General Information

The European Renewable Electricity Certificate Trading Project (RECerT)

Final Technical Report

ENERGIE

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1 EXECUTIVE SUMMARY

1.1 PROJECT OVERVIEW

RECerT, the European Renewable Electricity Certificate Trading project, was conceived early in 1999 by an experienced team of EU energy companies, researchers and consultants, led by ESD Ltd. Its stated objective was to ensure that TGC market development was coordinated, and that information and understanding was shared among key stakeholders in the EU, with the aim of minimising barriers to Tradable Green Certificate (TGC) trade between Member States. The project conception reflected the increasing interest being shown in various EU Member States in the use of tradable economic instruments, coupled to various demand drivers, to incentivise the exploitation of renewable energy resources.

The project was relatively large and ambitious, spanning 18 months and with direct participation from 27 partners in 16 countries. It was given financial support by the European Commission's Fifth Framework Programme for R&D, and began in February 2000. RECerT was primarily aimed at information dissemination and raising awareness of TGC developments, rather than fundamental research, but the project nevertheless contained several research elements.

Key elements of the project included:

- Project initiation and website creation (http://recert.energyprojects.net);
- Structured reviews of renewable energy support policies and the status and prospects for tradable instrument schemes in 15 EU countries and Norway;
- An estimation of the potential future size and value of the TGC market in Europe, under various scenarios;
- A set of controlled experiments exploring TGC market parameters, employing a computer-aided economic simulation;
- The adaptation of an existing manual trading simulation for use in country workshops;
- Day-long workshops held in 15 countries to examine TGC developments to date, with attendance by 550 people in total;
- An international conference on TGC development, sponsored by international companies and provided at no cost to delegates, attracting some 175 delegates from 18 countries;
- A cost benefit analysis of TGC trading compared to other options for supporting renewable energy development;
- The design of a complex Europe-wide TGC trading simulation incorporating some of the elements of actual TGC trading schemes being developed in EU Member States
- Running the TGC trading simulation with over 140 participants from 16 countries through a live, real-time, internet-enabled trading platform, providing feedback to participants and disseminating the results of the work;
- A review of related non-TGC market developments in order to draw lessons for effective TGC market design;
- A final workshop run in collaboration with other 'clustered' TGC projects;
- Information dissemination through publications and conferences

The project core team comprised ESD (UK), KWI (Germany), ECN (Netherlands) and DTU (Denmark). The 23 other project partners comprised electricity companies and consultants from the EU15 countries plus Norway. A single project member, under the overall responsibility of ESD, led each element of the project (work packages and tasks). The project was run in close cooperation with two other Commission-supported projects focusing on renewable energy, ELGREEN and InTraCert, in the so-called green electricity cluster.

1.2 CONTEXT

When the RECerT project was conceived, interest was growing in the use of tradable instruments to incentivise renewables growth. This drew notably on the experience of the Dutch electricity sector in its voluntary ‘Groenlabel’ (Green Label) scheme, designed to facilitate the least-cost achievement of a voluntary target for renewables growth by harnessing a market mechanism.

By the end of the RECerT project in July 2001, the concept of using market mechanisms to fulfil renewable energy quotas or targets had moved into the mainstream of debate on renewable energy policy. Now some seven EU Member States are developing tradable certificate schemes which all conform the same underlying basic structure. This structure comprises three main elements; a tradable instrument representing the renewable energy attribute of physical electricity and conferring property rights to the holder, the creation of demand for certificates through obligations, tax exemptions etc, and the necessary supporting institutional infrastructure and processes.

The acceptance of tradable renewable certificate schemes by these EU countries has fuelled a vigorous debate between proponents of the 'feed law' approach to renewables support, and proponents of tradable certificate schemes. The 'feed law' approach is defended on the basis of demonstrated effectiveness; the tradable certificate approach is defended on the basis of its promise to deliver both effectiveness and economic efficiency.

At this point in time European TGC schemes are in their infancy. They have been developed with insufficient international coordination, and they are highly fragmented. Despite this commercial pressure is already present, driving the trading of TGCs between different jurisdictions. It remains to be seen how quickly the political, practical and legal barriers to trade will be broken down.

Such evolution must also be seen against the background of the EU Renewables Directive, which opens the way for the Commission to review progress against targets in all Member States, and push for greater harmonisation of support schemes within five years. Any full EU-wide harmonisation is likely to be politically difficult, and in any case would not be achieved until around 2010.

1.3 KEY CONCLUSIONS

1.3.1 Projecting the size and value, costs and benefits of an EU-wide TGC market.

The research done by ZEW on total market size and value, costs and benefits indicates clearly that Europe-wide TGC trading has the ability to reduce overall economic cost in the achievement of renewables growth targets, when compared with other policy options such as feed laws. The analyses suggest:

- Assuming that markets are competitive and function correctly, a TGC_{el} system is more cost-efficient and effective in achieving RES-E targets for EU Member States than a feed-in tariff system.
- The net cost savings as well as other benefits of a TGC_{el} system are greatest when a cross-border or EU-wide certificate trading scheme is established, rather than isolated domestic schemes
- Assuming that cross-border trade in TGCs is facilitated, a substantial TGC_{el} market size and cross-border trading volume can be expected under 'high' and 'low' scenario assumptions;
- There seems to be a need for trade if an objective is to exploit renewable resources across Europe in the most economically efficient way;
- The annual rate of growth of renewable resources seems crucial in estimating future TGC_{el} prices, implying that EU and national policies should facilitate the development of renewables, and that obligations should be as flexible as possible to avoid unintended and damaging price effects.
- The interrelationship between CO_2 emissions reduction targets and renewable energy growth targets and needs careful consideration in determining whether individual countries benefit or lose from an international TGC trading regime

- Searching for efficient institutional arrangements that reduce transaction costs and share the risk are a key to the potential success of all renewable support policies, but in particular of the TGC_{el} instrument.
- The higher the liquidity and transparency of the TGC_{el} market, the lower the transaction costs are, and the higher the benefits of a market-based system like the TGC_{el} system.

1.3.2 Experimental simulation of TGC market variables

ECN undertook novel research, collaborating with the University of Amsterdam experimental economics laboratory, to understand better the relationship between some of the basic variables in TGC market design, notably penalty rate, banking and borrowing. Their work suggests:

- A penalty for non-compliance with an obligation should be proportionate. It should be at a level above the expected equilibrium price for TGCs. Below this rate the penalty behaves as a simple tax (penalties are paid but no new renewable capacity is built), and if well above this rate, the penalty risks driving the cost of compliance too high, in the absence of any other flexibility.
- Flexibility for obligated parties and for certificate producers is desirable (through banking and borrowing), but can lead to anomalies if used incorrectly.
- Allowing unlimited banking of certificates could, depending on their cost of holding certificates, cause sellers to 'hoard' in the expectation of higher prices in future, leading to an unsustainable upward pressure on prices and preventing short-term compliance. However limited banking would provide sellers and buyers to adapt to natural variations in TGC production, and should be permitted.
- Borrowing for obligated parties seems to be politically difficult, since, depending on the cost of borrowing, parties might 'put off' compliance indefinitely. However the ability to borrow can produce a downward pressure on prices and is an important element of flexibility that should be permitted.

1.3.3 Live internet-enabled EU-wide TGC trading simulation

ESD led the creation of Europe's first large-scale internet-enabled trading simulation for TGCs. Over 140 participants took the roles of virtual generators (supplying TGCs to the market), virtual consumers (buying TGCs from the market) and virtual traders. The simulation compressed ten years of trading activity into ten short periods, using an internet-based trading platform provided by M-co. The demand-side parameters reflected some of the complexity emerging in domestic TGC scheme design, with demand differentiated by penalty rate, size of obligation, technology exclusions, banking and validity period. On the supply-side participants invested in new capacity all over the EU, in a variety of technologies, based on an economic model and constrained by rate of investment and speed of build.

Beyond the considerable 'learning by doing' value for participants, broader conclusions are suggested by this work:

- The significant political, practical and legal barriers to free trade in TGCs across the EU, before harmonisation of renewables support mechanisms is achieved, will result in low liquidity, poor information and relatively high uncertainty for participants. Trading will be 'over-the-counter' (OTC) and brokered, and will have high transaction costs. A 'real world' version of the internet enabled trading platform seen in RECerT-sim can only achieve its full value in reducing transaction costs, simplifying price finding and meeting policy objectives when legal harmonisation of domestic TGC schemes is achieved.
- A 'European TGC Gold Standard' certificate, comprising a 'basket' of appropriate vintage, technology, resource, origin etc., would act as a reference product and encourage the emergence of a liquid market, easy price finding and the evolution of derivatives.
- RECerT-sim penalties, because the market was 'short', acted effectively as rigid price caps, leading to high profits for generators and suppressing the ability of demand-side players to react to price signals. Care therefore needs to be taken in future market design to permit elasticity of demand. Means to be considered would include defining compliance penalties in non-financial terms, recycling penalty payments to obligated parties in proportion to their compliance, imposing penalties on a sliding scale depending on the degree of compliance of the obligated party, the use of banking

and borrowing, permitting the fungibility of TGCs with other related environmental instruments, and the use of taxation rather than obligation as a demand driver.

1.3.4 Overall

The next few years will be a period of intense learning for all Member States which have embarked on the development of tradable certificate schemes to support renewables growth. With hindsight it is easy to see that these individual developments would have greater ability to succeed and achieve cost-effective renewables growth if they had been closely coordinated and cohesive, part of an EU-wide framework designed to permit a single market in TGCs across the whole EU.

The value of TGC schemes will only be proven once renewable energy schemes are built in large numbers, and countries show signs of meeting their individual renewables growth targets. To do that, renewables developers and financiers must be able to operate in a transparent, secure, fairly regulated market, which minimises risk, permits price finding and enables the estimation of future value.

At this early stage, when no European scheme has yet passed through a single compliance period, it is not possible to predict the medium-term success of these schemes. The RECerT project has researched some of the fundamental building blocks of tradable certificate schemes, and exposed a large number of stakeholders across Europe to the issues inherent in these developments.

The challenge now for policy makers and regulators is to build on what has been done to date and to work to achieve the full potential of tradable instrument markets. The integration of national schemes should be facilitated, leading to the emergence, ultimately, of a single EU-wide market for the attributes of renewable energy. Only in this way will the ultimate efficiency and effectiveness benefits of tradable certificates be realised. Certificate trading schemes must be seen in the wider context of the goal of an EU-wide single, liberalised market for energy, and they can then play their full part in helping Europe to meet its challenging White Paper targets for renewables growth.

CONTENTS

List of figures and tables

2 INTRODUCTION

The RECerT project was conceived in early 1999, following on a preceding project, 'REALM[1]', also part-funded by the European Commission, which had drawn distinct conclusions about the value of a system of tradable instruments being used to maximise economic efficiency in the deployment of renewable energy in Europe.

At the time the RECerT project was proposed, there was the beginning of wider interest in the use of such tradable instruments, largely following on the pioneering approach taken by the Dutch electricity sector in its voluntary 'Groenlabel' (Green Label) scheme. The Green Label scheme was designed to allow the achievement of a renewable energy growth target for the whole of the Netherlands, whilst recognising that certain regions were more or less endowed with renewable energy resources. 'Green Labels' were awarded to generators, and sold to distribution companies who had adopted a voluntary target for renewables growth. The objective of the system was to permit the achievement of the voluntary targets at least economic cost, to spread the cost of the obligation among all distribution companies, to reward renewable generation regardless of where it is physically located, and to use market principles to achieve this.

By the end of the RECerT project in July 2001, the concept of using market mechanisms to fulfil renewable energy quotas or targets had moved decisively from a minority and research interest to the mainstream of debate on renewable energy policy in the EU. Now some seven EU Member States are in the process of developing tradable certificate schemes which all conform the same underlying basic structure.

This structure comprises three main elements:

- ***A tradable instrument***. In the RECerT project the phrase 'Tradable Green Certificate' (TGC) has been used, but there are many others. The key characteristic of the TGC in each case is the separation of physical energy flow from certificates, enabling certificates to be created, traded and consumed in isolation from electricity.
- ***The creation of demand for certificates***. The dominant model is that of a legal obligation placed on specific electricity sector participants (for example electricity retailers), to purchase a certain percentage of total electricity from specified. An alternative is the exemption of renewable electricity from an energy tax.
- ***Supporting institutional infrastructure and processes***. The key to the success of certificate schemes is confidence on the part of market participants. In turn this depends on clear rules, long-term demand, a mechanism to ensure the 'quality' of certificates, and oversight and control by government. The crucial processes are the issue of certificates to specific renewable energy generators on the basis of measured electricity output, and the 'redemption' (or 'acquittal') of the certificates against the obligation or other demand driver.

The acceptance of tradable renewable certificate schemes by so many EU countries has fuelled an impassioned debate between proponents of the 'feed law' approach to renewables support seen most clearly in Germany, Spain and until recently Denmark, and proponents of tradable certificate schemes. The 'feed law' approach provides a fixed level of subsidy to all qualifying renewable energy generation schemes, typically set at a level that provides a strong incentive for new developments through the level of profit that can be achieved.

[1] REALM, 'Renewable Electricity and Liberalised Markets', part-funded by DG Research

Feed-laws	***Tradable certificates***
Proponents of feed law schemes generally defend this approach on the basis of their unquestionable effectiveness. The rate of growth of windpower under a feedlaw system in Germany has been the highest of any country in Europe. Developers and financiers benefit from the relative simplicity and clarity of the system. Detractors point out that the costs of the system are very high, providing an unnecessarily high level of profit for some renewable developers. Distortions in competition in the electricity market can also be seen, for example where new renewable generation occurs mainly in one region, placing an inequitably greater burden on local electricity consumers.	Proponents of tradable certificate schemes defend this approach on the basis of economic efficiency. They argue that by creating a competitive market in certificates, a downward pressure is exerted on the price of renewable generation. Renewable generation should thus be developed according to a hierarchy of cost, meaning that the most economic resources (highest windspeed areas etc) will be developed first, and that the reduced overall cost of renewable generation is spread more fairly among consumers. Detractors point out that the systems are largely untried to date, and that new renewable generation will face uncertainty over revenues, and will therefore be more difficult to finance.

Neither type of scheme guarantees the rapid development of renewables. The relative success or otherwise of all schemes must be seen in the context of particular national and regional social and environmental conditions. There are many fundamental issues in renewables development that must be tackled to release a fast growth of renewables. Not least these include social and local environmental impact, pressure on land area and amenity, planning, the distribution of economic burden, and the relationship with physical electricity markets.

Given the rapidly growing interest in tradable certificate schemes, the RECerT project was conceived basically as an information and promotion project. It was designed to raise awareness of tradable certificate schemes in all the EU15 plus Norway, to feed the debate with timely and focused research, and to provide a 'hands-on' experience of how TGC markets could operate.

It is clearly possible for individual Member States to devise tradable obligations for renewable energy, subject to these being acceptable from a competition and state aid perspective. However the wider context for interest in tradable certificate schemes is the on-going liberalisation of the energy sector in the EU, and the expectation of the achievement of a true single market in energy. The economic and political logic of these goals is now accepted, with notable exceptions, following lengthy debate.

It follows that the objectives of an emergent support mechanism for renewables must be tied to those of a single European market for energy. Specifically the mechanism must embrace competition, trading, the free movement of goods, third party access to networks, and consumer choice.

Thus the RECerT project took as its reference point the longer-term goal of creating unified EU-wide certificate trading that brings the benefits of competition, trading, economic efficiency and fair burden distribution to all countries in the EU, and perhaps beyond. This approach assumes that the overall interests of the Union are best served if renewables development conforms to a hierarchy of economic cost and resource availability. This approach does not dismiss the challenge of integrating renewables into local social and energy planning, but rather these issues become a few of the many factors influencing where renewables will be developed preferentially in the EU. Others include the quality of resource, the local economic value of electricity, and the availability of expertise and technology.

It has become clear during the project that there is a pressing need to move the debate on to EU integration of renewables support. This debate has so far been held principally in the context of the EU Directive on renewables, finally adopted in September 2001. Whilst the evident environmental and other benefits of renewable energy promotion are accepted, it seems that Member States are unwilling to embrace the principles of the single market in this area, at least in the short term.

At the end of the RECerT project, we observe the slow development of a number of renewable tradable certificate schemes among some EU Member States, in which the detailed policy and mechanism design tends to divide them more than it unifies them. In the main, Member States have found themselves in a relatively exposed position through their adoption of tradable certificate schemes, requiring them to put barriers in place to prevent certificates being exported or imported. Thus the benefits of EU-wide trading are lost, at least in the short term, and the enormous mobilisation of capital and change in attitude necessary to achieve the EU's indicative renewables growth target looks that bit more difficult.

One development standing against this trend is the RECS (Renewable Energy Certificate System) project. This industry-led, independent initiative (see www.recs.org) has succeeded in developing a practical and robust system to permit certificates to be created, traded and consumed. However the test phase of the project depends on the existence of voluntary green consumers to redeem the certificates to, and this market has very limited size and uncertain growth prospects in any EU country. Ironically, the prospects for voluntary green markets are actually damaged by the existence of obligation schemes.

Over the next few years the challenge for EU-level and national policymakers will be to harness the commercial forces in the electricity sector and to permit differences in certificate value between different schemes to drive trading. This should lead naturally to the negotiation of reciprocity arrangements between Member States, finally leading to something close to a unified approach to certificate trading in the EU.

While these policy-level questions are debated, and while the idea is developed of using source certificates in general (certificates proving the origin of electricity, be it renewables, CHP, nuclear or fossil) to enhance consumer choice, the single most important question remains unanswered. Will tradable certificate schemes succeed in causing new renewable energy generation to be built rapidly, and on a scale that will deliver the challenging renewables growth targets set out in the renewables White Paper?

3 OBJECTIVES, TEAM AND PROJECT STRUCTURE

3.1 SUMMARY OF OBJECTIVES

The overarching objective of the project was:

- To ensure that REC market development is coordinated, and that information and understanding is shared among key stakeholders in the EU, with the aim of minimising barriers to REC trade between Member States.

The sub-objectives were:

1 to review REC developments in all participating Member States, to review analogous but non-TGC trade developments which can improve understanding of the new TGC markets, and to review the costs and benefits of purchasing renewable energy benefits through TGCs;

2 to adapt existing industry simulation tools to create exciting market simulation games which will be used by key stakeholders to help them understand the basic principles of TGC trade and market design;

3 to run an international conference to present the reviews and the project outputs, to expose key stakeholders to relevant international experiences and developments;

4 to run a series of national workshops to explore TGC trading issues on a country-by-country basis, and at which the market simulation games will engage key stakeholders in an interactive exploration of key issues in REC trade;

5 to run a web-based, hands-on, EU-wide 'live' simulated trading exercise, involving a wide range of stakeholders from all participating Member States, plus any other stakeholders who become involved during the project progress, to help them understand how such trade could develop, and reinforce the European integration potential of TGC trade;

6 to build-in to the work programme a continuous process of disseminating information and understanding to these key stakeholders and to a wider audience, using a dedicated project web site which is the focus for the publication of results and inviting the participation of stakeholders in the discussions and exercises.

3.2 PROJECT TEAM

RECerT was a project with a wide geographic spread, (EU Member States plus Norway), involving some 27 partner companies. The RECerT project team collectively presented a mixture of skills and knowledge in the area of tradable environmental instruments. The concept of the team was a combination of commercial electricity sector partner with a local consultant partner in each country, complemented by a core team of principal partners who were research and consultancy specialists with prior experience in the field of tradable environmental instruments and European renewable energy policy. The electricity sector partners provided a practical, commercial understanding of the electricity sector in each partner country, while the consultant partners provided local knowledge of renewable energy policy and practice. Not all partner countries had the same combination of electricity sector partner and consultant partner.

The principal partners and many of the consultant and industrial partners had worked together on previous projects, although not in this precise group.

Partner	Responsibilities
ESD	Overall project management, leadership of the RECerT-sim
ECN (Netherlands), ZEW (Germany), DTU (Denmark), KEMA (Netherlands), University of Amsterdam (Netherlands)	Project principal partners, responsible for leadership of research, simulation and dissemination work packages
Norsk Hydro, Electrabel, Elkraft System, HEW, Birka Energi, VEOe, ESB, Fortum, NUON	Electricity 'utility' partners, hosts for country workshops and provision of expert advice and opinion.
PwC (Norway), 3E (Belgium), Kan Energi (Sweden), Observ'ER (France), Heliostat (Greece), Eirtricity (Ireland), SERVEN (Italy), TEE (Portugal), KWI (Austria), E&E (Luxembourg), University of Madrid (Spain).	Consultant partners, responsible for data gathering, arrangement of in-country workshops and expert advice and opinion
M-co Europe	Acting as a sub-contractor to ESD. Specialist market company, responsible for provision of the RECerT-sim internet trading platform

3.3 PROJECT STRUCTURE

The project was built on the foundation of a review phase, followed by an experimental simulation phase, which gave rise to information and reports that were disseminated through the first in-country workshops. The project then entered the period of preparation of the live internet-based simulation, during which time the international workshop was held and the second round of country workshops. The web-based trading simulation was completed, leading to the final workshop, reporting and information dissemination. This is summarised in the following diagram:

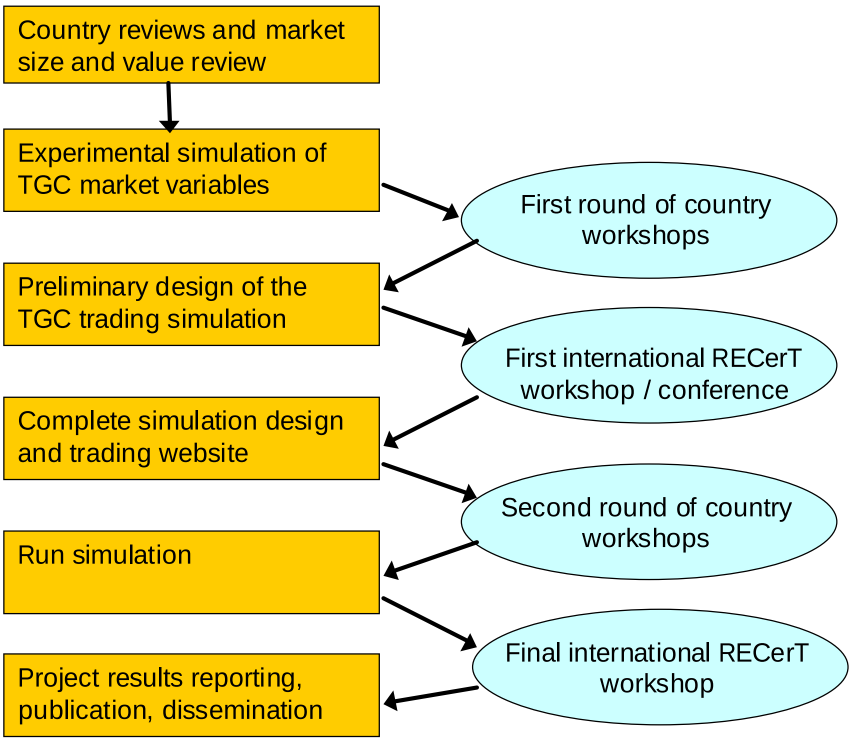


Figure 1: Project structure

3.4 WORK PACKAGES

The project is constructed around seven work packages. In most cases work packages contained a number of linked tasks. Each task was under the control of a single project partner, with overall control by ESD. Individual work packages have not necessarily been separately reported during the project. Rather, individual tasks have been reported, where agreed, and the overall progress of the project has been reported through the six monthly progress reports.

Work package No	Work package title	Deliverable No.
1	Project initiation and baseline reviews	3, 5, 6, 8
2	Simulation game preparation, testing and implementation	24
3	Cost benefit analysis	10
4	First dissemination workshops	11
5	Second dissemination workshops and simulated EU trading	14, 15, 4, 25
6	Final central workshop and information dissemination	17
7	Project and information management and reporting	1, 18, 19, 20, 21, 22, 23

Table 1: Work package list

Deliv. No.	Deliverable title	delivery date (month)	Dissemination level
1	Kick-off meeting minutes (Task 1.1)	2	CO
22	Six month report	6	CO
3	15 country reviews (Task 1.2)	6	PU
5	REC market report for contact break-point decision (Task 1.4)	6	CO
6	Country review synthesis report (Task 1.2)	6	PU
11	1st round country workshops consolidated report (Task 4.4)	6	PU
24	TGC Economic simulation report (Task 2.4)	6	PU
23	Twelve month report (mid-term report)	12	CO
25	Draft RECerT-sim design document (Task 5.1)	12	CO
8	International conference proceedings (Task 1.6)	12	PU
14	2nd round country workshops consolidated report (Task 5.4)	18	PU
15	Simulated web-based trading report (Task 5.8)	18	PU
17	Final workshop presentations (Task 6.4)	18	PU
4	Non-REC related developments report (Task 5.9)	18	CO
10	Cost-benefit analysis report (WP3)	18	PU
18	Draft final project report	18	CO
19	Draft final publishable report	18	CO
26	Updated country review synthesis report (Task 1.2)	18	PU
20	Final project report	20	CO
21	Final publishable report	20	PU

Table 2: List of deliverables[2]

[2] Note that deliverable numbers 2, 7, 9, 12, 13 and 16 are deliberately left blank.

Deliverable No	Month Due	Report	Associated deliverables
1	2	Kick-off meeting minutes	-
22	6	First six month report.	3, 5, 11, 24
23	12	Second six-month report	25, 8
18	18	Draft final project report	4, 14, 15, 17, 26, 10
20	20	Final project report	-
19	18	Draft publishable final report	-
21	20	Publishable final report	-

Table 3: Periodic Reports

A consolidated list of all outputs of the project is included in annex 1.

3.5 PROJECT PLAN

The project timetable is summarised in the Gantt chart on the following page:

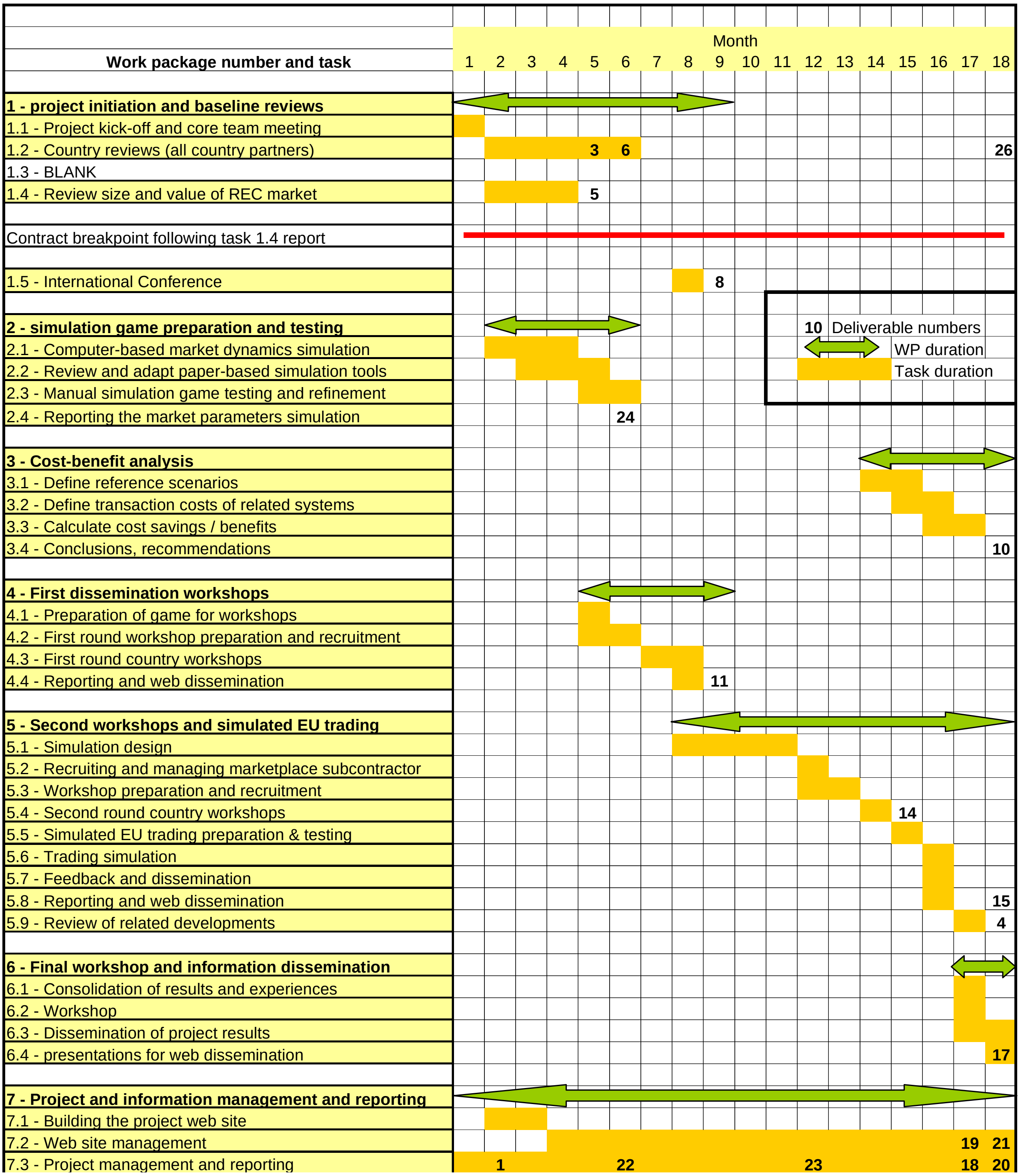


Figure 2: Project gantt chart

3.6 WORK PACKAGE DESCRIPTIONS

3.6.1 Work package 1 - project initiation and review

3.6.1.1 Objectives

To establish the project and the information baselines. To explain and discuss the interactions with the other clustered projects (InTraCert and ELGREEN) and the associated industry initiative the 'RECS Group'. To undertake a number of reviews to understand the 'baseline' situation in each country, and to identify the potential stakeholders and a potential institutional framework that could support the issuing, trade and redemption of certificates in each country. The purpose of the first international meeting at the end of phase one is to present the conclusions of these various reviews, and the degree of interest in certificate trading, to the whole project team. This will give an overview of where certificate trading is developing most quickly. This first meeting will present and discuss the idea of trading across European borders, and will explain the purpose of the simulated trading activities which come later in the project.

3.6.1.2 Description of tasks

Task 1.1: project initiation and kick-off (leader ESD). contract negotiation, work plan review, kick-off meeting etc

Task 1.2 : Country reviews (leader DTU). Each participating country partner reviews and reports the present state of development of renewable energy certificate trading. This task will be closely coordinated with the needs of InTraCert and ELGREEN. The RECERT country review tasks will replace the equivalent tasks of these two projects to a large extent. The list of requirements and information template will be created in cooperation with these projects. The first country review will be produced in time for the first round of country workshops. The reviews will be subsequently be repeated, but in much less detail, in order to update the reviews in time to disseminate at the end of the project.

Task 1.3: This task deliberately left blank

Task 1.4: Review of size and value of REC market (leader ZEW). The T1.4 report will form the basis of the Commission's break-point review, to determine whether the RECerT project should continue. This task is dedicated to investigating the potential size and importance of a green certificate market. ZEW will produce a task report that will draw on the information contained in T1.2, plus other specific investigation. Discussions will be held with the RECS group, with the international brokers who are beginning to offer services in trading TGCs, and with potential providers of TGC exchange services. In addition ESD will assist with this task. The task will not be limited to the question of whether a market for TGCs currently exists. Rather, it will take a medium and long-term view, and determine whether, and how, such a market is likely to grow. In the T1.4 report, we will also make estimates of the likely monetary value of such a market. Other issues, such as the type of policy action required to stimulate such a market, will be left to other clustered projects to answer. Furthermore, this task will be coordinated carefully with the Commission, in order that the central questions are answered to enable the Commission to decide whether to proceed with the project.

Task 1.5: International workshop / conference (leader ESD). This brings all partners together to present the conclusions of the various reviews, the degree of interest in certificate trading, and an overview of where certificate trading is developing most quickly in Europe. The conference will also discuss the status and concept of trading TGCs across European borders, and will present and explain the purpose of the simulated trading activities, which come later in the RECerT project. The event will be coordinated with the other clustered projects. The three clustered projects will work closely together to design a programme for this workshop / conference that brings the maximum benefit to all European Green Certificate stakeholders. A platform will be provided for the RECS group to report progress. The main intentions of the RECerT international workshop will remain. Discussions will be held with the leaders of the other clustered projects to seek ways of coordinating the events to maximise effectiveness and minimise costs. It may also be appropriate to seek industrial sponsorship. The event will take place in October 2000, in Brussels.

Task 1.6: Reporting international workshop / conference (leader ESD)

3.6.2 Work package 2 - simulation game preparation, testing and implementation

3.6.2.1 Objectives

To take existing tools developed by electricity sector project partners, and adapt these to provide:

- a computer-based economic simulation to test the effect of parameters such as certificate validity, banking, borrowing, technology exclusions etc, and how these impact on equilibrium price, liquidity etc.
- a paper-based, hands-on, interactive learning aid for use in country workshops.

The economic modelling / simulation will help all future REC market users, and to give clarity to all project participants on how an EU-wide REC market should be structured, and to identify areas of weakness or developments which could be barriers to future EU-wide trading. The industry-driven RECS process continues with its mission of proving the basic validity of international trade by undertaking a limited-scope feasibility study and operational trial. However, there is great value in undertaking a more deliberate simulation of REC market design parameters, especially since future REC markets in Europe are likely to evolve and change over time. This is especially important considering the wider, longer-term aspects of tradable instruments being investigated by ECN through the InTraCert project.

3.6.2.2 Description of tasks

Work package two focuses on two relatively small-scale simulations. The first is an economic simulation based in the University of Amsterdam, based on students using networked computers. The second is a much simpler paper-based trading simulation (game) that is used in the first round of country workshops.

Task 2.1: Computer-based simulation of TGC parameters and market dynamics (leader ECN) The simulation game will be designed and its processes and objectives fixed. It will seek to illustrate key REC market design issues such as the role of issuing bodies, issues of liquidity, expiry and redemption of certificates, banking and borrowing. The computer-based simulation will be run in the experimental economics laboratory at the University of Amsterdam, using a number of networked PCs linked to a central economic model that replicates the behaviour of the whole market. Different 'runs' will be made and reported, and the results interpreted in a stand-alone report on the simulation. One of the purposes of this simulation is to feed-in to the design of the more ambitious internet-based trading simulation in WP5.

Task 2.2: Review and adapt existing manual market simulation tools (leader ECN). Existing manual (paper-based) market simulation tools currently used by KEMA will be reviewed and adapted to suit the workshops. ECN will work closely with KEMA to develop the successful Dutch ‘Groenlabel’ paper-based simulation into a standard format that can be used in the first round country workshops.

Task 2.3 manual simulation game testing and refinement. Ensuring that the simulation game works effectively in a workshop environment.

Task 2.4 Reporting of the results of the computer-based simulation of TGC market parameters (leader ECN) feeding back information from the simulation that will contribute to the design phase of the internet-based simulation.

3.6.3 Work package 3 – cost benefit analysis

3.6.3.1 Objectives

To help all key stakeholders to understand the basic costs and benefits of REC trading, and coordinated REC development across Europe, in terms of business and transaction costs. However the ELGREEN project aims to cover some of the same ground, especially in ELGREEN WP1 and WP2. Therefore ZEW will carry out this WP in close cooperation with ELGREEN. It should also be noted that the conclusions of

WP3 will be of direct interest and value to both the InTraCert project and to RECS. WP3 will build on the foundation of task 1.4.

3.6.3.2 Description of work

Task 3.1: Defining reference scenario (leader ZEW) - building on the reviews in WP1, defining the baseline for comparison with REC trade. ZEW will draw heavily on the work of ELGREEN and also the work of the "Implications of Tradable Green Certificates on the Deployment of Renewable Electricity" (this Altener-funded project will be complete by the time RECerT starts), and the "REALM" project, to define the reference scenarios.

Task 3.2: Define transaction costs of related systems (leader ZEW). Using the output from WP1, defining the costs and business processes in other ways of trading renewable energy. ZEW will cooperate closely with the ELGREEN team on this task.

Task 3.3: Calculate cost savings/ benefits (leader ZEW) Compared to 'competing' systems. These cost savings and other benefits will need to be measured against an appropriate baseline, which reflects the future growth of renewables generation in the EU. Again this task will be completed in close cooperation with the ELGREEN team.

Task 3.4: Conclusions and recommendations (leader ZEW). Preparing output ready for dissemination through the WWW site and other means. The WP3 report will be both a high-level economic analysis as well as a business-oriented analysis of the costs and benefits of using a REC trading system for all potential system users.

3.6.4 Work package 4 – first dissemination workshops

3.6.4.1 Objectives

The first round of country workshops will be a chance for stakeholders in each country to undertake a mock trading exercise based on national trading of certificates, to uncover some of the basic issues around certificate trading. These issues are principally the matching of supply and demand in an environment of unequal cost of production and purchase budgets.

These workshops will also be a chance to discuss in more detail the institutional framework for certificate trading in that country (i.e. issuing bodies, industry self-regulation, the role of government, the role of certificate exchange / brokering, how certificates are redeemed, the influence of national fiscal arrangements etc). Since these issues are mainly national in character, these workshops have a basically national focus.

One of the most important opportunities offered by WP4 is the chance to integrate the purpose of the dissemination workshops into the aims of the RECS group. By the time the dissemination workshops take place, the work of the RECS group will be more advanced, and it will be possible to illustrate the benefits of REC trade by reference to examples from within the RECS group. Furthermore the direct experience of some of the European leaders in REC markets (notably Denmark, the Netherlands, Belgium and the UK) can be offered through the workshops.

The RECerT proposal was submitted in June 1999. Developments in TGCs are moving very fast, and it should also be noted that in the period leading up to the first workshops, it is likely that the number of countries actively involved in the RECS process will have grown. For these countries the nature of the workshops will probably need to be altered, to meet their needs. It is too early to say which those countries will be, or what their precise needs will be, at this stage.

Another very important aspect of the workshops is raising awareness of the possibilities of certificate trading and the commercial and policy issues around these schemes, at both national and international levels.

3.6.4.2 Description of work

Task 4.1: Preparation of game for workshop (leader ECN). Final testing of the game, including 'dry-running' the national simulations and designing the presentations.

Task 4.2: First round of country workshops – preparation and recruitment (leader ESD). Ensuring that a wide range of key stakeholders are present, using local contacts and web site resources. ESD's close involvement with the RECS process will ensure close coordination between the two events. Central to this task will be the need to design the workshop contents carefully for each country, to meet a variety of different needs, depending on the state of development of REC markets, and other variables. ESD will carry out the design of the country workshops in close consultation with the country partners, to ensure that a wide range of key stakeholders are present.

Task 4.3: First round of country workshops (leader ECN) Workshops are run in each participating Member State to demonstrate the principles of REC trading, to disseminate information on the key institutional framework which needs to be created to allow REC trading, and to determine the questions and key country issues which workshop participants have. REC trading will be demonstrated using the simulation tool, within the workshop. ECN will work closely with ESD in running the workshops. A platform will be provided for the RECS group to raise awareness of its activity.

Task 4.4 - Reporting the first round country workshops (leader ESD). The first round country workshops report will be stand-alone, and included in the first six-month reporting. Workshop participant lists and presentations will be placed on the project website

3.6.5 Work package 5 – second workshops and simulated EU trading

Work package five was the largest individual work package, containing several very large, linked tasks.

3.6.5.1 Objectives

The second round of country workshops will introduce the use of simulated trading in the international arena. The workshops will introduce the international internet-based trading simulation.

The live, internet-based trading simulation will be open to up-to 150 participants, which means that all RECerT project partners have the chance to take part in the simulation and many more stakeholders in addition. The design of the live trading will be based largely on the experience of the 'GETS2' Greenhouse gas and electricity trading exercise run by PwC and Paris Bourse under sub-contract to Eurelectric. The trading will take place in five sessions each simulating two years, thus covering 10 years trading in total. Buy and sell offers will be 'posted' on the specially designed web site, and deals will be struck automatically. The day's trading will be reported and explained through the project web site. This will be an exciting, live experience of what certificate trading could be in the future.

The purpose of the simulated international trade is to provide potential users with 'hands-on' experience of how they could use such a system in future, what kind of features a system would need to have to properly service the needs of users, and how to mitigate risk by the use of forward trading.

The purpose of the review of related developments is to put the results of the simulated trading into a wider context, specifically the lessons of trading in environmental derivatives such as carbon emissions, sulphur emissions and recycling credits, to observe similarities and differences and lessons from trading in other instruments that could be applied to TGCs.

There is potential to integrate WP5 with the existing RECS process, ESD will coordinate with the RECS Group to ensure this potential is realised if appropriate.

3.6.5.2 Description of work

Task 5.1: Simulation design (leader ESD supported by OMEE) - OMEE's expertise in running environmental markets will be used to help design the simulation as a whole, starting with the existing conditions that are seen in the TGC schemes being adopted by different Member States (in terms of parameters such as certificate validity, penalty rate, banking and borrowing. From this starting point the structure of the simulation is built, in terms of the number of allowable participants, the design of the demand and supply side, the number of years to be simulated, the number of hours for each year trading etc. The design process needs to take account of the experience gained by the ECN / UoA economic simulation, and to define how the European supply and demand for renewable energy will be modelled. It is important to have a good interface with the RECS group process, since many RECS group members are likely to be participants in the simulation. The extent of the collaboration between RECerT and RECS will depend on the progress made by RECS, particularly the success of the limited-scale operational trial. Note also that the design document will specify success criteria by which the success of the simulation may be measured.

