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Interplay between Environmental Regulation and Power Markets

Klaus Skytte

EUROPEAN UNIVERSITY INSTITUTE
Robert Schuman Centre for Advanced Studies
Florence School of Regulation

EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

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KLAUS SKYTTE

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For further information
Florence School of Regulation
Robert Schuman Centre for Advanced Studies
European University Institute
Via delle Fontanelle, 19
I-50016 San Domenico di Fiesole (FI)
Fax: +39055 4685755
E-mail: fsr@iue.it
http://www.iue.it/RSCAS/ProfessionalDevelopment/FSR/

Abstract

This paper discusses the difficulty of having three different objectives for the electricity supply sectors in the EU: renewable energy goals, emission reduction goals and minimising consumer prices. In the environment associated with the power markets, the regulatory mechanisms interact with each other and thus the attainment of the specified goals.

Analytical discussions in the paper show that synergies do exist between the different regulation mechanisms and the targets. However, the challenge of having the different targets lies in the fact that the mechanisms at present cover different geographical areas and sectors, and that the targets are set differently within each Member State.

This is an analytical paper, and its aim is to shed some light on the complexity of this regulation area and inspire more researchers to work in it.

Keywords

regulatory mechanisms; electricity; renewable energy; emission allowances, green certificates

JEL-classifications: D50; Q28; H21; O21

Introduction[*]

The regulators face different challenging questions when working with the regulation of the power sector in the European Union (EU). Some of these questions are: Can different energy goals co-exist in the power markets? How can the different goals be simultaneously regulated? Are there synergic effects between the regulation mechanisms that help the regulator to achieve the goals?

Different political goals have been set within the power sector in the EU in the last twenty years. During this period, the supply side of the power markets in the EU has been liberalised. One of the main goals of this liberalisation was to create an efficient power supply with low prices for the consumers (EU Directives 96/92/EC and 2003/54/EC).

Concurrently, there is a growing focus on the use of electricity from renewable energy sources (RES-E) within the EU. Indicative targets have been decided for the Member States (EU Directive 2001/77/EC) adding up to a target of 22% of the EU-15 electricity consumption by 2010 compared with a RES-E share of 13.9% in 1997.

Recently, the EU ratified the Kyoto-protocol on greenhouse gas reduction targets with an overall reduction of 8% during the period 2008-2012 relative to 1990 (EU Directives 2003/87/EC and EU 2002/358/EC).

Therefore, there are (at least) three main political targets that have to be taken into consideration when analysing the power markets in the EU. These main targets are:

1. Low consumer prices;
2. RES-E targets with increased use of RES-E;
3. Greenhouse gas reduction targets with respect to emissions from the power sector.

Some sort of regulation is required in order to achieve these targets. Looking separately at each target, it could be argued simply that three different regulation mechanisms are needed in order to achieve the three different targets. However, the targets have to be achieved simultaneously, and since the different targets and regulation mechanisms interact, it is not straightforward simply to choose and apply regulation mechanisms. This is the cornerstone of this paper.

From a welfare economic view point, without looking at the positive externalities of renewable energy[1] and emission reductions, the most advantageous allocation of ressources is determined in a competitive electricity market without environmental regulation. Compared to this the introduction of environmental regulation and targets lead to reductions in social welfare. However, taking account of externalities it might be argued that it is reasonable to introduce environmental regulation and targets (Hohmeyer, 1988, Söderholm and Sundqvist, 2003).

This paper does not go further into the discussion of externalities and whether it is a good idea to have environmental regulation and targets. Instead it is assumed that the three targets of low consumer prices, increased quotas of RES-E, and reduction of emissions have been set.

Instruments of regulation such as taxes, tariffs or quotas guarantee that the defined objective will be achieved at the lowest cost (Baumol et al., 1971). Recent analyses of the EU support schemes for

* This paper was presented at the Florence School of Regulation Workshop ‘Energy and the Environment: the Market Approach’, conducted on 12-13 November 2004 in Florence, Italy.

1 Renewable energy decreases dependency on limited fuel resources, decreases emissions, and increases local production and the security and diversification of the energy supply.

RES-E have shown that price-based and quantity-based approaches are seen as comparable methods for achieving RES-E targets (Menanteauet et al. 2003, Finon and Menanteau 2003, Ringel 2006).

The challenge, therefore, is not to choose between different regulation instruments designed to achieve the same target, but rather to choose between instruments in order to fulfill different targets. Most studies of these targets are made seperately for each target (e.g., Soleille 2005, Boemare et al 2003). Only a few studies have so far analysed the acheivement of the three targets simultanously (e.g., Jensen and Skytte 2003, Boots 2003).

The question remains of how to regulate in order to achieve the three targets simultanously when the different regulation instruments interact. The objective of this paper is to discuss these interactions and to emphasise any positive synergy effects[2] there may be between the mechanisms which can help towards the achievement of the targets. This can be used to give an indication of which mechanisms should be used and at what level.

This paper discusses analytically the interactions between different regulation mechanisms and discusses how the three main targets can be achieved. The paper begins with a short description of the main regulation mechanisms that are designed to promote RES-E or to reduce emissions from the power sector. It then looks at the interactions between the mechanisms and the targets in closed national markets. Potential synergy effects are emphasised in a discussion on how the mechanisms can be used in order to achieve the different targets. Similar discussions of bi-national and international markets follow on. The paper closes with some final remarks.

