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A RENEWABLE MANDATORY MARKET SHARE FOR CHINA

Lessons from the Dutch Experience

The Dutch Expert Group on Tradable Green Certificates

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Acknowledgement/Preface

This report is the final output of a collaborative effort of a group of Dutch expert institutes on the topic of green certificate trading. This group includes the following experts and their institutes:

- Peter Niermeijer from EnergieNed, the Association of the Dutch electricity sector, which was responsible for starting the first green certificate trading scheme in the world and took a leading role in setting up the European Renewable Energy Certificate System (RECS). During this project he acted as a general advisor and reviewer of the different Chapters.
- Walter Ruijgrok, Hans Cleijne and Mariëlle Vosbeek from the independent research institute KEMA, which developed and managed the administrative software of this system; Authors of Chapter 2.
- Jos Benner and Norbert Vasen from the consultant CEA, which acts as the secretariat of the RECS; Authors of Chapter 1.
- Kees Kwant and Li Hua from the Netherlands organisation for energy and environment (Novem), which acts as an agency for energy and environmental programs of the Dutch government; Novem specific responsibility in this project was the organisation of a study tour for Chinese policy makers.
- Gerrit Jan Schaeffer and Monique Voogt from ECN, the national Dutch energy research centre with specific expertise in studying, analysing and designing green certificate systems in Europe and around the world. Gerrit Jan Schaeffer is the author of Chapter 3 and the editor of the report. Monique Voogt is the author of Chapter 4.

The papers that appear as Chapters in this report have been written in the framework of a contract (No. 7111690) with the World Bank. The aim of the work under this contract was to contribute to the understanding in China of green certificate trading systems as an important element in a possible Mandatory Market Share policy to support renewables. The report is registered under ECN project number 77321.

The Chapters are written in full responsibility for the authors, including any flaws or inaccuracies.

Abstract

This report, financed by the World Bank, has been written to share the European and especially Dutch experience with tradable green certificate systems and Renewable Portfolio Standards with Chinese policy makers and policy advisors. It briefly explains the working of the European industry-led initiative Renewable Energy Certificate System (RECS). It draws lessons from the first RPS-system world-wide that has been operational, the Dutch Green Label system. It describes the organisational and administrative requirements of well-functioning software registry system, illuminated by examples from the Dutch Green Label system software 'Labelaar'. Finally it describes the working of REBUS-China, a spreadsheet model tool that can help to determine differentiated targets for the different provinces in China on the basis of a common national target and a variety of burden sharing rules.

The main conclusion of the report is that enough experience is available for the Peoples Republic of China with regard to the procedural and operational aspects of an RPS system to be able to start considering the introduction of an RPS in the PRC. The documents contained in this report could help to better understand and design such a policy.

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INTRODUCTION

Since early 2000 Chinese policy makers have been considering the possible introduction of a Renewable Portfolio Standard as one of the policy options to stimulate electricity generation from renewable energy sources in the Peoples Republic of China. When the concept was first introduced many questions emerged: How does an RPS exactly work? What are the advantages with regard to other policies? How simple or complex is it to introduce such a system? What are the operational costs? How do you set a target obligation? How do you divide an obligation equally over such a huge country as China with such different levels of wealth?

These questions led to the desire to look at experiences with RPS abroad. Experiences in RPS-designing were available from Europe as well as the US. Experience with the working of an RPS in practice was scarce. Only in the Netherlands for a short time of three years (1998-2000) an RPS was in operation. To exchange information on these experiences several international workshops were being organised in Beijing. Apart from that a World Bank financed project, led by ECN, delivered a set of papers and articles on the European and Dutch experiences. This report summarises these findings.

The first Chapter deals with the European 'RECS-system'. RECS stands for Renewable Energy Certificate System. It has started as an industry-led initiative and has culminated in a network of industry, governments and other stakeholders, which provides a platform for discussion on all issues related to tradable green certificate systems. In 2001 a test trading phase has started as a common learning experience. The Chapter deals with the description of the basic idea and some concrete issues with regard to green certificate trading, which can be considered as an intermediate outcome of this process. The most important temporary outcome, the so-called Basic Commitments, have been added to this report as Annex A.

Chapter 2 contains a description of the Dutch Green Label system, the first renewable portfolio standard that has been operational world-wide. The main conclusion of this Chapter is that the Dutch experience shows that the principle of green certificate trading can be put in practice, but that at the same time some important improvements must be made. One of the main items is to design the demand side of the system (the obligation) in such a way that long-term security for investors is maintained. Other issues concern the need for good additional policies, e.g. in the area of planning permit procedures, the need for certain flexibility in compliance to the obligation and the need for a transparent green certificate trading place.

An important operational aspect is highlighted in Chapter 3: the issuing and registration software. The principals and organisational requirements (which are comparable to the organisational structure requirements as put forward in Chapter 1) are described and illuminated with the Dutch example of the 'Labelaar'-software. A description of a training program to learn about the organisation and administrative software of green certificate systems is added to this report as Annex B.3.

An important policy issue of RPS system is dealt with in Chapter 4: how to distribute a national target over the different provinces of China, given the differences in size, geography, population and economic wealth of these provinces. This is of course a political question and will be the outcome of a political process. What is presented in this Chapter is a tool that could be of help to policy makers to determine adequate targets: the REBUS (Renewable Energy Burden Sharing) approach. In brief this approach tries to identify adequate targets by first constructing realistic cost-potential curves for renewable electricity production in each province, and then to apply a burden-sharing rule (e.g. 'equal cost per capita' or 'equal cost per yuan GDP'). This approach has been worked out in the REBUS-China model. Part of the project was to give a training in using this model to a Chinese policy advisor. The evaluation of the training can be found in Annex C. It should be noted that the model gives only adequate results if the inputs are sufficiently valid. Especially with regard to cost-potential curves for every province that is quite a challenge, which still has to be met.