Task 5.2: Recruiting and managing a marketplace sub-contractor (leader ESD) - ESD will seek a sub-contractor who is able to provide a high-quality, proven, web-based trading environment that can be rapidly adapted to suit the needs of the RECerT simulation. The sub-contractor must be able to both provide the system and support and maintain it during the simulation process, and support the design of the simulation as specified in the design document.

Task 5.3: Workshop preparation and recruitment (leader ESD)- Key stakeholders will be invited to attend the second round of country workshops to learn about the running of the simulation..

Task 5.4: Second round country workshops (leader ESD)– The workshops will be based around a detailed explanation of the structure and rules of the simulation, and further explore national issues. Furthermore presentations will be made directly to RECS group members during regular RECS group meetings in order to recruit them to the simulation.

Task 5.5: Simulated EU trading preparation and testing – (leader ESD) Final preparation of the simulation game. This task will take the RECerT-sim design document and use it to build the simulation website, support website and associated functions. ESD will take responsibility for overseeing the trading site sub-contractor as they build the site. The data flows between the RECerT-sim support website and the trading site will be de-bugged. It will be crucial to involve the RECS group in this preparation, in order to reflect the latest stage of development of the RECS feasibility study and operational trial. The management team, led by ESD, will ensure that the web trading tool is fully tested before use.

Task 5.6: Trading simulation (ESD) The simulated trading will be designed to run over a one month period. The decisions over how to run this will depend on user's needs. Where appropriate, these will be canvassed directly.

Task 5.7: Feedback and dissemination (leader ESD) The results of the simulation at the end of each trading period will be analysed and fed back to participants through regular communications and on the RECerT-sim support website.

Task 5.8: Reporting and web dissemination (leader ESD). The results and conclusions of the web trading will be presented widely, and prepared for presentation through paper media, conferences and web sites. These results and conclusions will include an analysis of the benefit of such a system to all users, and recommendations for how such a future international system could be optimised, based on the experience of the simulation. Furthermore a separate publishable summary report of the simulated trading will be produced and disseminated through the website.

Task 5.9: Review of related developments (ESD). REC trading focuses on renewable energy, but has precedents in many other international technical areas, such as power exchanges, packaging certificates, sulphur and carbon credits, financial derivatives, etc. These will be reviewed in order to give insight into the future parameters and operation of a REC market. This task overlaps with the InTraCert project especially in the work proposed on carbon and sulphur. Thus the RECerT project will obtain this information and analysis from InTraCert team rather than carry out original research. ESD will also ensure close cooperation with the RECS process.

3.6.6 Work package 6 – final workshop and information dissemination

3.6.6.1 Objectives

The final workshop will bring together all RECerT partners together with the project teams from ELGREEN and InTraCert to evaluate and report on the results and knowledge of the project to the European Commission.

It is premature to suggest what the final results and recommendations of the project will be, in terms of the practicality and desirability of creating an international REC trading system. Furthermore other key 'external' influences may have changed by this point in the work programme, notably national and EU-level legislation or initiatives to promote REC trade, or promote other ways of achieving an EU-wide renewables market.

3.6.6.2 Description of work

Task 6.1: Consolidation of results and experiences –(leader ESD) All participants will prepare specific inputs to the workshop, based on the various activities that have taken place, and the individual conclusions.

Task 6.2: Workshop –(leader ESD) We intend that this will be held on the premises of the Commission, and will work through the highlights and lessons learned from all three clustered projects. From RECerT the specific focus will be on the results of the RECerT-simulation. Attendance at the workshop will be invited from all RECerT project partners and all RECerT-simulation participants, a total of over 190 organisations.

Task 6.3: Dissemination of project results (leader ESD) Project results from RECerT will be disseminated through a variety of means. One of the most crucial will be the project support website, where public domain documents will be posted, along with links to partner projects. In addition the project team will prepare articles for publication that will go to influential journals that are likely to reach a relevant audience of TGC stakeholders.

Task 6.4: Presentations from the workshop (leader ESD) The presentations at the final project workshop will be posted on the RECerT support website

3.6.7 Work package 7 – project and information management and reporting

3.6.7.1 Objectives

To ensure that dissemination is placed at the heart of the project process, to use project resources prudently and efficiently, and to ensure achievement of deliverables and project benefits.

3.6.7.2 Description of work

Task 7.1: Building the project support web site (leader ESD) - this will be constructed and linked to ensure the maximum usability and impact. The project website will be a repository of all information, communication records, report drafts etc, for the project team. In this capacity it will be one of the major project management tools available to the project manager and partners. It will also be the primary source of publicly available information coming from the project. In this capacity it will be one of the major dissemination tools available to the project. This website will also become the principal resource for supporting the internet trading simulation.

Task 7.2: web site management - this will last for the duration of the project and ensure that the web site is maintained, and problems are fixed as they arise. It will also enable the collection of statistics from the site, such as the number and origin of visitors to the site.

Task 7.3: Project management and reporting - this will ensure that the project adheres to the overall plan, ensure that all necessary reports are produced, and the project process, and that the consortium, Commission and the public are aware of progress and outputs. There is potential to produce integrated reports covering aspects of the RECerT project and the clustered projects.

Task 7.4: Liaison with parallel projects - It will be very important for the final success of RECerT to ensure that activities are coordinated with other parallel projects. These principally include the other cluster projects ELGREEN and InTraCert, but also the RECS group. The RECerT project manager will attend RECS group regular meetings to present reports on RECerT progress and request comments / suggestions for RECerT.

4 SUMMARY OF RESULTS - WORK PACKAGE ONE

Work package one comprised project initiation and review, and contained five separate tasks:

- Task 1.1: project initiation and kick-off (leader ESD).
- Task 1.2 : Country reviews (leader DTU).
- Task 1.3: [This task deliberately left blank]
- Task 1.4: Review of size and value of REC market (leader ZEW).
- Task 1.5: International workshop / conference (leader ESD).
- Task 1.6: Reporting international workshop / conference (leader ESD)

4.1 TASK 1.2 : COUNTRY REVIEWS

The purpose of task 1.2 was to produce an accurate overview of the state of development of tradable certificate schemes across all EU Member States, plus Norway, to inform TGC stakeholders and increase the opportunities for coordination in policy development and international trading.

During the life of the RECerT project, TGC schemes were undergoing a rapid development. For this reason Task 1.2 was split into two parts. The first part entailed the detailed collection of data and creation of a report in time for the first round of in-country workshops. Workshop participants reported that the summary of EU-wide developments was a valuable component of the workshop contents. The second part entailed an up-date of the report in time for the end of the project, reflecting the fact that information rapidly goes out of date in this area. Both reports were made available on the project website. The summary provided here is based on the updated report, prepared in time for the end of the project.

4.1.1 Summary

Results are presented for the coverage by Renewable Energy Sources (RES) in each country with a focus on electricity produced by RES (RES-E). The results are presented with and without inclusion of large hydro. Overall, by far the largest contributions are due to large hydro, except in those countries with no potential for this type of energy (e.g. Denmark and the Netherlands). The RES contribution in these countries is mainly based on wind power and energy from biomass.

The country reports illustrate the existence of a considerable spread in the opening of electricity markets among the investigated countries. Some EU Member States are lagging behind the opening stipulated by the EU directive, while other countries already have a 100% opening of their market. It is expected, however, that within the next five years or so most of the countries will have established full market opening.

Most countries have only indicative RES and RES-E targets and only a vague (or no) action plan for RES and RES-E.

The promotional schemes for RES-E vary significantly between the investigated countries. Thus, seven countries rely on some version of the feed-in model, while another seven countries are in the process of introducing different versions of green certificate trading in combination with different versions of green quota. The remaining two countries apply tender systems or green pricing.

The experience with feed-in models (e.g. in Denmark, Germany and Spain) has documented a high degree of effectiveness in promoting RES-E. A controversy concerning a possible conflict with EU rules for State Aid has been resolved by the EU Court in March 2001. The Court has ruled that the German feed-in model is acceptable within the framework of the EU rules.

It has been discussed whether the green certificate model with obligatory quota or the feed-in model are most in conformity with a liberalised market environment. The team from the Technical University of Denmark, which was responsible for this work package, sees no clear answer on this question. The certificate model with quota in practice fixes the quantity of green electricity and leaves the price determination to the market. In contrast, the feed-in model fixes the price and leaves the quantity of green electricity to the market.

The seven countries that are involved in the development of TGCs are following different routes, especially as concerns the combination with quotas for the coverage by green electricity. Some countries aim at obligatory consumer quota (e.g. Denmark), other countries prefer a quota at the level of electricity retailers (e.g. the UK), while the Netherlands so far prefer voluntary negotiated quota, albeit with the possibility for the government to switch to obligatory green quota.

There is no consensus so far concerning the definition of “green electricity”. Thus, the question whether large hydro and waste (and even nuclear power) should be included is still up for discussion. These and other questions will have to be solved before a large volume of international trade is to be expected.

A number of countries presently relying on feed-in models, tender models or green pricing are considering switching to TGC. However, it should also be noted that France has recently decided to introduce a feed-in model, so the overall future development is uncertain at this time. It should not be overlooked that there is opposition to the switch to TGC in several countries from green movements and RES-E producers due to uncertainties concerning the resulting economy for producers in a system based on green certificates. The success of TGC will be dependent on the attractiveness of the system for investors in new production of RES-E, i.e. the degree of certainty concerning the profitableness of such investments.

As an example of the importance of present uncertainty concerning the future value of green certificates, in Denmark the private investments in wind turbines has experienced a sudden stop when the feed-in model was replaced by the certificate model in January 2000. For the past 18 months practically no private investments in wind power have been made in Denmark in strong contrast to the previous years. Thus more than 400 MW of wind capacity was installed during year 2000 funded by private investors and ordered before January 2000.

The institutional framework for TGC is in an early phase in most countries, but may be expected to develop rather fast within the next couple of years.

The following tables and figures illustrate some of the main results.

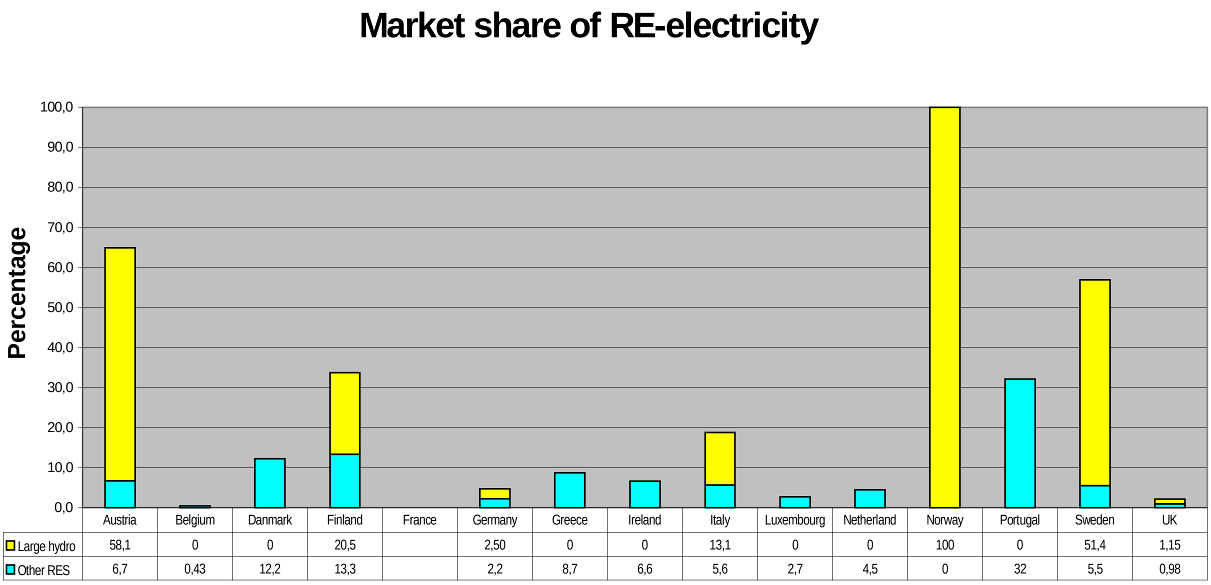


Figure 3: Market share of RE electricity[3]

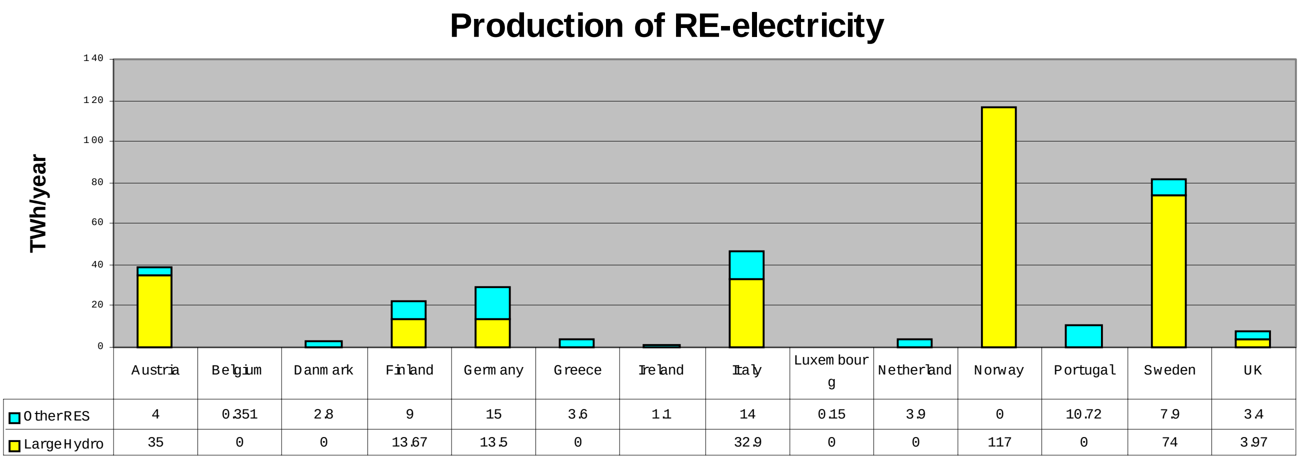


Figure 4: Production of renewable electricity in TWh/year.[4]

[3] Percentage market share of RE-electricity divided into hydropower and other RE-technologies. Note that the countries with large market shares of RE-electricity also are the countries with large production from hydropower. Values for France are missing due to lack of data.

[4] Note that large-scale hydro is the dominating renewable electricity source.

	Au	Be	Dk	Fi	Fr	Ge	Gr	Ir	It	Lu	NL	No	Po	Sp	Sw	UK	Total
Feed in	X				X	X	X			X			X	X			**7 (6)**
Tender					(x)			X									1 (2)
Green pricing				X								(x)					1 (2)
TGC*		X	X						X		X	X			X	X	**7 (6)**

Table 4: Overview of European promotional schemes for Renewable Electricity[5]

Table 5 on the following page gives an overview of the countries that currently are discussing, planning or implementing national TGC-systems. As can be seen from the Table, there are large differences between the systems with regard to both coverage, demand driver and the existence of minimum and maximum prices.

[5] * TGC's are in most cases only in preparation

Country	Legal Status for TGC System	TGC Market Starting Date	Demand Driver	Sources Excluded	Minimum Price of Green Certificate	Maximum Price of Green Certificate	Penalty for Non Compliance	Period of Validity, Banking and Borrowing	International Trading
Flanders (Belgium)	Directive approved	2001	Supplier obligation	Waste incineration	None	Determined by penalty	2001: 2 BF/kWh 2002: 3 BF/kWh 2003: 4 BF/kWh 2004: 5 BF/kWh Penalty paid to the regulator	2 year validity. Banking allowed Borrowing ?	Trading restricted to Flandern until bilateral agreement is reached.
Denmark	Confirmed[6]	2002	End user obligation 20% by 2003	Waste Hydro>10 MW	0.10 DKK pr. kWh.	Determined by penalty	0.27 DKK/kWh paid to RES-E-Fund	Unlimited validity Banking allowed. Borrowing with deposit	Expected - Subject to restrictions.
Italy	Confirmed	2001	Supplier obligation	Pumping hydro	Set by fixed selling price of issuing body	None	Access to the grid denied	2 year validity. No Banking. Borrowing against a penalty price.	Yes – if accompanied by actual electricity import.
Austria	Confirmed	2001	End user obligation	?	?	?	?	?	No
Netherlands	Voluntary	2001	Voluntary	Waste incineration	?	?	None		Yes
Sweden	Government bill expected in autumn 2001.	Suggested 2003	Consumer or distributor obligation	Large scale hydro is expected to be excluded	?	?	?	?	Yes: Expected from 2005
UK	Planned	1st Oct 2001	Suppliers' obligation 5% by 2003, 10% by 2010	Hydro>10MWh Waste incineration.	None	Determined by penalty plus financial reward to compliant suppliers.	Approx. 5 euro cents /kWh (3p/kWh)	Indefinite, limited banking and borrowing	Foreign Certificates acceptable, subject to restrictions

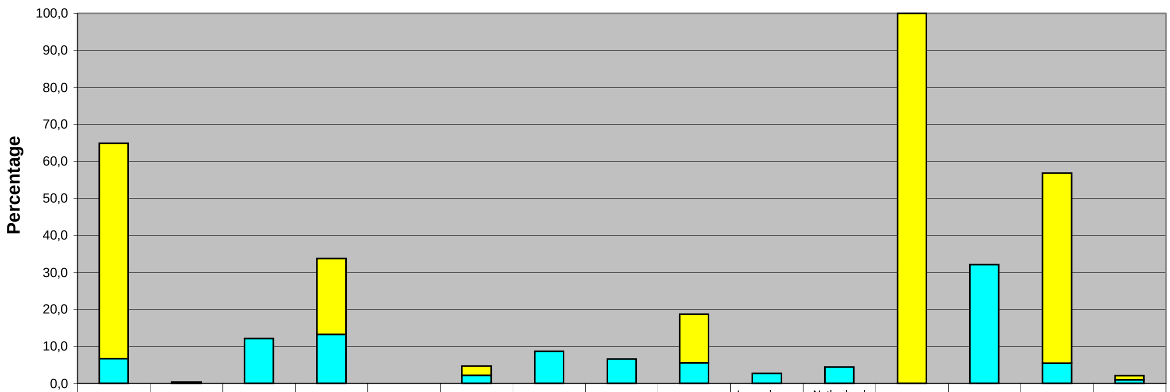
[*]Possibly supplier obligation combined with eco-tax exceptions in the future

Table 5: Summary of national TGC systems in Europe

[6] However, since these reviews were carried out, Danish plans for a green certificate trading scheme were 'frozen' following severe criticism, especially by the Danish Wind Industry Association, in September 2001. The future of the scheme is uncertain.

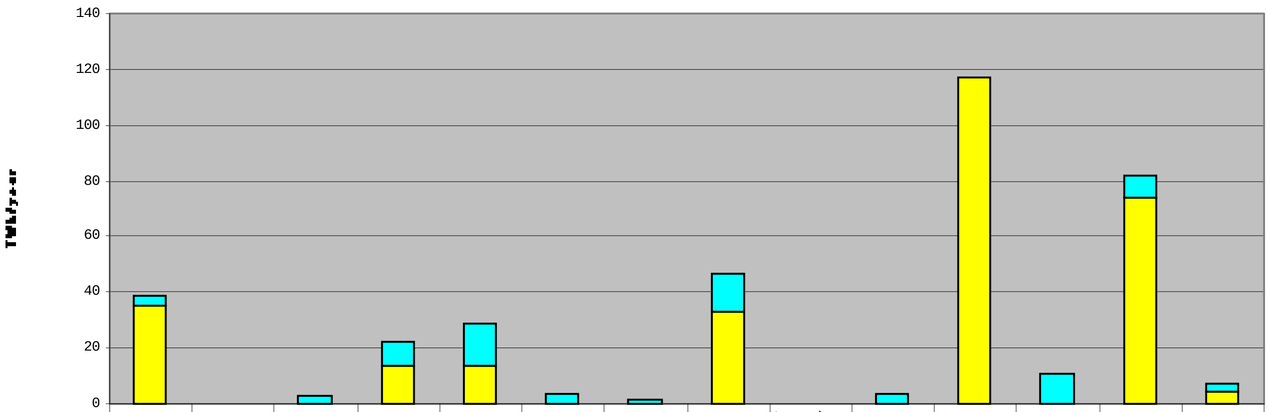
4.1.2 RE market share

The market share of renewable electricity varies from close to zero in Belgium to 100 % in Norway, as can be seen in Figure 5 below. It should be noted that except for Portugal, large market shares of renewable electricity is a result of large-scale hydropower. It should also be noted, that Norway, Sweden and Finland, which are among the four countries with the largest market share of renewables, also are the countries with the largest per capita consumption of electricity. This is in part due to the relatively low-cost of hydropower available in these countries.



	Austria 96	Belgium '99	Danmark '98	Finland '99	France	Germany '99	Greece '95	Ireland '98	Italy '97	Luxembourg '99	Netherland '98	Norway '98	Portugal	Sweden '98	UK '97
Large hydro	58,1	0	0	20,5		2,50	0	0	13,1	0	0	100	0	51,4	1,15
Other RES	6,7	0,43	12,2	13,3		2,20	8,7	6,6	5,6	2,7	4,5	0	32	5,5	0,98

Figure 5: Percentage market share of RE-electricity divided into hydropower and other RE-technologies[7].



	Austria	Belgium	Danmark	Finland	Germany	Greece	Ireland	Italy	Luxembourg	Netherland	Norway	Portugal	Sweden	UK
Other RES	4	0,351	2,8	9	15	3,6	1,1	14	0,15	3,9	0	10,72	7,9	3,4
Large Hydro	35	0	0	13,7	13,5	0		32,9	0	0	117	0	74	3,97

Figure 6: Production of renewable electricity in TWh/year (newest available data for each country)

The picture of large scale hydro as the dominant renewable electricity resource is clearer when looking at the actual production numbers in the countries as seen in Figure 6.

[7] Note that the countries with large market shares of RE-electricity also are the countries with large production from hydropower.

4.2 ENERGY AND ENVIRONMENTAL POLICIES

4.2.1.1 Kyoto/EU Targets

At the Conference of Parties in Kyoto in 1997 (COP-3) the European Union was committed to reach a reduction target of 8% by 2008-2012 compared to 1990. Legally, the countries have signed the Kyoto protocol individually and are thus individually committed to the 8% target. The European Union has formed a cluster to rearrange the burden sharing amongst the countries as shown in Table 6. Norway has a commitment on maximum one per cent growth in the emission up to 2008-2012.

	Percentage share of EU emissions in 1990	Emissions in 1990 in Mt $(CO_2)_{eq}$	Emissions in 1990 in t $(CO_2)_{eq}$ per capita	Evolution from 1990 to 1994 (% change)	Evolution from 1990 to 1995 (% change)	Burden sharing	Burden sharing in Mt $(CO_2)_{eq}$ by 2010
Austria	1,7	74	9,2	-1,3	0,6	-13%	64
Belgium	3,2	139	13,7	4,1	4,4	-7,5%	129
Denmark	1,7	72	13,7	15,2	10,0	-21%	57
Finland	1,7	73	14,2	-3,6	-0,5	0%	73
France	14,7	637	11,0	-2,9	-1,1	0%	637
Germany	27,7	1201	14,7	-12,1	-12,3	-21%	949
Greece	2,4	104	9,9	3,2	4,6	25%	130
Ireland	1,3	57	16,0	2,6	4,3	13%	64
Italy	12,5	542	9,5	-2,9	1,7	-6,5%	506
Luxembourg	0,3	14	34,7	-10,2	-45,0	-28%	10
Netherlands	4,8	208	13,5	3,4	7,5	-6%	196
Portugal	1,6	69	7,0	6,0		27%	87
Spain	7,0	301	7,6	4,0	8,0	15%	347
Sweden	1,6	69	7,9	-2,6	-3,3	4%	72
UK	17,9	775	13,3	-6,9	-8,4	-12,5%	678
Total EU	**100**	**4334**	**13,1**				**3998**
Norway						1%	

Table 6: Greenhouse gas* emissions and goals in the European Union and in Norway[8].

* $CO_2 + CH_4 + N_2O$ Source: "Annual European Community Greenhouse Gas Inventory 1990- 1996, submission to UNFCCC", prepared by the European Environment Agency for the European Commission (DGXI), April 1999

Figure 7 shows the per capita emissions of CO_2-equivalents in the EU countries in 1990. The high emission in Luxembourg should partly be seen as a result of cross border trade. This means that the energy traded in Luxembourg is not necessarily consumed in Luxembourg.

[8] The Norwegian commitment is part of the Kyoto Protocol, while the European union form a cluster that takes over the individual commitments of the Member States

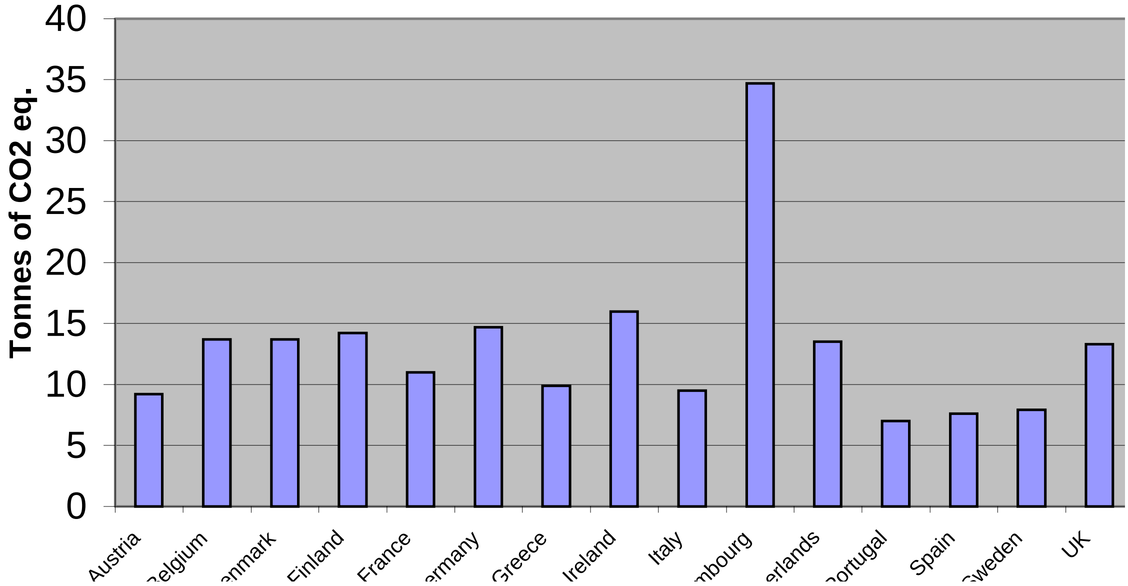


Figure 7: Per capita emissions in tonnes CO_2-equivalent in 1990

4.2.1.2 Legislation and Targets for RES

Both the individual countries and the European Union as a whole have targets for renewable energy. National targets for market shares of RE-electricity as known by mid 2000 for the most relevant countries in regard to TGCs are shown in Figure 8 Indicative targets for all countries are shown in the following figures.

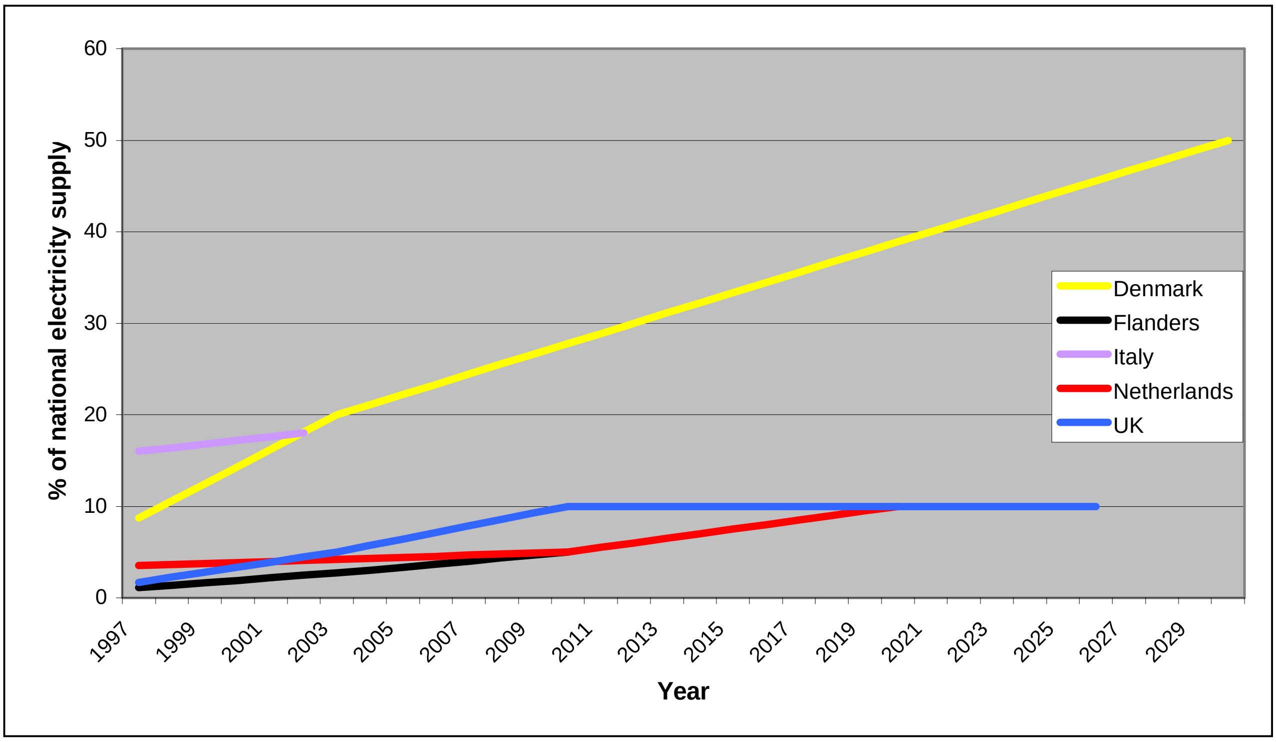


Figure 8: National renewable electricity targets in Europe as of mid-2000 for relevant countries in regard to TGCs

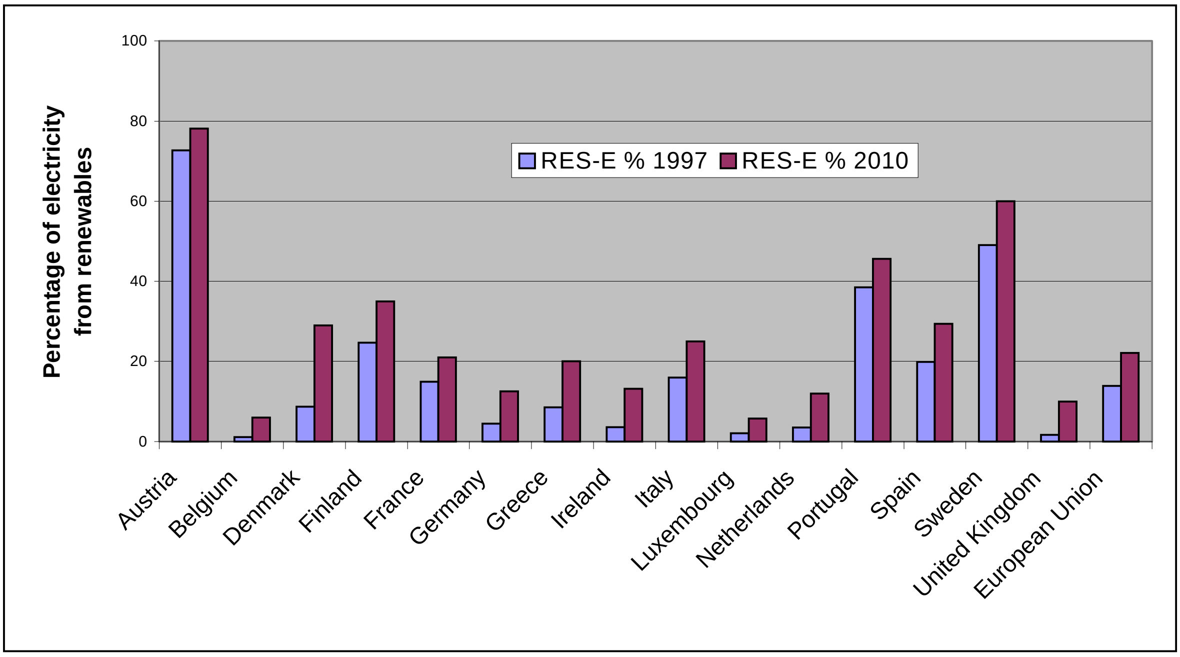


Figure 9: European indicative targets for renewable electricity (including large hydro).

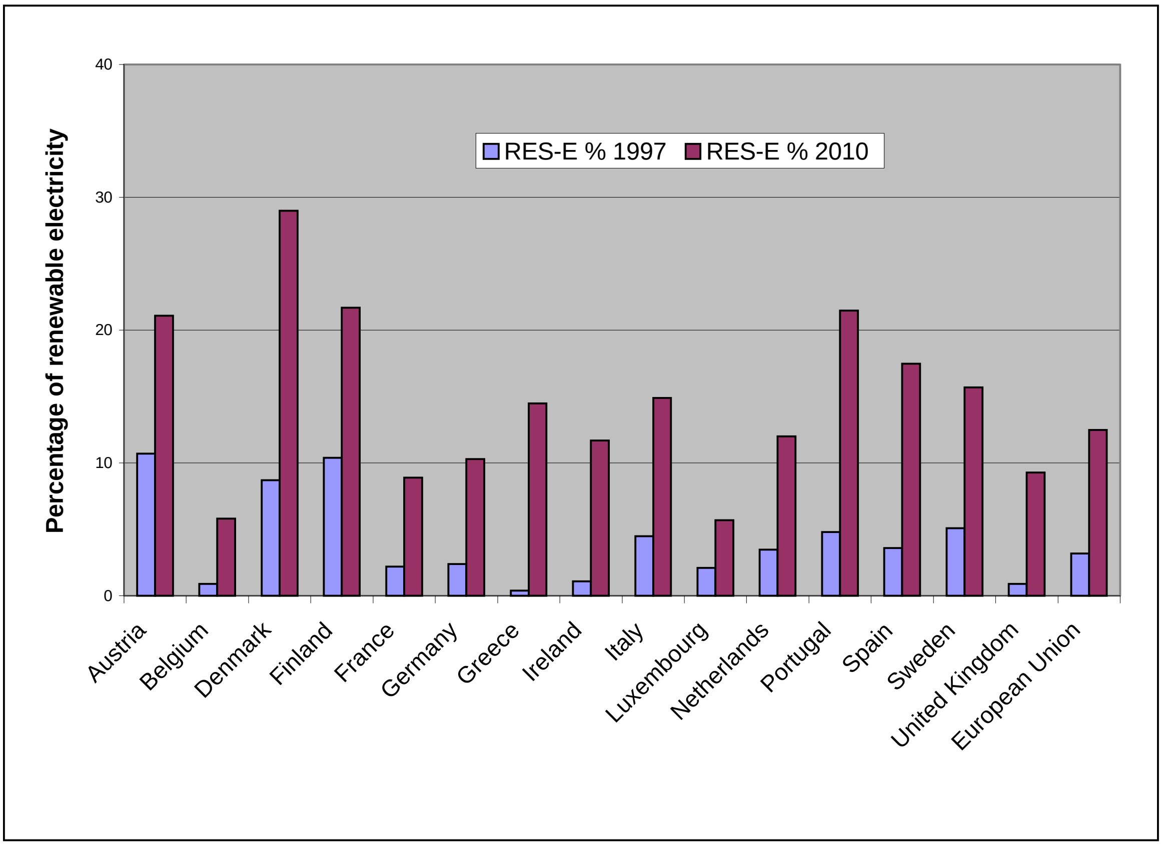


Figure 10: European indicative targets for renewable electricity (excluding large hydro).

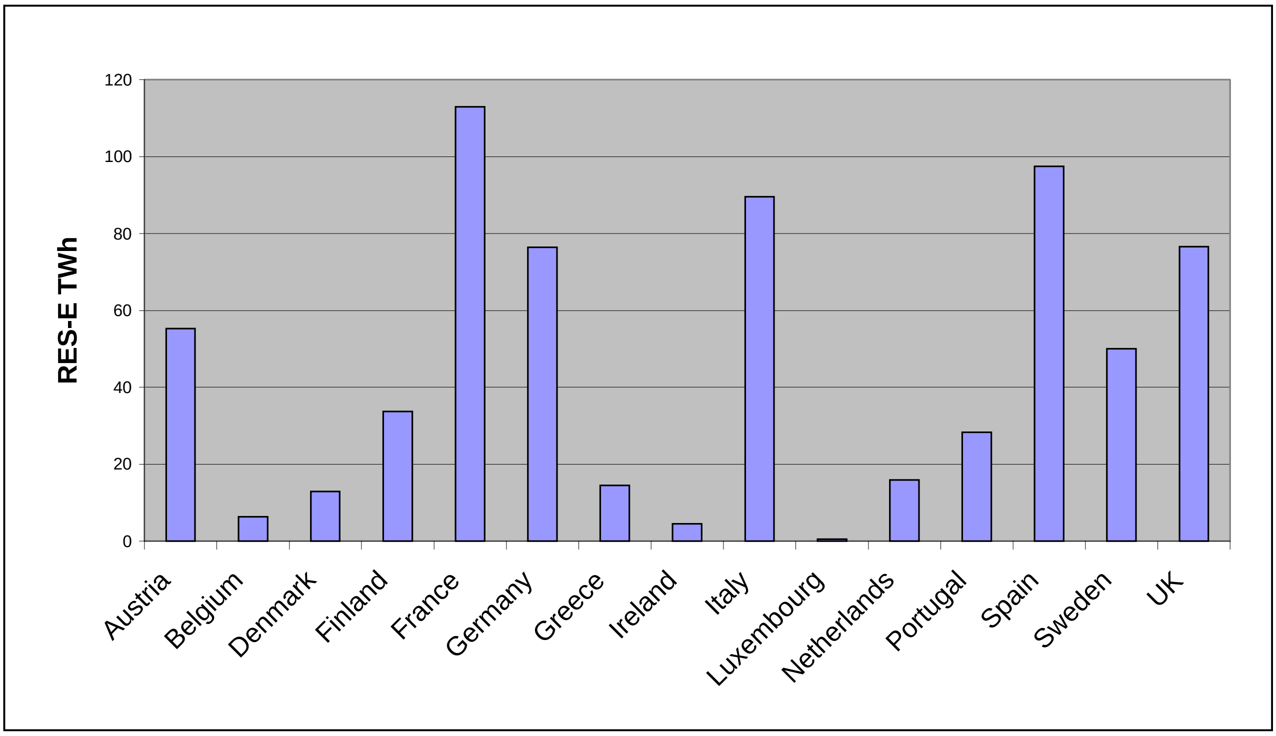


Figure 11: Indicative renewable electricity targets by 2010 (including large hydro)

4.2.2 Support Schemes for RES -E

Table 7 below is a brief overview of the support schemes for RES for the individual countries

Austria	Austria has for some time had a 'feed in' model. The new scheme from May 1998 does, however, have tender elements.
Belgium	TGC market is in preparation to help meeting RES-E obligations (2001: 0.96%; 2004: 3%)
Denmark	The new Danish electricity act from 1999 defines a change in the Danish RES support scheme from a combination of a 'feed in' model with subsidy for green electricity towards a TGC system with specific consumer obligations. Low 'Buy-out' price puts effective cap on certificate value. The aim is to have a working TGC market by 2001-2002. The target for RES-E is 20% by 2003.[9]
Finland	Voluntary "green pricing". Standard green energy accreditation since July1998 (excludes new hydro, peat and waste). Emphasis on biomass, investment subsidy for wind (35%).
France	Modest tender scheme for wind (15 year power purchase agreement with EdF). New climate action plan aims for 3 GW wind by 2010. Due to a recent decision in the French Parliament a feed-in system will be introduced.
Greece	Feed-in model. New electricity acts supports RES-E (1999). New regulator April 2000. The grid infrastructure is week.
Germany	Feed-in model. New law from April 2000 with favourable rates. Not submitted for notification at the EU commission electricity regulatory committee. Court decision in March 2001 accepts German feed-in model..
Ireland	Tender scheme. Comparable to UK NFFO scheme. Guarantee to successful developers of a 15 year power purchase agreement with the Irish utility, (part of "Alternative Energy Requirement" of 1994). Installed capacity by 1999 low (100MW - mostly wind and biomass)
Italy	TGC system in preparation. New electricity act Nov. 1999. TGCs by 2002.
Luxembourg	Feed-in model. Favourable tariffs for RES-E. Investment subsidy for wind and PV.
Netherlands	TGC in phase 1. Green pricing since 1995. Since Jan. 1998 no extra tariff. ("Zero tariff") Voluntary agreement with utilities on TGC, operational from January 2001 (uncertain!)
Norway	Modest green pricing. Swedish eco-labelled electricity is offered. Take up rate very low. TGC-system may be presented for initial discussion in autumn 2001 due to a decision in parliament spring 2001.
Portugal	Feed-in model. Favourable tariffs and investment subsidies. Targets for RES-E are only indicative, no concrete action programmes.
Spain	Feed-in model. Favourable premium tariffs regulated by law since 1998. Fast growth of wind power (2 GW).
Sweden	Green pricing. New TGC system just announced
UK	TGC in preparation. New act introduces TGCs and a 10% green electricity obligation on suppliers by 2010 to replace NFFO scheme. 'Buy-out' price puts effective cap on certificate value at approx. 3.8 euro cents/kWh. Presently about 20 green tariffs, but low consumer uptake. Uncertain whether voluntary demand will be additional to official target. New electricity trading arrangements from late 2000.