Main Regulation Mechanisms

EU recognises the need to promote RES-E as a priority measure given that “their exploitation contributes to environmental protection and sustainable development. In addition this can also create local employment, have a positive impact on social cohesion, contribute to security and diversification of energy supply and make it possible to meet emission targets more quickly” (EU Directive 2001/77/EC).

At present, most supplies of RES-E are more costly to generate than conventional power based on fossil fuels. Therefore, in order to achieve the energy targets of using more RES-E, it is necessary to subsidise this production. There is a wide array of different support mechanisms in order to promote RES-E. The three main mechanisms within the Member States are feed-in tariffs, green certificates and tendering systems. All three mechanisms give priority to RES-E compared to conventionally produced electricity.

The feed-in tariff is a subsidy on output in the form of a guaranteed fixed price in combination with a purchase obligation imposed on the utilities. Within a green certificate system, the green certificates are given to RES-E producers according to the amount of RES-E that they feed into the system. The RES-E producers can sell these certificates, which yields revenue in addition to selling their physical power. The demand for green certificates is guaranteed by imposing a purchase obligation, either on consumers or on the suppliers of electricity[3]. This purchase obligation is often set as a green quota, for example where the consumers have to purchase an amount of green certificates that correspond to 10% of their electricity consumption if the green quota for the consumers is 10%.

In tendering or bidding systems, tenders are invited by a public body to compete either for a certain financial budget or a certain capacity of RES-E generation. These systems often guarantee the winners of the bids sales of a certain amount of RES-E to the prices bid. In other words, they work more or less like the feed-in system, where the tariff is determined in the tendering auction.

2 In this paper, we refer to a positive effect if it helps towards achievement of the targets.

3 For the remainder of this paper, we refer to green certificate systems with the purchase obligation at the consumer side.

In both the feed-in and the tendering systems, the subsidy cost is the difference between the guaranteed price and the market price for electricity. This cost is often reimbursed by a non-discriminatory levy paid by all electricity consumers. In that way, the cost of the subsidies is shared as in the green certificate system. However, the systems differ in the way that the amount (the green quota) within the green certificate system is fixed and the price and total cost are determined in the market. In the feed-in system, the price is fixed and the amount and total costs are determined in the market.

Regulation is also needed in order to implement the emission reduction targets. The most widely used regulation mechanisms within the EU are emission taxes, fuel taxes and tradable emission allowances. These mechanisms have in common that an extra cost is charged to the conventional power producers. Therefore, the costs of conventionally based power supplies are increased by the use of these regulation mechanisms. RES-E producers are often exempted from emission and fuel taxes.

Emission allowances are the main mechanism in the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) that help towards a pan-European emission market (EU Directive 2003/87/EC). An emission allowance is an allowance to emit one tonne of carbon dioxide (CO_2) equivalent greenhouse gas[4] during a specified period. The emission allowances are allocated within each Member States according to national allocation plans. The emission allowances are tradable and can be transferred between persons within the EU and between the EU and third countries if there is a mutual reorganisation.

If a producer wishes to produce more than the allocated emission allowances permit, he can purchase more emission allowances from other producers that do not use them. The supply and demand of emission allowances will determine their market price and work as an emission tax on the production that exceeds the individual amount of allowances. The production that does not exceed the individual amount of allowances is in principle exempted from the extra cost of buying allowances.

The price for emission allowances drops to zero if the actual total emission level is lower than the total emission target, i.e. if the target is fulfilled without the use of emission regulation.

Part of the reduction in emission can also be obtained by applying Kyoto-mechanisms (EU Directive 2004/101/EC), e.g., joint implementation (JI) and clean development mechanisms (CDM).

National Markets

Each regulation mechanism was originally designed to achieve a specific goal, e.g., lower consumer prices, a certain amount of RES-E, or emission reduction. However, a mechanism might also help to achieve one of the other goals simultaneously with achieving the goal it is designed for. These synergies will be examined below—first within closed national markets (autarchy) and then within international markets.

Synergies with RES-E Regulation

Feed-in tariffs, green certificate systems, and RES-E tenders are regulation mechanisms that are designed to achieve RES-E targets. However, a larger share of RES-E will displace an equivalent amount of conventionally based power and thereby lower the amount of emissions from the power sector. There is therefore positive synergy between the use of RES-E regulation and the target of emission reduction.

There might also be synergy with the goal of lowering the consumer prices. The RES-E displacement of a similar amount of conventional power exerts pressure on the conventional power,

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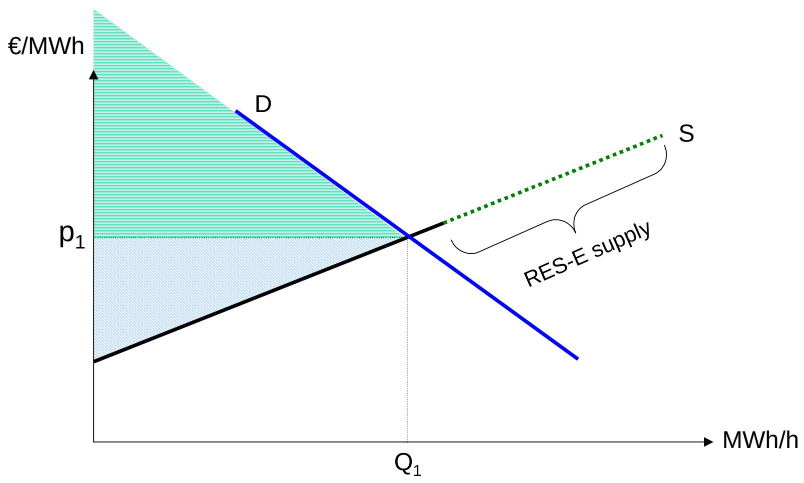
4 The greenhouse gases referred to are Carbon dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride (SF6).

i.e. demand and wholesale prices for conventional power decrease. This might result in a lowering of the consumer price aswell.

