)
Welfare mixed generators	↓ (small)	=	↓ (very small)
Sustainability benefits	=	=	=
GHG emissions	=	=	=

Conventional generators in AICs and NAICs will be relatively unaffected by the introduction of the TGC scheme.[15] AIC RES-E generators will be worse off, because the TGC scheme is more risky to RES-E investors and revenues are more uncertain and lower than in scenario II.[16] There is no incentive to increase RES-E in this country. Independent RES-E generators in the NAIC would be unaffected. Mixed generators in the AIC would be unaffected concerning their conventional part, but negatively affected in their RES-E part (lower revenues). Mixed generators in NAIC are unaffected.

Therefore, it makes sense for an AIC that already uses CERs to comply with its GHG target to implement a TGC scheme, because it reduces the costs for the AIC consumers (without leaving the NAIC worse off).

[14]It could be argued that RE-CDM projects do not lead to a large "RES-E leakage" from AICs to NAICs because the investment context for RES-E projects is currently more attractive in AICs (with stable support schemes and relatively higher support levels) than in NAICs, where RE-CDM projects allow the issuing of CERs but, in contrast, have additional risks for the investor.

[15]Note that, by assumption, the TGC scheme does not increase RES-E deployment and, thus, a reduction in conventional electricity generation and in electricity prices cannot be expected.

[16]Revenues are lower because TGCs are considered a more cost-effective instrument than feed-in tariffs. The risk can be mitigated by introducing certain design elements (such as minimum prices for TGCs and banking).

4.4.3. Comparing scenarios III and IV

The realisation of a RE-CDM project in the NAIC would generate CERs and TGCs. TGCs could be given to the investor or to the host country, which could sell them to obligated parties under the AIC TGC scheme. This would effectively reduce the AIC RES-E target. Less RES-E is deployed in the AIC compared to a situation without TGCs from CDM projects being accepted. No change in CO_2 emissions would result. However, the other benefits of RES-E would remain in the NAIC and would be lower for the AIC.

The reduction of RES-E deployment in the AIC in scenario IV would increase the price of electricity but the cost of complying with that quota would be lowered, leading to contradictory impacts on the consumer.

For the NAIC, RES-E deployment would increase, since awarding TGCs to CDM projects makes investing in these projects more attractive. The higher RES-E reduces the electricity price and reduces the costs for electricity consumers.

Summing up: the move from III to IV is interesting for NAIC, but not for AIC. However, GHG emissions are lower in scenario IV both in the NAIC and overall despite the emissions increase in the AIC (Table 5).

When TGCs are attached to CDM projects, the impact on the welfare of different generators is difficult to predict, because this depends on how those TGCs are shared between the AIC investor and the NAIC project developer. Assuming that TGCs are shared equally (and that the NAIC actor receiving the TGCs sells those TGCs to obligated actors in the AIC) then AIC RES-E generators would have their RES-E quota reduced compared to scenario III. Since there are more TGCs for the same quota, the price of TGCs, the quota compliance costs, the revenues and RES-E deployment in AIC would all be lower. This is negative for AIC RES-E generators but those in NAIC would be unaffected. Attaching TGCs to CDM projects makes these projects more attractive for investors. But a higher RES-E deployment in NAIC without a TGC scheme in this country does not affect existing RES-E generators.

Conventional electricity generators in AIC would be better-off in scenario IV due to the lower RES-E deployment, leading to a higher spot market price and higher revenues. In NAIC, conventional generators would be worse-off for the opposite reason: more RES-E involves a lower price of electricity and lower conventional power sales. The comparative welfare of mixed generators is uncertain in both countries.

Table 5
Comparing scenarios III and IV

	AIC	NAIC	Total
RES-E production	↓	↑	=
Conventional power production	↑	↓	↓
Spot price of power	↑	↓	?
Final consumer costs	=	↓	↓
Welfare conventional generators	↑	↓	?
Welfare independent RES-E generators	? (contradictory impacts, although negative effect may dominate).	=	?
Welfare mixed generators	?	?	?
Sustainability benefits	↓	↑	?
GHG emissions	↑	↓	↓

4.4.4. Comparing scenarios II and IV

In this case, two major changes are analysed: the implementation of a TGC scheme in the AIC and the fact that TGCs created in RE-CDM projects can be used to comply with the RES-E quota in the AIC. Do both effects work in the same direction?