Table 7: Overview of the support schemes for RES-E for the individual countries

The support mechanisms can be divided into four types: Feed-in tariffs, Competitive tender systems, Green pricing (special tariffs for green electricity products) and Tradable green certificate (TGC) systems. A summary of the use of the four systems in the 16 countries can be seen in Table 8. Seven countries

[9] However, note that since these reviews were carried out, Danish plans for a green certificate trading scheme were 'frozen' following severe criticism, especially by the Danish Wind Industry Association, in September 2001. The future of the scheme is uncertain.

have feed-in tariffs, seven have TGCs systems in preparation, one country runs a tender based system and one has only green pricing.

	Au	Be	Dk	Fi	Fr	Ge	Gr	Ir	It	Lu	NL	No	Po	Sp	Sw	UK	Total
Feed in	X				X	X	X			X			X	X			**7 (6)**
Tender					(x)			X									1 (2)
Green pricing				X								(x)					1 (2)
TGC*		X	X						X		X	X			X	X	**7 (6)**

* Most TGS-systems are under preparation

Table 8: Overview of European promotional schemes for Renewable Electricity.

The promotional systems can be judged on both a criteria of 'Effectiveness' and criteria of 'Economic efficiency'. The 'Feed-in' system is judged to be most effective in promoting new renewable energy capacity based on previous experience. TGC in combination with green electricity obligations is claimed to have a potential for both effectiveness and economic efficiency. So far, the practical experience with TGC is very limited. The tender system may be economic efficient, but practical experience so far has demonstrated low effectiveness. The judgement of the systems is uncertain and dependent on the specific implementation and accompanying political measures.

As seen in Figure 12 only Netherlands, Italy and Belgium have obligations and tradable green certificates today, while the majority of the countries have feed-in tariffs. Finland has green pricing and Ireland has a tender system. This is about to change, as seen in Figure 13, as Denmark, Sweden, Norway and United Kingdom have plans for the combination of obligations and tradable green certificates within the next couple of years, while there are discussions going on in the remaining countries.

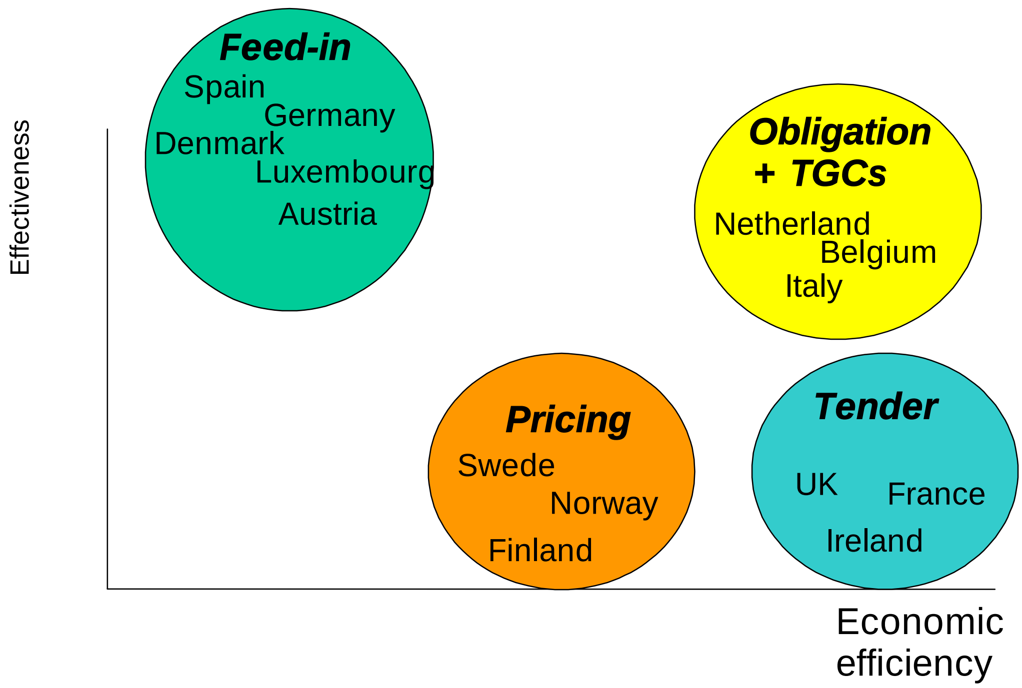


Figure 12: Support mechanisms by early 2000 for renewable electricity production in the analysed countries

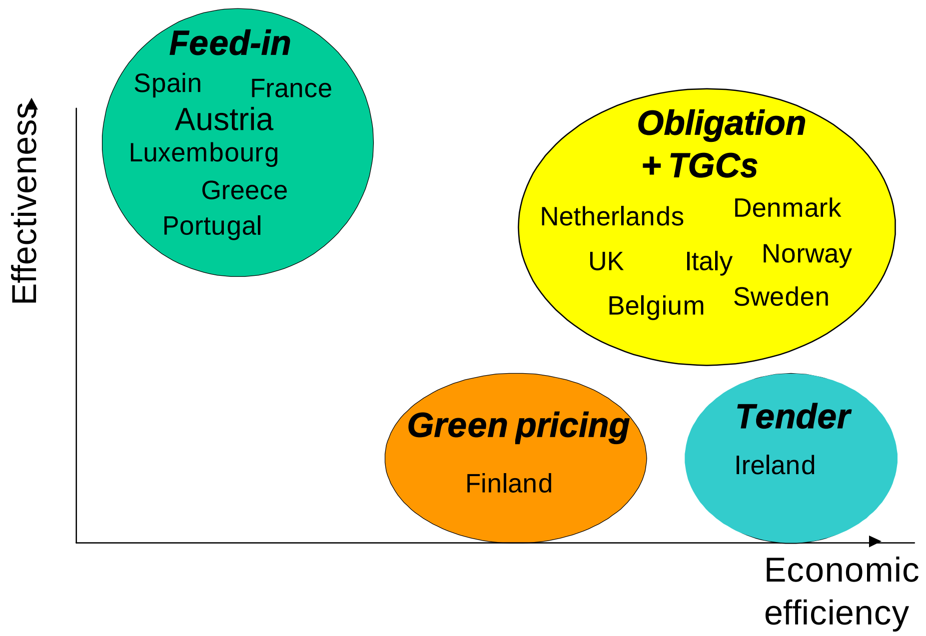


Figure 13: Expected support mechanisms for Renewable electricity In the coming years.

4.3 TASK 1.4: REVIEW OF SIZE AND VALUE OF THE TGC MARKET

The review of the prospective size and value of the TGC market was required by the European Commission as input to a project 'breakpoint' at which a decision would be taken whether to continue with the project. The breakpoint was necessary since, at the start of the project, an assumption was made that the EU TGC market would be of significant size, but without sufficient information to confirm it.

The task is dedicated to investigating the potential size and importance of a green certificate market. ZEW was responsible for the production of a task report that drew on the information contained in the country reviews, plus other specific investigations. The task was not limited to the question of whether a market for TGCs currently exists. Rather, it took a medium and long-term view, and aimed to determine whether, and how, such a market is likely to grow. The T1.4 report also estimates the likely monetary value of such a market.

4.3.1 Summary

Task 1.4 of the RECerT project is dedicated to assessing the potential size and monetary value of a tradable green certificate (TGC_{el}) market in the electricity sector of the European Union. It takes a medium- and long-term view, and determines how such a TGC_{el} market is likely to grow up to 2010.

The basic data used in our analysis was collected in a pragmatic way due to limited resources for this task. The figures are derived from a small number of earlier surveys of the projections we need for our assessment, which are for all EU-15 countries estimates of the technical and market potential for different sources of renewable electricity as well as of the electricity price and consumption development to 2010. Based on the available information, we develop TGC_{el} price-potential curves for each Member State as well as an aggregated curve for EU-15. The base year is 1995.

We present results for 4 TGC_{el}-trade scenarios:

- EU-15, EC-targets scenario: all Member States participate in certificate trading; the 22.1% target of the Commission is reached by Member States accepting the quantitative indications given by the Commission in their recent proposal for a Directive[10] (CEC 2000a);
- EU-15, national targets scenario: all Member States participate in certificate trading; the targets currently set in national legislation and energy programmes (add up to 17% for the whole EU) are reached by 2010;
- EU-5, EC-targets scenario: only the 5 countries at present most advanced with the implementation of a green certificate system (NL, DK, UK, I, Flanders) manage to trade among each other; they accept the targets recommended by the Commission (CEC 2000a);
- EU-5, national targets scenario: only the 5 countries at present most advanced with the implementation of a green certificate system (NL, DK, UK, I, Flanders) manage to trade; they stick to the targets currently laid down in their national legislation or programmes.

For all calculations, we assume that there is only one generic green certificate product, i.e. only one single market develops. Further simplifying assumptions are that there are no trade barriers or other market distortions as e.g. additional promotion schemes for renewable electricity, or upper and lower price limits, i.e. we are in an ideal economic world. Moreover, only renewable energy plants (including large hydro, excluding waste) built after the base year 1995 are eligible for green certificates. Finally, the view we take is mainly static. Production cost effects due to economies of scale or technological progress have been integrated exogenously as averages in the periods 2001-2005 and 2006-2010. Also, the commodity prices are assumed to change in these two periods. Thus, the derived cost-potential curves change in the course of time, they are different for the periods 1996-2000, 2001-2005, and 2006-2010, respectively.

[10] Since the Task 1.4 research was done the Directive has been adopted, on 27 September 2001

Based on our data and assumptions, green certificates representing 130 TWh RES-E production would be traded cross-border in 2010 under the EU-15, EC-target scenario; this is more than one third of the total certified RES-E production. In our model, this trade volume equals a trade value of about € 3.4 billion; the total TGC_{el} market value is at about € 9.5 billion. Both the estimated trade volume and the estimated market size are about half under the EU-15, national targets scenario. If only the five most advanced countries with respect to TGC_{el} policies started a fully co-operative trading scheme, the international market could still be expected to be sizeable. TGC_{el}s representing more than 30 TWh could be traded between the five countries. (cf. Table 9 Under the EU-5 scenario, Flanders, Italy, and the Netherlands turn out to be net importers, while Denmark and the UK are exporters of TGC_{el}s due to the assumed substantial offshore wind energy resource.

	TGC_{el} market value (in billion €)			TGC_{el} trade volume (in TWh)			TGC_{el} trade value (in billion €)		
Scenario	2000	2005	2010	2000	2005	2010	2000	2005	2010
EU-15, EC-targets	1.1	3.9	9.5	10	46	130	0.27	1.2	3.4
EU-15, nat. targets	0.15	0.97	1.6	6.8	28	75	0.038	0.31	0.58
EU-5, EC-targets	0.13	0.55	1.6	3.0	15	47	0.037	0.19	0.58
EU-5, nat. targets	0.084	0.35	0.81	1.5	8.4	30	0.012	0.077	0.23

Table 9: Estimated market, trade volumes and trade values under 4 different TGCel scenarios

It should be noted that the incentive for green certificate trading comes from international cost/price differentials only, i.e. we are estimating trade volumes and values as a result of relative differences between country-specific renewable energy targets and assumed national resource availability. Further TGC_{el} trades, e.g. within a country or due to arbitrage opportunities at a TGC_{el} exchange, are not considered here.

The results are very sensitive to assumptions about the availability of renewable energy sources, in particular of offshore wind. Therefore, sensitivity analyses have been carried out based on the assumption that only a tenth of the originally assumed amount of the wind offshore potential could be exploited in the medium run. In such scenarios, solar thermal electricity generation in the Mediterranean countries of the EU gets to play a major role in the 2010 TGC_{el} market. Consequently, TGC_{el} transactions from Northern to Southern countries decrease compared to the original scenarios leading to an overall reduction of the trade volume by 20 to 30%. The estimated trade value, however, turns out to be substantially higher than in the original calculations. Due to the fact that, switching from one analysis to the other, comparably cheap offshore wind farms are substituted by more expensive solar thermal power plants, equilibrium TGC_{el} prices rise by a factor 5 to 10 compared to the four original scenarios.

The following conclusions could be drawn from our analyses:

- A substantial TGC_{el} market size and cross-border trading volume can be expected under both EU-15 and EU-5 trading schemes (in the light of the ambitious RES-E targets formulated by the European Commission as well as by the national governments).
- If the national targets indicated by the European Commission in the recent proposal for a Directive[11] were implemented, the EU Member States Austria, Finland, Luxembourg and Sweden could fail to meet these targets without TGC_{el} trade.
- Since the national governments' targets and the EC-targets do not reflect the distribution of RES-E potentials across the EU, there seems to be a need for trade. Our sensitivity analysis shows that the estimated trade volumes may be considered robust. Our market and trade value estimates, in contrast, are very sensitive to assumptions, in particular concerning the exploitation rates of the offshore wind resource.

[11] Since adopted

- In general, we find that the annual exploitation rate of renewable resources is a crucial issue with respect to TGC_{el} price. Therefore it is important that European and national policies focus on facilitating the development of renewable resources (e.g. by infrastructural measures) and on making obligations more flexible to fulfil (e.g. via instruments like banking and borrowing of TGC_{el}s).

4.3.2 Scenarios, Data and Assumptions

For an assessment of the potential future size and value of a TGC_{el} market, we have chosen the years 2000, 2005 and 2010 (base year 1995).

Data collection has comprised:

- Inventory of official national targets for renewable electricity up to 2010; comparison to the indicative Commission target laid down in the White Paper (CEC 1997), and those national targets which the Commission has recently suggested in connection with the proposal[12] for a renewable electricity Directive (CEC 2000a).
- Survey of technical and market potentials in EU Member States for different renewable sources of electricity (wind onshore and offshore, small and large hydro, photovoltaics, solar thermal electricity and biomass (co-firing of biomass as well as electricity generation from wood, biogas and energy crops)). Our technical potential figures are mainly based on papers by the LTI-Research Group (LTI 1998), LTI being a research project that was in part funded by the European Commission in the framework of the APAS programme. The cost potentials have been obtained from several studies (BMU 1999, Kaltschmitt/ Wiese 1997, Matthies et al. 1995, Semke/Markewitz 1998) and supplemented with own estimates where necessary.
- Review of electricity market projections for EU-15 countries with the help of the Shared Analysis Project (CEC 1999c); as the base year of that project is 1995, we have also chosen 1995 as base year for estimating the future size and value of TGC_{el} markets. Estimations of the price development for electricity have been drawn from Schlesinger/Schulz (2000) as well as Dany et al. (2000).

Two high estimates for the potential size and value of a future TGC_{el} market are derived from the available data, information, and our model:

- We assume that the maximum RES-E market size is given on reaching the ‘quantitative indications’ set by the Commission in the recent proposal[13] for a Directive to ensure that the EU renewable electricity use arrives at a 22.1% share by 2010 (*EU-15, EC-targets scenario*).
- A second high estimate results from calculations presuming that the market size in 2010 will get to the volume linked with the official national targets for RES-E set today (*EU-15, national targets scenario*).

For both scenarios, we assume that all Member States fully participate in TGC_{el} trading.

The low estimates for the future TGC_{el} market are based on an assessment of the current state of renewable electricity policies in EU Member States. As a minimum of 5 countries is in the process of introducing some type of TGC_{el} system, the two low estimates are:
3.+4. estimates of the market size and value of a TGC_{el} market between the Netherlands, Italy, Flanders, Denmark and the UK, either with the Commission targets (*EU-5, EC-targets scenario*) or with nationally set targets (*EU-5, national targets scenario*).

Many basic assumptions underlie the calculations and results. Most of them had to be made for simplification and in order to attain first rough estimates at all.

- There is only one generic green certificate product, i.e. only one single market and TGC_{el} price develops in the model.

[12] Since adopted
[13] Since adopted. Note that the 'Reference Values' for the Member States' national indicative targets for renewables up to 2010 in the Directive, adopted in September 2001, are effectively unchanged from the proposed Directive referred to here.

- Only renewable energy plants (including large hydro, excluding waste) built after the base year (1995) are eligible for green certificates. Older plants may be subsidised under other RES-E promotion schemes.[14]
- There are no trade barriers or other market distortions like additional promotion schemes for (eligible) renewable electricity, upper and lower price limits, etc., i.e. we are in an ideal world except for limits set on the annual exploitation of the technical potentials.
- Technical progress and economies of scale are taken into account to some degree. Production costs are reduced exogenously at two points in time (2001 and 2006). Other market dynamics have not been included.
- Technical potentials (except offshore wind up to 2005) can be exhausted at an annual rate of 2% which is a rate slightly higher than the current exploitation rate in the European onshore wind sector.
- Our power production costs and the commodity prices are different for different renewable sources and technologies. Yet, the technology-specific costs and prices are presumed to be identical all over the EU.

In this paper, the terms ‘trade volume’, ‘trade value’, and ‘market volume/ value’ are defined in the following way:

The trade volume is equivalent to the sum of all TGC_{el} exports (or imports) in a certain year.

The trade value is obtained from trade volume multiplied by the equilibrium TGC_{el} price in the period under analysis.

The TGC_{el} market value equals the total amount of certified RES-E production in a certain year (market volume) multiplied by the TGC_{el} price at that point in time.

4.3.3 The Current Renewable Electricity Market[15]

In EU Member States, the only renewable source of energy, which had been exploited on a significant scale before 1990, was (large) hydro power. During the nineties, growth rates have mostly been in two figures for non-hydro renewable energies due to a diverse range of renewable electricity promotion policies by national governments and the European Community. Yet, the importance of renewable electricity is still very diverse in different European countries. The growth rates differ a lot depending on the source and Member State.

In 1997, electricity generation in the EU reached 2,400 TWh, showing an average growth of 1.7% per year since 1990. Despite a limited increase in generating capacity since 1990, hydro and wind power together had increased their production by 2.2% per year on average since 1990 to generate 13% of the total in 1997. Since 1990, wind production has multiplied by 10. It is the fastest growing renewable source of electricity, but its contribution still only represented 0.3% of the total production even though some European countries are amongst the largest world contributors (CEC 2000b, 57).

Today wind energy projects across Europe produce enough electricity to meet the domestic needs of 5 Million people. Latest figures show that close to 9,000 MW of wind energy capacity were installed in the countries of the EU at the end of 1999. This is an increase of more than 2,000MW in a single year, a percentage growth of over 30%. Three quarters of that additional capacity were installed in Germany, a fifth in Spain and in Denmark, respectively (http://www.ewea.org).

According to ADEME, the operational peak capacity of photovoltaic installations in the world at the end of 1998 can be estimated at 600MW, for an annual energy production of 500GWh. EurObserv’ER has

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[14] The question of eligibility is a question of policy objectives. In the public debate, it has often been linked with debates on transitional regimes. Possible pro and con arguments have been listed in diverse research papers. In the end, the eligibility question is usually being decided politically.

[15] For a more detailed overview on the current situation and policies for renewable sources of electricity in the European Union, you are referred to the country reports written within the RECerT project for each EU Member State and also summarised for EU-15. Visit http://recert.energyprojects.net for further information.

worked on an estimation which, on the basis of trends recorded over the past few years, comes to a figure of approximately 124MW_p for installed PV capacity in the European Union at the end of 1999. That equals a 19% growth rate for 1999. PV electricity production for the EU in 1998 is approximated at 80GWh (Photovoltaic barometer in Systèmes Solaires N^o 136, 2000).

The 1997 White Paper of the European Commission (CEC 1997) set out an indicative target for the Community as a whole of doubling the share of renewable energy from 6% to 12% of the gross inland energy consumption by 2010. This overall objective has been translated into a 22.1% RES share in the electricity sector for 2010. The recent proposal for a Directive[16] on the promotion of RES-E (CEC 2000a) once more emphasises the importance of this policy field for the EU. However, it also stresses that additional efforts are necessary at the Community level as well as in Member States in order to achieve the objective. Tradable green certificates are seen as one possible policy instrument to facilitate the medium-term significant increase in RES-E within the EU. In the following, we assume that the introduction of TGC_{el} support schemes is harmonised between those countries that opt for it.

4.3.4 Market Penetration Targets for Renewable Electricity

In the light of EU policy, many Member States have formulated a market penetration target for renewable sources of energy in 2010. Intermediate and technology-specific targets are often fixed as well, but for different points in time and different technologies. Not all national targets are consistent with the White Paper, that mainly is, they are not as ambitious as in the White Paper. Some Member States have not at all set national targets for the domestic future consumption of RES-E. To ensure that the level of RES-E develops in conformity with their 22% objective and that each Member States contributes its portion, the Commission has proposed 'indicative' targets for each Member State.

	RES-E share 1997	**'EC-targets' for RES-E in 2010**		**Increase 1997-2010**	**'National Targets' for RES-E until 2010***	
	(in %)	**(in%)**	**(in TWh)**	**(in TWh)**	**(in % and year)**	**(in TWh)**
Austria	72.7	78.1	55.3	15	3% (non hydro) in 2005 (non large hydro)	+2 (+0.11)
Belgium	1.1	6.0	6.3	5.4	Flanders: 3% in 2004 5% in 2010 Wallonia: 8% in 2010	Fla.: 0.9 1.8
Denmark	8.7	29.0	12.9	9.7	20% in 2003 30% in 2010	7.5 13
Finland	24.7	35.0	33.7	16	Doubling bt. 1990-2010	32
France	15.0	21.0	112.9	47	No Target	0
Germany	4.5	12.5	76.4	52	10-12% in 2010	61
Greece	8.6	20.1	14.5	11	No Target	0
Ireland	3.6	13.2	4.5	3.8	5.1% in 2000 20% in 2010	1.2 6.8
Italy	16.0	25.0	89.6	43	+2% in 2002 Doubling until 2010 ?	+4.5 78
Lux'bourg	2.1	5.7	0.5	0.4	No Target	0
Netherlands	3.5	12.0	15.9	12	8.5% in 2010 17% in 2020	11
Portugal	38.5	45.6	28.3	14	500 MW small hydro, 47 MW biomass, 290 MW wind by 2006	+3
Spain	19.9	29.4	76.6	40	12% in 2010 (non-large hydro)	62
Sweden	49.1	60.0	97.5	26	+1.5 TWh/a betw. 1998 and 2002	79
UK	1.7	10.0	50.0	44	5% in 2003, 10% in 2010	21 50
EU-15	13.9	22.1	675	339		

[16] Since the Task 1.4 research was done the Directive has been adopted on 27 September 2001

***Table 10: EC and national targets for RES-E in EU-15*[17]**

Table 10 shows the Commission's ideas as to what extent the individual Member States should contribute to the renewable electricity target for the whole EU ('EC-targets') and compares them with the actual targets formulated by Member States' governments in official documents ('National Targets'). For countries like Austria, France and Portugal they differ considerably, whereas the targets set by Denmark and the UK exactly correspond with the goals of the Commission. In the last column "+" stands for additional production compared to the 1997 level.

Under the EC-targets scenarios, France, Germany, Italy, Spain, Sweden, and the United Kingdom would obviously need to contribute the most to future European RES-E development in absolute terms.

To approximate the potential renewable energy market sizes in 2000, 2005, and 2010, we partly needed to calculate fictitious goals by forward or backward projections of the targets actually fixed nationally. Table 11 summarises the additional RES-E production envisaged by the Member States for 2000, 2005, and 2010 according to our calculations that are built on the baseline figures (cf Table 12) and the targets in Table 10. The assessment demonstrates that the national targets scenario would only result in an overall increase of the RES-E share in EU-15 electricity consumption from 13% in 1995 to 17% in 2010, whereas the Commission strives at 22.1% in 2010.

	1996-2000	2001-2005	2006-2010	1996-2010
Austria	0.060	0.048	0.16	0.27
Belgium	0.21	0.71	0.92	1.8
Denmark	0.57	4.9	6.3	12
Finland	4.1	4.1	4.1	12
France	no target	no target	no target	no target
Germany	4.5	12	23	39
Greece	no target	no target	no target	no target
Ireland	0.52	1.2	4.2	6.0
Italy	3.9	9.1	27	40
Luxembourg	No target	No target	no target	no target
Netherlands	0.59	2.8	7.2	11
Portugal	0.49	2.6	4.8	7.9
Spain	3.4	4.8	9.3	18
Sweden	4.5	5.4	6.5	16
UK	4.6	11	29	44
TOTAL	27	59	120	210
White Paper and Directive Total	*42*	*106*	*215*	*363*

Table 11: Derived national targets for additional RES-E production in EU-15 (in TWh/a)

It must be noted that the target path for an EC-targets scenario (last row in Table 10) is already an outcome of the calculations described later. It was chosen under the assumption that in the case of a TGC_{el} trading regime, TGC_{el} prices might need to be more or less constant over time (1996-2010), or at least not decrease rapidly, in order to avoid large stranded investments. Due to decreasing production costs and increasing exploitable offshore wind energy potentials over time, stable TGC_{el} prices require an exponentially growing RES-E market, and thus exponentially growing RES-E targets. If a fully co-operative EU-15 TGC_{el} market was started in 1996, slightly more than 10% of the 2010 targeted RES-E production should be striven for in the first 5-year period. The intermediate target for 2005 should be fixed to contribute another 30% to the final RES-E target, and between 2006 and 2010 the major part (60%) of additional RES-E production should enter the market. These considerations are reflected in the target paths for the EC-targets scenarios.

[17] Sources: Columns 1-3: CEC (2000a), column 4: own calculations based on CEC (1999b), columns 5+6: compilation from & calculations based on RECerT & InTraCert country reports

To derive absolute figures for the future RES-E market size (as in Table 10 and Table 11), it is necessary to consider the development of the European electricity market up to 2010. We have used the figures of the Shared Analysis Project (CEC 1999c) to which the European Commission refers as well in their Directive[18] proposal (cf Table 12). As indicated by their projections, the European electricity market is expecting substantial growth rates until 2010. Thus, even if the RES-E shares in the EU member countries were to remain on their 1995 levels, a considerable increase in renewable power generation would be necessary until 2010.

	Total electricity production				**Total electricity consumption**			
	1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
Austria	55	58	62	68	53	61	66	71
Belgium	74	87	93	101	78	89	98	105
Denmark	37	40	42	44	36	39	42	44
Finland	64	76	84	91	71	81	90	97
France	490	544	575	588	420	471	511	538
Germany	532	546	570	606	536	552	577	613
Greece	41	52	61	71	42	52	61	72
Ireland	18	24	30	34	18	24	30	34
Italy	237	273	307	335	275	301	331	359
Luxembourg	1	1	2	3	5	6	7	8
Netherlands	81	93	106	129	93	105	118	133
Portugal	33	41	54	63	34	42	53	62
Spain	165	192	219	250	170	200	229	256
Sweden	148	157	162	161	147	154	162	163
UK	333	380	431	483	349	398	450	500
EU-15	2308	2563	2799	3028	2327	2576	2823	3054

Table 12: Assumed development of European electricity markets (in TWh)[19]

4.3.5 Technical and Market Potentials for Electricity Supply from Renewable Sources of Energy

There are several studies on the technical potential of renewable energies. The LTI-Research Group has comprised these studies and come up with ranges for technical potentials of renewable energies in the 15 EU countries. We largely base our calculations on the work of that group with the following additional assumptions:

- The annual exhaustion rates of the source-specific potentials are limited. Due to several restrictions to the renewable energies market development that have been observed in the past we assume that a maximum of 2% of the technical potential can additionally be used per year to increase the market share of renewable electricity.

- With respect to offshore wind energy, we assume that wind farms might enter the electricity market at a maximum annual rate of 1% of the technical potential not starting before 2001. After 2005, the offshore wind energy potential is treated like the other sources of energy.

- Since it turns out that the penetration of offshore wind energy is crucial in our scenarios with respect to determining TGC_{el} prices, we also provide results assuming that the offshore wind energy potential can only be exploited at a one-per-thousand rate between 2001 and 2005 and a two-per-thousand rate between 2006 and 2010.

[18] Since the Task 1.4 research was done the Directive has been adopted, on 27 September 2001
[19] Source: CEC (1999c)

The structure of gathered information on country-specific technical potentials is shown in the following table.

EU-15 – Technical Potential				
WIND ENERGY				
Wind: onshore	*7.5m/s*	*6.5m/s*	*5.5m/s*	
	38	124	209	
Wind: offshore	*10m*	*20m*	*30m*	*40m*
	601	935	944	570
HYDRO ENERGY	Large hydro	Small hydro		
	138	16		
SOLAR ELECTRICITY	Photovoltaics	Solar thermal		
	432	1404		
BIOMASS ELECTRICITY	Fuel switch	Wood	Biogas	Crops
	58	32	56	37

Table 13: The accumulated technical potential for RES-E in EU-15 (in TWh/a)[20]

Table 13 illustrates the aggregated RES-E potential of all 15 EU Member States differentiated according to renewable energy source and technology. The wind potential has been split into several categories depending on average wind speeds (onshore) or different water depths (offshore). In addition to common biomass potential studies it is assumed that the co-firing of biomass will play a role in renewable energy market development. Based on data from CEC (1999c) we assume that 10% of the fossil fuels used as input for electricity generation can be replaced by biomass. In addition, we assume that all other types of biofuels are converted to energy in CHP plants with a fuel efficiency of 65% on average. 33% of the remaining useful energy is assumed to be converted to electricity.

The above mentioned restrictions concerning exploitation rates shall be explained here with the large-hydro potential serving as an example. 2% of the large-hydro potential mean that a maximum of 2.8 TWh of additional large-hydro electricity can penetrate the European electricity market annually. In the five-year time periods considered here, this translates into an exploitable European large-hydro potential of 14 TWh in the period between 1996 and 2000. For the following periods, the overall large-hydro potential is reduced by the part of the potential that was realised between 1996 and 2000.

According to the LTI survey, the EU-15 technical potential is distributed unevenly across the different Member States (cf Figure 14). Denmark, France and the United Kingdom can make use of a large offshore wind energy potential, whereas Spain, Italy, and Greece could exploit a large solar electricity potential. These two types of renewable energy technologies are dominating the technical RES-E potential in the European Union.

The data shows that the countries with a large targeted RES-E production in 2010 are not necessarily those with the largest renewable energy resource. This fact already gives a hint that RES-E trade will be important when the indicated RES-E targets by the European Commission and by the national governments are turned into serious commitments.

[20] Source: Compilation from LTI (1998)

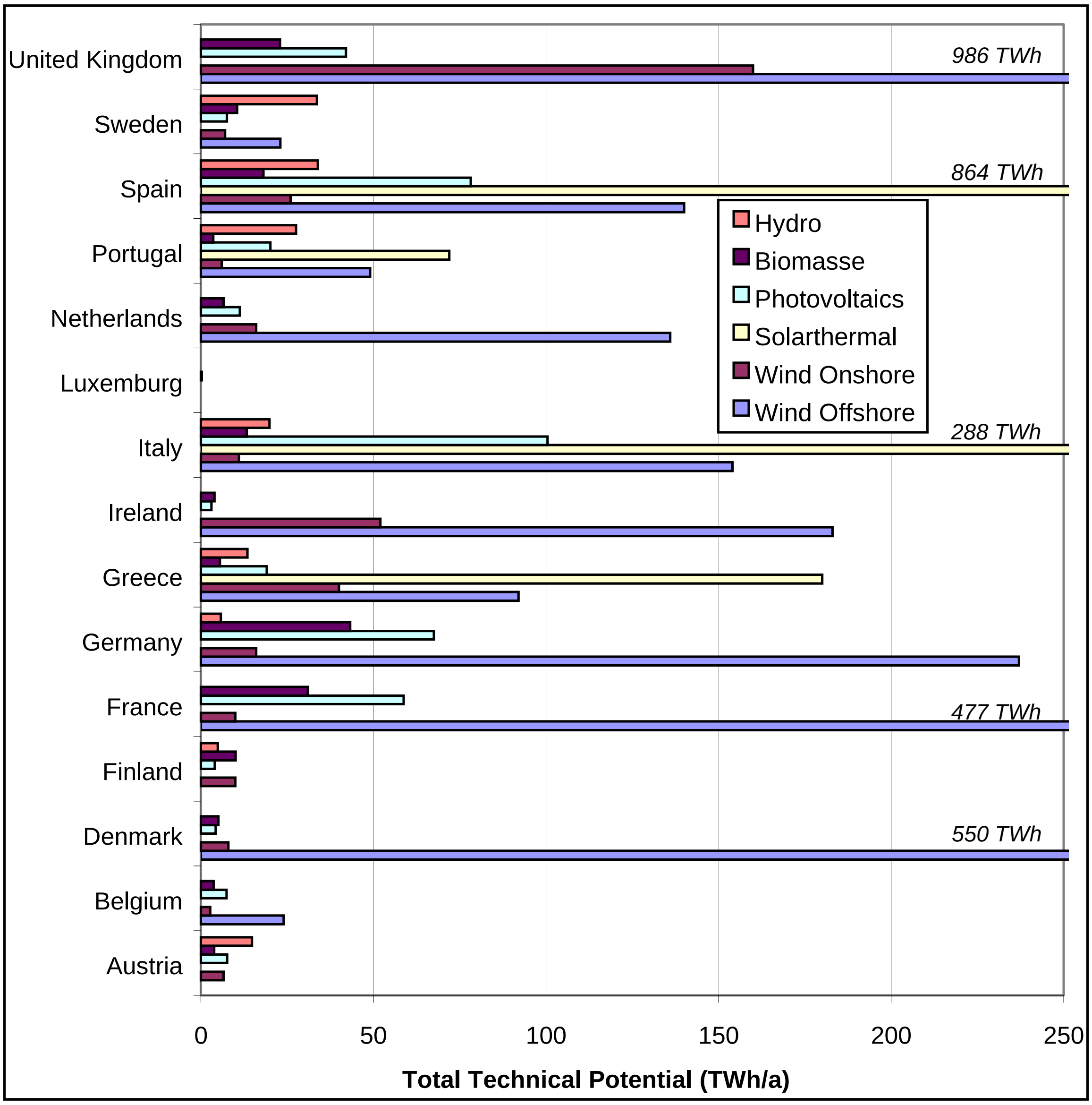

Figure 14: Distribution of the RES-E potential across EU-15 (in TWh/a)[21]

Estimates of the current and future RES-E production costs are a further essential input variable for a review of the TGC_{el} market development. The results from a little survey of ours are illustrated in Table 14. Based on the cost predictions and the estimates of technical potentials in Figure 14, we can then calculate cost-potential curves for each of the 15 EU countries.

For that purpose, some additional assumptions are necessary. We assume e.g. that the 6.5m/s feasible onshore wind resource of 12.4 TWh between 1996 and 2000 will be exploited at costs linearly increasing from 3.5 cE/kWh to 7 cE/kWh. This method is used for all technology categories. Finally, we obtain the European cost-potential for each of the three time-periods under consideration by accumulating the individual cost-potential curves.

[21] Sources: Compilation from LTI (1998), Semke/ Markewitz (1998)

	1996-2000		2001-2005		2006-2010	
	Low	**High**	**Low**	**High**	**Low**	**High**
Wind: onshore						
7.5m/s	2.5	4.5	2.0	4.0	1.8	3.5
6.5m/s	3.5	7.0	3.0	5.5	2.5	5.0
5.5m/s	5.5	9.5	3.5	7.0	3.0	6.0
4.5m/s	8.0	15.0	5.0	11.0	4.0	9.0
Wind: offshore						
10m	3.3	6.0	2.7	5.3	2.3	4.7
20m	4.7	9.3	4.0	7.3	3.3	6.7
30m	7.3	12.7	4.7	9.3	4.0	8.0
40m	10.7	20.0	6.7	14.7	5.3	12.0
Large Hydro	3	6	3	8	3	8
Small Hydro	5	17	5	17	5	17
Photovoltaics						
North	60	90	48	72	38.4	57.6
Central (FR, AT)	50	75	40	60	32	48
South (GR, IT, PO, SP)	40	60	32	48	25.6	38.4
Solar electricity	15	25	12	20	10	15
Biomass electricity						
Fuel switch	5.5	5.5	5.5	5.5	5.5	5.5
Wood	2	20	2	20	2	20
Biogas	6.5	100	6.5	100	6.5	100
Crops	3.8	12	3.8	12	3.8	12

Table 14: Production costs developments of the different technologies (in cE/kWh)[22]

The following figure (Figure 15) shows the accumulated cost-potential curve of EU-15 in the period 1996-2000 based on the assumptions given above. The overall exploitable RES-E potential in that period sums up to about 250 TWh, most of which (about 200 TWh) could be utilised below 30 c€/kWh. However, the national and the derived EC targets for that period are much lower. They amount to 27 TWh and 42 TWh respectively (cf. Table 12). Taking a closer look at that section of the cost-potential curve (1996-2000) reveals that under full co-operation between the 15 Member States, the production costs for reaching the targets would be far less than 10c€/kWh (Figure 15), according to our data.

[22] Sources: BMU (1999), Kaltschmitt/ Wiese (1997), Matthies et al. (1995), Semke/ Markewitz (1998) and own estimates

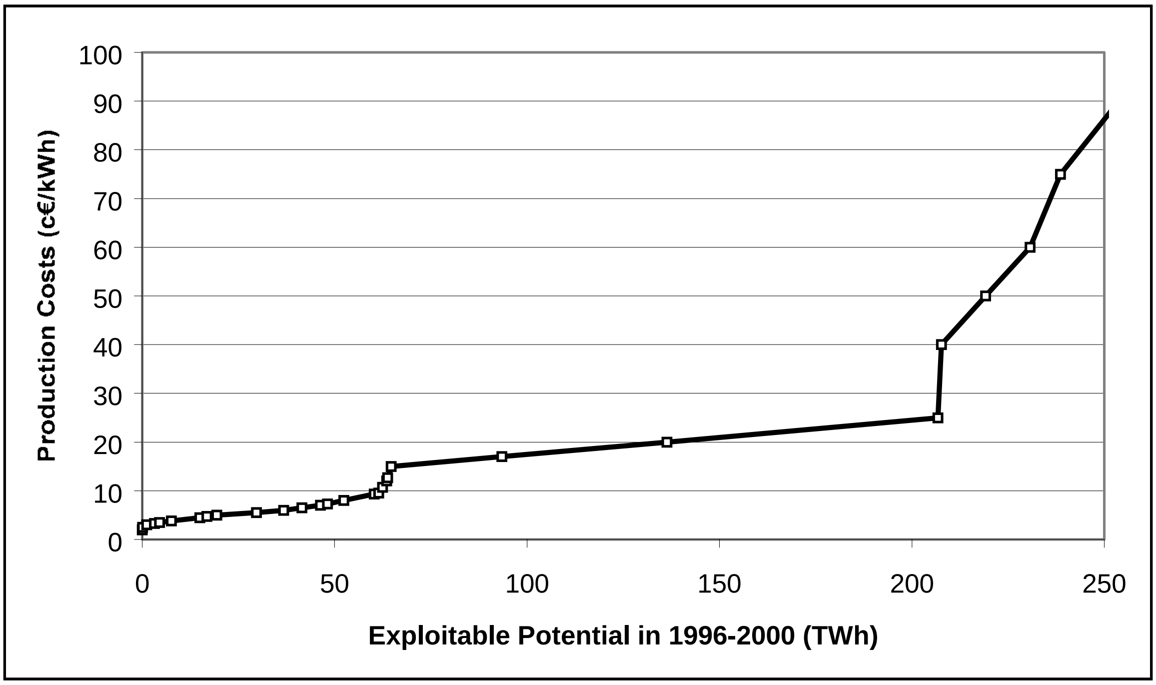

Figure 15: Cost-potential curve of EU-15 in the period 1996-2000

4.3.6 Projections of Future EU Electricity Market Prices

In order to estimate the TGC_{el} (and not only the RES-E) market size and value, it is now necessary to make assumptions on the price RES-E producers can achieve for feeding their electricity into the grid (commodity price). The figures in Table 15 present low and high estimates for the development of the commodity prices over the time periods under consideration. They are drawn from two very recent German studies. We make the (strong) assumption that they are valid for all EU Member States alike.

	1996-2000		2001-2005		2006-2010	
	Low	High	Low	High	Low	High
Wind / Solar electricity	1.53	5.62	1.66	4.60	1.79	5.11
Large hydro	5.11	5.62	3.08	4.60	4.09	5.11
Small hydro	5.62	5.62	4.60	4.60	5.11	5.11
Fuel switch to biomass	5.11	5.62	3.08	4.60	4.09	5.11
Other Biomass	5.62	5.62	4.60	4.60	5.11	5.11

Table 15: Development of commodity prices (in c€/kWh)[23]

The commodity prices differ subject to the grid level and the value of the delivered electricity. The high estimates reflect the market price for electricity at low voltage levels. The minimum high value is reached between 2001 and 2005 when competition and price dumping due to the existence of over-capacity in the electricity sectors are supposed to have a maximum effect on prices (cf. Schlesinger/ Schulz 2000).

For small hydro and biomass use other than co-firing, we assume that the low voltage grid level is the only feasible to feed in electricity. Accordingly, low and high commodity prices are supposed to match. Due to the fact that delivering electricity from wind energy and photovoltaics at a given date is more uncertain, the value of this intermittent product might be below the low voltage level market price for electricity. Based on Dany et al (2000: 52) we assume the value of electricity from wind energy and photovoltaics to be at least 1.53 c€/kWh. If in the long run capacity effects are fully reimbursed the value

[23] Sources: Schlesinger/ Schulz (2000), Dany et al. (2000)

of wind and solar electricity is supposed to be 1.79 c€/kWh. The low values for electricity from large hydro and fuel switch to biomass are relevant if the electricity is directly sold to the high voltage grid.