In order to examine this effect on the consumer prices it is first necessary to examine the effect on the wholesale power prices of promoting RES-E. In order to do so, we start by looking at a reference case with a closed power market without regulation. In this case, we assume that all RES-E and conventional technologies compete in the same power market with marginal price setting. In order to keep the illustrations simple, it is assumed that the RES-E is more costly than the conventionally based power. This is illustrated by the dashed part of the power supply curve (*S*) in Figure 1. The demand for power is illustrated by the demand curve (*D*) in the figure.

Figure 1: Market without regulation (reference case). The hatched area indicates the consumer and producer surpluses.



The intersection of the demand and supply curves determines the equilibrium demand (Q_1) and price (p_1) for electricity[5]. The producers that can supply at a cost lower than or equal to p_1 will do so. They all receive the same price (p_1) for each unit of electricity they supply. Since the RES-E part of the supply curve lies to the right of the equilibrium quantity, no RES-E is supplied in the reference case.

In this case, where there are no subsidy costs, the net consumer price equals the price (p_1) for electricity in the conventional wholesale market. The net consumer cost (without transmission losses and costs, taxes, etc.) can be determined as the total demand times the consumer price, i.e., as Q_1 x p_1. The consumer surplus is the hatched area between the retangle Q_1 x p_1 and the demand curve *D* in Figure 1. The hatched area below this and above the supply curve is the producer surplus.

In order to achieve a RES-E target, it is necessary to regulate. As mentioned in the introduction of this paper, the three main mechanisms, feed-in tariffs, green certificates and tendering systems, all give priority to RES-E compared to conventionally produced electricity. In order to see this, a graphic illustration is shown in Figures 2a and 2b.

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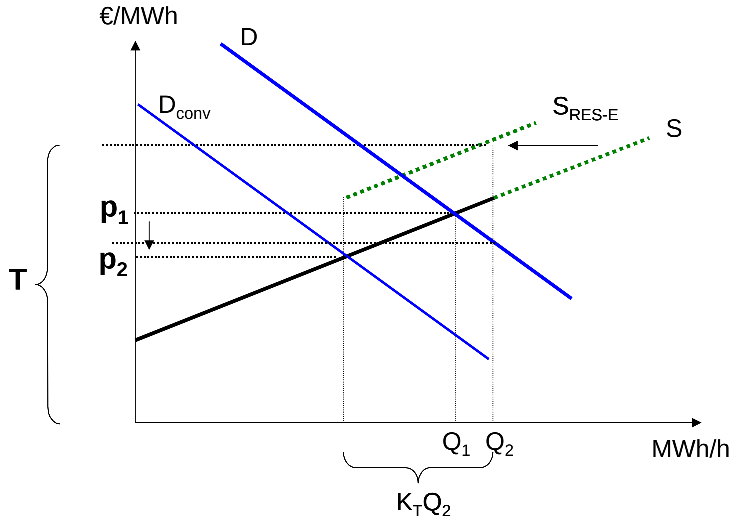
5 The equilibrium price (p_1) equals the marginal cost of the marginal power supplier.

Figure 2a: Markets with regulation using feed-in tariffs



Imposing a feed-in tariff (T) implies that the part of the RES-E supply which has lower costs than the tariff will be given priority compared to conventionally produced electricity. In other words, a certain share (K_T) of the consumption (Q_2) will be RES-E. This share is determined by the size of the tariff and by the supply curve for RES-E (S_{RES-E}).

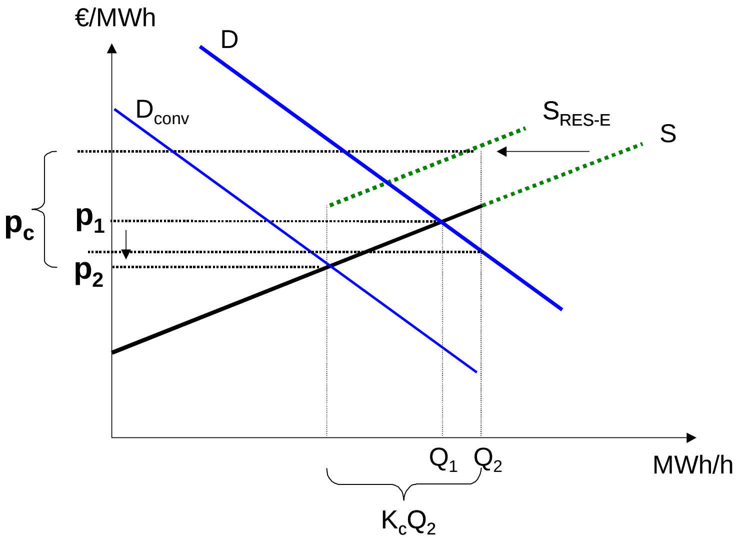
This amount of RES-E (K_TQ_2) will displace a corresponding amount of conventional power, and thereby lower the demand for conventional power (D_{conv}), which decreases the market price for electricity. This is illustrated in Figure 2a with a decrease from p_1 before the tariff is introduced to p_2 after the tariff is introduced. It is assumed that the subsidy cost of the feed-in system is reimbursed by a non-discriminatory levy paid by all electricity consumers according to their power consumption, i.e. the consumer price is given as the power price plus the share of RES-E multiplied by the tariff. The consumer price is equal to p_1 before the feed-in system is introduced. The consumer price is equal to $p_2 + K_TT$ after the feed-in system is introduced.