Concerning RES-E deployment, compared to the previous RES-E promotion scheme, the TGC system only leads to lower consumer costs, but not to higher RES-E deployment (by assumption). But if TGCs are attached to RE-CDM projects, this would effectively mean a reduction of the AIC RES-E target (quota) and a lower deployment compared to II. However, since RES-E projects in NAICs would be now more attractive for investors (who are given TGCs in addition to CERs), RES-E deployment in the NAIC would increase. Total RES-E production (AIC + NAIC) would remain constant compared to the reference scenario. Conventional power generation would increase in AIC and decreased in NAIC.

How would consumer costs be affected? There are conflicting influences at stake. In the AIC, the implementation of a TGC scheme leads to lower costs while the aforementioned lower RES-E production causes an increase in the spot price of power but also a reduction of RES-E specific promotion costs. Therefore, consumer costs tend to be reduced, although probably not to a large extent. For the NAIC, a lower electricity price (due to a larger RES-E deployment which, in turn, is caused by the higher attractiveness of RE-CDM projects after attachment is implemented) results, leading to lower costs for the consumers.

The welfare of RES-E producers in AIC would generally be lower, although this depends on how the TGCs are shared (see comparison of scenarios III and IV). An effective reduction of the AIC RES-E quota would occur, leading to lower TGC prices and revenues for RES-E generators.[17]

[17]In addition, the spot price of power is reduced, which could affect negatively RES-E generators. But in reality this does not occur, since the price of TGCs increases when the price of electricity goes down leaving total RES-E support constant.

Table 6
Comparing scenarios II and IV

	AIC	NAIC	Total
RES-E production	↓	↑	=
Conventional power production	↑	↓	=
Spot price of power	↑	↓	?
Final consumer costs	↓	↓	↓
Welfare conventional generators	↑	↓	?
Welfare independent RES-E generators	↓	=	↓
Welfare mixed generators	?	?	?
Sustainability benefits	↓	↑	=
GHG emissions	↑	↓	=

The welfare of RES-E generators in the NAIC remains largely unaffected, although it tends to increase given the increased attractiveness of RES-E investments in NAIC caused by the attachment. Again, a higher RES-E deployment in NAIC without a NAIC TGC scheme does not affect existing RES-E generators.

Concerning the welfare of conventional generators in AIC, the implementation of a TGC scheme does not directly affect them. But the lower RES-E production, higher conventional electricity production and higher spot power price (a consequence of attachment) do, leading to an unambiguous improvement for them. This is in contrast to conventional generators in NAIC who, for the opposite reasons (lower conventional production and lower spot power price) would lose. The comparative welfare of mixed generators is uncertain in both countries. Finally, a lower AIC RES-E deployment and a higher NAIC RES-E production leads to lower sustainability benefits and higher GHG emissions for the former and the opposite for the NAIC.

To sum up, the move from the reference scenario to having TGCs attached to RE-CDM projects does not represent an unambiguous overall improvement. It is a generally positive change for NAIC, but a negative change for AIC (Table 6).

4.4.5. A non-realistic scenario: NAIC TGC scheme

Up to this point, we have discussed the implications of linking CDM projects and TGC schemes when a TGC scheme is implemented in the AIC. But we could also consider the effects when a TGC is applied in NAIC. In this case, the AIC would continue to apply its existing (non-TGC) promotion scheme and the NAIC implements a quota with TGC scheme. RE-CDM projects in the NAIC may or may not lead to the issuance of TGCs in addition to CERs. In the former case, the TGCs created would accrue to the host country actor or to the RE-CDM project investor, who could sell them to obligated parties in the NAIC to comply with their RES-E quota.

Linking CDM projects and TGC schemes in this case would have a conceptual advantage: it would be easier to separate the value of CERs (carrying the GHG value of RES-E) from the TGC value (representing the "local value"), The former could be traded internationally while the later would be traded locally (i.e., within the NAIC), leading to no major complications.