To create TGC_{el} price-potential curves for each country in the European Union, we accept the broadest price range possible. What this means is again exemplified with the wind onshore potential at a 6.5 m/s wind speed in the period 1996-2000. The lowest value of production costs minus the highest possible commodity price is -2.12 c€/kWh (= 3.5-5.62 c€/kWh). We assume that the TGC_{el} price is linearly increasing from that vale to the highest value of 5.47 c€/kWh determined by the high value of the production costs and the low value of the commodity price (= 7.0-1.53 c€/kWh).

Accumulating all country-specific functions we obtain the EU-15 TGC_{el} price-potential curve. For the first period (1996-2000) under analysis, the curve section up to 50TWh of the total 250 TWh exploitable potential is illustrated in Figure 16 below.

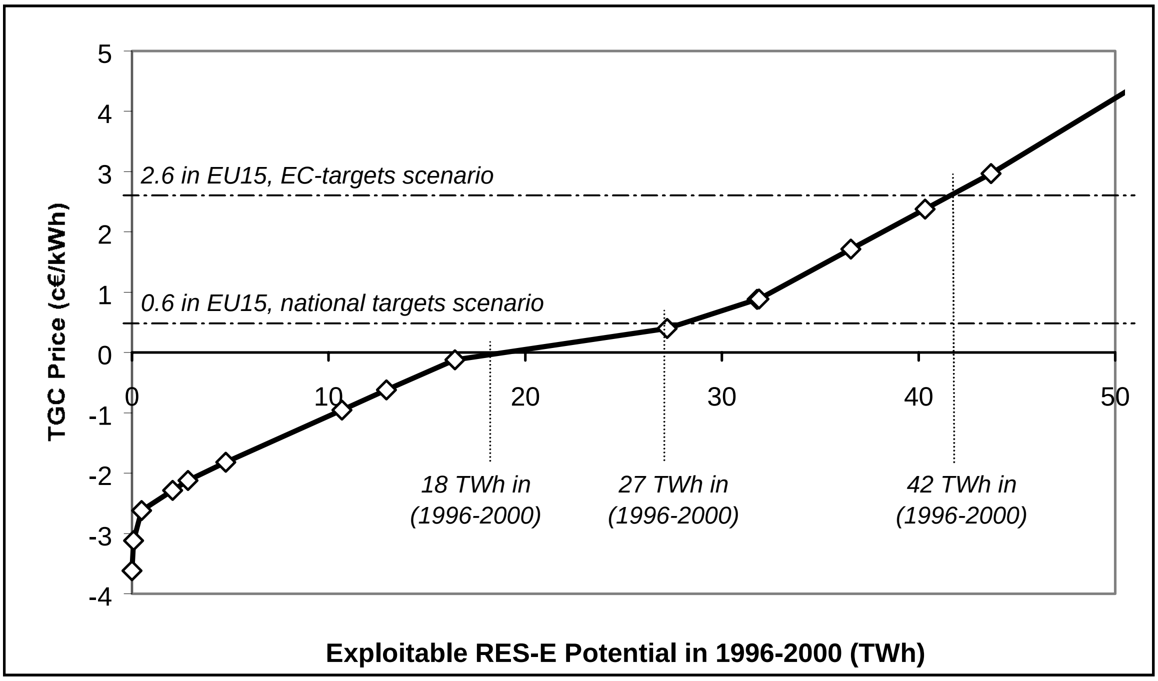

Figure 16: TGCel price-potential curve (up to 50 TWh) of EU-15 in the period 1996-2000

With our figures and assumptions, we must conclude that even without subsidies some 18TWh of RES-E production would have penetrated the European electricity market. Preconditions for that result are the non-discriminatory access to the grid for RES-E and a single market in electricity. A basic assumption on (quota-based) market functioning says that the producer's cost at the margin (of the quota) determines the market price (cross-section of demand and supply function). Under a fully co-operative EU-15 TGC_{el} trading scheme, the 2000 national target (27TWh) results in a TGC_{el} price of less than 0.6 c€/kWh, whereas the 2000 EC target (42TWh) is estimated to be met at about 2.6 c€/kWh in our model (cf Figure 16).

4.3.7 Estimates of the Potential Size and Value of a Future TGC_{el} Market

Based on the information, assumptions and methodology given in the previous chapters, we can now present first rough estimates of the potential size and monetary value of a tradable green certificate market in the electricity sector of the European Union.

We distinguish 4 TGC_{el}-trade scenarios:

- EU-15, EC-targets scenario: all Member States participate in certificate trading; the 22.1% target of the Commission is reached by Member States accepting the quantitative indications given by the Commission in their recent proposal for a Directive[24] (CEC 2000a);
- EU-15, national targets scenario: all Member States participate in certificate trading; the targets currently set in national legislation and energy programmes (add up to 17% for the whole EU) are reached by 2010;
- EU-5, EC-targets scenario: only the 5 countries at present most advanced with the implementation of a green certificate system (NL, DK, UK, I, Flanders) manage to trade among each other; they accept the targets recommended by the Commission (in CEC 2000a);
- EU-5, national targets scenario: only the 5 countries at present most advanced with the implementation of a green certificate system (NL, DK, UK, I, Flanders) manage to trade; they stick to the targets currently laid down in their national legislation or programmes.

For both sets of targets we calculate the RES-E production in each European country, the trade volume, and the TGC_{el} market price. Thus, we can derive the overall TGC_{el} market volume and the TGC_{el} trade value (Table 16)

Assessing prices, the pure national strategies help to explain expected imports and exports of the full-trade scenarios: an exporter of TGCs will meet the national target at costs below the full-trade price level, while importers will not be able to meet their national targets at full-trade prices.

The mechanism is once more described with an example: Suppose Germany and the United Kingdom co-operate in meeting their RES-E targets. Germany has a comparably poor RES-E resource and consequently faces high specific costs to meet its national target. The United Kingdom is able to meet its national target domestically at specific costs far below the calculated German equilibrium TGC_{el} price. With German TGC_{el} prices, the UK could produce at RES-E levels beyond its national targets. Thus, if Germany and the UK co-operated, the equilibrium TGC_{el} price under co-operation would range between the (isolated) national TGC_{el} prices of the two countries. As an effect, Germany buys TGCs in the UK (cf Figure 17).

The target path designed above (cf Table 11) for the period 1996 to 2000 presents nearly equal national targets for Germany (4.5TWh) and the United Kingdom (4.6TWh). Yet, based on our model, the TGC_{el} price necessary to reach the targets nationally would be about 3.8 c€/kWh for Germany compared with 0.3 c€/kWh for the UK. The broken line in Figure 17 represents the TGC_{el} price-potential curve of Germany and the United Kingdom under full co-operation. The overall 2000 target of 9.1TWh RES-E could be produced at a TGC_{el} price of about 0.6c€/kWh. At this price level, about 5.6TWh RES-E would be produced in the UK and about 3.5TWh in Germany. Hence, the UK is exporting TGCs equivalent to 1TWh RES-E production to Germany in this example.

[24] Since the Task 1.4 research was done the Directive has been adopted, on 27 September 2001

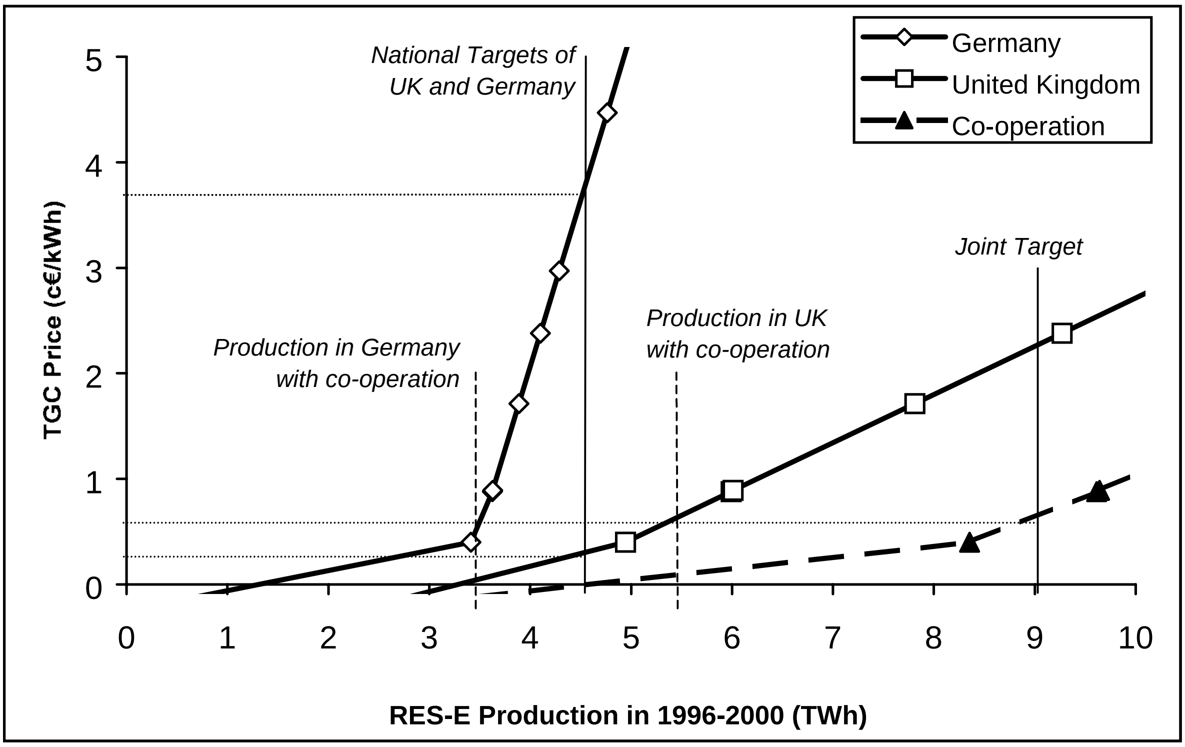

Figure 17: Example of Co-operation between UK and Germany

The amount of TWh covered by the TGCs sold from the UK to Germany (1 TWh) is interpreted as the trade volume. The trade volume is then multiplied by the equilibrium TGC_{el} price (0.6 c€/kWh), the product stands for the TGC_{el} trade value (€6m.). The accumulated national targets or the renewable electricity certified in total (market volume of 9.1 TWh) multiplied by the TGC_{el} market price yields the TGC_{el} market value (ca. €55m) under full co-operation.

The trade volume in an EU-15 or EU-5 scenario equals the sum of all TGC_{el} exports (or imports) of the 15 (or 5) co-operating countries in TWh. The market volume is determined on the assumption that only electricity from additional renewable energy plants (base year 1995) is certified and receive TGCs. If plants built before 1995 are eligible to receive TGC_{el} for their production, the market volume may even be larger. But, as said before, this will mainly be a political decision.

In our EU-15, EC-targets, full-trade scenario, an estimated certified RES-E production of 130TWh (out of 360TWh) is traded between the EU Member States in 2010; this comes to a market value of about €3.4billion (see Table 16). Thus, the EU-wide trade volume amounts to more than one third of the certified RES-E production in 2010. These figures indicate that there is a huge potential for TGC_{el}-trade between the 15 Member States. If the targets formulated by the national governments are implemented (EU-15, national targets, full-trade scenario), the trade volume is estimated to be at about half of the EC-targets case; the TGC_{el} market value in 2010 would be €1.5 billion, which is still a considerable market size. If only the five most advanced countries with respect to TGC_{el} policies started a fully co-operative trading scheme, the international market could still be expected to be sizeable. TGCs representing more than 30 TWh are expected to be traded between the five countries. Flanders, Italy and the Netherlands turn out to be net importers. Denmark and the United Kingdom are estimated to be exporters of TGCs due to their substantial offshore wind energy resource.

Scenario	TGC_{el} market volume (in billion €)* 2000	2005	2010	TGC_{el} trade volume (in TWh)* 2000	2005	2010	TGC_{el} trade value (in billion €)* 2000	2005	2010
EU-15, EC-targets	1.1	3.9	9.5	10	46	130	0.27	1.2	3.4
EU-15, nat. targets	0.15	0.97	1.6	6.8	28	75	0.038	0.31	0.58
EU-5, EC-targets	0.13	0.55	1.6	3.0	15	47	0.037	0.19	0.58
EU-5, nat. targets	0.084	0.35	0.81	1.5	8.4	30	0.012	0.077	0.23

Table 16: Estimated market, trade volumes and trade values under 4 different TGCel scenarios

TGC_{el} prices for each Member State were approximated assuming that national targets have to be fulfilled domestically, i.e. without cross-border trade. The results reveal that Austria, Finland, Luxembourg and Sweden could have difficulties in meeting the EC-targets without trade. The only country which is, based on the information given, not able to fulfil the RES-E target set by its national government is Finland.

It has already been mentioned before that the results are very sensitive to the assumed production costs and exploitation rates, in particular of offshore wind energy. If we reduce the possible exploitation rate per year to a tenth of the original assumption, the resulting TGC_{el} prices turn out to be 5 to 10 times higher (than those underlying the results presented in Table 8); under such a scenario with EC-targets, the TGC_{el} price is for example expected to reach about 14 cE/kWh. This higher TGC_{el} price is the consequence of solar thermal power plants entering the RES-E market after 2005. TGC_{el} trade, however, decreases by 20 to 30% since RES-E production is increasing substantially in the South of Europe and simultaneously, TGC_{el} transactions from those areas with a large offshore wind potential in the North of the EU can be cut. In total, the estimated value of traded TGC_{el}s exceeds the value of our original calculations due to higher expected TGC_{el} prices by about a factor of five.

The following overall conclusions may be drawn from our analysis:

- A substantial TGC_{el} market size and cross-border trading volume can be expected under both EU-15 and EU-5 trading schemes (in the light of the ambitious RES-E targets formulated by the European Commission as well as by the national governments).
- If the national targets indicated by the European Commission in the recent proposal for a Directive[25] were implemented, the EU Member States Austria, Finland, Luxembourg and Sweden could fail meeting these targets without TGC_{el} trade.
- Since the national governments' targets and the EC-targets do not reflect the distribution of RES-E potentials across the EU, there seems to be a need for trade. Our sensitivity analysis shows that the estimated trade volumes can be considered as robust. Our market and trade value estimates, in contrast, are very sensitive to assumptions, in particular concerning the exploitation rates of the wind offshore resource.
- In general, we find that the annual exploitation rate of renewable resources is a crucial issue with respect to TGC_{el} price. Therefore it is important that European and national policies focus on facilitating the development of renewable resources (e.g. by infrastructural measures) and on making obligations more flexible to fulfil (e.g. via instruments like banking and borrowing of TGC_{el}s).

4.4 TASK 1.5: INTERNATIONAL WORKSHOP/CONFERENCE.

4.4.1 Overview

A core objective of the RECerT project is the dissemination of understanding about TGC systems. The international workshop / conference was designed to be a single focus for results of all the current

[25] Since the Task 1.4 research was done the Directive has been adopted, on 27 September 2001

research and other developments, enabling participants to become fully aware of developments and issues during a single day.

The event, on 12 October 2000, was highly successful, with more participants (175) than were originally expected. Papers were presented from a wide range of speakers. The conference took place after the first round of RECerT country workshops, and was closely coordinated with the other FP5 clustered projects, and with the RECS group. Industrial sponsorship was used to expand the size of the event and secure a very good quality venue, a conference suite at the Radisson hotel in Brussels, and a high standard of service to participants.

The conference attracted participants from 18 different countries - Austria, Belgium, Denmark, Estonia, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and USA.

The agenda (see below) was deliberately tight, since the objective was to transmit a large amount of up-to-date information on TGC developments in Europe in an efficient manner. Unfortunately this left little room for discussion or questions.

Participant satisfaction was high, as evidenced by the feedback from the post-conference questionnaire. Dissatisfaction was expressed with the limited time available for discussion, and for aspects of the venue that made it difficult for some attendees to hear the presentations.

4.4.2 Sponsorship

The organisers decided to expand the scope of the workshop in terms of quality of venue and number of invitees, beyond that which could be supported by the budget available through the three green electricity cluster projects. This decision was taken in order to expand the impact of the event, and in order to achieve this, limited additional funding was necessary. Financial sponsorship was provided from seven companies, and marketing sponsorship from one. These were:

e-fets.com

ENVIRONMENT EXCHANGE www.t2e.co.uk

ELECTRABEL

NATSOURCE-TULLETT Europe Ltd.

Enel Produzione

Shell Renewables

HEW

GreenPrices www.greenprices.com

4.4.3 Agenda

Morning

09:00	Registration and coffee
09:30	Chairman's overview - *Mr Christopher Crookall-Fallon, ESD, UK*
09:40	Keynote address: The Renewable Energy Directive - the provision for green certificate trade, and a view to the future *Mr Luc Werring, Head of the Unit "Promotion of renewable energy sources and demand management" in the Directorate-General for Energy and Transport at the European Commission.*

Session one - Progress and developments in Europe

10:00	The RECS Group - objectives, growth and success to date *Mr Peter Niermeijer, RECS Group Chairman, EnergieNed, Netherlands*
10:20	The interaction of Tradable Green Certificates with other policy instruments, and the Green Electricity Cluster *Mr Reinhard Haas, Technical University of Vienna, Austria*
10:40	A summary of key TGC market developments in Member States *Ann Goossens, Advisor, European and Institutional Affairs, Electrabel, Belgium*
11:15	A summary of global developments in TGC markets *Dr Gerrit Jan Schaeffer, Green Certificate Specialist, ECN Policy Studies, Netherlands*.

11:30	Refreshment break

Session two - Perspectives

11:50	The market imperative - Eurelectric's view of the need for TGCs *Mr Inge Pierre, Eurelectric Inter-Domain group on Renewables*
12:10	A utility's perspective *Dr Helmuth Groscurth, Hamburgische Electricitaets-Werke AG (HEW), Germany*
12:30	A major energy user's and green producer's perspective *Kurt Lekås, Vice-President Energy Procurement, SCA HQ, Belgium*
12:50	A broker's perspective on the development of trading in green certificates *Garth Edward, Natsource Tullett Europe*

13:10	Buffet lunch

Afternoon

Session three - Future gazing

14:00	Are tradable certificates the right way to promote renewable energy in the EU? *Dr Stephan Singer, Head of European Climate and Energy Policy Unit, WWF, Brussels*
14:30	The future size and value of a European-wide market in TGCs - results of research work carried out under the RECerT and REBUS projects *Isabel Kühn, Economist, Centre for European Economic Research (ZEW GmbH), Germany*
15:00	Linkages between TGCs and carbon trading - provisional results of research carried out under the InTraCert project *Dr Lise Nielsen, Senior Scientist, Risoe National Laboratory, System Analysis Department*

15:30	Refreshment break

Session four - Next steps

16:00	The RECS trial trade - aims, objectives, timetable and opportunities to get involved - *Peter Niermeijer, EnergieNed, Netherlands*
16:20	The RECerT international internet trading simulation - objectives, timetable and opportunities to get involved *Christopher Crookall-Fallon, ESD, and Angus Macpherson, OM Environment Exchange, UK*
16:40	Chairman's summary and workshop close

4.4.4 Participant feedback

Feedback on the workshop was requested in order to gauge success, and to enable the organisers to improve future events of this kind. Participants were requested by e-mail to rate the conference on several aspects on the scale from one (poor) to five (excellent), and were invited to make further comments. 41 responses were received (about 23% of the audience). Average scores are shown in the following table, and have a total average of 3.82, close to the 'very good' adjectival grading. Given the limited resources of this conference we regard this as a very satisfactory outcome.

Rating scale:

1 = poor
2 = fair
3 = good
4 = very good
5 = excellent

Question	**Average rating across all respondents**
To what extent did the agenda cover current issues in the 'green certificates' debate?	3.99
How would you rate the quality of the speakers and presentations?	3.60
Were you satisfied with the workshop material?	3.30
On what scale would you rate the venue?	3.93
How would you rate the overall organisation of the event?	4.30
Average 'score' for the whole event	***3.82***

Table 17: Participant feedback

5 SUMMARY OF RESULTS - WORK PACKAGE TWO

Work package two comprised simulation game preparation, testing and implementation. It contained four linked tasks:

- Task 2.1: Computer-based simulation of TGC parameters and market dynamics (leader ECN)
- Task 2.2: Review and adapt existing manual market simulation tools (leader ECN).
- Task 2.3: manual simulation game testing and refinement.
- Task 2.4: Reporting of the results of the computer-based simulation of TGC market parameters (leader ECN)

5.1 TASK 2.1: COMPUTER-BASED SIMULATION OF TGC PARAMETERS AND MARKET DYNAMICS

One of the core elements of the RECerT project is simulations. The simulation undertaken in Task 2.1, led by ECN, was designed to explore some fundamental TGC market design issues such as expiry and redemption of certificates, banking and borrowing. The computer-based simulation was designed by ECN and the University of Amsterdam team, and was run in the experimental economics laboratory at the University of Amsterdam, using a number of networked PCs linked to a central economic model that replicated the behaviour of the whole market. Students were used to perform a series of different 'runs'. One of the purposes of this simulation is to feed-in to the design of the more ambitious internet-based trading simulation in WP5. The results of the laboratory experiment were presented during the first round of national workshops.

5.1.1 The laboratory simulation experiments

ECN (the Netherlands Energy Research Foundation) has been in charge of this first part of the simulation activities together with CREED (Centre for Research in Experimental Economics and Political Decision-Making). CREED is a research institute at the University of Amsterdam very familiar with development and use of laboratory experimentation to study economic problems. Experimental economics is a recently developed academic field and its use for the laboratory simulation experiment is pioneering in studying TGC systems. The outline of the experiment seeks to illustrate key TGC market design issues such as the role of issuing bodies, issues of liquidity, expiry and redemption of certificates.

In the experiment subjects (students) have been assigned roles. The relation between the average price of TGCs on the simulated market and investor behaviour has been simulated by software. The laboratory experiment was during the first two weeks of May, 2000.

The focus of the experiment was on the following key variables of a TGC design.

- How high could (should) be the **penalty** for non-compliance?
- Can one use leftover certificates from one year, for demand in a later year (“**banking**”)?
- If you are not able to fulfil your obligation in one year, to what extent should you be allowed to 'catch up' in a later year (“**borrowing**”)?

Two of these variables (banking and borrowing) could either have a high value or a low value. The level of the penalty had three possibilities. Not all of the possible 12 combinations were tried. Some of the most interesting were performed twice. There were 16 runs in total.

5.1.2 Starting points

The first of two starting points in the simulation is that the government in principle has to give some pressure to ensure that there will be a demand for the TGCs. The main driver is a penalty in the TGC system. Penalties are never high or low per se. It always depends on their relation to the equilibrium price, which is, de facto, merely theoretical. A penalty of 15 Eurocents/kWh is high for a low general RE obligation in a country with lots of potential but is (too) low for an obligation for which only PV is allowed.

Very high penalties give an enormous pressure on buyers, since, if they do not comply, they have to pay a very high price. Moreover, high penalties may induce higher prices for the certificates. Indeed, although the level of the penalty should not influence the equilibrium price, in practice it will have a price signalling function.

Lower penalties obviously relieve some of the pressure on the buyers. But it seems to make no sense to have a penalty below the equilibrium price. (However, in practice there is a lot of political pressure to keep penalties low.) With very low penalties, sellers would start to offer their units for prices higher than the penalty. This would leave them only with voluntary demand customers. Moreover, a country that might have chosen a penalty price lower than the equilibrium price can not expect much additional capacity installed. Of course, these and other market effects will be affected by the incorporation of other variables in the TGC system such as those mentioned below.

The second starting point is that the combination of a varying supply (because of climatic factors and a time lag between investment decisions and actual production start) and a fixed point-demand, will give rise to market problems if there is no flexibility in fulfilling demand: banking or borrowing. From the point of view of compliance in terms of the production of the renewable electricity, policy makers may be inclined to discard borrowing, since they are afraid that it will easily lead to non-compliance. Banking might be more popular, since it is then known that (at least) the desired amount of renewables has been produced.

The possibility of banking can be designed into a system at least in two ways:

- having a period of validity that is longer than the year of production;
- allowing an obligatory actor to bank a certain percentage of the certificates with regard to his obligatory demand.

- The possibility of borrowing can be regulated at least in the four following ways:
    - allowing a certain percentage leeway on fulfilling the obligation (e.g. used in Texas), except, of course, for the last year of the scheme;
    - requiring non-compliant actors to buy 'missing' certificates at a fixed high price from the TGC-Issuing Body. This Issuing Body will buy the TGCs back from the market for market prices within a certain period (Italy);
    - allowing certificates which still have to be produced (to be shown by contracts) to account for compliance for an obligation (one of the options considered in Denmark) whereby the certificates will be redeemed immediately as soon as they are produced;
    - applying ‘redeemable penalties’, i.e. penalties are applied but will be given back when the obliged actor has caught up in the following year (considered in Australia).

5.1.3 Variable values

The three variables, penalty, banking and borrowing, are varied as follows:

1. The penalty could be *low* (about 0.5 x theoretical price), *medium* (about 1.5 x theoretical price) or *high* (about 4 x theoretical price). With a theoretical equilibrium price of about 6.5 Eurocents/unit this translated to:
- low = 3 cents
- medium = 10 cents
- high = 25 cents.

2. Banking (or validity period which is theoretically similar) could be *high* (unlimited banking/no expiration date) or *low* (no banking/only valid in year of production), which means in the current case no banking or 100% banking.

3. Borrowing could be *low* (no leeway on obligation) or *high* (50% leeway on obligation).

The design was 'incomplete': not all combinations are used; moreover, interesting sessions have been replicated (in order to exclude outliers and events caused by error or irrational behaviour by subjects).

5.1.4 Implementation

For the simulation the relevant energy characteristics of an imaginary EU country was designed. Some of the starting assumptions are:

1. There is an obligation to increase the supply of renewables from 3 TWh in the first year to 6 TWh in the sixth years (appr. 15% growth a year);
2. Every year there is an obligation, leading to the final obligation in the last year;
3. This obligation is equally divided over 4 buyers (buyers with obligation);
4. The obligatory buyers can comply to their obligation by having enough valid certificates on their account by the end of each year;
5. Apart from the obligation there is a voluntary demand, the size of which depends heavily on the TGC-price;
6. The voluntary demand for every year is communicated to and divided equally over two buyers (buyers without an obligation). These buyers are told how many certificates they can cash for how much money at the end of the year;
7. In principle there is sufficient domestic RE potential;
8. The total demand in first year is matched by production of existing capacity;
9. The total electricity consumption is 100 TWh;
10. The equilibrium price is about 6.5 Eurocents/kWh are;
11. In the country six RE technologies can be implemented:
    - Wind near the coast
    - Wind inland
    - Wind offshore
    - Small biomass installations
    - Large biomass installations
    - Grid-connected solar electricity
12. The investor model supposes that investors take their investment decision on basis of expected electricity production price (assumed to be constant at a level of 3 Eurocents/kWh) plus expected average TGC-price over next 15 years.
13. There is a time lag of 1 year between the investment decision and start of production of TGCs. Prices of year 1(2,3,4) determine investments in year 2 (3,4,5), which is added to the existing RE capacity in year 3 (4,5,6), producing TGC according to climatic statistics (if applicable) in that year.
14. The expected TGC-price equals average price of last year, minus a correction for price volatility.
15. The renewables electricity production over a year is not completely predictable because of varying climatic conditions. It becomes only known over the year. Each year is divided in 4 sub-periods.

The subjects did not know the equilibrium price. In theory, traders can have multiple roles, for example, they have obligations and also sell green electricity to consumers. To make the experiment not too difficult to understand for the subjects and to shorten the needed explanation, each subject got a specific role and kept this role during the whole experiment.

Three kinds of traders are in the market.

- Buyers with obligations: these buyers receive money at the start of each period. They have to buy a certain number of units before the end of each period (if they do not comply, a penalty is applied). Thus, they spend their money on purchasing units and eventually penalties. They keep the money they still have at the end of the period.
- Buyers without obligations: two buyers also receive money at the start of each period. They try to buy units below their redemption value. Their profit is the difference between the redemption values and the prices they paid. Buyers without an obligation get money (less than buyers with obligation) and are told at the beginning of a period that they can receive an X amount of money at the end of the period, for every unit they are able to buy on the market. X = average price of foregoing period + 1 Eurocent. The exact amount is derived from a predetermined demand curve.
- Sellers: 6 sellers receive at the beginning of each sub-period units to sell. The money they make by selling these units is their profit.

5.1.5 Overview of the results

5.1.5.1 The 25 cents penalty sessions

- ***Session 1, banking and borrowing.*** No penalties were imposed, only little borrowing occurred (16 units in total). Both buyers and sellers banked, and the prices were very high (up to 20 cents). This resulted in overproduction in the later periods and a crash of the prices.
- ***Session 2, banking but no borrowing.*** 24 penalties were imposed. Both buyers and sellers banked, and the prices were very high (up to 15 cents). This resulted in overproduction in the later periods and a crash of the prices.
- ***Session 3, no banking, borrowing.*** No penalties were imposed, only little borrowing occurred (22 units in total). Prices are very stable around 7-8 cents, until the last period
- ***Session 4, no banking, no borrowing.*** 27 penalties were imposed (in the first 5 periods). Prices started quite high (9-10 cents), which caused overproduction in the later periods.
- ***Session 5, banking and borrowing, (replicated session 1).*** Due to a software problem, only the data of the first three periods of the market are available. Prices were between 14 and 15 cents, which caused considerable overproduction in later periods (very much like session 1).
- ***Session 6, banking, but no borrowing, (replicated session 2).*** 11 penalties were imposed. Both buyers and sellers banked, and the prices were very high (around 18 cents). This resulted in overproduction in the later periods and a crash of the prices (somewhat ‘worse’ than session 2).

5.1.5.2 The 3 cents penalty sessions

In all three sessions a lot of penalties were imposed. Typically, units are sold for a little more than 3 cents to buyers without obligations, only if the production was higher than the demand of the buyers without obligation, the buyers with obligations could buy some units, for prices of almost 3 cents.

- ***Session 7, banking, and borrowing.*** 571 penalties are imposed.
- ***Session 8, banking, but no borrowing.*** 753 penalties are imposed.
- ***Session 9, no banking, no borrowing.*** 768 penalties are imposed.

No replication was carried out because of the clarity of the outcome.

5.1.5.3 The 10 cents sessions

- ***Session 10, no banking, no borrowing.*** 16 penalties (16) are imposed. Prices are very stable around 7-8 cents until the very end. In period 5 some sellers lose some units, probably in an attempt to prevent lower prices.
- ***Session 11, banking, and borrowing.*** No penalties were imposed, only little borrowing occurred (21 units in total). Both buyers and sellers banked. Prices started around 8 cents and gradually decreased.
- ***Session 12, no banking, borrowing.*** Subjects borrowed a lot (192 units in total, more than 25%). Only in the final period penalties were imposed (21). Prices are very stable between 5.5 and 6.5 cents.
- ***Session 13, no banking, borrowing, (replicated session 12).*** The remarkable results of session 12 were not replicated. Buyers borrowed less (only 35 units) and part of the production was lost (not sold). This caused high prices in the first 3 periods and overproduction in the later periods. No penalties were imposed.
- ***Session 14, banking, no borrowing.*** Sellers banked a lot, which caused high prices, close to the level of the penalty (10 cents). In the first three periods 35 penalties were imposed. The high prices caused overproduction and a crash.
- ***Session 15, banking, no borrowing, (replicated session 14).*** In this session both buyers and sellers banked. Prices stayed high up to period 5, in period 6 the prices dropped to 0, but nobody needed units anymore. Only 1 penalty was imposed.
- ***Session 16, banking and borrowing, (replicated session 11).*** No penalties were imposed. A lot of banking by the sellers kept the prices high. Also a lot of borrowing (128 units) was observed. Overproduction in the last period caused a crash of the prices.

5.1.6 Preliminary conclusions

To set an appropriate penalty, at least a well-founded estimate of the equilibrium price should be made. However, the above given simulation results showed that it is not an easy task. An equilibrium price cannot be known beforehand. (It depends mostly on the real potential of a technology and the real cost-reductions in technology.) The results of the simulation allow some tentative conclusions to be drawn.

With a very low penalty (about 0,5 x the theoretical price of the certificate), the average price resulted a little bit above the penalty. And because of such low prices, a substantial voluntary market came into view. (Although at these prices only around 2 % of the electricity customers choose for green electricity, this is substantial in a market that starts with a 3% obligation.) The result is that there has been barely any additional capacity installed.

In the case where sellers could bank, they did not care too much if they could not sell all their certificates. They knew they could sell them anyway for 2.99 cent (slightly under the penalty price), and also they can bank the units, so that they might be able to sell them in the following year again on the voluntary market. This meant that in the banking cases the price in all but the last year, was well above penalty price. In several sessions the whole obligatory market has been ‘neglected’ this way for several years. However, even without banking, penalty application was very high (but, of course, the cost was not), often more than 50% and in some years 100%. This means that the penalty functioned as a tax: nothing happens (there is no compliance) and the penalty is applied.

With a very high-penalty (about 4 x the theoretical price) in the simulation, the prices were not stable and very high in the early periods. There was an enormous pressure on buyers, since, if they did not comply, they had to pay a genuine penalty.

Figures 18 to 22 below illustrate typical outcomes of chosen sessions, differentiated by penalty, banking and borrowing parameters.

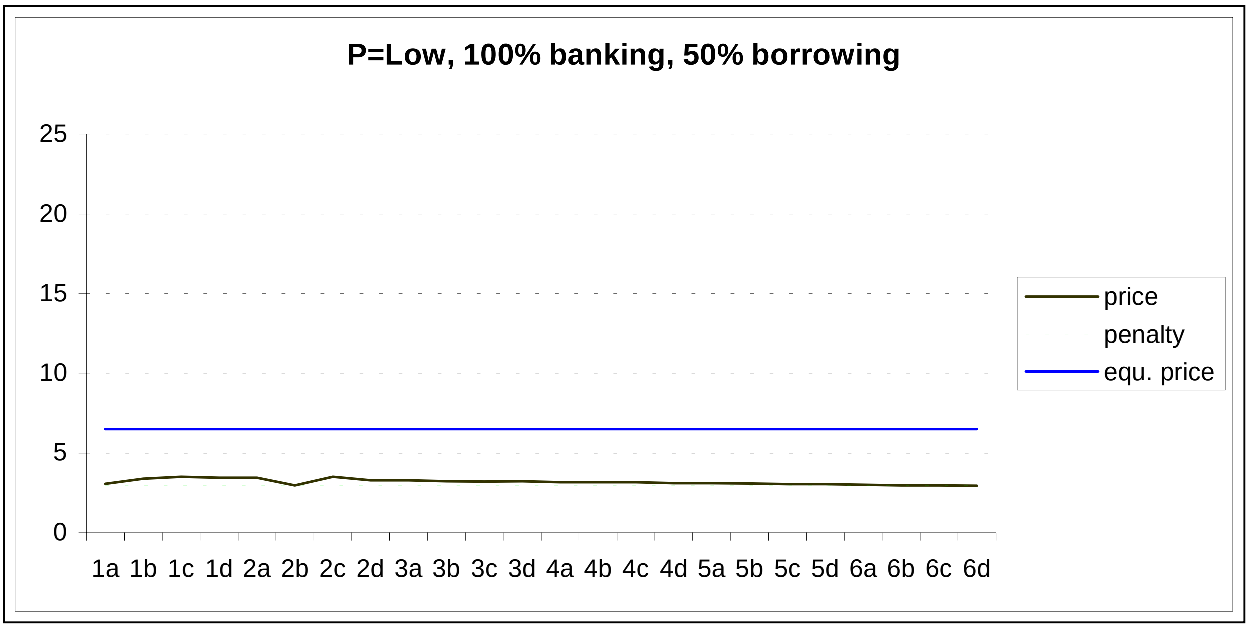

Figure 18: Low penalty, 100% banking, 50% borrowing

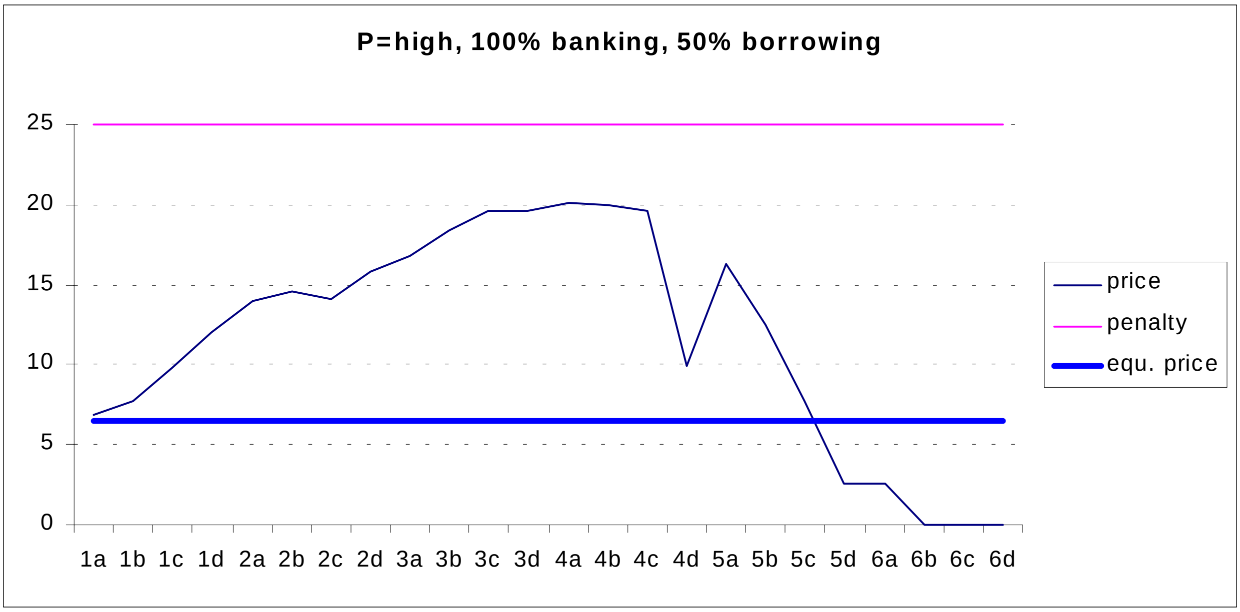

Figure 19: High penalty, 100% banking, 50% borrowing

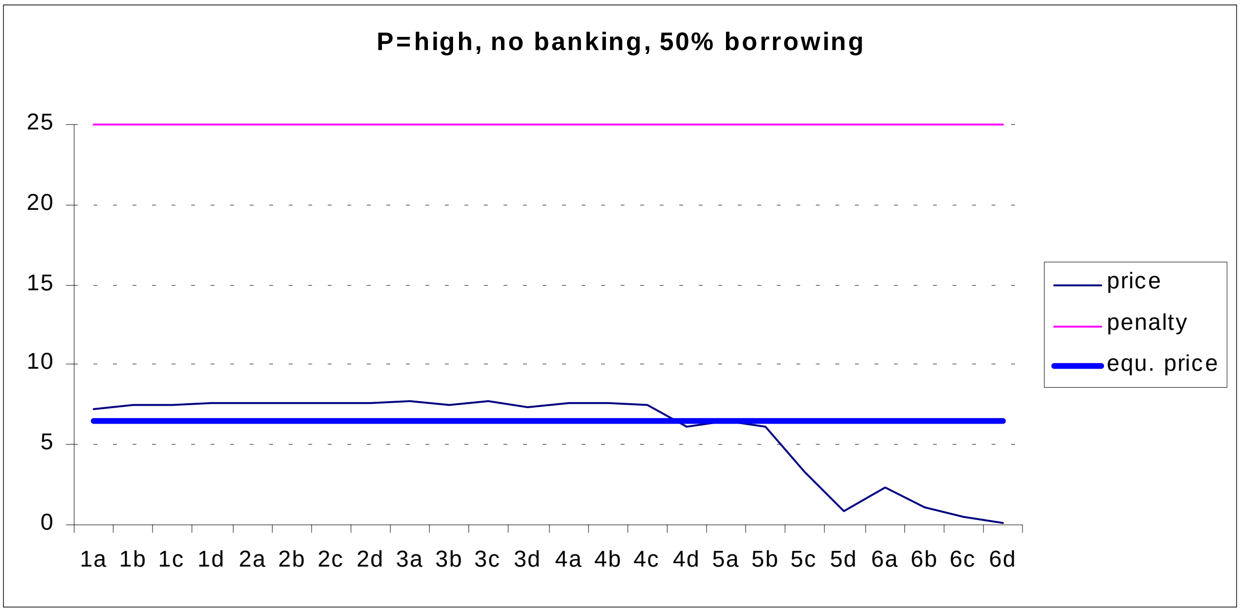

Figure 20: High penalty, no banking, 50% borrowing

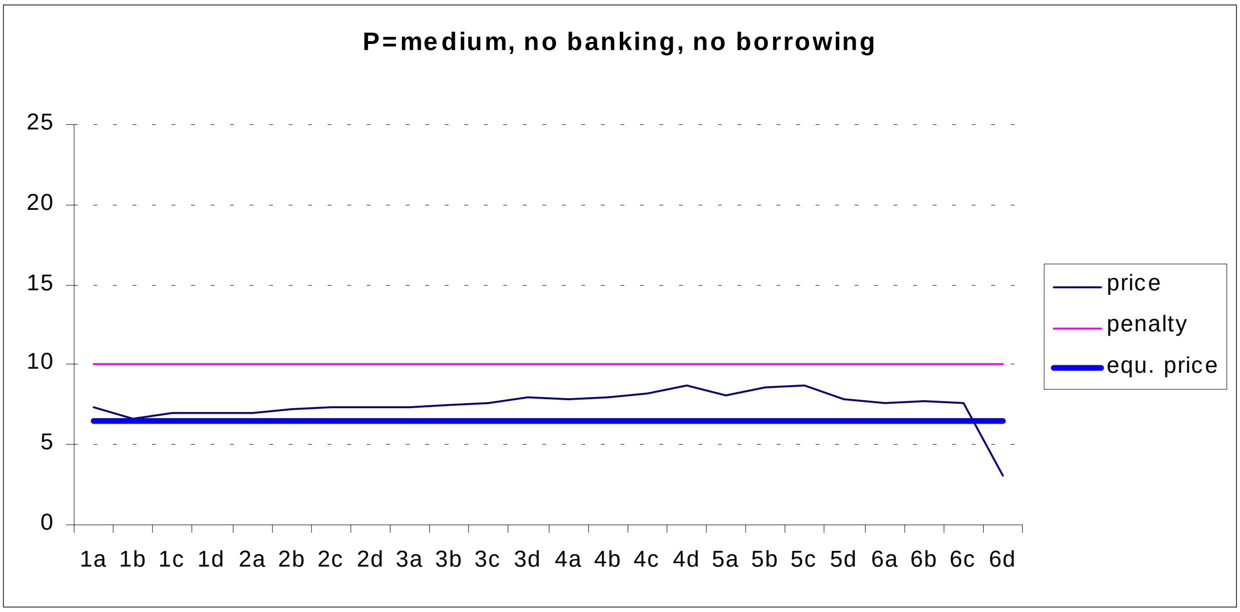

Figure 21: Medium penalty, no banking, no borrowing

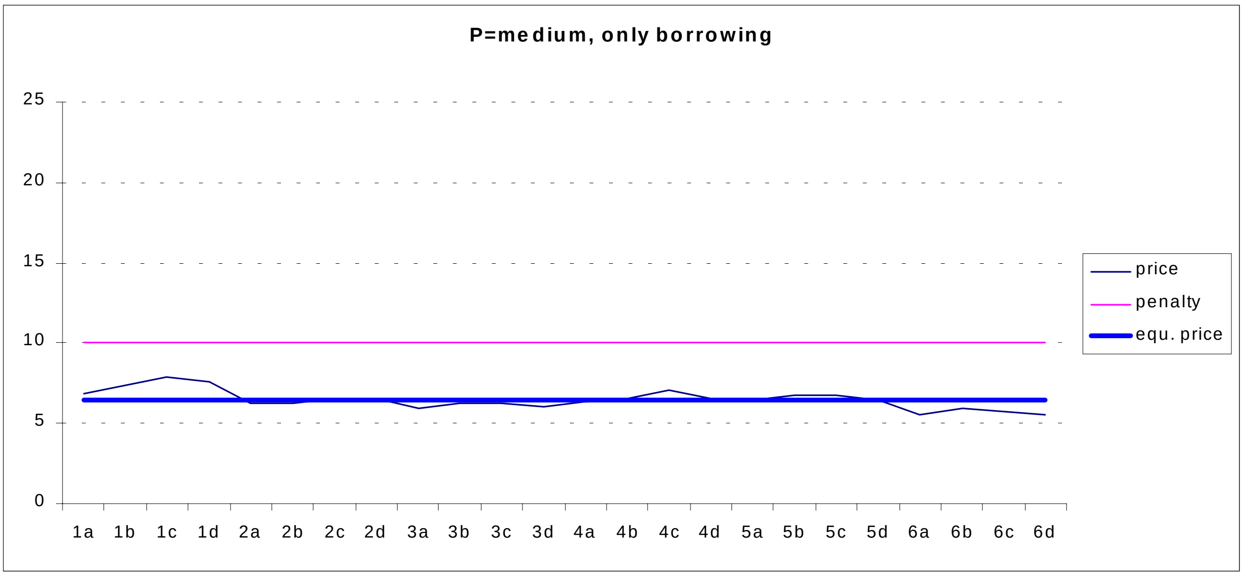

Figure 22: Medium penalty, no banking, 50% borrowing

In the simulated cases when sellers could bank, sellers were simply offering the certificates for high prices. If they were not able to sell them all, they banked them, and offered them on the market again in the next year. Since buyers were unsure how many certificates would be offered on the market next year, they tended to bank too, at least when possible. Both behaviours led to an upward pressure on prices. This caused, after some time delay, an enormous overproduction, understandably followed by a market crash, and thus very low prices in the end. Indeed, one has to realise that with overproduction up to a factor 2 above the obligation in the last year on the market, this would cost at least another 6 years of 15% increase of obligations per year to get at the obligatory demand at the same level.