For the consumers there is a cost saving from lowering the power price, and an additional cost (K_TT) following the use of RES-E instead of conventionally produced power. The decrease in the power price from p_1 to p_2 may be either higher or lower than the additional cost (K_TT). As a result, the consumer price may either increase or decrease when the feed-in system is introduced. Figure 2a illustrates a case with a decrease in the consumer price (the dashed line between p_1 and p_2) and an increase in the equilibrium demand from Q_1 to Q_2.

Similar observations can be made for a quota-based system, for example, a green certificate system with purchase obligation imposed on consumers. This is illustrated in Figure 2b. The authorities introduce the green quota (K_c) as a percentage of consumption. This corresponds to the demand for green certificates, and thereby also to the demand for RES-E. As in the case of feed-in tariffs, this amount (K_cQ_2) will displace a corresponding amount of conventional power, thereby lowering the demand for conventional power and decreasing the market price for electricity. This is illustrated in Figure 2b with a decrease from p_1 before the quota is introduced to p_2 after the quota is introduced[6].

6 Similar observations can be made for a tender procedure based on guaranteed prices.

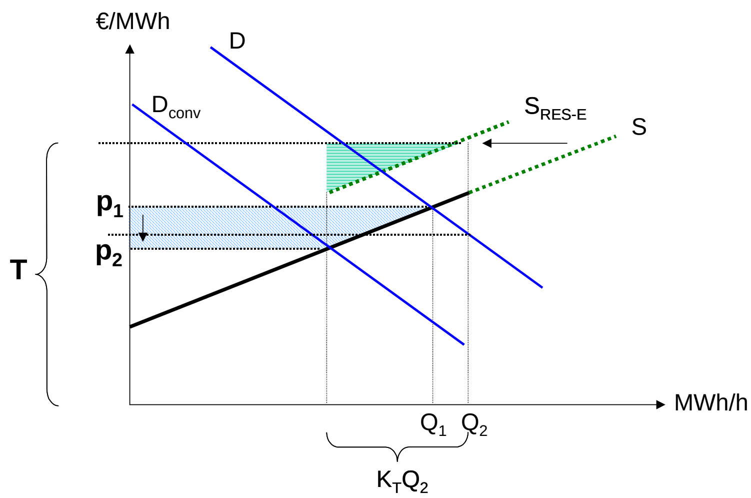
Figure 2b: Markets with regulation using green certificates



The RES-E suppliers offer their power at low prices in order to be sure to sell their power at the market price (p_2). The price for certificates (p_c) is determined by the market as the difference between the market price for electricity (p_2) and the marginal cost of RES-E.

Somehow the possible decrease in the consumer price seems contra intuitive when displacing conventional power generation with more costly RES-E. Comparing Figures 1 and 2a/b indicates that the producer surplus changes when the RES-E regulation is introduced. These changes are illustrated in Figure 3. The conventional producer surplus decreases with the left hatched area in Figures 3. The RES-E producers receive a producer surplus equal to the right hatched area in Figure 3. The costs to the RES-E suppliers are thereby covered, and only the conventional power suppliers will de facto experience a decrease in revenue.

Figure 3: Changes in producer surplus from regulation.



Similar observations can be made for the change in the consumer surplus. There may either be an increase or a decrease in the consumer surplus. In the illustrated case there is a redistribution of the producer surplus from the conventionally based production to the RES-E production and to the consumers.

In other words, the conventional power producers pay part of the costs of introducing more RES-E by lowering their profit—even though the remaining regulation costs are reimbursed by the electricity consumers. Consequently, RES-E regulation does not counteract the target of low consumer prices—even though consumer prices do not always decrease, the consumer costs might be lower than if another mechanism had been applied. In other words, positive synergy exists between the RES-E target and the goal of low consumer prices.

When introducing a green quota, the quota (K_c) is set as a percentage of consumption. Therefore, the consumer price changes from p_1 to $p_2 + K_c\ p_c$. An ambiguous result with respect to consumer surplus implies a correspondingly ambiguous result with respect to the consumer price (p_1 versus $p_2 + K_c p_c$). In other words, the effect on the consumer price following an introduction of a feed-in tariff or of green certificates is ambiguous; there is a possibility of lowering as well as increasing the consumer price—even though the RES-E is more costly than the conventionally produced power.

The ambiguous effect on the consumer price is illustrated with arbitrary numbers in the text box. For more detailed and mathematical discussions, see (Skytte, 2001 or Jensen and Skytte, 2002).

Example of decreasing consumer prices (arbitrary numbers).