In terms of the impact on variables and actors, the NAIC TGC scheme option presents several advantages. In general (and assuming that, previously, the NAIC did not have a well-organised RES-E support system), the implementation of the NAIC TGC scheme is an unambiguous improvement for NAIC RES-E generators since there is now a RES-E quota to be fulfilled (greater incentive for RES-E deployment, higher sales and revenues) and, then, RES-E generation can be expected to increase compared to II, triggering a reduction in the spot power price and in conventional electricity production.[18] However, final consumer costs would not be necessarily be lower, because the lower electricity price has to be compared now with the (higher) costs of RES-E support, which would increase when the TGC scheme is implemented (given the previous low level of support). The welfare of RES-E generators would increase and that of conventional generators would be reduced. The picture is ambiguous for mixed generators in NAIC (more revenues concerning their RES-E part, but lower regarding the conventional electricity part). The higher RES-E deployment level increases the sustainability benefits enjoyed by the NAIC and reduces its GHG emissions.

The AIC can be expected to benefit indirectly. Investments in RE-CDM projects would now be more interesting. If TGCs accrue to the investor, he can sell them in the NAIC TGC market. If TGCs accrue to the host country, the AIC investor would be in a better position to ask for all CERs from the project (rather than sharing them). The increase in the implementation of RE-CDM projects leads to more CERs (and a lower CER price), allowing AIC to comply with its target at lower costs. This reduces the electricity price for AIC consumers and also benefits conventional generators. The extent to which AIC RES-E generators gain from a NAIC TGC scheme depends on whether a higher or lower RES-E generation results in AIC. In principle, no major RES-E crowding out from AIC to NAIC can be expected, because although it is now more attractive to invest in RES-E deployment in NAIC, RES-E investments in AIC are mostly determined by its support scheme (which is assumed to be effective). The lower electricity price would reduce the incentive for RES-E deployment in the AIC, but probably the effect would be marginal.

If a TGC scheme was implemented in the AIC, the reduction in the electricity price would not lead to lower

[18]This would happen regardless of whether TGCs are attached or not attached to the CDM project.

revenues for the RES-E generator, because the TGC price adjusts accordingly and a constant level of support results.

Therefore, having a TGC scheme in the NAIC would be generally beneficial. Total RES-E deployment would increase and overall GHG emissions would be lower.

We can further analyse if it would make any difference whether TGCs are attached or not attached to RE-CDM projects with a NAIC TGC scheme. For AIC it does not make a difference whether TGCs are attached or not. If TGCs are attached, the incentive to invest in RE-CDM projects would increase, but probably the effect would be negligible.

For the NAIC, attaching TGCs to RE-CDM projects and being able to use those TGCs to comply with the RES-E quota in NAIC would involve an effective reduction of the NAIC RES-E quota easing compliance (compared to non-attachment) and leading to a lower TGC price (more TGCs being issued than in non-attachment). This would allow the NAIC to reach its RES-E target at lower costs and benefit consumers, who would then have to pay less for the RES-E policy (this should be compared with a relatively higher spot power price as a result of more conventional generation). In principle, this would lead to a lower RES-E deployment than in the non-attachment case (although still higher than in the reference scenario). However, this might not be necessarily the case because, if the TGCs accrue to the host country, this could have a positive indirect effect on the RE-CDM project investor, which could then claim all the CERs generated without having to share them with the NAIC (see comparison between II and IV). This makes more attractive the realisation of RE-CDM projects in NAIC.

This higher RES-E deployment would lead to a reduction in the price of electricity, benefiting consumers. Therefore, the extent to which TGC attachment is beneficial for the NAIC depends on many variables and cannot be predicted. However, if a higher RES-E deployment results, this would be beneficial for the NAIC and overall (AIC + NAIC). Greater sustainability benefits and lower GHG emissions would then result.

Finally, we could wonder if it was better to attach TGCs to CDM projects when a TGC scheme exists in the AIC or the NAIC. For the AIC, this is ambiguous because its renewable generation would be lower if TGCs were attached and there was a TGC scheme in the AIC, leading to a higher price of electricity. But, on the other hand, consumer costs in AIC attachment would be lower than with NAIC attachment. It is also ambiguous for NAIC, since RES-E generation is higher in AIC attachment, but consumer costs would be lower in NAIC attachment. Regarding total emissions, moving from AIC attachment to NAIC attachment involves an increase of NAIC emissions but a reduction of AIC emissions, leaving total emissions probably unchanged.