Finally, when only borrowing was allowed, pressure was relieved from the buyers. No penalties were applied in this case, meaning that everybody always fulfilled his obligation (i.e., full compliance and/or borrowing to some allowed extent). This led to far lower prices, a more stable market and less overproduction (always < 50% with regard to obligation). However, also in this case the average price during the first 4 periods was higher than the equilibrium price, and in the last period the prices went steeply down again.

As the appearance of overproduction may be readily linked to the concept of cost-effectiveness, these simulations showed that TGC systems will not every time be cost-effective. A promotion system for renewables based on TGCs has the potential of enhancing the deployment of renewable energy sources in a cost-efficient way, but its success will depend largely on the way it is designed.

In the design, the level of the penalty is important because it is already a good price signal by itself. Therefore it is interesting to comment briefly on the results of the medium-level penalty cases.

Obviously, a lower penalty (10 cents: about 1,5 x the theoretical price) relieved some of the pressure on the buyers. This medium penalty seemed also to lead consequentially to lower prices for the certificates. However, the nature of the results was not very different from the high-penalty cases. Overproduction still occurred in some cases, when banking was allowed, but less than in high-penalty cases due to lower prices. Unlimited banking had again observable negative effects on TGC-markets. Firstly, it led to high prices, but eventually reduced the value of certificates enormously.

The case with no banking but with borrowing looked as if it was a perfect run, definitely in the sense of being the most cost-effective case because of its constant and low prices. However, this run was replicated, with less superb results. The main difference between the two runs has been the amount of borrowing. In the ‘perfect’ case, this was at maximum 32% (with regard to the obligatory demand). In the worse case it was at maximum 10%. This means that borrowing can only relieve pressure on buyers if it is really used!

5.1.7 Conclusions on the laboratory experiment

To make sure that new renewable energy will be achieved at a cost-effective way, policy makers have to incorporate appropriate variables in the system. The ‘devil is in the detail’, as some say.

Policy makers are often conditioned to the idea of bringing into play a ‘penalty’; this also means that they are used to the basic principle of pricing ‘non-compliance’. A penalty regime can exploit this principle in two different ways. The level of penalty may be decided with a deployment goal in mind (i.e., when deployment of new renewable energy is most important) or with a compensation goal in mind (i.e., when short supply should not lead to an increased financial risk for the obliged actors).

A low penalty (i.e. lower than the price that is needed to attain the target) may merely function as a tax: nothing happens (there is no compliance) and the penalty is applied. Then, the next issue is to agree on what to do with the penalty money (to put it in RE Funds, to feed it back to the industry), but a discussion of that is beyond the present report. The mere conclusion here is that, all in all, penalties that are too low do not seem to make sense. A switch from the TGC system to a totally voluntary system, or the appliance of a straightforward tax should then be considered.

But, of course, the effect of the variable ‘penalty’ in the design of a TGC system will depend on the effects of the other variables. The variables can not be appropriate on their own; they also have to fit each variable with each other one. And as said earlier, besides penalty, policy makers should also seriously consider both banking and borrowing as basic features of their TGC-system.

The concept of banking seems fairly popular among policy makers, since they know that, at least, the desired amount of renewables will be produced. However from the results of the laboratory experiment, it appears that banking leads to an upward pressure on prices. It gives the opportunity to sellers to offer certificates at higher prices, without caring too much if they remain unsold, at least not at the beginning of the validity period. Somewhat unexpectedly, uncertainty over the amount of certificates offered seems to have formed an incentive for buyers to ‘bank’ too.

Unlimited banking has negative effects on TGC-markets as it induces higher prices, and eventually reduces the value of certificates enormously. That is not good for the industry of renewables and its trust in TGC-systems.

Banking could also be seen as an instrument to stabilise the market by way of rising prices when sellers feel these are too low. To enhance the flexibility of suppliers of green certificates to follow demand, it is convenient to use certificates produced in a year of abundant production to fulfil demand in a later, less-abundant year. Therefore, banking is needed or the validity period of the certificate needs to be more than one year. However, it does not need to be eternal; there is a clear trade-off.

We should be aware that the price crash observed in the last period of almost all the experiment sessions is at least partly due to the natural 'end effect', caused by the lack of value of certificates in periods beyond the end of the simulation. This means that the price effects might be less marked in reality than they appear to be in the simulation.

The concept of borrowing, used alternatively or concurrently with banking, looks as if it is far less popular among policy makers, since they are afraid it will lead easily to non-compliance. However, from the results of the laboratory experiment, it appears that limited borrowing leads to a downward pressure on prices, as the ‘obligation pressure’ on buyers is, to some extent, relieved, whereas still almost full compliance is reached. Thus the laboratory experiment suggests that borrowing may be an instrument to stabilise the market by way of reducing prices when buyers feel they are too high.

5.2 TASK 2.2: REVIEW AND ADAPT EXISTING MANUAL MARKET SIMULATION TOOLS

This task was led by ECN. The purpose was to review and adapt existing manual (paper-based) market simulation tools that had been developed by KEMA, to suit the first round country workshops.

This task was the second element of the simulations that were central to the RECerT project. The purpose of the simulation game was to introduce participants to some of the principles of trading TGCs, while also helping to make the country workshops lively and interesting.

5.2.1 The national workshop game

The TGC workshop game functioned as a refreshing change from traditional presentations, to get the workshop participants acquainted with the idea of trading environmental benefits. It provided a 'hands-on' simulation of trading conditions for TGCs, and gave workshop participants some insight into the decision-making and processes of such a market. The game was a slightly adapted version of the game that KEMA-Sustainable developed for the introduction of the Green Label system in the Netherlands in early 1998, which had been played a number of times with different audiences. KEMA Sustainable is a knowledge-intensive organisation active in the field of electric energy systems and environmental technology and management.

At each workshop either someone from KEMA or someone from ECN was responsible for carrying out the workshop trading game.

5.2.2 Basic features

The participants in the workshop were divided in two groups:
- sellers of certificates
- buyers.

Each participant received before the start of the game an envelope with:
- rules of the game
- price instructions for his or her role
- set of playing cards
- market information.

When the “market” opens, participants have to find another party to deal with. In addition to the market information in their envelopes they can follow the price development which is shown on a video screen. The price information on the video screen follows a pre-set price scenario, but the traders have no knowledge about the future occurrence of this price as this scenario is only shown during the game. Participants have to note the deals they have made on their playing cards. When they have concluded their business, they hand over their cards to one of the organisers to process their transactions. The game is played for about 30 minutes. The organiser analyses these results and determines a winner of the game. Somewhere in the afternoon session of the workshop a short analysis of the game is presented and the winner(s) receive an award.

The ratio of buyers : traders is set at 10 : 18, and the ratio of sellers : traders is set at 8 : 18. There are (more or less) as many certificates offered by sellers as needed by buyers (10 certificates per seller available and 8 certificates needed per buyer). To avoid players executing the whole volume in a single transaction, a deal-size maximum limit of 4 certificates is imposed.
A maximum price is indicated to buyers and a minimum price to sellers. These maximum and minimum prices are differentiated.

Role	% of participants
Buyer with low maximum price	20
Buyer with high maximum price	35
Seller with low minimum price	30
Seller with high minimum price	15

The figures are indicative. The real distribution differed each time, because of the different sizes of the player group and because of change factors in the process of handing out the envelopes.

Buyers were allowed to buy more certificates than needed for their own demand with the purpose of trying to sell them at higher prices. Also sellers were allowed to buy certificates on the market with the aim to sell them at higher prices. These extra deals had to be noted on so called 'broker cards'.

5.2.3 Some observations

The fact that the price scenario is pre-set is not mentioned to the players. This means that the traders often think they influence price forming. In practice, they hand over their cards to one of the organisers to process their transactions. Because all trading information is entered as soon as their deals are made, the traders are inclined to imagine such an impact. The result is a lot of fervent buyers and sellers and quite a lively trading floor.

Thus, however simplified the way the games have been played, this kind of simulation still demonstrated to RECerT workshop participants some of the key features of the trade in renewable certificates. They at least had experience of the mechanism of price setting and the role of demand and supply, and the importance of transparency of the market and the need for information.

6 SUMMARY OF RESULTS - WORK PACKAGE THREE

Work package three comprised a cost-benefit analysis of European TGC trading, in terms of business and transaction costs, and comparing TGC trading with other renewable energy support mechanisms.

6.1 OBJECTIVES AND BACKGROUND

The objectives of Work Package 3 are to help all key stakeholders to understand the basic costs and benefits of REC trading, and coordinated REC development across Europe, in terms of business and transaction costs. The study elaborated the costs and benefits of a European-wide TGC_{el} system in comparison to (isolated) national systems and alternative support schemes for RES – other things (such as deployment targets etc.) being equal.

The WP3 report was intended to be both a high-level economic analysis as well as a business-oriented analysis of the costs and benefits of using a REC trading system for all potential system users. ZEW was responsible for the work package, in which the four sub-tasks are treated continuously and give rise to a single report. Task 3.1 defines a reference scenario or baseline, building on the reviews in WP1. Task 3.2 defines transaction costs of related systems. Task 3.3 calculates the cost savings/ benefits compared to 'competing' systems. Task 3.4 draws conclusions and makes recommendations.

Work Package 3 is closely linked to Task 1.4 for which ZEW came up with first rough estimates of the potential size and monetary value of a Tradable Green Certificates (TGC) market in the European Union (cf. Bräuer / Kühn 2000).

6.2 REFERENCE SCENARIOS AND METHODOLOGY

The basic data used for the calculations below has been derived from a small number of earlier surveys of estimates of the technical and market potential for different sources of renewable electricity (RES-E) in each EU-15 country. Electricity market projections for EU-15 have been taken from the Commission's Shared Analysis Project. Estimations of the price development for electricity have been drawn from Schlesinger/ Schulz (2000) as well as Dany et al. (2000). Based on the available information, TGC_{el} price-potential curves for each Member State as well as an aggregated curve for EU-15 have been developed. The base year is 1995.

For the TGC_{el} market modelling, we assume that there is only one generic green certificate product, i.e. only one single market develops. Further simplifying assumptions are that there are no trade barriers or other market distortions as e.g. additional promotion schemes for renewable electricity, or upper and lower price limits, i.e. we are in an ideal economic world. Moreover, only renewable energy plants (including large hydro, excluding waste) built after the base year 1995 are eligible for green certificates. Finally, the view we take is mainly static. Production cost effects due to economies of scale or technological progress have been integrated exogenously as averages in the periods 2001-2005 and 2006-2010. Also, the commodity prices are assumed to change in these two periods. Thus, the derived cost-potential curves change in the course of time.

For the following comparison of RES-E support policies, we assume that they are designed and implemented to fulfil the RES-E targets set in national legislation and energy programmes (cf. Table 10

	RES-E share 1997 (in %)	'National Targets' for RES-E by 2010 (in % and year)	(in TWh)
Austria	72.7	3% in 2005 (non-large hydro)	+2 (+0.11)
Belgium	1.1	Flanders: 3% in 2004 5% in 2010 Wallonia: 8% in 2010	Fla.: 0.9 1.8
Denmark	8.7	20% in 2003 30% in 2010	7.5 13
Germany	4.5	10-12% in 2010	61
Italy	16.0	+2% in 2002 Doubling until 2010	+4.5 78
Netherlands	3.5	8.5% in 2010 17% in 2020	11
Spain	19.9	12% in 2010 (non-large hydro)	62
UK	1.7	5% in 2003 10% in 2010	21 50
EU-15	13.9	About 17% in 2010	

Table 18: National targets for RES-E in Austria, Germany, Spain and EU-5 (Status: 05/2000)[26]

6.3 ESTIMATES OF COST SAVINGS

Cost minimisation, economic efficiency and market conformity are the most common arguments for implementing market-based environmental policies like TGC_{el} systems. In frictionless, fully competitive market scenarios, this should definitely be true. The following calculations based on the RECerT Task 1.4 model can give an idea of the order of magnitude of the possible cost savings.

We choose two different scenarios given the RES-E targets formulated by the national governments (cf. Table 18).
In the first scenario, we compare the regulation costs of the national feed-in systems in Austria, Germany, and Spain with the costs of (isolated) national TGC_{el} systems in these countries, and with the costs of national TGC_{el} systems in these Member States as part of an EU-wide trading scheme.
In the second scenario, we estimate the cost savings derived from cross-border TGC_{el} trading in contrast to (isolated) national TGC_{el} systems in EU-5 – EU-5 being the countries most advanced with the design and implementation of a TGC_{el} system (Italy, Flanders, Denmark, the Netherlands, and the U.K.).
Regulation costs are defined here as the technology-based marginal costs of RES-E minus the commodity price times the kWh generated with RES. Under TGC_{el} systems the regulation costs equal the market value of all issued TGC_{el}s. For feed-in systems, the regulation costs come to the accumulated feed-in payments per kWh minus the average commodity value of RES-E from different technologies as assumed in the Task 1.4 model.

6.3.1 Regulation Costs of National Feed-in vs. National TGC_{el} systems

The model results in Table 19 tell three different stories. Obviously, the assumed Austrian national RES-E target for 2010 can be achieved by simply paying the RES-E producers the commodity price of electricity. Therefore, a national TGC_{el} system would see a TGC_{el} price of zero Euros, within our data and model framework. But the Austrian feed-in system generates regulation costs of 21 million Euros. This documents an inefficient regulation design compared to a national TGC_{el} system or – in other words – a national TGC_{el} system in Austria would reach the national RES-E target with lower regulation costs even if the transaction costs of the TGC_{el} system summed up to 20 million Euro. In an EU-wide TGC_{el} system based on national targets, Austria would face regulation costs since the TGC_{el} price of the European system is expected to be higher than in an isolated Austrian TGC_{el} market. This

[26] Source: Task 1.4 report

corresponds to the result in Task 1.4 where Austria would be a TGC_{el} seller under the EU-15, national targets scenario.

Million Euro	Feed-in	National TGC_{el}	EU-wide TGC_{el}
Austria	21	0	6,1
Germany	1300	1200	260
Spain	840	54	35

Table 19: Regulation costs of feed-in vs. TGCel systems

In relative terms, the German feed-in system seems to be more efficient than the Austrian one. The regulation costs of the feed-in system are in the same order of magnitude as the expected costs of a national TGC_{el} system. However, Germany would benefit from an EU-wide TGC_{el} system. Under the EU-15, national targets scenario, the regulation costs in Germany would drop by about 1 billion Euro compared to any national support mechanism.

In contrast, the Spanish feed-in system seems to be extremely inefficient compared to a national TGC_{el} system. This is basically due to the fact that Spain guarantees a comparably high tariff for electricity production from photovoltaics which makes this technology economically viable between 2005 and 2010, in our model.

6.3.2 Regulation costs of EU-5, trade vs. EU-5, non-trade TGC_{el} System

The model results for the five most advanced European countries in TGC_{el} trade (Flanders, Denmark, Italy, the Netherlands, and the United Kingdom) clearly show that international cooperation is cost-efficient in total (cf.Table 20). Regulation costs can be reduced by 4 billion Euro. But there are winners and losers in international trade. Italy can profit the most, in particular from the assumed large wind offshore potentials of Denmark and the United Kingdom.

Million Euro	National TGC_{el} Trade	EU-5 Trade
Flanders	16	15
Denmark	22	97
Italy	4600	320
The Netherlands	108	85
United Kingdom	84	360
EU-5 Total	4830	877

Table 20: Regulation costs in the EU-5, national targets scenario of international vs. national TGCel trade

6.3.3 Summary

We can conclude that the model runs support the most common arguments for implementing TGC_{el} schemes. As we assume frictionless, competitive markets, that market prices are determined by the marginal production cost of the last RES-E kWh that enters the market and that the RES-E targets are fulfilled with the cheapest options available. Total regulation costs are minimised. The net gains get even larger, when cross-border trade is allowed.

In addition, the results of the model runs back two other issues emphasised in economic textbooks. First, the closer the regulator gets to real production costs and the market prices when setting feed-in tariffs, the more equal the total regulation costs of an (isolated) national TGC_{el} system and a national feed-in system can become. However it is very difficult for the regulator to obtain this information. Secondly, there are not only winners, but also losers of policy changes. In the U.K. it is the consumers, in Italy it is the producers who earn a lower surplus under an EU-5, trade scenario in comparison to an EU-5, non-trade scenario. However, in total, the EU-5 societies are benefiting.

6.4 TRANSACTION COSTS OF RES-E SUPPORT SCHEMES

Market-based instruments, and more specifically tradable permits, have been widely discussed on theoretical grounds. Many economists highlight their advantages. However, up to now their implementation has remained poor at both the national and international levels. This fact is usually attributed to the problems of acceptability in administration and society, and more technically and broader speaking to transaction costs. Transaction costs accompany the implementation of all policy instruments and are involved in all market transactions. Model simulations (like the above) that neglect the existence and evaluation of transaction costs over-estimate the potential benefit from (international) trade. The primary economic tool for policy analysis, cost-benefit analysis (CBA), is deficient in its handling of transaction costs, so that CBA presents an incomplete view of the social welfare effects of policies. In the following, we investigate the issue of transaction costs of TGC_{el} and feed-in systems in more detail.

6.4.1 General

Coase defined transaction costs as the costs that arise from initiating and completing transactions, like finding partners, negotiating, consulting with lawyers and other experts, monitoring agreements, etc., or opportunity costs, like lost time and resources. The most obvious impact of transaction costs is that they raise the costs for the participants of the transaction and thereby lower the trading volume or even discourage some transactions from occurring. Transaction costs that fall under this definition can take many forms. Different authors have used different subcategories. They, for example, divide the so-called market transaction costs into:

- ***Search costs****:* costs of finding interested partners to the transaction as well as the costs of identifying one's own position and optimal strategy.
- ***Negotiation costs:*** the costs for coming to an agreement. Negotiating terms may for example take time, visits to the site of a project, and hiring lawyers to draft contracts.
- **Approval costs:** arise when the negotiated exchange must be approved by a government agency. Modifications could be imposed on the deal.
- ***Monitoring costs:*** are the efforts the participants must make to observe the transaction as it occurs, and to verify adherence to the terms of the transaction.
- ***Enforcement costs:*** the expenses to insist on compliance once discrepancies are discovered.
- **Adjustment costs:** costs of changing strategies, due to a change in regulations or new scientific discoveries.

These costs can occur with every transaction that is carried out; they are also called periodic transaction costs.

But there is also another category of transaction costs. These are those costs that arise in designing and implementing public policies. The so-called set up or institutional transaction costs are considered very relevant for TGC_{el} systems, and tradable environmental policy instruments in general, by many experts, market actors, and politicians. They include:

- Developing the instrument in question,
- Enacting it by legislature,
- Establishing of an administrative infrastructure,
- Implementing and enforcing the policy by administrative agencies and the courts,
- Fighting political opposition against the instrument; campaigning for social acceptance.

6.4.2 TGC_{el} Systems vs. Feed-in Systems

For the following discussion, we assume two alternative financing mechanism of feed-in tariff systems and two variants of tradable green certificate models, acknowledging that many additional design differences are possible. We highlight some subcategories of transaction costs that are very similar and some that are rather different.

One feed-in tariff system is modelled after the German feed-in tariff system where both, the grid and supply companies are responsible for purchasing and selling the eligible RES-E produced, as well as for the administration of the nation-wide balancing of qualified RES-E power and costs of the support scheme. We will refer to it as Feed-in System 1, in the following. Under *the other feed-in tariff scheme*, the government/ a ministry is involved as well, as it is to collect money from taxpayers and to redistribute it to the grid companies who transfer the respective tariffs per kWh to the RES-E generators (Feed-in System 2). The differentiation we make for the TGC_{el} system concerns the competition on the electricity market. Under *an "ideal" TGC_{el} scheme* in a liberalised market, the purchase of RES-E is not guaranteed at a minimum price, but subject to negotiations and competition (TGC_{el} System 1). Most of *the national TGC_{el} schemes* that have been designed so far do, however, include a purchase obligation for RES-E at a fixed minimum rate. This element makes the latter system more equal to a feed-in system and reduces the risks for renewable generators (TGC_{el} System 2).

6.4.3 Market Transaction Costs

Concerning the periodic transaction costs, we perceive key differences between the 4 selected support schemes in the two categories:

- Economic risks, and
- Search and negotiation costs.

Under both types of a feed-in tariff system, the investment risk for the renewable plant operator is very low compared to a "normal" market. He knows exactly what revenue to calculate and does not need to worry about demand (fluctuations).

Under TGC_{el} System 1, the renewable generator operates under "normal" market conditions, the future development of market prices of electricity and TGC_{el}s is uncertain. Demand is not guaranteed, although the minimum total market size is known. So an additional project risk exists under TGC_{el} System 1, that the ex-post realised net present value may differ from its ex-ante planned value. As a result, the RES-E generator will need to include a risk premium in his calculations or hedge against the risk of failure by investing in a portfolio of projects with non-correlated risks.[27]

TGC_{el} System 2 leaves some uncertainty for the RES-E generator concerning the TGC_{el} price development. But the other critical parameters are fixed for the RES-E investor. The above deliberations lead us to the ranking of economic risk from the RES-E generator perspective as low, low, high, and middle, respectively (cf. Table 21).

From the perspective of the supply companies, there is an economic risk under Feed-in System 1 that the costs cannot be passed on to the consumers. As the retail power market is supposed to be competitive, the cost sharing between companies is an important feature of the Feed-in System 1 that impedes discrimination and helps to reduce economic risks. If the money is collected via taxes (Feed-in System 2), there is no price risk for the supply companies. The risk shifts to the public budget. Under both TGC_{el} systems, the supply companies who are the obliged parties under the renewable obligation have to cope with "normal" economic risks. This is also true in TGC_{el} System 2, as electricity prices are swinging while the minimum reimbursement paid to the RES-E generators by the grid company is legally fixed. Thus, we suggest categorising the economic risk from the supplier perspective as middle, low, high, and high, respectively (cf. Table 21).

With respect to search and negotiation costs, the main difference is that under Feed-in Systems it is only the grid and supply companies that have to sell power and find customers for their product on the market, not the RES-E generator (cf. Table 21).

[27] It should be added that it is very likely that a financial market will emerge in which TGC_{el}s for future delivery etc. will be traded. This financial market will contribute towards creating greater certainty to players with respect to future TGC_{el} prices.

	Feed-in System 1	Feed-in System 2	TGC_{el} System 1	TGC_{el} System 2
Market Transaction Costs				
Economic risk for				
RES-E Generator	Low	Low	High (Normal)	Middle
Grid/ Supply Companies	Middle	Low	High (Normal)	High
Search and Negotiation Costs for				
RES-E Generator	Low	Low	High (Normal)	Middle
Grid/ Supply Companies	Middle	Middle	High (Normal)	Middle
Institutional Transaction Costs				

Table 21: Main Differences in Transaction Costs of TGCel and Feed-in Systems

6.4.4 Institutional Transaction Costs

In the ongoing discussion about TGC_{el} systems, the high transaction costs of enacting, implementing and monitoring such a scheme are often cited as a main disadvantage. Yet, hardly anybody has so far made a comprehensive attempt to list the relevant parameters and to quantify them. Furthermore, usually it is not mentioned that other renewable support schemes like feed-in tariff schemes and tax exemption policies also cause institutional transaction costs; nor are thorough qualitative or quantitative analyses made. Neither is a comprehensive (quantitative) comparison of the transaction costs of feed-in and TGC_{el} systems possible within the scope of this paper.

In the PwC report to the Danish Energy Agency (PricewaterhouseCoopers 1999, App. 10) and the KPMG report for the Dutch Ministry for Economic Affairs (KPMG 1999), transaction costs got some attention, but the thoughts and estimates remain rather general. The Danish Energy Agency report goes into somewhat more detail. On the basis of discussions with the system operators and possible candidates for operating the market place, the expenses of establishing and operating the system are assessed at DKK 12 million a year plus/ minus DKK 3 million. The specific costs for establishing and operating (from issuing to quota fulfilment) a TGC_{el} system in Denmark are estimated to amount to 10-17% of the maximum certificate price of 0.27 DKK/kWh in 2000 and to drop to 0.9-1.4% of this maximum price in 2003 (Energistyrelsen 1999). These estimates of course very much depend on the assumed market and trade volumes which are not expected to become very high under the Danish system for the years to come, mainly due to generous transition periods from the feed-in to the TGC_{el} system. For comparison, a number from the financial and asset markets: Depending on the size of the company, costs of Going Public are usually between 6 and 12% of the emission volume (Blättchen/ Jasper 1999).

In fact, there are several categories of institutional transaction costs where the difference between Feed-in Systems and TGC_{el} Systems seems to be negligible. For example: RES plants are subject to an approval procedure prior to connection to the electricity grid, and checks are conducted and reported to the system operator regarding electricity production from RES plants. For delivery to the grid, meter data must be collected. The Institutional set up in both type of support scheme is concerned with auditing and measuring the amount of RES-E produced. Also, all RES-E power produced has to be recorded, the accounts of the grid and supply companies have to be managed and balanced. Overall electricity sales and consumption data need to be obtained.

Thus, the necessary functions for running RES-E support schemes are in fact more similar than discussions suppose. However there are many different possibilities for the institutional set-up. Searching for efficient institutional arrangements that reduce transaction costs and share the risks are keys to the potential success of policy instruments. It is the transaction cost and risk sharing that is handled somewhat differently under our 4 systems.

The functioning of a TGC_{el} scheme is more responsive to transactions costs than feed-in tariffs schemes are. To maximise certificate-trading volumes, transaction costs will need to be as low as possible. The less liquid and less transparent the market, the higher the transactions cost per contract will be. If the transaction costs were to be high, trading might not get under way properly. Especially during the first stage of a TGC_{el} system, transaction costs may be an essential cost factor. However, they decline with the accumulated number of trades. A cross-border or EU-wide trading scheme gives quite an advantage in this respect.

Finally, tradable instruments are rather new instruments in practice, but not in theory. The different market players, administration and society as a whole have not yet come too far on the learning curve. Therefore, it may take longer to solve issues, and to come to agreements. Resistance may as well as the investments in information distribution may be higher.

6.5 NON-MONETARY BENEFITS OF TGC SYSTEMS

It is not only transactions costs but also non-monetary and other societal benefits cost-benefit analysis is deficient in handling. Some of these benefits are subject of section 5; we restrict our assessment to an EU-wide TGC_{el} system.

6.5.1 Common Market goals

In favour of international TGC_{el} systems it is argued that if such a market develops, (as compared to isolated Member State TGC_{el} markets operating without cross-border trading), it will deliver greater liquidity, greater volume of trade, more reliable price indicators, reduced investment risk, and ultimately faster investment in new renewable energy capacity. More politically speaking, TGC_{el} trading could promote European integration by linking companies and consumers across the EU. If the trading is based on the subsidiarity principle – a set of universal minimum criteria for TGC_{el}s – it gives maximum independence to Member States, and works in harmony with a liberalised energy sector and with different renewable energy support measures used in the EU. TGC_{el} trading promotes sustainable economic and environmental development for the EU, by maximising the cost-effectiveness of new renewables, and helping to accelerate their implementation. TGC_{el} trading can bring social benefits by giving greater choice to electricity consumers, and can help give consumers the power to influence the environmental performance of the EU electricity sector.

6.5.2 CO_2-reduction effects

One major goal of renewable energy support policies is the reduction of greenhouse gas (GHG) or CO_2 emissions. But as the carbon intensities of electricity production vary across Europe, the CO_2-emissions reduction potentials of RES varies from country to country, depending on the carbon intensity of displaced generation. In addition, the actual CO_2-emissions reduction under TGC_{el} trade and non-trade scenarios differ, since the geographical distribution of RES deployment is different. In order to estimate the annual CO_2-reductions in 2010 compared to a baseline scenario, we use the projected carbon intensities of electricity production from the Shared Analysis Project (c. second column in Table 22). Major shifts can be observed in Denmark, Germany, Ireland, Italy, Spain, and in the UK. However, the CO_2-intensities in these countries are very similar. Thus, no major difference between the trade and no trade scenario can be observed. Actually the trades scenario may generate more CO_2-reductions than the no-trade case. This is basically due to an expected increase in the Irish and Greek RES-E production compared to the no-trade case.

	t CO_2/MWh 2010*	Mt CO_2 2010 no trade	Mt CO_2 2010 trade
Austria	0.13	2.1	0.6
Belgium	0.22	1.3	0.7
Denmark	0.29	3.3	14.0
Finland	0.21	3.0	0.9
France	0.09	3.5	3.7
Germany	0.38	21	12
Greece	0.68	7.9	12
Ireland	0.42	1.6	10
Italy	0.35	18	6.4
Luxembourg	0.31	0.1	0.0
Netherlands	0.31	4.7	5.2

Portugal	0.38	7.2	3.3
Spain	0.31	16	7.6
Sweden	0.07	1.7	0.8
United Kingdom	0.33	15	36
EU15		106	112.8

Table 22: Assumed CO_2 intensities & CO_2-emissions under the EU-15, EC-targets scenario[28]

The following Table summarises the CO_2-effects in the scenarios of Task 1.4. In all of these scenarios we do not find any major CO_2-effect of trade vs. no trade cases, although on a national level substantial differences can be observed. If e.g. Germany was interested in renewables only from a CO_2-perspective it would hesitate to support an EU-wide TGC_{el} trading system since the domestic CO_2-reductions would decrease from annual 21 Mt CO_2 in 2010 to 12 Mt of CO_2. Countries like the United Kingdom, Ireland or Denmark on the other hand would benefit from an EU-wide TGC_{el}-system with respect to CO_2-reductions.

CO_2-reductions	National Targets		EC Targets	
Mt CO_2	EU5	EU15	EU5	EU15
Trade	34.65	64.89	41.01	112.82
No-Trade	35.82	65.34	42.14	105.68

Table 23: CO_2-reductions in different trade scenarios compared to non-trade scenarios

6.5.3 Impact on Cohesion Countries

Under the assumption that a country can benefit from additional investments into renewable energy technologies with respect to domestic CO_2-reductions, employment and welfare, the cohesion countries exporting TGC_{el}s get additional benefits from a European-wide system. In the scenarios of Task 1.4 Greece and Ireland are expected to export TGC_{el}s whereas Portugal and Spain would import TGC_{el}s and thus do not benefit from a European TGC_{el} system with respect to the additional goals of employment and CO_2 reductions. The latter countries do, however, achieve their RES-E target cost-efficiently and have the possibility to allocate their saved resources towards the goals of employment and CO_2 reduction.

6.6 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the above analysis:

Under the assumption of frictionless, competitive markets, a TGC_{el} system is a cost-efficient and effective mechanism for achieving the RES-E targets set by the EU Member States. The costs to fulfil the RES-E targets are minimised, and society can allocate the cost savings towards other ends. Thus, TGC_{el} trading promotes both economic and environmental sustainable development for the EU.

The net cost savings as well as other benefits of a TGC_{el} system are greater, when a cross-border or EU-wide certificate trading scheme is established.

However, a cross-border or EU-wide TGC_{el} system cannot be recommended to potential TGC_{el} importing Member States without further investigation, if their main goals are domestic CO_2 reduction, and the creation of employment and a RES industry at home. Further analysis may come to the conclusion that other and separate policies than a RES-E output subsidies policy should be implemented to achieve these main goals effectively and cost-efficiently.

If the objective of potential TGC_{el} importing Member States is to increase the domestic deployment of RES power generation plants at home, then a cross-border TGC_{el} scheme cannot be recommended, at least until the targets are met. But if the European Union aims at developing a common electricity market, national interests and perspectives of this type should be ruled out in the longer run.

[28] * CEC DG TREN (1999)

TGC_{el} trading can help promoting European integration better than other RES-E support policies, as it is made for EU-wide trade, and works in harmony with a liberalised energy sector. On the other hand, it can be based on the subsidiarity principle – a set of universal minimum criteria for the TGC_{el} market to work gives enough room to Member States for additional RES policies.

Searching for efficient institutional arrangements that reduce transaction costs and share the risk are a key to the potential success of all renewable support policies, but in particular of the TGC_{el} instrument. The higher the liquidity and transparency of the TGC_{el} market, that is the lower the transaction costs, the higher the benefits of a market-based system like the TGC_{el} system.

Under a feed-in system transaction cost can also be high. Their influence on the functioning of the system is rather low, however, since the RES generator will not be affected by it. The price is fixed. Transaction costs of the system are paid by the other players, either grid and supply companies as well as consumers or the government and taxpayers

7 SUMMARY OF RESULTS - WORK PACKAGE FOUR

Work package four comprised the first round of country workshops.

7.1 OBJECTIVES

The first round of country workshops were a chance for stakeholders in each country to undertake a mock trading exercise based on national trading of certificates, to uncover some of the basic issues around certificate trading. These issues are principally the matching of supply and demand in an environment of unequal cost of production and purchase budgets.

These workshops were also a chance to discuss in more detail the institutional framework for certificate trading in that country (i.e. issuing bodies, industry self-regulation, the role of government, the role of certificate exchange / brokering, how certificates are redeemed, the influence of national fiscal arrangements etc). Since these issues are mainly national in character, these workshops had a basically national focus.

Another very important aspect of the workshops was raising awareness of the possibilities of certificate trading and the commercial and policy issues around these schemes, at both national and international levels

7.2 OVERVIEW

The first round of in-country workshops were held in fifteen countries between 22nd May 2000 and 26th September 2000. In total over 550 people attended the workshops.

The first workshops served to introduce a wide range of stakeholders in individual partner countries to the RECerT project, inform people of the principles of green certificate trading and the progress in different countries and present the results of the review work done in the first few months of the project.

The workshops generally followed a common format. There were differences in the workshop agendas in different countries, depending on the circumstances of the workshop and the level of development as regards green certificate issues in each of the countries.

In general presentations were given on the following topics:

- An introduction to the basic principles of green certificate trading
- An overview of the RECerT project (history, project team, timetable, outputs) and introduction / recruitment to RECerT-Sim the internet trading simulation.
- An overview of green certificate developments in the European countries, based on the task 1.2 the country reviews, coordinated by DTU in Denmark.
- The results of the TGC trading simulation (work package 2) performed by ECN, KEMA and the University of Amsterdam.
- The results of task 1.4, the review if the potential size and value of the European TGC market, produced by ZEW in Germany.
- An overview of the country situation as regards renewables and green certificates, given by a representative of the country.
- A presentation of the history, organisation and activities of the Renewable Energy Certification System (RECS) group.

In addition, the paper-based TGC simulation game, which gave participants a practical experience of green certificate trading principles, was played in all workshops except Denmark and the Netherlands. The game was highly effective at getting people to understand how green certificates systems can work. Just as importantly it helped create a more informal atmosphere which discussions could take place more freely.

Country	Date
Austria	3rd Austria 2000
Denmark	22nd May 2000
Finland	28th June 2000
Germany	4th September 2000
Greece	10th July 2000
Ireland	20th July 2000
Italy	25th September 2000
Luxembourg	26th September 2000
Netherlands	27th June 2000
Norway	22nd June 2000
Portugal	18th July 2000
Sweden	26th June 2000
Spain	12th September 2000
UK	7th July 2000

Table 24: Dates of first round in-country workshops

In contrast to the original plan, a workshop was held in Spain, but not in France. It proved difficult to find a host for a French workshop whereas contacts in Spain were keen to host a workshop. Spain was left out of the project at the time of the proposal submission because no suitable project partner could be found before the proposal submission date.

Belgium was another special case. Plans for a green certificate system in the Flanders region of Belgium are already well advanced, but there were questions over whether the system would spread to other federal regions of Belgium. It was thus inappropriate to hold a dedicated RECerT workshop in Belgium at that time, although the project was presented at a closed meeting on green certificates in Belgium by the in-country facilitating consultant.

The response of participants at each workshop varied from country to country. For some countries green certificate trading is a new concept, for example in Greece, Portugal and Luxembourg. Participants in these countries were interested to hear about the basic principles of green certificate trading and the developments on the European scene. Individuals attending both the Greek and Portuguese events appeared interested in the green certificate system, perhaps because the renewables industry do not have comprehensive support policies for renewables. For Luxembourg, with only 400,000 people and limited resources the workshop was more an 'information item' rather being of direct relevance to them.

In countries where green certificates systems are already developed or are being considered (namely the Netherlands, Denmark, Italy and UK), participants had already formed opinions on green certificate trading, and more detailed discussions were possible. Nevertheless, it was striking that in such countries many misconceptions still exist about the basic principles of green certificate trading.

Individual reports of country workshops, agendas and attendees are not part of this Final Technical Report. Rather, this detail is provided in the first workshops report submitted as a separate item.

8 SUMMARY OF RESULTS - WORK PACKAGE FIVE

Work package five was the largest single work package of the whole project. It comprised the design, running and reporting of the internet-enabled TRC trading simulation 'RECerT-sim', the second round of country workshops and the recruitment and management of a subcontractor to support the simulation.

8.1 TASK 5.1: SIMULATION DESIGN

The design of the internet-enabled trading simulation RECerT-sim was critical to its eventual success. The design was led by ESD with main inputs from OMEE and ECN. The output of the task was a detailed design document, described as the RECerT-sim 'Rule Book', which was made available to participants through the RECerT website.

This rulebook is not reported separately here. Details of the design are included in the overall report on the simulation, task 5.6.