Numerical example with a green certificate system:

- Assume that the RES-E quota Kc = 10%, the marginal RES-E cost is 30 €/MWh, and that the power price changes from p1 = 22 €/MWh to p2 = 18 €/MWh.
- Then, the certificate price pc = 30—18 = 12 €/MWh.
- This implies a consumer price of p2 + Kc pc = 19.2 €/MWh.
- In other words, the consumer price decreases from 22 to 19.2 €/MWh when the RES-E quota, Kc, is introduced compared to the reference case without RES-E regulation.

The sizes of changes in producer and consumer surpluses and in volumes depend on the slope and level of the two supply curves (S and S_{RES-E}) as well as the size of the quota (K_c)[7]. It is ambiguous as to whether the consumer surplus will increase or decrease as a result of introducing or increasing a feed-in tariff or a green quota. Skytte (Skytte 2001) shows that the effect changes when the quota increases. With given supply and demand functions, a quota at a low level might result in a decrease in the consumer price, whereas a high level might lead to an increase in the consumer price.

Bye (Bye 2003 and Bye et al 2002) makes a quantitative analysis with a model of the Norwegian power market. He shows that the effects on the consumer price and volume are ambiguous under a wide range of alternative levels of the quota. However, when the quota increases above a certain level, the consumer price increases again and the volume effect is negative. Although the effects are sensitive to elasticities of demand and supply of both conventional and RES-E technologies, the main results are robust against a variety of combinations of elasticities.

Similar quantitative model simulations can be found in Hindsberger (Hindsberger et al. 2003) for the Baltic markets.

Synergies with Emission Regulation

Emission taxes, fuel taxes and emission allowance systems are regulation mechanisms that are designed to achieve emission reduction targets. These mechanisms imply an introduction of additional

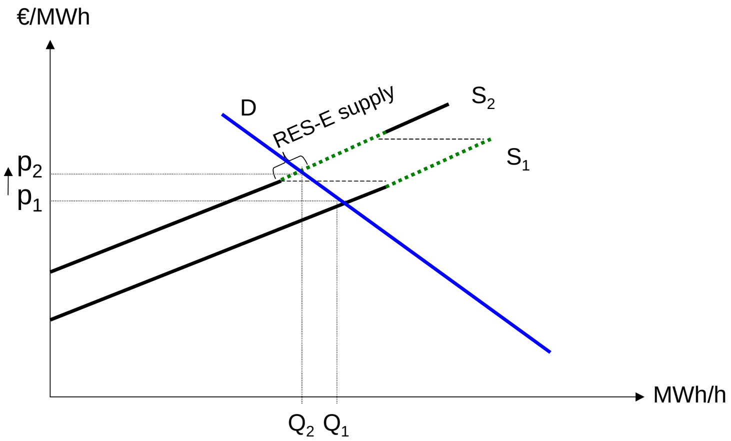
7 Or the size of the tariff in a system with feed-in tariffs.

costs to the conventional producers, for example, from purchasing emission allowances. This causes the cost of conventionally based power supplies to increase, which makes RES-E more competitive. In other words, there is positive synergy between the use of emission regulation and the RES-E target.

Starting from the reference case in Figure 1, in a market without regulation, the effect of emission regulation is illustrated in Figure 4. The conventional producers face an additional cost, which shifts the conventional supply curve upwards according to the additional costs from S_1 to S_2. Consequently, the costs to the highest-costing suppliers and those with the highest emissions will be very high, so that the RES-E producers are better off. This is illustrated in Figure 4, where after the introduction of the emission regulation some of the RES-E are to the left-hand of the demand curve, as well as some of the conventional power being to the right-hand of the demand curve.

The amount of ousted conventionally based power relates to the corresponding decrease in emissions cf. the emission quota.

Figure 4: A market with emission regulation



In this case, the price faced by the consumer equals the power price. Therefore, the consumer price increases from p1 top2, which is an unambiguous increase since the cost to the marginal power supplier is higher than that without regulation. In other words, there is no direct positive synergy between the use of emission regulation and the goal of lowering the consumer prices.

Two Targets and Two Mechanisms—National Markets

The foregoing sections in this paper have shown that synergies do exist. RES-E regulation has a positive effect on emission reduction and it may lead to lower consumer prices. Emission regulation is beneficial for the RES-E target, but it results in higher consumer prices.

From the discussion on synergies between the mechanisms, it is possible to formulate some general guidelines for applying the mechanisms in closed national markets.

If a country only has a RES-E target besides the goal of lower consumer prices,

- the RES-E regulation mechanisms should be applied.

If the country only has an emission target besides the goal of lower consumer prices,

- the RES-E regulation mechanisms can be applied when there is positive synergy between the consumer price and the RES-E regulation, thus achieving both the emission target and lower consumer prices;

- the emission regulation mechanisms can be applied when there is no positive synergy, and only the emission target will be achieved.

The choice of regulation mechanisms also depends on the costs of using the mechanisms. Even though the use of RES-E regulation in some cases increases the consumer price, emission regulation may further increase the consumer price. In addition, it is necessary to analyse which conventional technologies are displaced by the RES-E regulation. The use of RES-E regulation to achieve an emission target is difficult if the displaced conventional technology has a very low emission compared with the remaining technologies. In other words, it is easier to use RES-E regulation in order to achieve an emission target if the marginal conventional power plants are high emitters[8].

If the country has both RES-E and emission targets,

- both types of regulation mechanisms can be applied, for example, setting the quotas equal to the targets, when there is no positive synergy effect between RES-E regulation and the consumer price;
- RES-E regulation[9] can be applied when there is positive synergy between RES-E regulation and the consumer price.