Nevertheless, having a NAIC TGC scheme is a highly unrealistic situation because the practical implementation of a TGC scheme in a NAIC is probably very difficult since a significant institutional change and a high level of political commitment is required when other more pressing priorities exist.

5. Limitations of the study and some suggestions for further research

This study is partly based on the relationships between variables identified in other theoretical studies on interactions. However, the analyses and the approach on which it is based may have several limitations.

(i) *Results may be very sensitive to the assumptions made*:

- *Constant electricity demand in both countries*. If demand was not constant after a change in market conditions, then induced effects could affect the results of the scenarios. For example, a higher electricity demand caused by a reduction in the electricity price, due to higher RES-E deployment or to a reduction in compliance costs, could increase GHG emissions. This assumption is very common in the studies on interactions. Also, the low elasticity of electricity demand has been confirmed by empirical studies.
- *TGCs are as effective and more cost-effective than previous instruments*. One of the alleged advantages of TGCs is cost-effectiveness in attaining RES-E targets. However, the effectiveness and cost effectiveness of TGC schemes still has to be proven empirically. If they were not as cost-efficient or as effective as assumed, this would affect the results of this study, particularly scenarios III and IV. Consumer costs would not be reduced when TGCs displace other instruments.
- *No electricity interconnections between AIC and NAIC countries.* If interconnections existed, then the increase of RES-E in the NAIC as a result of the CDM project could be fed (partially or totally) into the AIC grid. This would also affect the results of the analysis, although it would probably reinforce the direction of effects. A RES-E increase in the AIC would reduce CO_2 emissions (liberating CO_2 allowances) and would also reduce the spot power price and, therefore, the costs for the consumer. The import of the physical electricity would also mitigate the problem of the value of what is traded in TGCs and CERs.
- *CDM project additionality and the implementation of TGC schemes in NAICs.* If a TGC scheme was implemented in the NAIC, the additionality of CDM projects could be affected because there would be more RES-E deployment in the absence of the CDM

project. The baseline emissions would be lower and also the CERs issued, making these projects less attractive for investors and affecting other variables (for instance, total costs for the consumer). However, since existing incentives to promote RES-E in most NAICs are relatively low, this should not be a concern.

- *Transaction costs of implementing a combined TGC-CDM system.* The design of a combined CDM-TGC scheme is not a trivial matter and may lead to substantial transaction costs, partially outweighing its benefits. Therefore, the linking would not contribute to the reduction of the high transaction costs of CDM projects, which is a major barrier to their implementation.
- *RES-E deployment and price of electricity.* A relevant assumption in this paper, based on Jensen and Skytte (2002, 2003), is that a higher RES-E deployment in one country causes a reduction in the electricity price in this country, because RES-E has a lower short-term cost. However, if this was not the case, the results of the analysis would be affected because, then, the costs for consumers would increase.[19]
- *No interrelationship of CER and TGC prices.* We have assumed that CER prices and TGC prices are not interrelated. While this might be the case when TGCs are not attached to CDM projects, it might not be a realistic assumption when TGCs are attached. Attachment would probably result in both a lower CER price (the investment in CDM projects being more attractive means an increased volume of CERs) and a lower TGC price (a lower RES-E quota). This price effect has not been considered in this paper and should be a focus of future research.
- *No crowding out*. It is assumed that, as a result of increased attractiveness of investments in RE-CDM projects due to TGCs being awarded to these projects, this does not reduce RES-E deployment in the AIC since this is mainly determined by the AIC RES-E support scheme. However, this may not be necessarily the case and, depending on the levels of CER and TGC prices and on how those currencies are shared between the parties, crowding out might occur.

The accuracy of these assumptions can only be tested empirically.

(ii) *Indirect effects and other criteria.* In this study only some of the effects and their main direction have been considered. However, indirect effects could affect the direction and the comparison between the different scenarios. In addition, other relevant criteria to assess the results of the interactions have not been considered (for example, the impact on dynamic efficiency, i.e. long-term technological change and dynamic cost reductions).

(iii) *Theoretical approach.* This is a first work on the topic. The theoretical exercise should be complemented with an empirical study in future research.