8.2 TASK 5.2: RECRUITING AND MANAGING A TRADING PLATFORM SUB-CONTRACTOR

This task was led by ESD. A sub-contractor was found who was able rapidly to provide an internet trading site to support the simulation. M-co, a company founded in New Zealand but with operations in Europe, have recently built a registry and marketplace for the Australian mandatory renewable obligation system MRET, which includes a green certificate trading system. This platform was adapted to provide a fully functional trading site that was dedicated to RECerT-sim. M-co worked with the RECerT-sim rulebook to devise the structure of the trading site, and also provided valuable ideas and feedback in the refinement of the simulation design.

The web server and marketplace software was provided in New Zealand, but controlled by ESD from the UK. The internet site providing access to the certificate exchange (http://www.recert-sim.com) was supported from New Zealand. Data files were downloaded and uploaded and swapped between the trading site and support (http://recert.energyprojects.net) during the simulation process. In almost every case this was achieved without problems and M-co were extremely fast to act following any reported problems, or to institute suggested changes or improvements. This was commented on by users in the simulation feedback questionnaire.

8.3 TASKS 5.3 AND 5.4: WORKSHOP PREPARATION AND SECOND-ROUND WORKSHOPS

ESD was responsible for this aspect of the preparation for the trading simulation. Thirteen workshops were held, in late March to early April 2001, in every participating country except France, Luxembourg and Ireland. The Luxembourg workshop was combined with the Belgian one, and in the absence of a French workshop, French participants in the simulation were contacted directly with information. The Irish workshop was cancelled due to the epidemic of foot and mouth disease, but Irish participants in the simulation were contacted directly.

The purpose of the first round of country workshops was to introduce the concept of TGC trading, and to discuss the application of TGC trading in each country. By contrast the purpose of the second round of workshops was focused more narrowly, on the trading simulation RECerT-sim. In addition to modules on RECerT-sim, most agendas included a short up-date on progress to date in the adoption / development of green certificate systems around Europe. The purpose of the workshops was therefore two-fold - to recruit participants to the workshops, and to train participants in the operation of the simulation.

Each workshop had a duration of just half a day (in contrast to the full day workshops held in round one). Furthermore most were significantly smaller than the first round workshops, since the purpose was to present RECerT-sim to those people who were most likely to actually take part.

A total of approximately 190 people attended the workshops. In-country organisation of the workshops was provided by the RECerT country partners. A typical agenda is given below:

9.15	Refreshments	
9:30	Welcome and introductions	Project partner / host
9:40	Overview of workshop and RECerT project progress	ESD representative
10:00	EU TGC developments, including progress with the RECS group test phase	Representative of RECS Group or ESD
10:30	Background to RECerT-Sim - objectives, purpose, opportunities	ESD representative
10:50	Description of the overall design and simulation process,	ESD representative
11:10	**Refreshment break**	
11:30	Roles, objectives and operations of the three types of RECerT-sim participant - Generators, Consumers and Traders	ESD representative
11:50	Description of M-co supported internet TGC trading site and associated functions	ESD representative
12:10	Simulation process – walk through of simulation activities	ESD representative
12:45	Questions and answers	
13:00	**Meeting close**	Project partner / host

The presentations made at the workshops were posted on the RECerT website, as a resource for all interested parties. The large number (about 180) of registrations for the simulation evidences the success of the workshops.

8.4 TASKS 5.5, 5.6 AND 5.7: SIMULATED EU TRADING PREPARATION, TESTING AND RUNNING

Preparation, testing and running the simulation, and providing information feedback to participants was the single largest and most ambitious work element of the whole project. It encompassed all the objectives of the project, reaching a large number of key European TGC stakeholders, and providing an experimental, 'learning by doing', hands-on experience of Europe-wide TGC trading. In the course of the simulation, key issues in policy and market design were uncovered, and the post-simulation feedback indicated a high degree of satisfaction by participants.

8.4.1 Summary

The simulation took place during May 2001. Over 180 participants registered and over 140 actively participated. 'Virtual' renewable electricity Generators, TGC Consumers and TGC Traders were created and subjected to a series of rules, including TGC purchase obligations on Consumers and generation capacity investment rules for Generators. Trading of TGCs was achieved using an internet marketplace build by M-co, a specialist markets company acting under sub-contract to the simulation manager, and responsible for the newly created Australian industry-governed marketplace for TGCs called GEM.

The simulation was broken into five separate trading sessions, one per week during May 2001, each representing two years of activity. Almost eight thousand individual trades were executed during over

16 hours of market operation, involving the creation, sale, purchase and redemption of over 2.3 billion certificates. Each certificate represented 1 MWh of underlying production of renewable electricity. Investment was made in new renewable electricity production plant, raising the installed capacity of renewable electricity plant by a factor of over five in ten years, from 27 GW in 2000 to over 130 GW in 2010.

The simulation was successful in its basic objective of increasing understanding of market processes for renewable energy certificates for the participants, although a number of observations are made on the simulation design and ways in which this could be improved in future exercises of this sort. Furthermore the simple technical viability of using the internet to run a Europe-wide market for TGCs has been proved.

Lastly we make some observations on the value of a liquid, EU-wide market for TGCs, and some of the steps that could be taken to promote this in the short/medium term.

8.4.2 Background and objectives

As TGC markets are created in Europe, a large number of parties will become implicated. On the supply side there will be a large number of renewable generators, developers and financiers and on the demand side mainly energy retail companies and end consumers. In most cases these players will be unfamiliar with the operation of TGC markets, and this is markedly the case for renewable energy generators who are typically small-scale and have not had to operate in such markets in the past. In addition to those directly affected, there are a large number of renewable energy stakeholders such as trade associations, NGOs, policy advisers and similar who need to understand more about how such markets could work.

RECerT-sim was created especially for these parties, and had the basic objectives:

- To provide a learning tool for renewable electricity generators, electricity retailers, investors, energy traders, policy makers and advisers, trade bodies and NGOs;
- To illustrate how Tradable Green Certificates, TGCs, can be created, traded and consumed in order to achieve renewable energy growth targets in Europe at least cost;
- To give insight into the risks and benefits of international green certificate trading from the perspective of EU and Member State policy makers, renewable generators, electricity retailers and the electricity sector in general;
- To illustrate the operation of an international TGC exchange and demonstrate how market participants may manage risks through the use of forward contracts in conjunction with 'spot market' trading.

8.4.3 Participants

Participation in RECerT-sim was invited from a wide range of electricity sector companies, consultants, NGOs, trade bodies and government bodies from the EU and beyond. The invitation list was drawn principally from invitees to the international conference on TGCs organised by ESD in October 2000, plus attendees at the country workshops held as part of the RECerT project. In addition we are grateful to Eurelectric who forwarded information on RECerT-sim to all members.

We were interested in widening participation in RECerT-sim beyond the EU partner countries, to include particularly EU accession candidate countries in central Europe, and countries within the EEA. We were partially successful in this objective.

The minimum number of participants to make the simulation technically feasible was 32 (one Consumer and one Generator in each country), but we took 64 participants as the success criterion for recruitment. In the event, interest in the simulation exceeded our expectations and 184 participants, representing some 130 organisations and companies from 18 countries had registered by the cut-off date.

The companies registered to take part in RECerT-sim are listed below:

Country	Participating organisation
Austria	KWI Project Development & Consulting Technical University of Vienna Verbund Osterreichische Elektrizitatswirtschafts KommunalKredit Energieverwertungsagentur VEOE Smart Technologies esg Linz
Belgium	Electrabel 3E Colruyt EURELECTRIC Federale Energie-administratie
Czech Republic	SEVEn University of South Bohemia
Denmark	Elkraft Danish Energy Agency Danske Energiselskabers Forening
Finland	Finergy SENER Fortum
France	Green Mix Accounts
Germany	Umweltkontor Renewable Energy AG EnBW Energie-Vertriebsgesellschaft mbH EnBW Gesellschaft fur Stromhandel mbH EnBW Kraftwerke AG Stuttgart E.ON Energie AG E.ON Trading Otto Versand Statkraft Energy Deutschland GmbH Verband der Elektrizitätswirtschaft VDEW HEW AG HWWA Aufwind Windenergie GmbH Mann NaturenergieGmbH & Co. KG Öko-Institut e.V. Bewag Aktiengesellschaft Schmack Biogas GmbH EWE NaturWatt Innovative Energieberatung NaturEnergie AG
Greece	CRES
Hungary	Hungarian Power Companies Ltd.

Ireland	ESB Power Contracts and Trading ESB Power Generation B9 Energy Services Ltd. Eirtricity Irish Bioenergy Association Irish Electricity Company National Treasury Management Agency University College Cork
Italy	ACEA Spa AET Azienda elettrica ticinese AICe scarl Autorita Energia Elettrica e Gas Bluenergy E.ON Italia S.p.A. EGL Italia ELETTROSTUDIO S.r.l. ENBW ITALIA SPA Enel Energy Services Italia ESI Gamesa Energia Italia S.p.A. Intertecnica Engineering Group Srl ITALCEMENTI S.p.A. MPE S.p.A. SERVEN Sondel S.p.A. Trafigura Electricity BV UNAPACE
Netherlands	WEOM bv ECN E-Connection Statkraft Energy NL Maycroft Consultancy Services Tennet bv Ecofys PAWEX Amsterdam Power Exchange
Norway	Norsk Hydro ASA Agder Energi
Portugal	APE AMESEIXAL AGEEN CEEETA EFACEC ENERNOVA TEE DGE CCE REN - Rede Electrica Nacional

Spain	ENDESA GENERACÓN SEMA CIEMAT UNESA IBERDROLA Universidad de Castilla La Mancha Universidad Autónoma de Madrid
Sweden	Green Portfolio Management (Environmental Products) Birka Energi AB Fnelco (Swedish National Energy Administration) Goteborg Energi AB KanEnergi Sweden AB MalarEnergi AB Sydkraft Energy Trading AB Vattenfall AB
Switzerland	State Secretariat for Economic Affairs (seco) Kiefer & Partners AG Rätia Energie Swiss Federal Institutes of Technology
United Kingdom	TXU Europe Energy Trading Aon EDF Trading First Renewables Impax Capital Corporation London Electricity Natsource Ofgem Centrica Energy Management Group Shell International Renewables Limited Campbell Carr Sustainable Energy Ltd Econnect Ltd Green Electricity Marketplace Powergen Hyder Industrial Scottish Power Tomen Power (Europe) Edison Mission APX Automated Power Exchange

8.4.4 Attendance

Most but not all registered participants took part in the simulation. The number of 'live' participants in attendance during the first trading session was 144.

Attendance by the key participants (Generators and Consumers) held up reasonably well during the simulation, as shown in the graph below. Attendance by Traders was not critical so is not shown in the graph. Note, however, that Trader attendance did drop towards the end of the simulation.

Attendance by the key players was not 100%, and this had consequences for the supply-demand balance in the simulation, as explained in later sections.

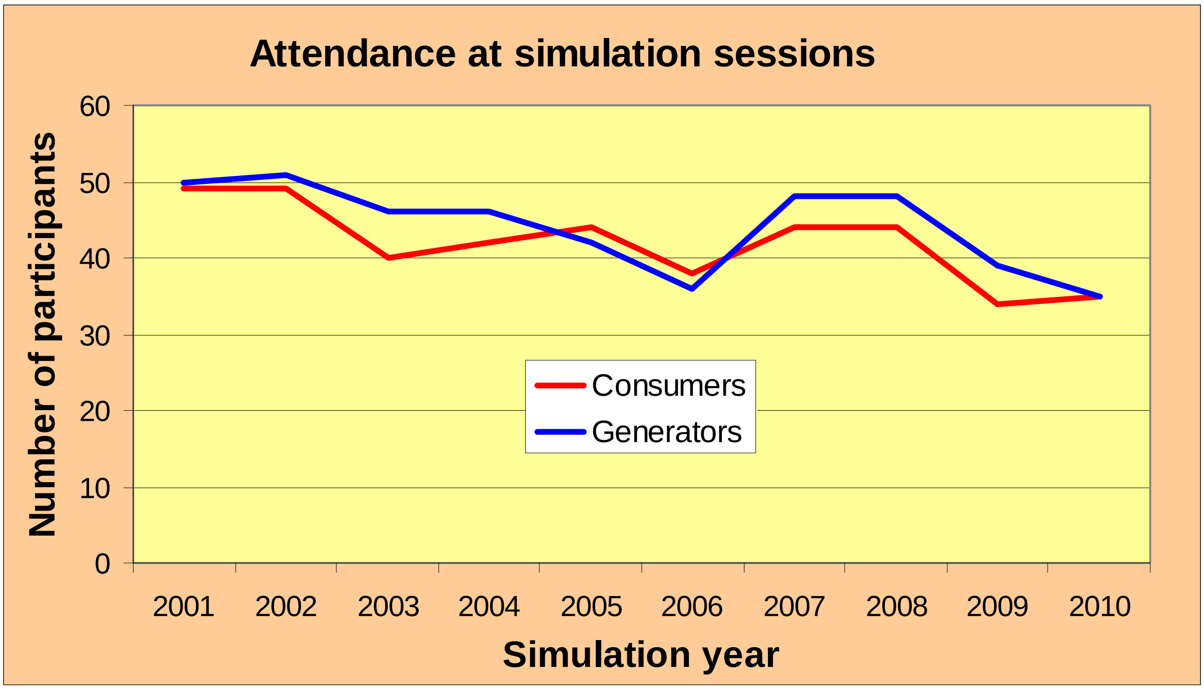

Figure 23: Simulation attendance

8.4.5 Simulation design

Full details of the simulation design are contained in the simulation 'rule book' distributed to participants through the RECerT-sim support website. This section is intended to be a brief summary only of the main design parameters.

The three participant roles were Generators, Traders and Consumers. Generators invested in generation assets, sold certificates on the market, and tried to achieve high profits and return on assets. Traders bought and sold certificates in the market and tried to make a profit on this. Consumers were under an obligation to buy certificates in the market, and try to do so at least cost. All three participant types were motivated by explicit performance measures that were intended to create coherent market behaviour.

The supply side of the simulation comprised Generators who were permitted to invest in new capacity anywhere in Europe. The demand side comprised Consumers whose rules and behaviour were fragmented by penalty rate, obligation rate, banking rules, certificate validity and technology validity.

Uncertainty and risk were induced by the simulation manager in the form of fluctuations in physical output from hydro, wind and solar generators, and in the form of one rise in penalty prices due to insufficient compliance.

Buyers (Consumers), sellers (Generators) and speculators (Traders) were bought together in the marketplace illustrated by the schematic below:

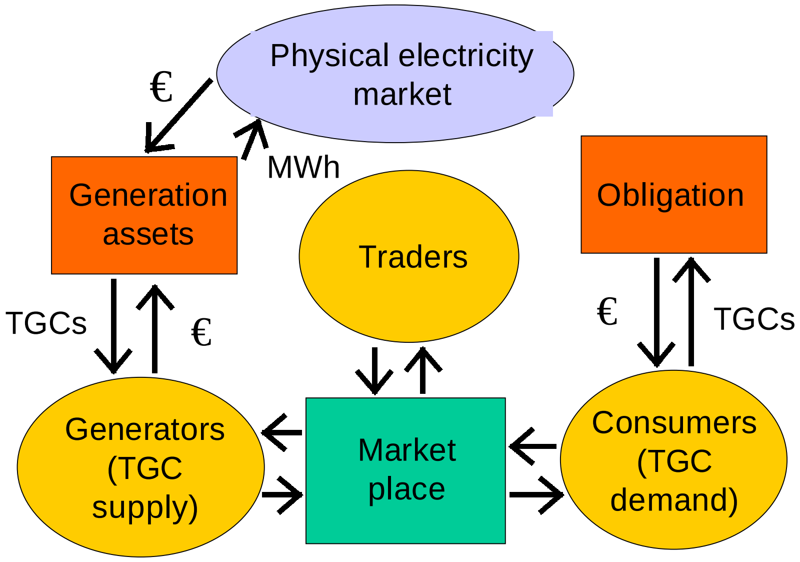

Figure 24: Schematic of marketplace

Being a simulation, no financial settlement took place, and the 'certificates' traded were not based on real underlying energy production. Two basic TGC products were traded; a generic green certificate and a waste certificate. Each product was further broken down into ten production years, making 20 products in total. Any of these products were able to be sold at any point in the simulation, representing the use of 'vintage', ‘spot’ and ‘forward’ trades.

The whole simulation was managed through two linked websites, the trading website, http://www.recert-sim.com, and the support website, http://recert.energyprojects.net. The support site permitted Generators to make investment decisions, provided performance feedback for all participants, and was a repository of common information.

The principal information feedback for all participants was through 'bulletins', distributed in .pdf format by the simulation manager. One pre-trading and one post-trading bulletin was issued for each of the five trading sessions.

8.4.6 Definition of TGCs in the simulation

TGCs are being formulated to satisfy obligations and voluntary markets in many different ways. In the Renewable Energy Certificate System (RECS), certificates will be differentiated by 17 categories of technology, up to 10 Issuing Bodies (implying 'domain' or country of origin), a very large number of production devices, the time of issuing, four categories of public support, and the size of installed capacity of the production plant. This approach to certification creates the potential for a large number of differentiated instruments, which will tend to restrict liquidity and therefore the effectiveness of the scheme in achieving the stimulation of renewable generation. For more liquid trading to occur in the RECS system, standard products will have to develop and become widely used.

By contrast, the purpose of RECerT-sim was to demonstrate the use of a standardised certificate type, in order to create a liquid, high volume market. Hence the RECerT-sim certificates carry the minimum information possible, consistent with permitting TGC consumers to fulfil their obligations. No financial transactions occur, thus no auditing is required, and individual certificates are not identified with unique serial numbers, as they would be in a real TGC system.

Each RECerT-sim certificate represented 1MWh of underlying renewable electricity generation, and carried two further pieces of information:

- The contract type (divided into two - 'generic green' that included onshore and offshore wind, biomass, solar PV and small-scale hydro sources, and 'waste' that included all energy from waste)
- Year of production (ten separate years, 2001 to 2010)

Note that the country of origin of the certificate is not known to buyers, and not recorded on the certificate. Hence each participant in each year had the ability to trade in just twenty contracts.

8.4.7 Demand side parameters

The demand side of RECerT-sim comprised demand drivers acting on the TGC Consumers. Obligations for Consumers were based on the year 2010 per-country targets for renewables growth contained in the draft[29] EU Renewables Directive. A rising obligation has been assumed, starting from a level of the estimated current (year 2000) renewables production, and ending with the Directive target for the year 2010 (approximately 22% of EU electricity consumption). Certain other specific country conditions were imposed on consumers, specifically whether certificates from waste technologies were eligible, the size of the compliance penalty, what level of banking of certificates was permitted, and what age ('vintage') of certificates were eligible for the obligation.

These parameters were selected to reflect some of the parameters that are likely to govern future trade in TGCs. If a more harmonised EU-wide policy on renewables support emerges in the future, certain of these parameters may also be harmonised.

Wherever possible, these demand conditions were taken from known current practice or policy intentions for those countries developing TGC systems, and for the other countries this was imposed by the simulation manager in order to achieve a balance of conditions on the demand side.

Waste and large hydro schemes are the most contentious technologies in the seven TGC schemes being developed by EU Member States. In the simulation we excluded large hydro (over 10MW) on the assumption that very little large hydro is likely to be developed in Europe over the next ten years.

The allocation of parameters to countries is given in the following table.

[29] Since adopted

					Directive target % of electricity consumption			EU electricity consumption forcasts, TWh/yr		Derived non-large hydro RES-E targets, TWh/yr			
Country	**Exclusions**	**Validity (years) U/L = unlimited**	**Banking Limit (%)**	**Penalty (Euro/MWh)**	**1997**	**2000**	**2010**	**2000**	**2010**	**2000**	**2010**	**Growth in RES-E generation, 2000 to 2010 (TWh/yr)**	**Growth in RES-E generation, 2000 to 2010, %**
AT	waste	1 yr	75	65	10.7	13.1	21.1	56.1	56.1	7.3	11.8	4.5	61%
BE	waste	2 yrs	25	80	0.9	2.0	5.8	89	105.2	1.8	6.1	4.3	238%
DE	waste	3 yrs	25	80	2.4	4.2	10.3	552	613.3	23.3	63.2	39.9	171%
DK	waste	U/L	25	80	8.7	13.4	29.0	39	44.4	5.2	12.9	7.7	147%
ES	none	2 yrs	0	70	3.6	6.8	17.5	200	255.6	13.6	44.7	31.1	229%
FI	none	1 yr	25	70	10.4	12.2	18.0	81	92	9.8	16.6	6.7	68%
FR	none	3 yrs	0	75	2.2	3.7	8.9	471	537.7	17.6	47.9	30.2	171%
GB	none	U/L	50	70	0.45	1.9	6.58	353.2	380.3	6.6	25.0	18.4	280%
GR	none	U/L	0	75	0.4	3.7	14.5	52	72.5	1.9	10.5	8.6	453%
IE	waste	3 yrs	50	75	1.1	3.5	11.7	20	29.22	0.7	3.4	2.7	382%
IT	none	1 yr	0	65	4.5	6.9	14.9	301	405	20.8	60.3	39.5	190%
LU	waste	2 yrs	50	75	2.1	2.9	5.7	6	7.95	0.2	0.5	0.3	158%
NL	waste	3 yrs	75	70	3.5	4.8	9.0	105	132.7	5.0	11.9	6.9	138%
NO	waste	1 yr	50	65	0.2	0.4	1.0	111	128	0.4	1.3	0.9	200%
PT	none	2 yrs	75	75	4.8	7.1	14.9	42	62	3.0	9.2	6.2	208%
SE	none	U/L	75	65	5.1	7.5	15	146.7	153.5	11.0	23.3	12.3	112%
									Totals	128	349	220	272%

Table 25: Demand side parameters – a range a 'purchase obligations' defined per country[30]

The calculation of the volume of TGCs required to satisfy the obligation in each year is based on an assumed rate of growth in electricity supply volume in Europe over the period of the simulation.

Penalties for non-compliance are listed for each country. These penalties were roughly based on equivalent penalties or opportunity costs that exist in each country (for example from existing TGC scheme proposals, production subsidies etc), but altered in order to reduce discrepancy between countries and narrow the spread of penalties.

8.4.8 Supply side parameters

Generators had the most complex responsibilities of any participant. Generators began with a 'starting portfolio' of generation assets, allocated by the simulation manager and based on the known or estimated year 2000 installed capacities of various technologies in the participating countries.

Generators had the goal of selling TGCs at the best price possible and maximising their profits through trading and taking decisions to invest in new capacity. A guide to the likely costs of investment and energy production was provided by the simulation organiser (through the support website) and these costs varied depending on the technology type, the country of investment and the installed capacity in that country at any point during the simulation.

Capacity growth was limited by the simulation manager to 50% per year. The performance of generators was determined at the end of the simulation and at each year-end on the basis of a simple 'return on capital' measure and a simple 'profit' measure.

[30] *Penalty rates were revised after 2001/2 trading*

Permissible technologies for investment were on-shore and offshore wind, solar photovoltaic, small hydro (below 10 MW capacity), biomass and waste. Investment was permitted in any of the 16 participating countries. Generators made investments through the RECerT-sim support site, using the 'investment notification' form provided. All Generators (and indeed all participants) were able to view current installed capacity and investment decisions taken on the support site. Each investment decision taken is subject to a 'time lag' between decision and commissioning, to reflect the different build times of different technologies.

The following table illustrates the starting 'portfolios' (capacities) for the year 2000 per country and per technology / resource type. The starting capacities are based on actual (estimated) installed capacities of renewable electricity generation in the year 2000.

Country	Installed capacity in 2000 (MW) by technology						Total (MW)
	Wind on-shore	Wind off-shore	Small hydro	PV	Clean biomass	Waste	
AT	79	0	675	0.89	247	14	1,016
BE	13	0	59.4	0	0	0	72
DE	6100	0	1370	54	500	540	8,564
DK	2301	10	10.4	0	0	171	2,492
ES	2481	0	1510	9	189	94	4,283
FI	38	0	33	0	2000	0	2,071
FR	60	0	2004	0	0	272	2,336
GB	402.2	3.8	161	1	64	379.7	1,012
GR	205	0	2.2	0	0	0	207
IE	93	0	0	0	0	11.9	105
IT	427	0	2186	0	0	180.2	2,793
LU	15	0	20.8	0	1.5	7	44
NL	447	2	38	11	67.5	101.5	667
NO	13	0	0	0	0	0	13
PT	90	0	240	1	15	30	376
SE	234	7	969	0	0	73	1,283
Total	*12,998*	*23*	*9,279*	*77*	*3,084*	*1,874*	*27,335*

Table 26: Starting portfolios by country.

At the start of each trading year certificates were automatically allocated to Generators, on the basis of their generation capacity. This output was affected by weather variations between years, reflected by the annual production load factor set by the simulation manager for the 'intermittent' generation assets (wind, hydro and solar), which was not known by the Generators beforehand.

It is important to note that Generators' net revenues included the sale of physical electricity, based on assumed medium-term forward contract prices on four regional markets (Nordic, Central, Southern and Atlantic).

One of the main purposes of introducing a 'random' weather element into certificate production was to introduce risk for Generators and Consumers, and encourage them to manage this generation risk actively using the means at their disposal.

8.4.9 Trading platform

The heart of RECerT-sim was the internet-enabled, real-time marketplace, or TGC exchange, built by M-co. The marketplace worked purely through the internet, and did not require any software to be operated by participants other than a standard web browser.

The trading platform was a greatly simplified version of the integrated marketplace, registry and compliance platform 'GEM', the Green Electricity Market, built by M-co for the Australian renewable energy rights market created by a government obligation. Considerable work was necessary to adapt the fully commercial trading platform to service the overall RECerT-sim design.

Participants were given confidential usernames and passwords, maintaining privacy for their operations. The marketplace was opened and closed according to a strict timetable. Participants were able to see a current 'trading board' for all 20 products traded in the simulation, and entered bids (to buy certificates) and offers (to sell) on-screen. A number of check screens were in place to reduce errors in placing bids or offers, although later in the simulation these checks were removed to permit faster operation. Once a bid or offer is matched, transfer occurs automatically, and the account of each trading party is updated automatically.

At the start of a trading year, the simulation manager up-loaded to the trading site the number of certificates created by each Generator on the basis of their generation capacity. Certificate accounts were run for each participant, and at the end of each compliance period (year), an automatic 'surrender' or 'redemption' algorithm was run on the trading site that removed certificates from Consumers' accounts in accordance with their purchase obligations. The records of all trades (product, volume, price, bid/offer and time) plus all redemptions from Consumers' accounts were down-loaded from the trading site by the simulation manager for later analysis.

In general terms there are some potential disadvantages with web-based trading, specifically a degree of risk for users in the event of access, speed or reliability problems with the web itself. However, for tradable instruments being traded to satisfy obligations with compliance periods measured in months or years, the cost advantages for users over client server solutions are very significant, and more than outweigh the potential disadvantages. Given the very high volumes of certificates and trades accommodated on the RECerT-sim market, and the extremely compressed timescales for trading, it is reasonable to conclude that 'real world' Europe-wide web-based trading of TGCs is a technically viable prospect.

8.4.10 Simulation process and analysis

One of the challenges of RECerT-sim was the attempt to involve a wide range of participants with widely varying degrees of knowledge and familiarity with trading issues. It was therefore inevitable that some of the more experienced traders found that the simulation lacked some depth. Conversely, those participants who were less familiar with trading issues and indeed the whole concept of using TGCs on an open market to fulfil purchase obligations found the simulation more satisfying.

8.4.10.1 Trading activity

Participants moved rapidly up a trading 'learning curve'. A clear trend emerges for both types of certificate of a falling number of trades and a rising volume traded. This shows the tendency of all players to place bids and offers in larger amounts as the simulation progresses, which in turn suggests less speculative activity. These trends are shown in the 'Generic green' and Waste certificates traded' graphs.

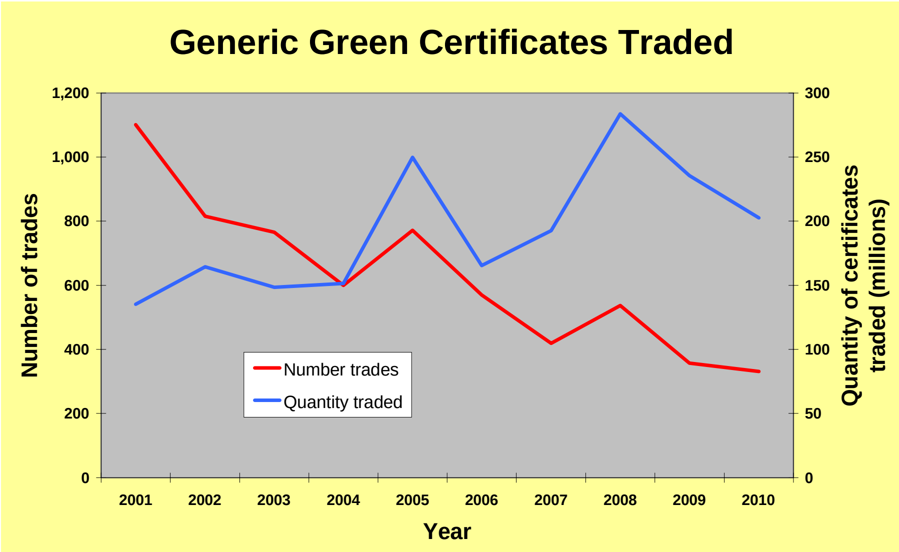

Figure 25: Bidding trends - generic certificates

Figure 26: Bidding trends - waste certificates

The trend towards larger individual trades and the implied reduction in speculative activity is supported by the evidence of the ratio of traded volume to compliance volume. This ratio, which can be thought of as the degree of "churn" in the market, represents how much buying and selling activity exceeded the minimum amount of trading necessary to transfer certificates from Generators to Consumers to satisfy Consumers' obligations. This information is expressed in the graph 'Market 'churn' and Trader activity' below.

This graph is explained partly by the buying and selling of forward contracts in early years, but also by a degree of speculative activity by Traders and other participants. The black line is a ratio of 1:1 between certificates traded and those redeemed against Consumers' obligations. It is interesting to note that while the ratio of traded : redeemed certificates was large (up to 2.5), the percentage of total trading activity accounted for by Traders themselves was a maximum of 25%. This suggests that Traders influenced the ratio, but that Generators and Consumers were largely responsible for the volumes concerned.

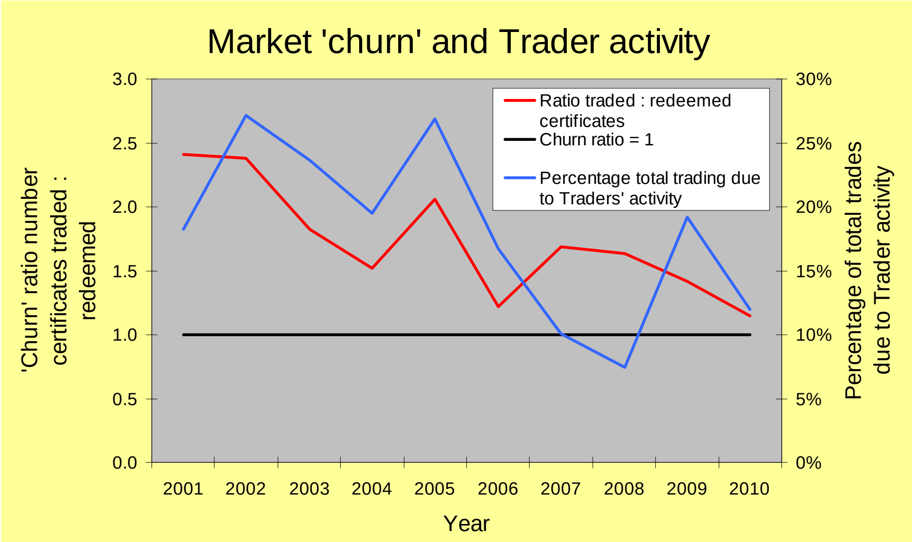

Figure 27: Market churn and trader activity

The appetite of participants to trade of forward and vintage products can be shown by an analysis of average volumes of trades in current year products plus one and two-year vintage and one and two-year forwards. This analysis covers the trading years 2003 - 2008 only, and is shown in the following graph. Trading volumes in current-year products were typically over ten times the volume of one and two year out forward or vintage products. Furthermore there was little difference in volume between vintage and forward products, and little difference in volume between one year out and two year out products, suggesting no consistent use of forward buying strategies by Consumers. This lack of the use of forward products was not expected at the start of the simulation, but can be explained by the relative lack of dynamism and price movement in current year products, the consequent low perception of risk by all Consumers, and therefore very little need to actively manage risks through forward buying.

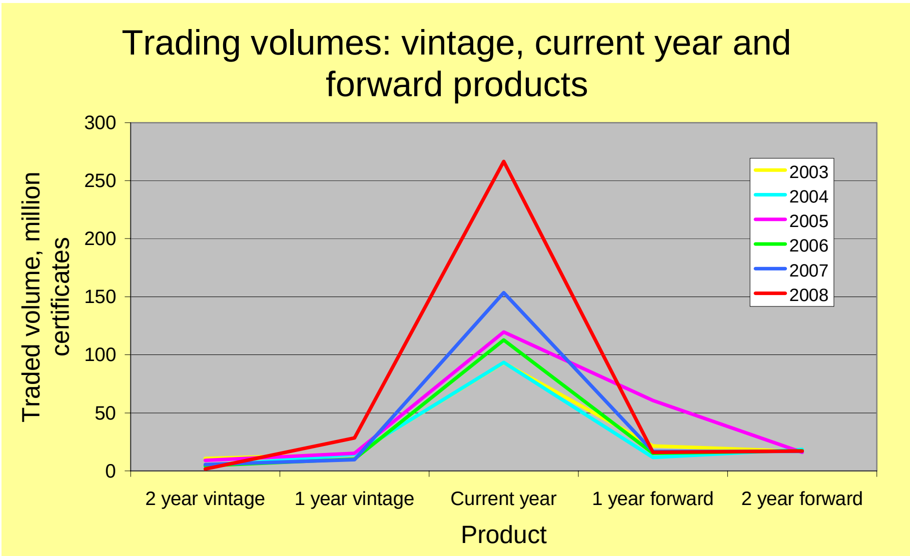

Figure 28: Trading volumes

It was noticed by the PowerGen team that there was little price depth on forward products, and they therefore proposed that their Trader participant act as a 'market maker', guaranteeing to maintain limited depth buy and sell orders on one-year and two-year forwards for generic green certificates at all times. The PowerGen team began market making in year 2005, and it might be argued that the greater traded volume of one-year forwards in that year is as a result of their efforts. However, despite the market making service this buyer behaviour was not sustained.

8.4.10.2 Certificate trading prices

The simulation manager built an economic model that was intended only to provide a platform from which to test trading strategies. The purpose of the whole simulation was ***not*** to derive firm predictions of future costs and supply of TGCs, and indeed it would be misleading to draw any conclusions on these quantities.

For this reason the policy adopted in this report is not to report certificate prices in Euro/MWh, but instead to use indices.

Average traded certificate prices are presented in the graph 'Price history', on a relative scale with 1=lowest starting penalty rate in year 2001. Prices remained remarkably flat during the simulation, with a continuous slight downward trend between 2003 and 2008. 2008 was the first year when certificates were traded at prices consistently below the lowest penalty rate, meaning that all Consumers were able to comply with their obligations. In 2009 the trend continued, and in 2010 prices collapsed as a result of Generators and Traders trying to close long positions and avoid the 'judgement day' penalties. Unsettled, 'spiky' prices in 2001/2 can be explained by uncertainty over equilibrium prices and the use of pre-trading periods in these years, with less uncertainty in 2003/4 due to greater learning by participants.

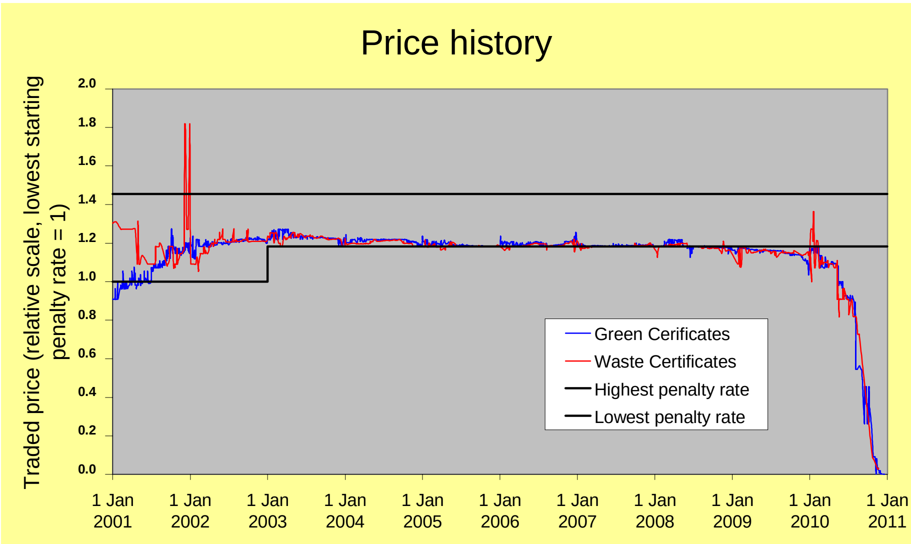

Figure 29: Price history

There was very little volatility in prices. Trading prices settled down to an approximate equilibrium price quite rapidly, and did not vary greatly. This was largely due to a lack of information and events in the market that would drive buyers and sellers to take a different view of the value of the products. The fact that the market was structurally short drove prices high, which in turn reduced the influence of other externalities such as weather effects and power price movements. Prices stayed around the level of the lower penalties since this represented the buyers' 'willingness to pay' and reflected the very low price elasticity of demand.

The price collapse in 2010 was largely expected, and an inevitable consequence of the end of the simulation, where all parties (particularly affecting Generators and Traders) were required to eliminate negative certificates balances or face fairly severe cost penalties (the so-called 'judgement day penalties'). In this final year, supply exceeded demand, but the price elasticity of supply was effectively zero, since no certificates could be carried over to future years. This led to 'dumping' as Generators and Traders tried to get rid of certificates that held negative value.

8.4.10.3 Generators

Generators' activity was crucial to the dynamics and final outcome of the simulation. Generators were required to create and execute strategies for both investment and trading. They were constrained by certain rules, namely:

- Rate of investment (based on investment decisions taken) could not be more than 50% of the previous year's installed capacity
- Investment lag meant that between one and three years passed before an investment decision became a productive asset
- Position penalties were applied to Generators forcing them to bring generated certificates to the market or pay penalties for certificates held over a certain limit

Investment in new generation assets was needed to provide a flow of certificates in the future to satisfy a quite steeply rising obligation.

The rate of investment rule was imposed to reflect a likely limit on the institutional capacity for renewables growth (planning permission, technology supply, capacity of developers etc), and to reflect possible 'real world' restrictions on financing. If this type of rule had not been imposed, it would have been possible for Generators to make unrealistically large investments that would not be achievable in the 'real world'.

A 'lag time' was imposed between the investment decision and the commissioning of the assets, specifically one year for PV, two years for on-shore wind and small hydro, and three years for off-shore wind and biomass. These 'lag times' were not intended to be an accurate reflection of the speed with which new capacity could be built in Europe, but simply added a degree of realism into the investment model. The practical build time of different technologies will vary greatly between different countries.

The results are given in the graph below showing the theoretical maximum growth rates compared to the actual growth rate seen in the simulation.

The combination of investment rate restriction and build lag-time limited the rate of growth of capacity. This in turn meant that the supply of certificates to the market was 'short' in the early years, resulting in high market prices. Capacity grew by a factor of about 5.1 over the ten years.

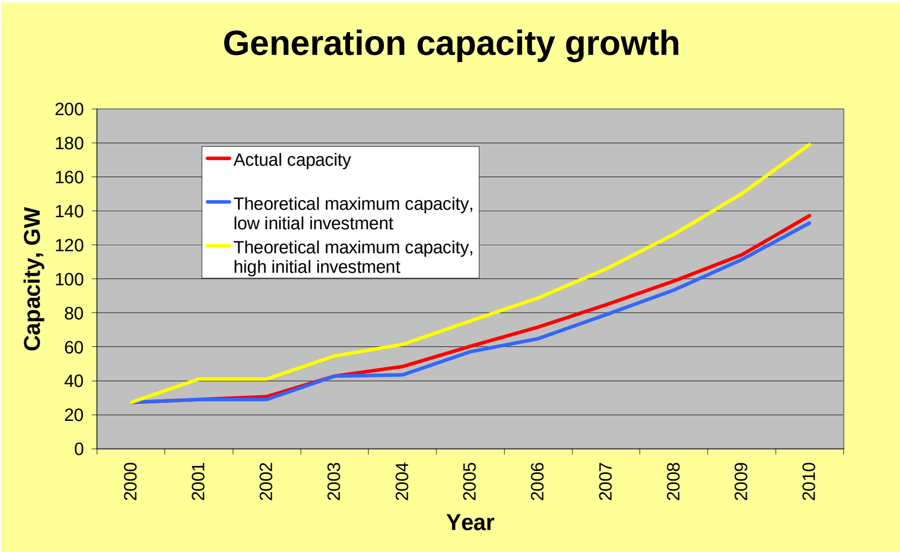

Figure 30: Growth in generation capacity

At the start of the simulation, Generators were encouraged to invest in new capacity from year 2001 onwards. The simulation manager had 'pre-loaded' investment decisions for the years 1999 and 2000 amounting to just 6% growth, in order to reduce the scale of investment lag in the early years. The theoretical maximum capacity in each subsequent year, assuming all Generators invested at the maximum rate (new capacity investment decisions equal to 50% of the previous year's installed capacity between 2001 and 2008, and that all investment is with a two year build lag), is shown by the 'maximum capacity with low initial investment' curve.