It is important to note that as long as the emission target is binding, an increase in the RES-E target wil not affect the actual emission level. However, the presure on the emission target will decrease. In a system like the EU emission trading scheme this means that an increase in the RES-E deployment lowers the price for emission allowances but the actual level of emissions stays at the emission target level as long as there is a positive price for allowances. This is beneficial for the conventional producers that buy emission allowances in order to produce electricity.

In other words, in a system with market-based pricing for emission reduction the synergy effect of an increased deployment of RES-E will more or less vanish; part of the decrease in the producer surplus for the conventional producers is counteracted by a decrease in the cost of buying emission allowances.

One way to avoid this is by regonising the CO_2-benefit of deploying RES-E and reducing the emission reduction target accordingly when increasing the RES-E target (Boots 2003). However, due to uncertainty of how much CO_2 reduction an additional amount of RES-E will create it is not an easy task to make a precise adjustment to the emission reduction target.

International Markets

So far, we have looked for synergies within closed national markets with national regulation. When a common power market is created with cross-border trading within the EU and with regulation systems that cover several Member States, it is essential to inverstigate whether these synergies also exist in these cases.

In addition, it is interesting to see whether international markets result in different power prices for the consumers due to different RES-targets, and whether levels of realised national CO_2-reduction differ compared to the efforts exerted.

The discussions are split in two main cases:

1. Common international markets where both the electricity, RES-E and emission regulations cover the same geographic area and sectors.

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8 For further discussion of the use of mechanisms, see Jensen and Skytte, 2003.

9 The RES-E quota must in some cases be set higher than the RES-E target in order to achieve the emission target.

2. Different markets where the electricity, RES-E and emission regulations do not cover the same geographic area or sectors.

Common Markets

In this case it is assumed that the electricity, RES-E and emission regulations cover the same geographic area and sectors. As an example, this could be a pan-European electricity market, a similar pan-European green certificate market, and a similar pan-European emission allowance market.

When all markets are international and cover the same geographic area and sectors, we observe the same effects as with national markets when using common forms of regulation. A common increase of RES-E will lower the total amount of emissions and it will lower the common power price. Similarly, a common regulation of the emission reduction is beneficial to the RES-E producers.

Therefore, from an overall perspective, the positive synergies observed in national closed markets can also be observed in the common markets. However, if a single Member State makes a national change in its regulation target, for example a national increase in a RES-E quota, it has little effect on the common international prices, if the corresponding national sector is small compared to the total market. In other words, for a small Member State, the synergies between the regulation mechanisms diminish if the other Member States do not change their regulations mechanisms simultaneously.

This can be illustrated by looking at a small Member State that is member of a large common power market, a similar common RES-E regulation market (e.g., a green certificate system) and a similar common emission regulation market (e.g., an emission allowances system). If the small Member State increases its national RES-E quota (or sets a higher quota than the other Member States), and if the other Member States keep their quotas constant, then the additional implementation of RES-E caused by the increase can take place in all the countries within the RES-E regulation market (Skytte, 1999). The implication is that the CO_2-benefits of the increase have to be shared with the other Member States. Since the Member State is small compared with the total market, the common power price will only be slightly affected by the increase in the national quota. With an insignificant counteraction in the prices when increasing the regulation costs, the power consumers of the small Member State pay most of the cost of the increase.

The example also illustrates that within common markets, countries with low RES-E targets benefit with respect to emission reduction, deployment of RES-E technologies and consumer prices, compared to countries with high RES-E targets. An example of this is the different national indicative RES-E targets that are set for each of the EU-15 Member States (EU Directive 2001/77/EC and Voogt et al. 2001).

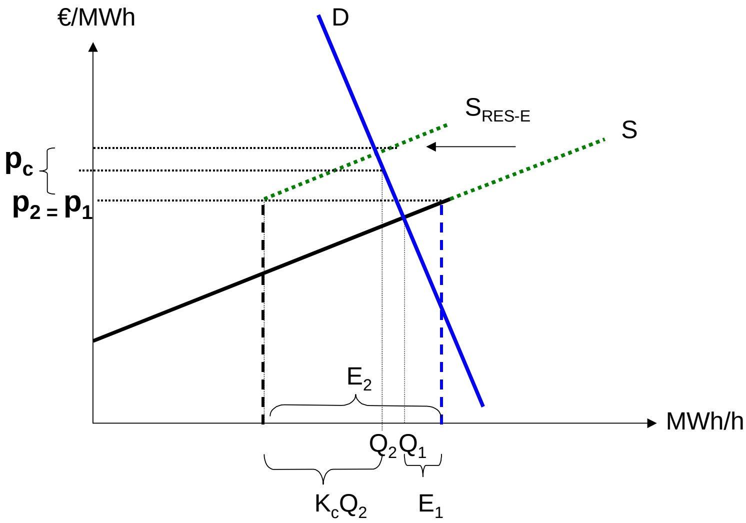
Different Markets

It is the intention of the EU Directives (EU Directives 96/92/EC and 2003/87/EC) to make common pan-European electricity and emission allowance markets. At present there is no similar declaration about creating a common pan-European RES-E market. In addition, there are often bottlenecks in the electricity network that split the power market into smaller markets with different electricity prices. At present and in the near future, it is therefore most likely that the electricity, RES-E and emission regulations will not cover the same geographic area or sectors.