(iv) *Realistic scenarios?* The practical feasibility of some of the scenarios considered is very low (i.e. the implementation of a TGC scheme in a NAIC). In addition, some EU countries, which currently use feed-in schemes, are very critical of TGC schemes and, therefore, the change to this system might not be feasible. Finally, attaching TGCs to CERs and using those TGCs in either the AICs or NAICs might be unrealistic.

6. Conclusions and policy implications

The major conclusions of this paper are:

- RE-CDM projects and TGC schemes may operate in the same direction (stimulating the substitution of RES-E for conventional electricity) and may lead to synergistic effects. However, combining both systems is a complex task and may raise difficult questions concerning the types of benefits included in the currencies traded. In addition, it would require a difficult political agreement between countries and actors within countries.
- Many of the real-world interactions depend on the specific design of the instruments (how the CERs and TGCs are shared between actors, who are the obligated actor by the RES-E quota, whether there is a minimum price for the TGCs, etc.). This paper only tries to clarify the main issues at stake by considering the main interactions in an abstract setting.
- There is not a unique design of a combined CDM-TGC scheme which is optimal for all the actors involved. Trade-offs might not be easily solved. The choice of one system over another depends on the negotiation position of the different actors and on the priorities set at, both, the national and international levels. This paper has mainly considered the most realistic case, i.e. when a TGC scheme exists in the AIC (and not in the NAIC).
- Notwithstanding, moving from an ex ante situation to the use of CERs by obligated actors in AICs to comply with their targets (reference scenario) is positive for all the variables and actors. Moving from this later situation to a combination of CDM projects with TGCs is also generally preferable when there is a quota with TGC in the AIC.

[19]Some authors suggest that a TGC system could lead to higher electricity prices. For example, Sorrell et al. (2003) cite a report by the UK government which estimates that the UK Renewables Obligation will increase average consumer prices by a maximum of 4.4% by 2010 (including the support for RES-E).

- Basically, the coexistence and interaction between AIC TGC schemes and CDM projects can take two forms: either TGCs are not attached to RE-CDM projects (i.e., RE-CDM projects lead to the issuance of CERs but not of TGCs, scenario III) or TGCs are attached to CDM projects (i.e., RE-CDM projects generate CERs as well as TGCs, scenario IV).
- Both alternatives have advantages with respect to a situation where CERs can be used to comply with GHG targets (ex ante situation) and to the case when a less cost-efficient RES-E promotion scheme exists in the AIC (reference scenario).

The choice between attachment and non-attachment mostly depends on the country, actor and variable considered. From the perspective of overall welfare (AIC + NAIC), it would be preferable to move from the reference scenario to a situation in which a TGC scheme exists in the AIC. This would be even better when no TGCs are attached to RE-CDM projects (scenario III). If more weight was given to the welfare of the poorer country (NAIC), then it would be better to have a TGCs scheme in the AIC with TGCs attached to RE-CDM projects (scenario IV). From the perspective of the AIC, the move from the reference scenario to having a TGC scheme implemented (with non-attachment of TGCs) would have a small positive effect, but the implementation of a TGC scheme when TGCs are attached to RE-CDM projects is not advantageous for the AIC.

- Compared to the reference scenario, non-attachment would benefit AIC electricity consumers, who would have to pay less for RES-E promotion. This is at the expense of RES-E generators in AIC, who would have their producer surplus reduced, but the main variables in AIC (GHG emissions, sustainability benefits or RES-E production) would not be affected. All actors and variables in the NAIC would remain unaffected when moving from the reference scenario to having a TGC implemented in the AIC with no TGCs attached. Therefore, the non-attachment option has relatively small overall and country-specific benefits, although it does not lead to any major complication on the interpretation of "what is traded".
- In contrast, attachment is generally beneficial for the NAIC, while it is generally detrimental for the AIC concerning most actors (except consumers) and variables. However, awarding TGCs to RE-CDM and using these TGCs in the AIC TGC scheme could be problematic from a conceptual point of view, because the TGCs would only include the local RES-E value in the NAICs.
- In principle, the interactions could also be analysed for the case when the TGC is implemented in the NAIC. If a TGC scheme was implemented in the NAIC, then it would be easier to separate the value of CERs (carrying the GHG value of RES-E) from the TGC value (representing the "local value", which remains in the NAIC). However, this could be considered as a highly unrealistic situation.

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