It was expected that a certain amount of 'absenteeism' by Generators could be accommodated, since active Generators would be able to increase their investment and 'close the gap' in terms of asset creation. In the event, the investment restrictions meant that active Generators found it difficult to close the gap, and in retrospect it can be seen that the supply side parameters should have been changed to reduce the vulnerability of the whole simulation to the 'absenteeism' effect.

We can conclude that the combination of investment lag and investment rate restriction did limit capacity growth, but the limited supply of certificates to the market is more generally explained by the 'absence' of some Generators from the simulation, whose certificates were not used. This is mentioned more fully in later sections.

Generators would have considered spreading their investments round the four geographic regions in the simulation in order to hedge weather and power price risk. Once again, it would be wrong to interpret these results as a useful prediction of likely national growth in renewables capacity, since in the short/medium term there is unlikely to be an integrated EU-wide market promoting renewables investment purely on the basis of most economic resource availability.

8.4.10.4 Costs and revenues

It is instructive to examine the total costs incurred by all Generators, and the total revenues they received, shown in the graph: 'Costs and revenues - all Generators'.

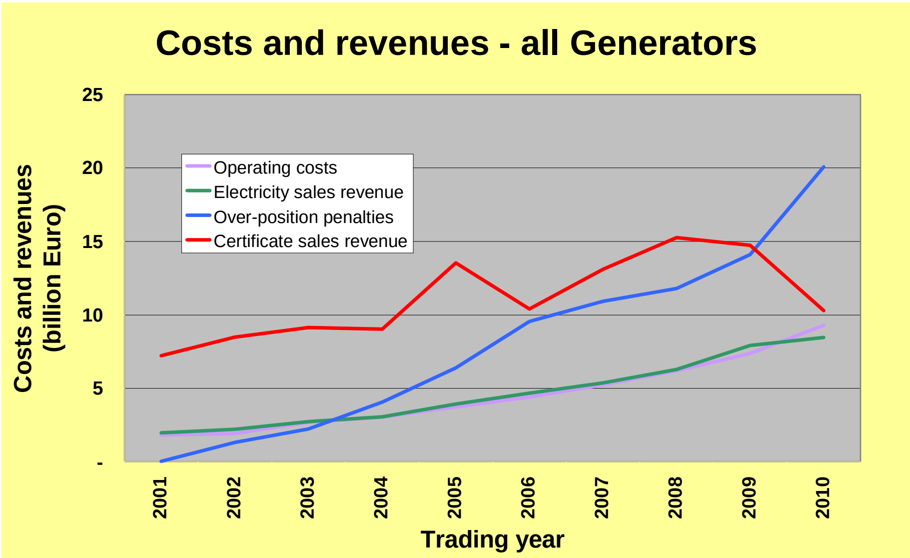

Figure 31: Costs and revenues, all Generators

Since certificate market prices were largely static throughout the simulation, we can infer information on Generator behaviour from the above curves.

Certificate sales revenue rose as the simulation progressed, with the exception of year 2010, when the general price collapse reduced this. The slow rise in revenues up to 2004 reflects the slow growth in capacity resulting from investment restrictions. High revenues in 2005 were due partly to growth in capacity, coupled with a higher amount of forward sales. Electricity sales revenues grew in line with installed capacity, with additional influence from weather effects. It is interesting to note that certificate sales revenues grew at a lower rate than electricity sales revenues, which reflects the presence of several Generators who did not participate. These 'absent' Generators received electricity sales revenues automatically, but did not receive certificate sales revenue.

Over-position penalties paid by Generators (charged on the number of certificates in excess of one million held at the end of each trading year) grew steadily as the simulation progressed. This was only partly due to active Generators failing to sell certificates, and was mainly due to non-activity by 'absent' Generators, who effectively 'stored' unsold certificates arising from their initial generation portfolio, thus incurring higher and higher penalties. The presence of these high penalties has the effect of reducing the average profit for all Generators, and incorrectly represents the profitability of individual, active Generators.

Cost of operation (ie, marginal cost of production) for Generators was roughly matched by electricity sales revenue, indicating that for active Generators, certificate sales revenue more or less represented 'pure profit' (since no charge was made for capital in RECerT-sim).

8.4.10.5 Performance

These costs and revenues are accounted for the cumulative average profit for Generators, and their efficiency performance, shown on the graph 'Generators' cumulative average performance'.

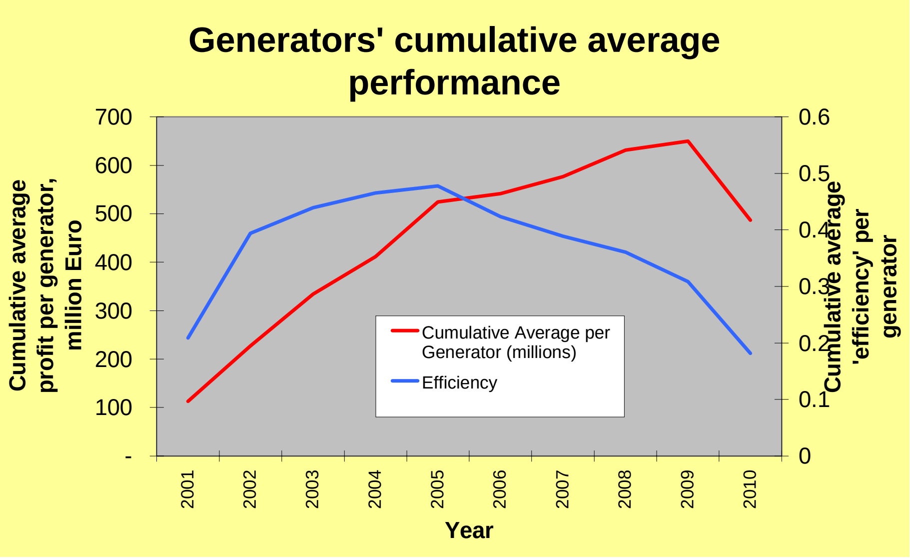

Figure 32: Gnerators' cumulative average performance

The graph indicates the two principal performance measures calculated for Generators - based on profitability and on 'return on assets'.

The cumulative average profit per Generator (net revenues less net costs) grows linearly in the first five years, indicating steady profit, but slows down in the second half of the simulation and finally reduces in 2010. This relatively poor performance overall is largely caused by the growing influence of position penalties (see previous graph) as the simulation progressed, and does not correctly reflect the performance of the 'active' Generators.

One option considered for the efficiency measure was to 'write down' or 'amortise' each asset over its expected financing period, and to charge the capital and interest costs to Generators. However this produces a strong incentive for Generators not to invest in new assets after a certain point, because there would be insufficient time remaining to achieve a viable return on the asset. This 'end effect' is hard to eliminate, but the means chosen in RECerT-sim was to set the 'efficiency' measure as a ratio of net cumulative profit to cumulative value of assets held, effectively a 'return on assets' measure which assumes a zero time value of money. The measure is crude, but was deliberately chosen to keep the measure simple and to minimise the investment 'end effect'.

The downturn in average efficiency for all generators was again largely due to the slow rise and eventual downturn in cumulative profitability for all generators, set against a rising asset base.

8.4.10.6 Consumers

Consumers were critical in the simulation, since their actions drove the demand for certificates. Consumers were charged with purchasing certificates in the market in order to satisfy mandatory purchase obligations. The total European obligation was divided among the Consumers registered at the start of the simulation. Some Consumers were 'absent' from the simulation from the start, so did not purchase certificates and did not comply with obligations. Absent Consumers had an irreversible effect on the simulation, since their 'share' of the demand could not be divided among the remaining Consumers (unlike investment activity for Generators). In the event, the simulation manager was able to cover a few positions for absent Consumers during trading, but the overall demand side of the simulation was depressed relative to the 'design' demand.

This reduction in expected demand was mirrored by a reduction in expected supply since a small number of both Consumers and Generators were 'absent' from the simulation. Despite this, supply and demand did not achieve an equilibrium and the market was 'short' of certificates for most of the simulation.

8.4.10.7 Absolute costs and compliance

The consequence of the lack of supply was high certificate prices, which in turn made it very difficult for several consumers to comply with their obligations, especially in early years, since market prices of certificates were at the same level as, or higher than, the obligation penalties. These dynamics are illustrated in the graph of Consumers' costs, obligation and compliance below.

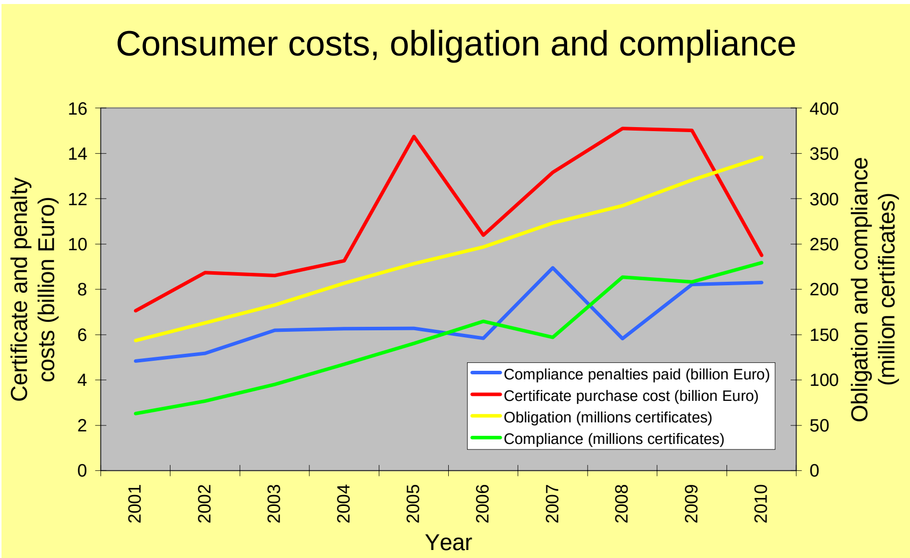

Figure 33: Consumer costs, obligation and compliance

The obligation curve rises steadily by a factor of about 2.4 from around 143 million certificates (150 TWh) in 2001 to around 345 million certificates (350 TWh) in 2010. The total compliance of all Consumers (number of certificates redeemed) rises from 44% in 2001 to 65% in 2010.

The very flat certificate prices seen during the simulation means that the net purchase cost of certificates tended to rise roughly in line with compliance. Year 2005 showed a sharp rise in cost of compliance, partly explained by greater forward buying by Consumers in that year.

8.4.10.8 Annual average costs and compliance

The cumulative performance curves described in the next section 'smooth out' sharper annual changes in the underlying quantities. However it is useful to look at the underlying changes on an annual basis in understanding the dynamics of the simulation.

The following graph shows annual average compliance rate and cost. Costs are presented as an index, with 2001 = 100. The cost of compliance includes the cost of certificate purchases and payment of penalties, and is divided by the number of certificates redeemed in each year to produce a 'per certificate' measure.

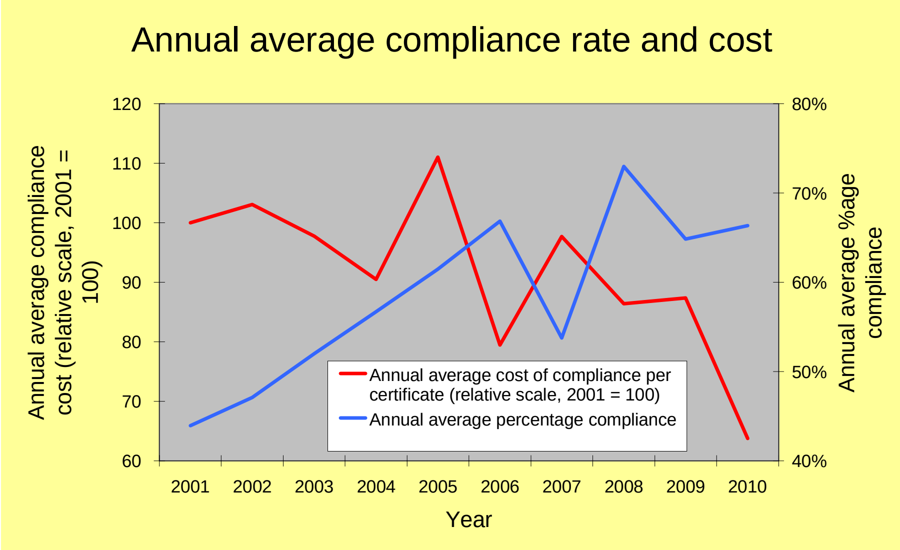

Figure 34: Annual average compliance

The major fall in cost of compliance per certificate redeemed occurs in year 2010, when market prices collapsed to zero. This cannot therefore be taken as representative of an underlying trend. A truer reflection of underlying trend shows a fall in cost by a factor of about 0.15. This fall is most readily explained by the slow fall in market price of certificates as a result of rising generation capacity and increased supply of certificates to the market. However this relatively minor fall in cost of compliance was certainly not sufficient to erode the very high profits being sustained by Generators, and this trend would need to be sustained over a much longer period before supply and demand came into balance. Annual changes in cost of compliance are best explained by forward purchasing of certificates for redemption in future years, the costs of which fall in the current year and therefore depress apparent performance.

The rise in annual average percentage compliance is again explained by the modest fall in certificate prices, but it is important not to forget that some Consumers were absent from the simulation, and hence this curve is not representative of those 'active' Consumers, whose rate of compliance was much higher.

8.4.10.9 Performance

Consumer performance was measured by two quantities; cumulative cost of compliance per certificate redeemed, and cumulative rate of compliance. The first performance measure was intended to indicate efficiency and the second a notional 'political' performance. Cumulative measures were used in order to derive a hierarchy of performance between all Consumers by the end of the simulation, to avoid penalising short-term high cost of compliance by Consumers choosing to buy forwards, to incentivise long-term rather than short-term performance, and to focus on trends rather than annual events.

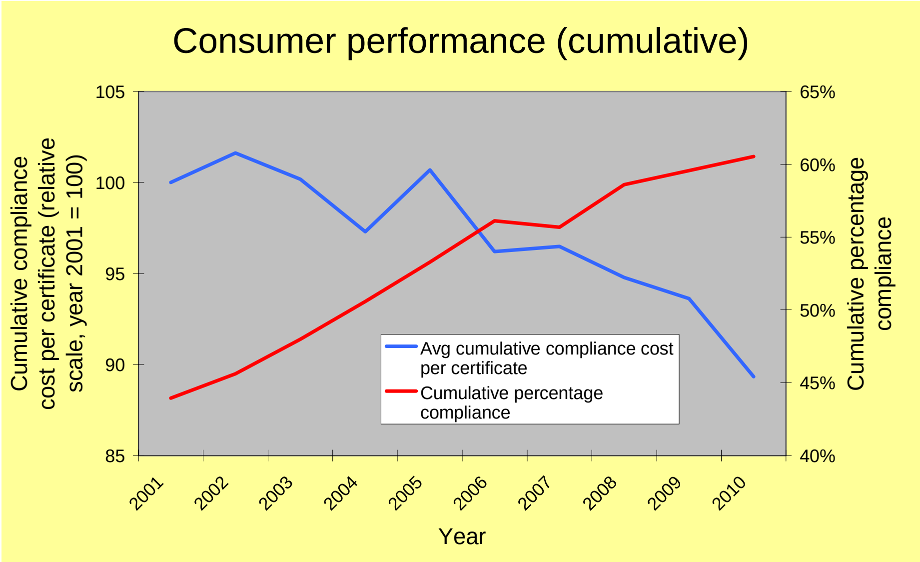

Figure 35: Cumulative consumer performance

The cumulative cost of compliance per certificate redeemed fell by around 12% over the course of the simulation, while cumulative percentage compliance rose from around 45% to over 60%.

8.4.10.10 Traders

Traders were the group least critical to the overall success of the simulation. Participants were advised that if they were unlikely to be reliable contributors to the simulation they should choose to register as a trader, as the presence or absence of traders does not disrupt the basic supply-demand balance. Traders' attendance in the simulation reduced towards the end of the simulation, and this fact makes interpretation of the statistics more difficult.

8.4.10.11 Traders' revenues, costs and traded volumes

Traders who were absent from the outset had no effect on the simulation, since they held no certificate position. Traders who were present at the start, who built a certificate position and then abandoned the simulation would incur annual position penalties (depending on the position limit), and would face the 'judgement day' penalty at the end of the simulation. The same 'judgement day' penalty was incurred by all active Traders who were unable to sell all the certificates they held in 2010 as the market price crashed. The effect of 'judgement day' penalties was extreme in the case of Traders, and year 2010 penalties paid were an order of magnitude higher than those paid in 2009. Year 2010 statistics have been removed from the revenues, costs and volumes graph.

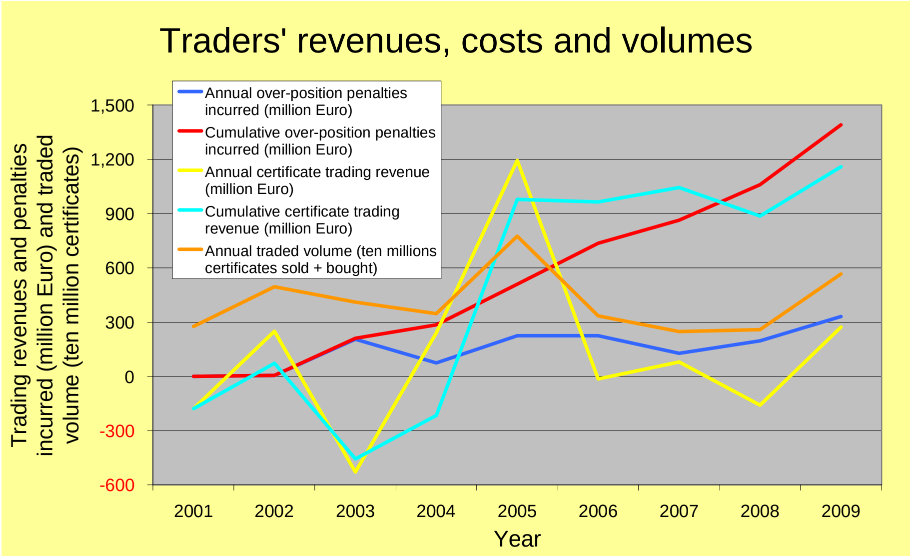

Figure 36: Traders' revenues, costs and volumes

Annual over-position penalties incurred are fairly constant after 2003, and the cumulative over-position penalties grow approximately linearly. Annual certificate trading revenue (value of sales less cost of purchases) fluctuates wildly, partly due to inconsistent presence in the simulation by some Traders, and partly reflecting forward buying and selling. Cumulative certificate trading revenue consequently starts negative and ends positive, indicating that active Traders were successful in their basic objective. The annual traded volume (buys + sells) fluctuates, again influenced by the presence or absence of traders, and by forward selling and buying.

In general, traders can only make money in a volatile market, where their presence provides greater liquidity. The RECerT-sim market was characterised by a lack of volatility, and hence there was little to keep Traders present.

8.4.11 Simulation lessons and conclusions

8.4.11.1 Simulation design observations

The foundation of the simulation was an economic 'model' that set the costs of investment in new generating assets, the purchase obligations to be fulfilled by Consumers, and the penalties on all parties for failing to comply with obligations and market rules. Hence the results of the simulation in terms of trading prices and the rate and location of investment in new capacity are basically the result of the base data, assumptions and rules set by the simulation manager, and not, in themselves, a useful prediction of future market behaviour.

The simulation design was necessarily a compromise between attempting to achieve an accurate portrayal of real-world conditions and decision making, and running a purely 'abstract' modelling process in which there was no explicit link with renewable energy. The design was flawed by the reliance on Consumers to collectively represent the entire demand for renewable energy certificates in Europe, and the reliance on Generators to represent the entire supply. This design was chosen on the grounds of simplicity, and demanded low 'absenteeism' by Consumers and Generators to work well. When this 'absenteeism' did take place, the supply-demand balance was affected.

An alternative simulation design could have guarded against this effect, by causing each participant to behave as a virtual company with a realistic portfolio of supply and demand and to have a much smaller role in the provision of overall supply and demand. This approach would have demanded the creation of a fully-featured 'economic model' to run in the background of the simulation, and the volumes traded would have been dominated by this model rather than by the actions of individual participants. Whilst this approach has the disadvantage of requiring the construction of a detailed economic model, it has the advantage of permitting the 'artificial' creation of price volatility, hence giving participants the opportunity to test risk hedging strategies 'against the model'.

8.4.11.2 Risks and risk management

One of the reasons for providing the simulation was to introduce participants, some of whom were not familiar with trading principles, with the idea of risk management in the face of future uncertainty over prices and supplies. In the event, the lack of supply in the market pushed prices upwards and the inelasticity of demand meant that prices rapidly reached an equilibrium level, effectively removing the price effects of the risk of weather effects for generators, and therefore removing much of the necessity of risk management.

A further criticism of the design is that insufficient information was provided and there were too few exogenous shocks to change participants' perception of risk and value. The information provided on regional electricity price movements and on weather effects was ex-post, not predictive, and hence the market could not usefully react to the information.

These observations on simulation design may be useful to designers of future similar simulations.

8.4.12 Participant feedback

All participants were invited to answer a questionnaire relating to the simulation. The questionnaire was designed to quantitatively assess the success of the project, looking at: overall simulation design and management; communication and support website; technical performance and trading website; and overall satisfaction. Analysis of the 17 responses (7 generators, 6 consumers and 4 traders) indicates a general level of satisfaction. The response rate to the questionnaire was approximately 12%. The responses to questions are summarised here.

8.4.12.1 Overall simulation design and management

Participants were generally satisfied with the variety and learning available through the simulation. However, responses indicated some dissatisfaction arising from over-simplicity and a lack of insight into risk management through the use of forward contracts. These criticisms reflect the fact that real-world trading of TGCs will be far more complex than the simulation allowed, and that risks were not sufficiently acute for participants, as a result of the under-supply of TGCs and the consistently high prices seen through most of the simulation.

8.4.12.2 Communications and the support website

High overall scores in this section suggested that participants were highly satisfied with the timeliness of communications and the performance and ease of use of the support website, which provided all the trading feedback and the investment process. This aspect of the simulation was very successful and suggests that good information and support is important for future simulations.

8.4.12.3 Technical performance and the trading website

Again, high overall scores suggested that participants were generally very satisfied with the performance of the trading website, and the ability of the project team to respond rapidly to requests for help and suggestions for improvements.

8.4.12.4 Overall satisfaction

Responses indicated a slight dissatisfaction with the lack of dynamism resulting from the market for TGCs being ‘short’, but in general an acknowledgement that the overall objectives of the simulation were adequately met.

8.4.12.5 Where next?

Over 70% of respondents indicated that they would like to take part in a future simulation, with changed parameters, new participants and new learning opportunities. This suggests that this kind of simulation can play a useful role in future.

8.4.13 Conclusions and recommendations

8.4.13.1 Barriers to trading and the need for standardised products

In the early days of a 'European' market for TGCs, markets are likely to be highly fragmented as the domestic markets in the seven leading TGC countries become established and as participants seek ways of hedging risks by operating in more than one such market. This is also the situation that RECerT-sim was modelled on, but RECerT-sim did not truly represent the many differences in domestic schemes that will exist in practice.

It seems highly likely that there will be significant practical and possibly legal barriers that will prevent the easy trading of TGCs between domestic schemes in the EU, at least in the short/medium term until further harmonisation of such markets may be proposed by the Commission.

Such barriers to trade will result in a lack of liquidity, a lack of information and an increase in risk. In these circumstances trading will not be achieved through a common trading platform such as that used in RECerT-sim. On the contrary, trading will be dominated by over-the-counter (OTC) and brokered trades, probably demanding the creation of bespoke terms of transfer and leading to significantly higher transaction costs than those that would be experienced in a 'real world' version of the trading platform seen in RECerT-sim.

The absence of a single market for TGCs will also make price-finding and price comparison more difficult. There is a good case to be made for the creation of a 'European TGC Gold Standard' certificate, which would comprise a 'basket' of the most universally acceptable TGCs in terms of criteria such as vintage, technology, resource, origin etc. The existence of such a 'Gold Standard TGC' would mean that a market could be created in this 'basket' of certificate types with larger liquidity than any other single TGC category, and that a reference price against which other prices may be measured could be created.

8.4.13.2 Creating demand for TGCs

The way in which demand for TGCs is incentivised is critical to the success of TGC systems, and ultimately their public and political acceptability. We have seen in the rather simplistic simulation provided by RECerT-sim the danger of driving demand with penalties that, in a short market, effectively act as a rigid price cap. The use of simple penalties for under-achievement of an obligation reduces demand elasticity since Consumers have no alternative but to buy the TGCs or pay the penalty.

However it must be noted that in RECerT-sim Consumers did not have the option of investing in new renewable electricity capacity themselves, or investing in generation companies. In the 'real world' Consumers may achieve a natural hedge against price risk by creating some of their own demand for certificates.

With little elasticity of demand, and no fungibility between TGCs and other tradable instruments, TGC prices in RECerT-sim were rapidly driven up to the level of Consumers' penalty rates. This ought not to happen in a more 'natural market', in which demand and price are related. There may be ways to incentivise demand for TGCs that permit demand to react more 'naturally' to price changes and keep the market in equilibrium. These are not explored in depth here, but could include:

- ***Defining compliance penalties in non-financial terms.*** Compliance with an obligation could be incentivised by non-financial penalties, for example by restricting or removing certain rights, privileges or flexibility enjoyed by electricity retailers by changing the terms of supply licences or other action by a government or energy regulator. Such penalties could be implemented on a longer timescale than an annual compliance period. The obligated company would of course have to translate the impact of any such penalty into financial terms in order to assess how much they would be willing to pay for certificates in the market. However, different companies would evaluate the costs / risks of such penalties in different ways, which would at least lead to a less homogenous demand side, and greater elasticity of demand. The difficulty with this approach is in setting the penalties, and making them fair.

- ***Recycling of penalties.*** This approach is proposed for the TGC scheme shortly to be adopted in Great Britain. Penalty payments by electricity suppliers who fail to fully comply with the obligation are collected into a 'fund'. This fund is then re-distributed to all suppliers in proportion to their compliance. Hence there is an added incentive for suppliers to buy certificates in order to 'beat the average' rate of compliance and benefit from some of the repayment from the fund. In terms of market operation, the advantage of this approach is that all retailers' 'willingness to pay' for certificates is not simply dictated by the penalty, but rather different retailers will value TGCs differently. Demand for certificates is therefore slightly more elastic than if the recycling fund did not exist.

- ***Sliding scale of penalties.*** It would be possible to reward higher compliance by obligated parties (we assume electricity suppliers), by applying a sliding scale of penalty to each. A very low rate of compliance would attract a higher penalty per 'missing' certificate, whereas a higher rate of compliance would attract a lower penalty for 'missing' certificates. In this way there is again an added incentive for non-compliant suppliers to enter the market with demand for certificates, and different suppliers will have a different willingness to pay. The effect should be a more elastic demand for certificates, and a less homogenous demand overall. In turn, this could help the market to reach a more 'natural' equilibrium price in conditions of limited supply.

- ***Banking and borrowing.*** One of the most effective ways to increase elasticity of demand is to permit obligated parties to bank and borrow certificates. Theory probably suggests that unlimited banking and borrowing has the most advantage for efficient operation of the market, but this is unrealistic not least from a political perspective. The experimental work done by ECN and University of Amsterdam early in the RECerT project pointed to potential dangers with high banking levels as certificates were 'stored' in the expectation of higher prices in future, leading to a price crash as the market went suddenly long. The same work indicated the advantage of borrowing to increase elasticity of demand. The RECerT-sim did not permit borrowing, and some national administrations seem to be uncomfortable with the concept of claiming compliance in the current period on the basis of generation that will, or should, happen in a future period. Nevertheless banking would significantly increase the ability of electricity suppliers or other obligated parties to resist high short-term prices for TGCs and discount the value of future TGC production with a discount rate based on a rational view of risk.

- ***Fungibility with other instruments or targets.*** A highly effective way of increasing elasticity of demand is to permit companies to meet their obligations through means other than by buying TGCs. One possible approach could be to use carbon emissions reductions as the common currency for environmental improvement in the electricity sector, and setting an 'exchange rate' between TGCs and other means of reducing emissions. Such an exchange rate would reflect the willingness of governments to support renewable energy development for a variety of reasons, but would not prevent companies from choosing other emissions reduction projects if TGC prices became too high, thus dramatically increasing demand elasticity for TGCs and carbon emissions reduction credits or permits. A second approach could be to define environmental targets for the electricity sector in broad terms, for example encompassing the efficiency of end-use of electricity, emissions of a variety of pollutants of local and global significance, and use of renewable energy. Demand could be created for a 'basket' of measures, with individual companies exploiting natural advantages in different areas to meet their obligations. The elasticity of demand for TGCs would thus become much higher as the market value of TGCs would relate to the cost of other compliance routes. Once again an 'exchange rate' device between TGCs and other instruments could be used to reflect government objectives or better incorporate the external costs and benefits of renewables.

- ***Use of taxation as a demand driver.*** The current Dutch green certificate regime uses exemption from an 'eco tax' levied on electricity sales (effectively a carbon tax), as a driver for demand for renewables. The tax is set at a level where the value of the exemption approximately equals the cost of providing renewable energy. Hence consumers may demand tax-exempt renewable electricity from their suppliers, and have this supplied at a cost that is the same as, or even slightly below, that of 'conventional' electricity. This system permits the proper operation of demand-side price elasticity, since as the cost of renewable certificates rises beyond the tax exemption value, consumers will react to the price signal and demand will reduce. In order for such a system to work well, great care still needs to be taken to ensure that the value of the tax exemption is proportionate to the expected future cost of renewables development, otherwise the potential advantage of economic efficiency can be lost.

8.5 TASK 5.8: SIMULATION REPORTING AND WEB DISSEMINATION

Feedback was provided to simulation participants through regular pre-trading and post-trading bulletins. These contained information and analysis on the results of the previous trading session (such as price movements, numbers of certificates traded etc), and information relevant to the following session (such as weather effects, timings etc). The bulletins were posted on the support website, and sent directly to participants. Information and analysis was also available directly to participants through the support website screens (such as 'My Trade History'). A total of 15 bulletins were circulated as .pdf and/or word files.

Reporting on the results of the simulation was achieved through the simulation report, made available to all participants through the website, and to specific non-participants who wished to see it. We judged that the report was too detailed to be a public-domain document however, and achieved public domain dissemination of results through other means (conference presentation and publication of articles). These articles and presentations are listed in section 11.2.

8.6 TASK 5.9: NON-TGC MARKET COMPARISONS

8.6.1 Summary

Tradable Green Certficate (TGC) schemes are under development in seven out of fifteen EU Member States, and in many other jurisdictions worldwide. Evidence in Europe suggests they tend to be developed, under the responsibility of energy regulators and energy departments of government, in too much isolation both from other national initiatives and from evidence and experience from related market developments world-wide.

TGC schemes are a sub-set of the general application of market instruments to achieve environmental and other policy objectives. Such market instruments range from simple charging linked to traditional 'command and control' policies, through to laissez-faire free market solutions.

There is considerable experience world-wide from the application of directly analogous schemes, in the emissions trading field. Much useful experience comes from recent years in the US where tradable permit schemes have already achieved maturity and demonstrated success in efficiency and effectiveness.

This report briefly reviews the theoretical background such tradable instruments, then looks at some experience from market developments related to TGCs, specifically the UK's Packaging Recovery Notes market, the US Acid Rain Programme NO_2 market, and the California RECLAIM market.

Based on experience from these analogous markets, some observations are made on issues of design and efficient market operation as they related to TGC developments in Europe.

8.6.2 Introduction

Seven out of fifteen EU Member States are in the process of defining renewable energy support schemes based on the creation, trading and redemption (or destruction) of Tradable Green Certificates (TGCs). In the main, these schemes are based on the imposition of an obligation on specific parties to ensure that a certain fraction of their total electrical energy consumption, supply or generation comes from renewable sources.

In devising such schemes, Member States have adhered to a common set of basic principles, specifically the splitting of renewable energy 'benefits' or 'rights' contained in the certificate, from the underlying energy, and secondly the incentivisation of demand for certificates. However we see many differences in approach and detail between different domestic schemes. The schemes have been developed in relative isolation, with only a low level of coordination between Member States. Furthermore very few references seem to have been made in designing such schemes to experience gained in other analogous markets.

The purpose of this short report therefore is to look beyond TGCs, to put TGC developments in the context of markets for other tradable environmental instruments which are analogous to TGCs, and from which it may be possible to draw lessons for the future design and development of TGC markets.

This report is one of the outputs of the European Renewable Electricity Certificate Trading project, RECerT, part-funded by the European Commission and managed by ESD, with partners drawn from all EU countries. It is intended for a general audience, but may be most relevant for those TGC market stakeholders whose background is principally in renewable energy policy and investment, rather than in market mechanisms and environmental instruments more widely.

8.6.3 The use of tradable instruments in environmental markets

8.6.3.1 The clean energy imperative and environmental trading schemes

The 'clean energy' market in Europe and North America is booming. There is now a growing body of opinion that the clean energy industry (meaning renewables, small-scale 'embedded' CHP, fuel cells, energy storage) is at the start of a steep growth curve. It is argued that we are entering a period of transition from an 'old world' model of electricity generation to a distinctly different 'new world' model. The 'old world model' has large-scale nuclear, oil and coal fired power stations pushing energy through a one-directional transmission and distribution system to consumers. The 'new world' model sees the emergence of intelligence in local networks, combined with a much greater use of small-scale, distributed, cleaner generation though micro-scale CHP, renewable energy and fuel cell applications, enabled by IT, communications and energy storage technologies.

This vision of the future of energy provision is no longer just subscribed to by some academics and environmentalists. Most major investment banks in Europe and America now have dedicated research teams who analyse the growth prospects of the 'clean energy' industry players, and track their performance. The 'clean energy' sector is seen by many as a significant investment and growth opportunity, and we are seeing the emergence of large funds dedicated to investing in this area.

Underlying this interest by the financial community is a growing concern on the part of consumers, industry and governments worldwide over environmental degradation and the options for improving environmental performance. The most obvious focus for this concern is global warming, now proven and unequivocally linked to anthropogenic emissions of greenhouse gases (GHGs), and the efforts of the international community to agree a framework for limiting emissions of GHGs through the Kyoto Protocol. These concerns are expressed more locally in schemes to improve air quality by limiting the emissions of pollutants such as nitrogen and sulphur oxides.

One of the most interesting trends in environmental protection is the emergence of tradable economic instruments to capture the costs and benefits of environmental damage or improvement. The underlying logic of all such instruments is that they enable a market to put a value on the environment, and deliver greater efficiency and flexibility in achieving environmental targets. It is argued that the use of these instruments is an improvement over the use of an 'old world' command and control approach to environmental improvement. Their use enables the internalisation of the costs of environmental damage borne by society in general (so-called externalities), thereby creating incentives for individuals and firms to undertake environmentally beneficial investment. In fact most such markets are effectively 'unnatural' since in most cases the demand drivers are created by government intervention. This intervention implies an evaluation of the cost of externalities by government, so it cannot be said that the use of such instruments represents a 'free market' valuation of the environment.

Nevertheless, tradable instruments such as carbon credits, sulphur dioxide emissions permits and tradable green certificates are emerging as a family of tradable instruments that have the potential to deliver greater flexibility and cost effectiveness in meeting environmental objectives. This can be done since emissions reductions can be achieved preferentially by those firms with the lowest marginal cost of abatement, and similarly, renewable generation can be achieved at those locations with the best resource or greatest generating efficiency.

8.6.3.2 Economic instruments in context

Economists tend to make a basic distinction between 'Command and Control' and market-based approaches to regulation in any sphere of human activity, in this case in the general field of environmental protection. However the distinction is not clear-cut, and the phrase 'market-based instruments' or 'economic instruments' covers a very wide range of approaches. These vary from fines or sanctions linked to command and control policies at one extreme, to laissez-faire approaches relying on consumer advocacy or private litigation to put a value on environmental protection or degradation, at the other. In all cases, the purpose of the instruments is to influence investment and management decision making in firms, to achieve environmental objectives.

For example a 1999 OECD report on environmental economic instruments[31] defines ten classes of economic instrument, of which tradable permits, rights or quotas is only one. Others include emission charges, taxes, deposit-refund systems, performance bonds and subsidies. Other classes or sub-classes of economic instrument, such as eco-labelling, can be added to the list.

Generally speaking, environmental policies aim to reduce environmental degradation (and in the case of renewable energy promotion, to achieve other non-environmental objectives also), at least overall cost to society. To achieve this efficiently it is necessary to accurately align private costs with social costs, in order that environmental 'externalities' (the global impact of pollution for example) become automatically incorporated into decision making at the level of firms or even individual consumers. This need to align private and social costs gives rise to the increasingly widespread use of economic, or market-based instruments. About 100 environmentally-oriented economic instruments were in place in 14 OECD countries by 1987, rising to 150 by 1993[32].

For the sake of this discussion, tradable renewable energy certificates, and the market drivers that underlie their use, can be seen as a sub-set of the general case of tradable economic instruments in the field of environmental protection and pollution prevention.

The major uses of tradable instruments in this area to date have been in emissions trading, specifically relating to the control of gaseous emissions with local or near-local pollution effects, specifically SO_x and NO_x. Most of the literature and recent experience relates to emissions trading in the US, through the application of tradable permits (TPs) in the context of its environmental protection programme. The US currently runs two major TP schemes for air quality management: the Acid Rain Allowance Trading Scheme (with power plants as the main parties), and RECLAIM in California, a system of tradable permits for NO_x and SO_2. The first of these is profiled in this paper.

8.6.3.3 Tradable renewable energy certificates

The use of tradable 'certificates of origin' coupled with obligations or tax incentives to promote the growth of renewable energy belongs to the general family of economic instruments. It is most natural to view them in the context of other tradable instruments in the area of environmental protection. However it is important to note that the desire of governments to promote renewable energy is not driven solely by narrow environmental considerations. Indeed, whilst global warming and Kyoto commitments are a major driving force, the equivalent cost of carbon abated through renewable

[31] Economic Instruments for Pollution Control and Natural Resources Management in OECD Countries: A Survey. ENV/EPOC/GEEI(98)35/REV1/FINAL October 1998
[32] Economic Instruments for Pollution Control and Prevention - A Brief Overview. Austin, World Resources Institute, 1999

energy developments is now, and over the short-medium term is expected to be, generally much higher than the cost of abatement through process change or energy efficiency improvement in various sectors of the economy. Hence whilst the environmental imperative lies at the heart of renewable energy promotion, governments are motivated by a number of objectives. These include securing the long-term security and diversity of energy supply, promotion of industrial growth and export opportunities, rural development, and to satisfy popular demand for visible progress in environmental improvement.

Market mechanisms to stimulate the growth of renewable energy using the currency of 'tradable green certificates' are favoured in some states in the US (under the title Portfolio Standards), in Australia and in seven countries in Europe, and are being seriously investigated in other countries including China and Japan. All such schemes share the same basic concept of the separation of energy from the 'environmental benefit' or 'renewable energy right'. However all schemes vary in many other respects, for example in the incentive mechanism, the types of technology and resource that are eligible etc. Such variation is inevitable since such schemes were not developed in a coordinated, coherent was in the context of an international treaty, and the consequences of such variation are likely to be lower liquidity and greater complexity.

The independent evolution of the markets allows the cross fertilisation of ideas between markets at different stages of development. However if the aim is develop an international market to efficiently utilise a region's renewable resources, then at the very least common products must be developed. If there is a failure to mutually recognise the product then the international future of TGC schemes will be limited. It is unlikely that unique national green certificates would develop an exchange market in the same way as currencies have.

8.6.4 Summary of selected trading schemes

There are many tradable instrument markets that could be examined in this paper. Two are briefly examined here, as examples of related developments that have relevance for TGC markets. These are the US national acid rain programme SO_X scheme, and the UK Packaging Waste Recovery Note (PRN) market. The two examples provide a contrast in terms of regulatory framework, market size, liquidity, market behaviour and the lessons that can be drawn.

8.6.4.1 Packaging waste recovery notes (PRNs)[33]

PRNs were introduced to assist the UK to meet its targets under the 1994 EU Packaging and Packaging Waste Directive. Each EU country has the freedom to decide on a system to ensure that they recycle 50% of packaging that is ordinarily thrown away. The UK scheme uses a flexible economic instrument that encourages producers and consumers of packaging to take responsibility for the disposal and recycling of the waste packaging. The scheme is effectively supply side management, placing the costs associated with responsible disposal of waste on the producers who can take measures towards more efficient packaging. The PRN scheme requires companies responsible for producing packaging waste, to prove that a predetermined amount of waste has been recovered and recycled. The waste producer does this by presenting sufficient PRNs to cover their recovery and recycling obligations. PRNs are created by waste collection / recycling companies.

The aim of the PRN scheme is to reduce the impact of packaging waste and to ensure the establishment of a single market in packaging and packaged goods. 56% of all packaging produced is to be recovered, with 25% to be recyclable and 18% recycling of each specific material. The size of the commitment is increased annually, and the current expectation for 2002 is 61%. Revenue earned by the waste management companies will stimulate investment in increased recycling capacity to match demand from increasing targets.

Waste management companies are naturally long on PRNs (their core business produces PRNs). The producers of waste must purchase PRNs to meet their recovery and recycling obligations, so have a short PRN position. This may be compared to tradable green certificates (TGCs) where the renewable

[33] Information provided by OM Environment Exchange

generation asset operators are long on TGCs and the suppliers of power have a short TGC position created by the obligation to supply power from a renewable source.