When only some markets are international, or when they do not cover the same geographical area or sectors, we do not observe the same effects as with national markets when applying common regulation. As an example, one can consider a small country that acts in international and national markets simultaneously, for example, an international common power market and a national green certificate market. In this case, the international power price is (more or less) independent of changes in the national quota.

Increasing the green quota in the national green certificate market (with an international power market) hardly affects the conventional production or the level of emission in that country. This is illustrated in Figure 5.

Figure 5: Supply and demand in a small country with an international power market and with national regulation using green certificates.



Introducing the RES-E quota, K_c, as a percentage of the national power demand, implies a prioritisation of K_cQ_2 of the national RES-E supply. This lowers the marginal national supply costs of conventional power. However, the power price is determined in an international market, and consequently not affected by the national increase in RES-E. As a result, a larger share of power will be exported from the small country. This is illustrated in Figure 5 where E_1 is the assumed initial export from the country to the other countries within the common power market. When the national RES-E quota, K_c, is introduced, the amount exported increases from E_1 to E_2.

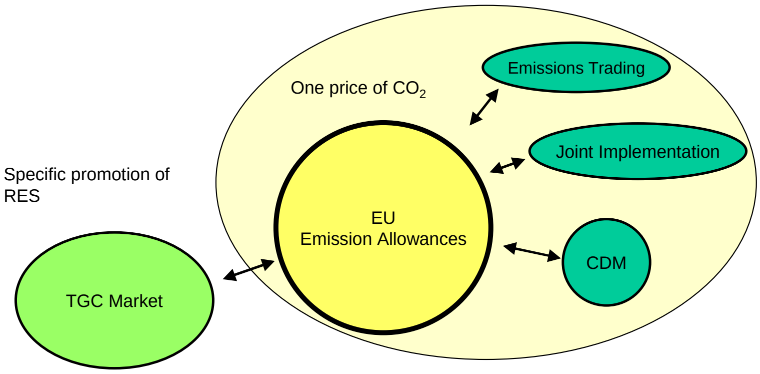
Since the conventional power production is hardly affected by the national increase of the RES-E quota, the emission level from the conventional power sector in the country is unaffected. The consumers of the country pay the entire additional cost of the national RES-E regulation since the power price does not interact with the increased use of expensive RES-E, and the positive synergies are attenuated. RES-E regulation hardly affects the emissions from the national power sector and the consumer price increases. RES-E can therefore only be used to achieve RES-E targets.

Similar observations can be made, with an increase in the national emission reduction. Since the power price is determined at the international market, the RES-E supplies will not become in a better competitive position when the small country increases its emission reduction regulation.

As indicated, the positive synergies disappear when the markets do not cover the same geographical area or the same industrial sectors. This is also the case with trade between the EU and other countries. The Greenhouse Gas Directive (EU Directive 2003/87/EC) opens up for mutual trade with emission allowances between the EU and other countries. In addition, the EU Linking Directive (EU Directive 2004/101/EC) makes it possible to use a certain share of Kyoto mechanisms in order to fulfil the national emission quotas.

In a closed system, an increase in the RES-E share decreases the market price for emission allowances. By trading emission allowances with third countries, using Kyoto mechanisms, or by international emission trade, the price for CO_2 will be determined in an international market (Jepma, 2003). Therefore, the price for emission allowances will hardly be affected by an increase in the RES-E share within a Member State of EU. This is illustrated in Figure 6.

Figure 6: International CO_2 markets



International mutual trading with CO_2 implies that promotion of RES-E in the EU might cause a release of emission allowances that can be sold to countries outside EU. This raises a dilemma, since the promotion of RES-E will be beneficial to the emission trade at the expense of the power consumers. Similarly, CDM/JI projects may reduce the price of emission allowances which might reduce the incentive to deploy RES-E within the EU (Rio González 2005).

Constraints in one of the markets may also work against the targets. Amundsen and Mortensen (2001) have studied the relationship between a green certificate market and a market for CO_2 allowances, under the constraint of upper and lower price limits on the green certificates. They particularly show that under certain circumstances harsher CO_2 constraints may lead to less deployment of RES-E.

Two Targets and Two Mechanisms—International Markets

The discussions of the international markets have shown that formulating general guidelines for the application of the different regulating mechanisms is not a straightforward process. Targets and regulations at the EU level must be distinguished from targets and regulations at national levels.

Looking at targets and regulations at the EU level, the recommendations for applying the different regulation mechanisms follow the recommendations that are given in this paper for closed national markets.

Looking at targets and regulations at national levels, it is necessary to consider how costs are divided between achieving RES-E targets and emission reduction targets. Even within common markets, different national targets can lead to differences in consumer costs.

Even if a certain geographic spread of RES-E deployment and emission reduction is efficient at the EU level, it might not be obtainable if the national targets differ or if the markets do not cover the same area or sectors. Countries with high RES-E or ambitious emission reduction targets might not be interested in using international markets when there is no synergy between the national RES-E and emission reduction targets. For a large company that owns both conventional production and distribution firms or firms that consume a lot of energy, it may be more profitable to deploy RES-E itself than to purchase both emission allowances and green certificates from other actors. This is the case if the supply cost of the company's RES-E is less than the CO_2 benefit plus the power and certificate prices of this production.

In the case of different targets and regulations at national levels a detailed analysis of the market structure is needed. Otherwise it is not possible to formulate general guidelines for applying the different regulation mechanisms.

Final Remarks

The focus of this paper is on the difficulty of setting goals for RES-E deployment and emission reduction while at the same time minimising consumer prices in an environment where the regulatory mechanisms affect each other and thus the attainment of the specified goals.

The analytical discussions in this paper show that positive synergies do exist between the different regulation mechanisms and the targets of lower consumer prices, a certain amount of RES-E, and emission reduction. Even though each regulation mechanism is originally designed to achieve a specific target, it might also help towards achieving one of the other targets simultaneously.

These synergic effects are mostly seen in a closed market. The effects are attenuated when the markets do not all cover the same geographical area or sectors. Similar observations can be made with other mechanisms. The more targets, mechanisms, sectors and areas there are, the more complex it is to regulate and to obtain synergies between the different mechanisms and targets.

The complexity can be illustrated by comparing four of the main mechanisms within the EU. Tradable emission allowances (TEA), tradable green certificates (TGC), Kyoto mechanisms, and tradable white certificates (TWC) are all mechanisms that are considered to be in line with the liberalisation of the power markets within the EU. However, as illustrated in Table 1, the targets they are designed for differ, as well as the sectors and areas they cover.

Table 1: Different Mechanisms and Markets

Goal	Mechanism	Sectors	Area
Low consumer prices	Supply competition at the power markets	Electricity	EU
RES-E	TGC	Electricity	Nat. / bi-nat.
CO_2 and other emissions	TEA	All	EU
CO_2 and other emissions	Kyoto	All	World
Efficiency / Consumption	TWC	Energy: Electricity, heat, natural gas, …	Nat./EU

With the current design of these mechanisms it might be hard to find synergies between them.

This calls for common markets *and* targets within the EU. Common markets are enough to ensure that the RES-E and emission reduction goals are achieved effectively. When all markets cover the same geographical areas and sectors, we observe the same effects as with national markets when using common regulation. However, without common targets, consumer prices (burden sharing) will vary between the Member States.

With the different national RES-E targets that are set for each of the EU-15 Member States (EU Directive 2001/77/EC) and with the different greenhouse gas reduction targets for each Member State (2002/358/EC), common regulation mechanisms will have different effects on the consumer prices in each Member State. In other words, the variations in national burden sharing of the regulation costs will depend on the national targets.

Independently of different targets, the RES-E production and the greenhouse gas reduction will take place where it is most economical. When a country has a large RES-E target, the corresponding RES-E production might take place in all Member States and the derived greenhouse gas reduction benefits have to be shared with the other Member States.

The consumer cost and price depend on the different targets. The consumer price will be higher in Member States with large RES-E targets than in Member States with low RES-E targets. Compared with the discussion of Figure 3 the additional cost of having a large RES-E target must be paid by the consumers in the country that maintains the large target whereas the corresponding savings in costs must be shared with the consumers from the other Member States. However, since the saved costs equal the reduction in the conventional producers’ revenue, the conventional producers in all Member States pay a part of the costs of using more RES-E. Thereby, the supply competition status of the conventional producers in the country with the large RES-E target is not reduced compared with the other Member States.

With respect to different emission reduction targets, an ambitious national emission reduction goal might result in a corresponding reduction in different Member States, and the increase in the power price and the derived benefits for RES-E have to be shared with the other Member States. The cost of achieving the emission reduction targets will be passed on to the emitting sectors in each Member State in accordance with the individual reduction targets. Thereby, the competition status of the conventional producers in a country with a large emission reduction target is reduced compared with the other Member States. However, the costs of reducing the emissions will affect the power price, which in a common power market will equally affect the consumer price within all Member States. There are thus pros and cons for each of the regulation mechanisms in common markets with different national targets.

A pessimistic reading of the foregoing sections could easily lead to the conclusion that it is almost impossible to regulate and achieve the three goals of low consumer prices, a certain amount of RES-E, and emission reduction when the markets cover different Member States or sectors. However, positive synergic effects still exist at the EU level: A larger share of RES-E will displace an equivalent amount of conventionally based power and thereby lower the amount of emissions from the power sector. When RES-E is given priority through regulation, it splits the power market into a prioritised part and a conventional part. The splitting of the power market makes the power price drop. Thereby, the cost of introducing more RES-E is partly paid by the conventional producers that face lower revenues and partly by the consumers.

Consequently, the RES-E regulation has a positive effect on emission reduction and it might lead to lower consumer prices at the overall EU level. Emission regulation is beneficial for the RES-E target, but it involves higher consumer prices.

The challenge of having RES-E goals, and emission reduction goals while at the same time minimising consumer prices in the EU lies in the fact that the mechanisms at present cover different geographical areas and sectors, and that the targets are set differently within each Member State.

The aim of this paper was not to give a clear-cut solution as to how the regulation mechanisms can be used most advantageously. The aim was to open up for a discussion of the use of different regulation mechanisms in an environment such as the EU power market where the regulatory mechanisms affect each other and thus the attainment of the different goals.

As the discussions in this paper indicate, there are still many issues within this area to be resolved by research. It is my hope that the paper has shed some light on the complexity of this regulation area and that the paper will inspire more researchers to work with this area.

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Klaus Skytte
Systems Analysis Department
Risø National Laboratory
Frederiksborgvej 399
DK - 4000 Roskilde
Denmark
Ph. (+45) 4677 5157
Fax (+45) 4677 5199
http://www.risoe.dk/sys/staff/esy/klsk.htm