Companies' inclusion in the PRN scheme is determined using a size threshold system which is imposed on British business that is applied to all tiers of the value chain. This obligation lies with the following:

Manufacturer	6%
Converter	9%
Packer	37%
Seller	48%

When the scheme began in 1998 companies with a turnover of more than £5 million and producing in excess of 50 tonnes of packaging were obliged to participate. In 2000 the threshold was revised to companies with a turnover greater than £2 million. A total of 13000 UK companies are included in the scheme following the imposition of the revised thresholds.

Companies with obligations are currently adopting one of three methods of procuring PRNs:

- The company may go directly to waste management firms and purchase PRNs;
- they may purchase PRNs using a screen-based exchange, of which there is currently only one;
- they may join compliance schemes, which assume the legal obligation for the delivery of sufficient PRNs to meet the obligation.

There are currently 13 such compliance schemes in operation, which aggregate clients' positions and ensure compliance. The companies operating the compliance scheme charge a membership fee in addition to other unit fee. A range of PRNs is available, relating to different products, and prices vary depending on the cost of recycling or disposal of the material and the demand for the material specific PRNs. The strong preference shown by companies to join compliance schemes betrays a lack of confidence, expertise or familiarity in trading direct on the market.

The PRN scheme appears to be economically efficient with the average cost of compliance to consumers estimated at £1.30 in the UK compared with £17 in Germany, where a trading scheme does not exist.

When the scheme was introduced in 1998 prices for each of the material were high, but soon fell. With the exception of plastic and steel the all the annual average price of materials fell by an average 46% between 1998 and 1999. This price movement was caused by ineffective regulation / verification. The waste management companies were exaggerating the volumes of material recycled to generate more PRNs and the waste producers were not declaring their full production to reduce the burden of purchasing PRNs. This lead to an oversupply and hence to falling prices. Estimates suggest that under-declaration to the order of 12% continues to be an issue.

8.6.4.2 Comparisons between the PRN and TGC markets

One key difference between the PRN scheme and a tradable green certificate (TGC) scheme is that waste producers generally do not have the ability to produce their own requirement for PRNs. Economies of scale dictate that only large specialised companies are able to collect and recycle waste, and hence produce PRNs. Thus companies on the supply and demand sides of the market tend to be completely separated. This means that waste producers (obligated companies) are fully exposed to price risk in the PRN market. Waste producers would be able to achieve a 'natural hedge' (ie risk protection) against very high prices of PRNs by holding an equity stake (or purchasing completely) a waste recycling company. However this requires the management and understanding of a separate business, and this will not be attractive to producers of packaging waste. In contrast, buyers of TGCs are well able to buy or develop renewable generation capacity (become vertically integrated) in order to provide a natural hedge against TGC price risk.

Demand elasticity is one area of similarity with TGC schemes. Just as in a renewable energy obligation, so demand for PRNs is set by a legal obligation. Thus when the price of PRNs rises, there is no corresponding fall in demand, since the PRN market is not a 'natural ' market where natural demand and supply are held in balance.

8.6.4.3 US Acid Rain programme SO_X scheme

A dominant instrument in USA's acid rain programme is the market based cap and trade system introduced to address the SO_2 emissions. The aim of this mechanism is to reduce the volumes of SO_2 emitted into the atmosphere by US electricity generators. A flexible cap and trade mechanism has been adopted to achieve the necessary reduction in the most economically efficient way.

The cap on annual emissions is compulsory. Plants are monitored 24 hours a day to allow accurate measurement of SO_2 emissions. To operate, a plant must have emission allowances (EAs), sufficient to cover the total emissions of the plant. Each year fewer emission allowances are available, so if demand remains constant while supply falls, then the price of the EAs will increase. As the price increases participants will be encouraged to invest in emissions abatement projects, as they become more financially viable than the purchase of EAs. The penalty for non-compliance is set at $2500 tonne of SO_2 emitted beyond the caps. This tough penalty is double the estimated cost of physical abatement and is considered to be one of the key factors in the success of the market and its continued track record of 100% compliance.

When the scheme was being drafted in the early 1990s the cost of SO_2 abatement to generators was estimated to be $1000/tonne of SO_2. However by 1998 the cost transparency provided by the market indicated that many generators could achieve abatement for as little as $100/tonne of SO_2. The establishment of a market is an efficient way to identify the true value/cost of a product. In the European energy sector wholesale electricity prices have been driven down by up to 50% through the establishment of the power markets. These price falls may be considered unsustainable, although if the real price of power is higher then an efficient market will realign itself.

Recent reports describe the growing depth of the US SO_2 market. The SO_2 market is now following a trend in line with the price of coal. The two are linked since coal combustion represents a major source of SO_2. In the first seven months of 2001 the market saw the price of EAs climbing from $120 to $218. Throughout September there was heavy selling and the price has slipped back to $185. The market activity is an indication of liquidity with the market responding well to related markets. The recent fall in price is believed to relate to the slowing of the US economy hitting electricity demand, and hence coal demand, and hence SO_2 EA demand. In addition there has been some emptying of SO_2 war chests in response to regulatory changes, which may include combined pollutant controls, which would require many plant to implement technological solutions rather than use the SO_2 markets.

In October 1998 the FT's Energy Economist reported that the cost of US power industry out performing the SO_2 emission targets was $ 1 billion p.a. adopting the cap and trade mechanism. This is a significant saving on the regulatory solution that was estimated to cost $ 5 billion p.a. Although it is not possible to indicate the success of a traditional regulatory regime, on a cost basis alone the traditional 'command and control' approach is inefficient relative to the consistent performance of the flexible market mechanism.

One of the key lessons to be taken from the well-established US SO_2 market is the great benefit to market participants of maturity, liquidity and transparency. The market has reached a point where participants may rely on an unambiguous clearing price, and where the market price follows a trend based on physically related markets (in this case coal). This makes financing of abatement projects less risky, and hence less expensive. Liquidity is assured by the fact that the market has become 'traded' - in other words more buying and selling take place than is required for simple compliance. This means that the 'depth' of the market has increased to the point where any buyer or seller entering the market has a very high chance of finding a willing seller / buyer and to transact the volume they require. These maturity characteristics can be expected in TGC markets over the medium term, and will deliver considerable benefits to all participants.

8.6.4.4 RECLAIM

The Regional Clean Air Incentives Market (RECLAIM) programme in Southern California covers both SO_2 and NO_X emissions, and allows 400 of the largest power production plants in the area to trade emissions of both. The system was introduced in 1994, replacing an ‘Air Quality Management Plan’ that the state had previously begun in 1991. Under RECLAIM, plants receive a certain number of emission allowances each year, depending on their peak fuel consumption over an agreed baseline period. Emission allowances are valid for one year only and cannot be banked. Allowances are made in two cycles, spaced by 6 months, in order to prevent uneven use of allowances over the year.

Allowances are also made in two separate zones of the region. Plants in the upwind zone cannot buy allowances from plants in the downwind zone. It is estimated that the programme cut the overall cost of reducing emissions in the region by around 40% in the period 1994 –2000. The RECLAIM market is liquid and fairly mature, and participants are facilitated to trade with maximum transparency through an internet-enabled exchange as well as brokers.

However there have been alarming price movements which are worth reviewing. Early 1999 market prices for NO_X credits had been around $0.13 per pound, rising to less than $1 per pound up to the year 2000. Prices rose from January 2000 up to $4.22/pound in April 2000, up to $6.25/pound in May, and $11.25/pound in June. By July 2000, with companies under pressure from reconciliation deadlines, market prices had reached $36.75/pound, although for small volumes.

There are important lessons here for TGC markets. The price rises seen in the RECLAIM NO_X credits market were caused by a tightening of emissions standards, the basic supply/demand dynamic when generators' allocations were less than their emissions, and second-order effects such as the payment of penalties for missing monitoring data in earlier years. The key issue however is that no demand change was possible despite the dramatic rise in market price. The timescale attaching to investment and commissioning of new emission abatement technology is long, so short-term responses to an under-supplied market are not possible. Demand elasticity is limited by this investment lag.

8.6.5 Comparison of generic tradable instrument schemes

It is possible to compare a generic emissions cap-and-trade scheme (typical of emissions trading such as CO_2 or SO_X) with a generic tradable renewables obligation (such as that proposed for the UK). They may be compared with respect to a number of factors, with the objective of illustrating key differences and similarities.

Generic schemes are compared since in this way the basic characteristics of the schemes may be compared, rather than the detail of specific schemes. An analysis of similarities and differences shows that the two trading schemes are fundamentally similar in their structure and operation. One difference appears to be between the 'positive' objective of the renewable obligation to create renewable generation, and the 'negative' objective of the emissions trading scheme to limit emissions. However this difference is only cosmetic, as the basic market processes are similar.

One more fundamental area of difference between the two schemes centres on the result of supply / demand imbalances. This is one area where important lessons may be learned from emissions trading and applied to tradable renewables obligations. This is treated more fully in the following section.

The experience of the US NO_X trading scheme shows that the cost of compliance has fallen more quickly than had originally been predicted. This was a result of the 'innovation' incentive delivered by the trading mechanism. Reacting to the economic driver provided by the scheme, firms looked more closely at abatement of emissions, and were able to innovate such that the individual abatement cost curves for firms were found to be 'flatter' (less expensive) than originally assumed. Emissions and the price of permits were thus reduced, and compliance achieved, more quickly than expected.

The same cannot yet be said for tradable renewable obligation schemes. Such schemes are in their infancy, so it is not fair to compare them to the mature US sulphur market. Nevertheless, it seems likely that the production cost curves for new renewable electricity generation will be fairly fixed, as the technology prices are fairly steady and the cost drivers are related to available locations. Perhaps more important than the renewables cost curves is the length of time it takes to develop new renewable generation. If new generation is developed more slowly than the rising obligation, the market for TRCs becomes structurally short, and perverse policy outcomes can result.

The key lesson here is the need for careful design of an obligation scheme so that the penalty rate and rise in obligation percentage reflect the natural ability of the sector to innovate and keep demand and supply in approximate balance.

8.6.6 Some considerations for the design and efficient operation of TGC markets

8.6.6.1 Verification and Product definition

Much of the success of the USA's SO2 emissions market is attributed to the accurate and representative recording and reporting of the emissions from plants. In the absence of reliable data any market will fail as the integrity of the data dictates the quality of the product. A common understanding of the product is essential and this is largely determined by reliable verification. The monitoring and verification in addition to the development of a transparent registry will be crucial to the markets success. The price movements of the PRNs between 1998 and 1999 demonstrate the impact on markets of the lack reliable verification.

The US SO_2 market's success may be under threat from product distortion. The New York State signed legislation in May 2000 limiting the sale of SO_2 to 14 upwind States. The justification for this legislation is simply that by selling allowances upwind of the state the allowances will return as acid rain. This distorts the market by geographically distinguishing between allowances, effectively creating two products. The products should therefore be priced differently as the allowances sourced from New York have a limited market. Traders could potentially bypass the legislation if New York derived allowance were bought by a counterparty in a permissible region and subsequently sold on to one of the restricted areas for a small fee. However, the serious issues here are uniformity of the product and it's impact on the market. If a trend of localisation develops many different products will develop. All SO_2 allowances represent a verified tonne of SO_2, but each with different conditions. This has serious implications for a national market as it rapidly becomes fragmented and distorted.

For TGC markets to work well it is essential that TGCs are accurately defined in terms of the property rights they infer to the holder, and that the 'quality' of the commodity is assured by rigorous verification and measurement. The Monitoring and Verification Protocol (MVP) must be accurate, reliable and trusted. A TGC market will perform much better if the commodity is uniform, and not diversified. This can be achieved if TGC demand drivers (obligations) are not differentiated in terms of technology or geographic region.

8.6.6.2 Liquidity

Liquidity is a critical issue in the establishment and success of any market. Participants must have confidence that sufficient liquidity exist to allow them operate within their risk parameters. One indicator of liquidity is the bid-offer spread (the difference between the price a product is bid and offered at a point in time). The implication is that the wider the bid offer spread, the less liquid the market. In immature, illiquid markets this may occur due to the lack of participants, or in the environmental field more likely because the majority of the players are on one side of the market.

A lack of liquidity will make it difficult to close positions when price movements cause an individual participant to face a loss making position. Put differently, participants are unable to find a counterparty for their trade fast enough to respond to price movement. This creates a risky environment within which to trade. In order to create liquidity a market requires a critical mass of active participants, who have a common understanding of the product and variety of needs. The US SO_X market provides an example of this, a well defined market and a large group of players.

A key contributor to liquidity is the action of traders - counterparties who are not physically involved (as an obligated party of creator of instruments) in the market, but who take a purely speculative position, aiming to buy and sell with the objective of making profit. The action of traders is encouraged by price volatility.

For a TGC market, it is therefore desirable to design the market mechanism such that a large number of players are involved, and to limit any disproportionate 'market power' that can be exerted by individual market players. It is also important to encourage as much volume of TGCs as possible to be traded, in other words to avoid conditions under which obligated parties may comply with an obligation purely by internal investment, requiring no interaction with the market. The action of traders is facilitated by clear terms of transfer and a low-transaction cost marketplace.

8.6.6.3 Participation

Participants (traders) make markets. Whilst all companies trade (buy and sell products and services), schemes described in this paper face the problem that many scheme participants will not be familiar with trading under newly imposed legislative frameworks. The economic instruments under discussion here have not evolved like traditional commodity markets (over a long period of time and in response to the need of natural buyers and sellers); rather they have been designed to achieve regulatory objectives/ targets.

It is the imposition rather than the evolution of the market that may represent a problem for regulators. Participants have to adapt rapidly to the new complexity of the market, and the result can be a reluctance to get involved. If a power plant manger is encouraged to deliver lower SO_X emissions, their natural tendency is to identify a fuel or technology/engineering solution (which could be described as bidding into the fuel and technology markets). If bidding for a ‘credit’ to cover emissions is an option, then how is that valued? The plant manger will be comfortable presenting the business case for an engineering solution, but may be uneasy with a market solution. If a market solution is to be successful it is therefore crucial that participants are made comfortable with the market, and are therefore willing to trade. The creation of the PRN compliance schemes demonstrates how businesses not willing or able to directly trade their permit/certificate/note positions can contract a third party to perform this function for them.

An example of this issue in the TGC environment would be smaller generators, who are typically not familiar with trading arrangements, so perceive a tradable instrument market as a barrier. The problem is compounded since as small players they are already at a disadvantage in terms of relative market power.

The involvement of smaller players in TGC markets can be encouraged by transparent trading and registry operations, the existence of standard terms of trade, and training.

9 SUMMARY OF RESULTS - WORK PACKAGE SIX

Work package six comprised the final project workshop and information dissemination.

9.1 FINAL WORKSHOP

The final one-day workshop was held in Brussels on 12 July 2001 and hosted by the European Commission DGTREN. It was organised jointly between the three FP5 'green electricity cluster' projects InTraCert, ELGREEN and RECerT. Its purpose was firstly to present the three projects to an audience of mainly Commission officials, and secondly to present the high-level conclusions of the three projects in a form that would be useful to external observers. The agenda was notionally split between the morning and afternoon sessions to achieve this.

Attendance, excluding Commission officials, was from 26 individuals from 20 organisations and companies in 12 countries. Individual presentations from each project were made available to attendees, and the RECerT presentations were posted on the RECerT website public area.

The agenda was as follows:

10:30	Welcome from the project officer (Lars Nielsen)
10:45	Very brief introduction of the three projects in the cluster, the joint issues and the differences (Reinhard Haas)
11:00	Presentations of the project RECerT including discussion (coordinated by Chris Crookall-Fallon)
11:30	Presentations of the project InTraCert including discussion (coordinated by Maroeska Boots)
12:00	Presentations of the project ElGreen including discussion (coordinated by Reinhard Haas)
12.30	Lunch
13:30	Chris Crookall-Fallon: "Results from Europe-wide simulated trading of green certificates – Lessons for the practical creation of a workable market"
14:15	Maroeska Boots: "A promising future for Tradable Green Certificates?"
15:00	Break
15:30	Reinhard Haas "Prospects for various types of instruments for enhancing the market penetration of RES"
16:00	Final discussion on how to facilitate the faster development of renewable energy in Europe, the lessons of the Green Electricity Cluster, and the need for future research / promotion.
16:30	Close

9.2 INFORMATION DISSEMINATION

RECerT was intended to be principally an information dissemination project. This has been achieved through the numerous country workshops, the international conference and the final workshop. There has also been considerable information dissemination through the project website, through published articles and conference presentations. The latter are listed here:

- *Europe's changing power market: what future for renewables?* - Christopher Crookall-Fallon, Wind Directions, 1999.
- *Printing a new currency for European renewable energy - Tradable Green Certificates* - Christopher Crookall-Fallon, Sustainable Energy Developments, February 2000.
- *A new currency for trading the environmental benefits of renewable energy* - Christopher Crookall-Fallon and Tim Crozier-Cole, Renewable Energy World, May 2000.
- *Tradable Green Certificates (TGCs) for renewable electricity - European and UK perspectives* - Christopher Crookall-Fallon. Presentation at the conference: Electricity Trading After NETA, London, September 2000.
- *The UK ETS – a new market for renewable energy?* - Cathy Hough and Tim Crozier-Cole, Power House (PRASEG), October 2000.
- *Europe plans trading in 'greenness'* - Christopher Crookall-Fallon and Tim Crozier-Cole, Environmental Finance, October 2000.
- *Renewables under Kyoto - new opportunities, new uncertainties* - Chris Crookall-Fallon and Fanny Calder. Presentation at The Commercial Opportunities in the Generation of Power from Renewables - the Renewable 2000 Summit, 9/10/11 October 2000, Café Royal, London.
- *Tradable Green Certificates (TGCs) for renewable electricity - European and UK perspectives* - Christopher Crookall-Fallon. Presentation at the conference: fifth annual Electricity Association conference on energy and environment, Edinburgh, United Kingdom, October 2000
- *European green certificate trading – opportunity or threat?* - Christopher Crookall-Fallon. Presentation at the CREA Seminar 'Renewable Energy Obligation', London, 2 November 2000
- *European trade in 'Tradable Green Certificates' and the results of the RECerT-sim project* - Christopher Crookall-Fallon. Presentation at the conference: 'Successfully Developing Commercially Viable Renewable Energy Projects', IIR Renewable Energy Conference, 27 / 28 June 2001, London.
- *Europeans test green certificate trading* - Chris Crookall-Fallon and Tim Crozier-Cole. Environmental Finance, July-August 2001
- *Exploring the development and use of Renewable Energy Certificates and how they may interact with Emissions Trading* - Christopher Crookall-Fallon. Presentation at the conference: 'Practical Strategies to Prepare your Business for the Introduction of Emissions Trading', IIR, London, 23/24 October 2001
- *Green Certificate Trading Simulation, plus: Lessons from Europe's first live green certificates trading simulation* - Christopher Crookall-Fallon and Tim Crozier-Cole. Trading Simulation and Presentation at the Green Certificates Trading Seminar, part of the Carbon Finance 2001 Conference, Environmental Finance, London, 10 October 2001

10 CONCLUSIONS

10.1 TGC DEVELOPMENTS IN CONTEXT

The 'clean energy' market in Europe and North America is booming. There is now a growing body of opinion that the clean energy industry (meaning renewables, small-scale 'embedded' CHP, fuel cells, energy storage) is at the start of a steep growth curve. It is argued that we are entering a period of transition from an 'old world' model of electricity generation to a distinctly different 'new world' model. The 'old world model' has large-scale nuclear, oil and coal fired power stations pushing energy through a one-directional transmission and distribution system to consumers. The 'new world' model sees the emergence of intelligence in local networks, combined with a much greater use of small-scale, distributed, cleaner generation though micro-scale CHP, renewable energy and fuel cell applications, enabled by IT, communications and energy storage technologies.

There is a growing concern on the part of consumers, industry and governments world-wide over environmental degradation and the options for improving environmental performance. The most obvious focus for this concern is global warming, now proven and unequivocally linked to anthropogenic emissions of greenhouse gases (GHGs), and the efforts of the international community to agree a framework for limiting emissions of GHGs through the Kyoto Protocol. These concerns are expressed more locally in schemes to improve air quality by limiting the emissions of pollutants such as nitrogen and sulphur oxides.

An important trend in environmental protection is the emergence of tradable economic instruments to capture the costs and benefits of environmental damage or improvement. The use of TGC markets to incentivise renewables growth fits into this pattern. The underlying logic of all such instruments is that they enable a market to put a value on the environment, and deliver greater efficiency and flexibility in achieving environmental targets. It is argued that the use of these instruments is an improvement over the use of an 'old world' command and control approach to environmental improvement.

10.2 EUROPEAN PROGRESS IN TGCS

Seven out of fifteen EU Member States are in the process of defining renewable energy support schemes based on the creation, trading and redemption of TGCs. In the main, these schemes are based on the imposition of an obligation on specific parties to ensure that a certain fraction of their total electrical energy consumption, supply or generation comes from renewable sources.

In devising such schemes, Member States have adhered to a common set of basic principles, specifically the splitting of renewable energy 'benefits' or 'rights' contained in the certificate, from the underlying energy, and secondly the incentivisation of demand for certificates. However we see many differences in approach and detail between different domestic schemes. The schemes have been developed in relative isolation, with only a low level of coordination between Member States. Furthermore very few references seem to have been made in designing such schemes to experience gained in other analogous markets.

10.3 THE RECERT PROJECT

The RECerT project was conceived in early 1999, when there was the beginning of wider interest in the use of such tradable instruments, largely following on the Dutch ‘Groenlabel’ (Green Label) scheme. By the end of the RECerT project in July 2001, the concept of using market mechanisms to fulfil renewable energy quotas or targets had moved decisively from a minority and research interest to the mainstream of debate on renewable energy policy in the EU.

Given the rapidly growing interest in tradable certificate schemes, the RECerT project was conceived as an information and promotion project. It was designed to raise awareness of tradable certificate schemes in all the EU15 plus Norway, to feed the debate with timely and focused research, and to provide a 'hands-on' experience of how TGC markets could operate.

The RECerT project has played an important role in bringing disseminating knowledge and understanding of the application of TGC schemes among the 15 EU Member States and Norway. During the course of the project we estimate that more than 650 individuals had been directly involved in the information dissemination process through workshops, the trading simulation and the international conference, with many more receiving information through the indirect route of published articles and access to the project website. The RECerT project successfully worked alongside the other FP5-funded 'green energy cluster' projects, and the Renewable Energy Certificate System (RECS) project, providing a common platform for explaining all these initiatives to TGC stakeholders.

RECerT succeeded in providing a 'learning by doing' experience of simulated TGC trading, plus information dissemination, but also complemented this with original research and thinking that has helped to advance the understanding of all TGC stakeholders.

10.4 TGC MARKET DESIGN AND OPERATIONAL ISSUES

The RECerT project has provided some insight into market design and operational issues.

10.4.1 Barriers to trading and the need for standardised products

In the early days of a 'European' market for TGCs, markets are likely to be highly fragmented as the domestic markets in the seven leading TGC countries become established and as participants seek ways of hedging risks by operating in more than one market. It seems likely that there will be significant practical and possibly legal barriers that will prevent the easy trading of TGCs between domestic schemes in the EU, at least in the short/medium term until further harmonisation of such markets may be proposed by the Commission.

Such barriers to trade will result in a lack of liquidity, a lack of information and increased risk. The complexity of trading between different regulatory and legal regimes means that trading will be dominated by over-the-counter (OTC) and brokered trades, probably demanding the creation of bespoke terms of transfer. This will lead to significantly higher transaction costs than would be experienced in a liquid, cleared, 'blind' marketplace listing standard contracts for a limited number of standard commodities.

The absence of a single market for TGCs will also make price-finding and price comparison more difficult. There is a good case for the creation of a 'European TGC Gold Standard' certificate, which would comprise a 'basket' of the most universally acceptable TGCs in terms of criteria such as vintage, technology, resource, origin, etc. The existence of such a 'Gold Standard TGC' would mean that a market could be created in this 'basket' of certificate types with greater liquidity than any other single TGC product, and that a reference price against which other prices may be measured could be created.

10.4.2 Creating demand for TGCs

The way in which demand for TGCs is incentivised is critical to the success of TGC systems, and ultimately their public and political acceptability. In the fairly simplistic simulation provided by RECerT-sim we have seen the danger of driving demand with penalties that, in a short market, effectively act as a rigid price cap. The use of simple penalties for under-achievement of an obligation reduces demand elasticity since Consumers have no alternative but to buy the TGCs or pay the penalty.

With little elasticity of demand, and no fungibility between TGCs and other tradable instruments, TGC prices in RECerT-sim were rapidly driven up to the level of Consumers' penalty rates. This ought not to happen in a more 'natural market', in which demand and price are related. There may be ways to incentivise demand for TGCs that permit demand to react more 'naturally' to price changes and keep the market in equilibrium. In brief these could include:

- ***Defining compliance penalties in non-financial terms.*** Compliance with an obligation could be incentivised by non-financial penalties, for example by restricting or removing certain rights, privileges or flexibility enjoyed by electricity retailers by changing the terms of supply licences or other action by a government or energy regulator.
- ***Recycling of penalties.*** This approach is proposed for the TGC scheme shortly to be adopted in Great Britain. Penalty payments by electricity suppliers who fail to fully comply with the obligation are collected into a 'fund'. This fund is then re-distributed to all suppliers in proportion to their compliance.
- ***Sliding scale of penalties.*** It would be possible to reward higher compliance by obligated parties (we assume electricity suppliers), by applying a sliding scale of penalty to each.
- ***Banking and borrowing.*** One of the most effective ways to increase elasticity of demand is to permit obligated parties to bank and borrow certificates. Theory probably suggests that unlimited banking and borrowing has the most advantage for efficient operation of the market, but this is unrealistic not least from a political perspective.
- ***Fungibility with other instruments or targets.*** A highly effective way of increasing elasticity of demand is to permit companies to meet their obligations through means other than by buying TGCs. One possible approach could be to use carbon emissions reductions as the common currency for environmental improvement in the electricity sector, and setting an 'exchange rate' between TGCs and other means of reducing emissions.
- ***Use of taxation as a demand driver.*** The current Dutch green certificate regime uses exemption from an 'eco tax' levied on electricity sales (effectively a carbon tax), as a driver for demand for renewables. The tax is set at a level where the value of the exemption approximately equals the cost of providing renewable energy. Hence consumers may demand tax-exempt renewable electricity from their suppliers, and have this supplied at a cost that is the same as, or even slightly below, that of 'conventional' electricity.

10.4.3 Verification and product definition

Successful emissions markets (for example SO_2 in the US) attribute much of their success to the accurate and representative recording and reporting of the emissions from plants. In contrast, problems experienced in the early phases of the UK Packaging Waste Recovery Note (PRN) are largely due to inadequate verification and monitoring.

For TGC markets to work well it is essential that TGCs are accurately defined in terms of the property rights they confer on the holder, and that the 'quality' of the commodity is assured by rigorous verification and measurement. The Monitoring and Verification Protocol (MVP) must be accurate, reliable and trusted. A TGC market will perform much better if the commodity is uniform, and not diversified. This can be achieved if TGC demand drivers (obligations) are not differentiated in terms of technology or geographic region.

10.4.4 Liquidity

Liquidity is a critical issue in the establishment and success of any market. Participants must have confidence that sufficient liquidity exists to allow them operate within their risk parameters, and have reliable price-finding. One indicator of liquidity is the bid-offer spread. In immature, illiquid markets a wide bid-offer spread may occur due to the lack of participants, or because the majority of the players are on one side of the market.

A key contributor to liquidity is the action of traders - counterparties who are not physically involved (as an obligated party of creator of instruments) in the market, but who take a purely speculative position, aiming to buy and sell with the objective of making profit. The action of traders is encouraged by price volatility.

For a TGC market, it is therefore desirable to design the market mechanism such that a large number of players are involved, and to limit any disproportionate 'market power' that can be exerted by individual market players. It is also important to encourage as much volume of TGCs as possible to be traded, in other words to avoid conditions under which obligated parties may comply with an obligation purely by internal investment, requiring no interaction with the market. The action of traders is facilitated by clear terms of transfer and a low-transaction cost marketplace.

10.4.5 Derivatives

As commodity markets mature, derivatives naturally emerge. Derivatives relate to the underlying physical commodity, but permit market participants to manage risk by, for example, buying options to buy or options to sell at a future point in time. The emergence of derivatives in TGC markets will be an important indicator of increasing maturity, and will furthermore enable participants to manage risk, thereby increasing the ability of project developers to raise finance for projects operating under a TGC market environment.

However derivative markets cannot emerge without the existence of a mature, liquid spot market in the underlying commodity. It is essential that counterparties in a derivatives trade are able to take a clear view of forward spot prices, based on past history and knowledge of structural changes and trends in the market. Certain derivatives contracts are directly linked to a future spot market prices. The challenge for market actors, policy makers and regulators at this point in time is encourage the creation of a liquid spot EU market in TGCs, so that a derivatives market may naturally emerge.

10.5 THE WAY FORWARD FOR TGCS IN EUROPE

It has become clear during the course of the RECerT project that there is a need to promote the debate on the EU-wide integration of renewables support. This debate has so far been held principally in the context of the EU Directive on renewables, finally adopted in September 2001. Whilst the evident environmental and other benefits of renewable energy promotion are accepted, it seems that Member States are unwilling to embrace the principles of the single market in this area, at least in the short term.

At the end of the RECerT project, we observe the rather uncertain development of a number of renewable tradable certificate schemes among some EU Member States, in which the detailed policy and mechanism design tends to divide them more than it unifies them. In the main, Member States have found themselves in a relatively exposed position through their adoption of tradable certificate schemes, requiring them to put barriers in place to prevent certificates being exported or imported. Thus the benefits of EU-wide trading are lost, at least in the short term, and the enormous mobilisation of capital and change in attitude necessary to achieve the EU's indicative renewables growth target appears more difficult.

One development standing against this trend is the RECS (Renewable Energy Certificate System) project. This industry-led, independent initiative (see www.recs.org) has succeeded in developing a practical and robust system to permit certificates to be created, traded and consumed. However the test phase of the project depends on the existence of voluntary green consumers to redeem the certificates to, and this market has very limited size and uncertain growth prospects in any EU country. Ironically, the prospects for voluntary green markets are actually damaged by the existence of obligation schemes.

Over the next few years the challenge for EU-level and national policymakers is to harness the commercial forces in the electricity sector and to permit differences in certificate value between different schemes to drive trading between jurisdictions. This should lead naturally to the negotiation of reciprocity arrangements between Member States, finally leading to something close to a unified approach to certificate trading in the EU.

As TGC schemes continue to be developed in Europe, it is more important than ever to review world-wide experience in this area and incorporate this into scheme design.

Annex 1 Consolidated list of outputs from the project

Many of the documents listed below are available from the project website, http://recert.energyprojects .net. This site will be maintained until the end of 2002.

Planned reports

Deliverable number	Deliverable title	Delivery date (month)	Dissemination level*	Available from
1	Kick-off meeting minutes (Task 1.1)	2	CO	
22	Six month report	6	CO	
3	15 country reviews (Task 1.2)	6	PU	http://recert.energyprojects.net
5	REC market report for contact break-point decision (Task 1.4)	6	CO	
6	Country review synthesis report (Task 1.2)	6	PU	http://recert.energyprojects.net
11	1st round country workshops consolidated report (Task 4.4)	6	PU	http://recert.energyprojects.net
24	TGC Economic simulation report (Task 2.4)	6	PU	http://recert.energyprojects.net
23	Twelve month report (mid-term report)	12	CO	
25	Draft RECerT-sim design document (Task 5.1)	12	CO	
8	International conference proceedings (Task 1.6)	12	PU	http://recert.energyprojects.net
14	2nd round country workshops consolidated report (Task 5.4)	18	PU	http://recert.energyprojects.net
15	Simulated web-based trading report (Task 5.8)	18	PU	http://recert.energyprojects.net
17	Final workshop presentations (Task 6.4)	18	PU	http://recert.energyprojects.net
4	Non-REC related developments report (Task 5.9)	18	CO	
10	Cost-benefit analysis report (WP3)	18	PU	http://recert.energyprojects.net
18	Draft final project report	18	CO	
19	Draft final publishable report	18	CO	
26	Updated country review synthesis report (Task 1.2)	18	PU	http://recert.energyprojects.net
20	Final project report	20	CO	
21	Final publishable report	20	PU	http://recert.energyprojects.net

* **(CO = confidential, PU = public)**

Periodic reports

Deliverable Number	Report	Status (restricted or public)	Available from
1	Kick-off meeting minutes	Restricted	
22	First six month report.	Restricted	
23	Second six-month report	Restricted	
18	Draft final project report	Restricted	
20	Final project report	Public	http://recert.energyprojects.net
19	Draft publishable final report	Incorporated into final project report	
21	Publishable final report	Incorporated into final project report	

Presentations at the first round of RECerT country workshops, Summer 2000

These presentations were aimed at audiences of key stakeholders within national energy sectors. Discussions varied according to the context in each country. However, presentations and discussions typically focused on:

- Introducing and debating the concept of Green certificate trading, both at a national level and regarding potential international trading.
- The progress towards national TGC systems and Community-wide trading
- The potential size and value of a Community-wide green certificate market
- The activities of the Renewable Energy Certificate Trading System (RECS) group
- Introducing the RECerT internet-based TGC trading simulation - 'RECerT-sim'

Most presentations are available to be downloaded from http://recert.energyprojects.net

Presentations at the international TGCs conference, 12 October 2000, Brussels

Presentation	Author	Available from
Keynote address: The Renewable Energy Directive - the provision for green certificate trade, and a view to the future -.	*Mr Lars Nielsen, Directorate for New Energies and Demand Management, DGTREN, European Commission*	http://recert.energyprojects.net
The RECS Group - objectives, growth and success to date	*Mr Peter Niermeijer, RECS Group Chairman, EnergieNed, Netherlands*	http://recert.energyprojects.net
The interaction of Tradable Green Certificates with European policy instruments, and the work of the Green Electricity Cluster	*Mr Reinhard Haas, Technical University of Vienna, Austria*	http://recert.energyprojects.net
A summary of global developments in TGC markets	*Dr Gerrit Jan Schaeffer, Green Certificate Specialist, ECN Policy Studies, Netherlands*	http://recert.energyprojects.net
A summary of key TGC market developments in Member States	*Ann Goossens, Electrabel, Belgium*	http://recert.energyprojects.net
The market imperative - Eurelectric's view of the need for TGCs	*Mr Inge Pierre, Eurelectric (coordinator of Eurelectric's position paper on tradable green certificates)*	http://recert.energyprojects.net
A utility's perspective	*Dr Helmuth Groscurth, HEW, Germany*	http://recert.energyprojects.net
A major energy user's and green producer's perspective	*Kurt Lekås, SCA HQ, Belgium*	http://recert.energyprojects.net
Are tradable certificates the right way to promote renewable energy in the EU?	*Dr Stefan Singer, Head of European Climate and Energy Policy Unit, WWF, Brussels*	http://recert.energyprojects.net
The future size and value of a European-wide market in TGCs - results of research work carried out under the RECerT and REBUS projects	*Isabel Kühn, Centre for European Economic Research (ZEW GmbH), Germany*	http://recert.energyprojects.net
Linkages between TGCs and carbon trading - provisional results of research carried out under the InTraCert project	*Dr. Lise Nielsen, Senior Scientist, Risø National Laboratory, Denmark*	http://recert.energyprojects.net
The RECS trial trade - aims, objectives, timetable and opportunities to get involved	*Peter Niermeijer, EnergieNed, Netherlands*	http://recert.energyprojects.net
The RECerT international internet trading simulation - objectives, timetable and opportunities to get involved	*Tim Crozier-Cole, ESD UK, and Angus Macpherson, OM Environmental Exchange, UK*	http://recert.energyprojects.net

Presentations at the second round of in-country workshops, February / March 2001

The second round of country workshops focused on preparation for running RECerT-sim. A common set of presentations was used in these workshops:

Presentation	Available from
European TGC developments and the RECerT project - an update	http://recert.energyprojects.net
RECerT-sim - a general description	http://recert.energyprojects.net
RECerT-sim - roles and objectives	http://recert.energyprojects.net
Timetable	http://recert.energyprojects.net
Market place screen shots	http://recert.energyprojects.net
Summary and next steps	http://recert.energyprojects.net

Presentations and documents specifically relating to RECerT-sim

Presentation / paper	Status (public / restricted)	Available from
RECerT-sim at a glance	*Public*	http://recert.energyprojects.net
RECerT-sim full introduction	*Public*	http://recert.energyprojects.net
RECerT-sim Trading Site	*Public*	http://recert.energyprojects.net
Participants	*Public*	http://recert.energyprojects.net
European TGC developments and the RECerT project - an update	*Public*	http://recert.energyprojects.net
RECerT-sim - a general description	*Public*	http://recert.energyprojects.net
RECerT-sim - roles and objectives	*Public*	http://recert.energyprojects.net
Timetable	*Public*	http://recert.energyprojects.net
Market place screen shots	*Public*	http://recert.energyprojects.net
RECerT-sim design document	*Restricted*	
RECerT-sim rulebook	*Restricted*	
RECerT-sim information bulletins, numbers 1 - 15	*Restricted*	

Journal articles and conference presentations - general

Output title	Author/responsibility	Date created/ published	Status*	Available from/notes
Journal article: Europe's changing power market: what future for renewables?	Christopher Crookall-Fallon (ESD)		P	Journal: Wind Directions, 1999
Journal article: Printing a new currency for European renewable energy - Tradable Green Certificates	Christopher Crookall-Fallon (ESD)	February 2000	P	Journal: Sustainable Energy Developments
Journal article: A new currency for trading the environmental benefits of renewable energy	Christopher Crookall-Fallon and Tim Crozier-Cole (ESD)	May 2000	P	Journal: Renewable Energy World
Conference presentation: Tradable Green Certificates (TGCs) for renewable electricity - European and UK perspectives	Christopher Crookall-Fallon (ESD)	September 2000	R	Conference: Electricity trading beyond NETA, London
Journal article: The UK ETS – a new market for renewable energy? -,	Cathy Hough and Tim Crozier-Cole (ESD)	October 2000	P	Power House (journal of the UK Parliamentary Renewable and Sustainable energy Group
Journal article: Europe plans trading in 'greenness'	Christopher Crookall-Fallon and Tim Crozier-Cole (ESD)	October 2000	P	Environmental Finance, http://environmental-finance.webserver.org/index.htm
Conference presentation: Renewables under Kyoto - new opportunities, new uncertainties	Chris Crookall-Fallon and Fanny Calder (ESD)	October 2000	R	Conference: Commercial Opportunities in the Generation of Power from Renewables - the Renewable 2000 Summit, London
Conference presentation: Tradable Green Certificates (TGCs) for renewable electricity - European and UK perspectives	Christopher Crookall-Fallon (ESD)	October 2000	R	Conference: Fifth annual UK Electricity Association conference on energy and environment, Edinburgh, UK
Conference presentation: European green certificate trading – opportunity or threat?	Christopher Crookall-Fallon (ESD)	November 2000	P	Conference: (UK) Confederation of Renewable Energy Associations; 'Renewable Energy Obligation', London, see http://www.britishwindenergy.co.uk/crea/sem/6-cf.pdf
Conference presentation: European trade in 'Tradable Green Certificates' and the results of the RECerT-sim project	Christopher Crookall-Fallon (ESD)	June 2001	R	Conference: 'Successfully Developing Commercially Viable Renewable Energy Projects', IIR Renewable Energy Conference, London
Journal article: Europeans test green certificate trading	Chris Crookall-Fallon and Tim Crozier-Cole	July-August 2001	P	Environmental Finance, http://environmental-finance.webserver.org/index.htm
Conference presentation: Exploring the development and use of Renewable Energy Certificates and how they may interact with Emissions Trading	Christopher Crookall-Fallon (ESD)	October 2001	R	Presentation at the conference: 'Practical Strategies to Prepare your Business for the Introduction of Emissions Trading', IIR, London, 23/24
Conference presentation: Lessons from Europe's first live green certificates trading simulation	Christopher Crookall-Fallon and Tim Crozier-Cole (ESD)	October 2001	R	Green Certificates Trading Seminar, part of the Carbon Finance 2001 Conference, Environmental Finance, London, see http://environmental-finance.webserver.org/index.htm

- P = public, R = restricted.

OPET NETWORK:
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NOTICE TO THE READER
A great deal of information on the European Union is available on the Internet. It can be accessed through the Europa server (http://europa.eu.int).

The overall objective of the European Union's energy policy is to help ensure sustainable energy system for Europe's citizens and businesses, by supporting and promoting secure energy supplies of high service quality at competitive prices and in an environmentally compatible way. The European Commission's Directorate-General for Energy and Transport initiates, coordinates and manages energy policy actions at transnational level in the fields of solid fuels, oil and gas, electricity, nuclear energy, renewable energy sources and the efficient use of energy. The most important actions concern maintaining and enhancing security of energy supply and international cooperation, strengthening the integrity of energy markets and promoting sustainable development in the energy field.

A central policy instrument is its support and promotion of energy research, technological development and demonstration, principally through the Energie sub-programme (jointly managed with the Directorate-General for Research) within the theme 'Energy, environment and sustainable development' under the European Union's fifth framework programme for RTD. This contributes to sustainable development by focusing on key activities crucial for social well-being and economic competitiveness in Europe.

Other programmes managed by the Directorate-General for Energy and Transport, such as SAVE, Altener and Synergy, focus on accelerating the market uptake of cleaner and more efficient energy systems through legal, administrative, promotional and structural change measures on a trans-regional basis. As part of the wider energy framework programme, they logically complement and reinforce the impacts of Energie.

The Internet web site address for the fifth framework programme is:
http://www.cordis.lu/fp5/home.html

Further information on Energy and Transport DG activities is available at the Internet web site address:
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