The main conclusion of the report is that enough experience is available for the Peoples Republic of China with regard to the procedural and operational aspects of an RPS system to be able to start considering the introduction of an RPS in the PRC. The documents contained in this report could help to better understand and design such a policy.

1. THE RENEWABLE ENERGY CERTIFICATE SYSTEM (RECS)

1.1 Introduction

Background

Renewable energy attracts increasing interest all over the world, since it contributes to a sustainable solution of environmental problems, to security of energy supply and to economic strength. These credits add extra value to renewable energy.

Over the world, different types of Green Certificates have been introduced, which represent the credits of renewable energy generation. These certificates cover the 'green part' only. Hence, the environmental and other benefits have been separated from the physical energy.

The availability of certificates helps to monitor renewable energy development and creates a basis for trade. Monitoring renewable energy progress usually is complex, because of the distributed character of the generators. Crediting the environmental value of renewable energy makes generators register their production themselves.

Green certificates guarantee the renewable character of the generators, since only eligible production will be certified. They also prevent double counting or double selling, since each production volume will be certified only once.

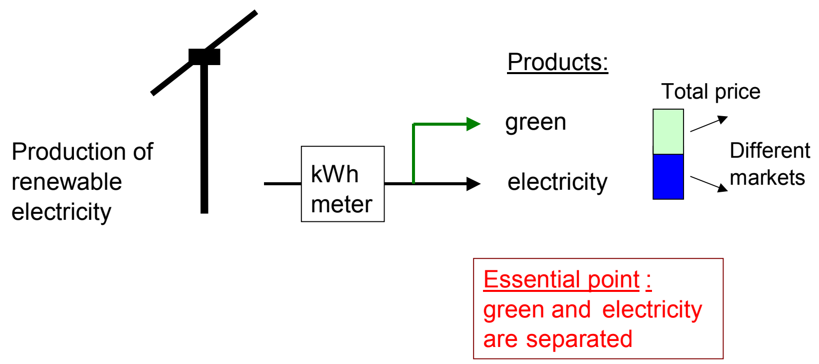

Figure 1.1 *Separate 'markets' for the certificates and the physical energy*

Green Certificates are a management tool for renewable energy in the same way as money is a means to manage economy. They allow individuals to materialise 'production' and to use it as a credit at a later time/ another place. Since the certificates are transferable, the environmental benefit is 'liquid' and not statically bound to the renewable energy source or to its owner.

Green Certificates are not an alternative to any mechanism to promote renewables, but a tool, facilitating <u>many</u> RE promotion mechanisms to be successful.

With respect to monitoring, money allows central banks and governments to monitor economies. Similarly, green certificates supply information about the renewable energy economy (generators, the owners of the credits, the quantity of energy produced etc.).

In The Netherlands a green certificate system has been tried out by the electricity sector in the period 1998-2000. In the mean time the practical Dutch system experience is incorporated in a European-wide development process (RECS), which will be described in this report.

Essential conditions for a green certificate system
Experience gathered so far in The Netherlands and at European level clearly shows that a green certificate system can only be successful when at least the following three conditions are met:

- availability of a robust organisation and software system (to issue, monitor and redeem certificates),
- actual need and demand in the energy market for the presented type of green certificates,
- general acceptance of the system by market actors, governments and interest groups.

The impact of these conditions on the final system is visualised in the following figure:

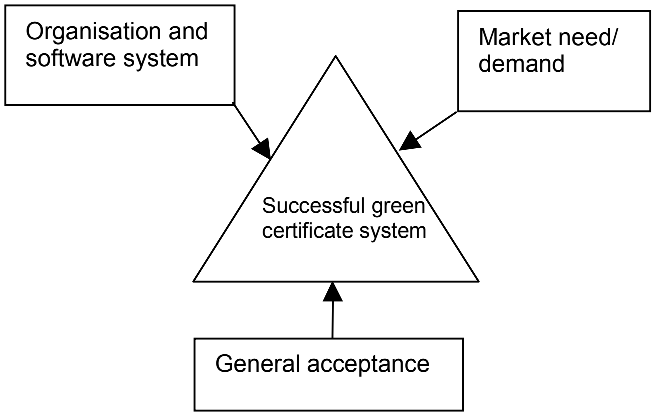

Figure 1.2 *Conditions for a successful green certificate system*

The market demand topic and the public acceptance topic have a strong local character. However, the organisation and software system needed for a successful green certificate system will be more or less the same everywhere. Therefore, this report concentrates on the description of the RECS system, in particular the issuing/ monitoring part of it.

RECS in brief
To offer a rough overview, the central points of the RECS will be explained here. The Sections 2.2 and 2.3 will elaborate on details.

The Dutch Green certificate system that was operational between 1998 and 2000 induced much interest in Green Certificate systems in Europe. Therefore, a small group of European energy company representatives, early 1999, took the initiative to promote *international* trade. The pioneers believed that international harmonisation of certificate trade could be achieved, and would deliver greater benefits than a series of disconnected national initiatives. The 'Renewable Energy Certificate System' (RECS) was born.

The RECS initiative started in The Netherlands, Denmark and the United Kingdom. Meanwhile almost 70 participants from Belgium, Germany, Italy, France, Austria, Norway, Sweden, Ireland, Finland, Greece and several international organisations join the process. Other countries are showing interest, even from outside Europe. The RECS Group includes major electricity companies, government departments, industrial bodies and related specialists. Membership of the RECS Group is, in fact, open to all interested organisations and individuals. Activities are co-ordinated by a Presidium of RECS Group members, assisted by a central secretariat (CEA) and a webmaster (Campbell-Carr).

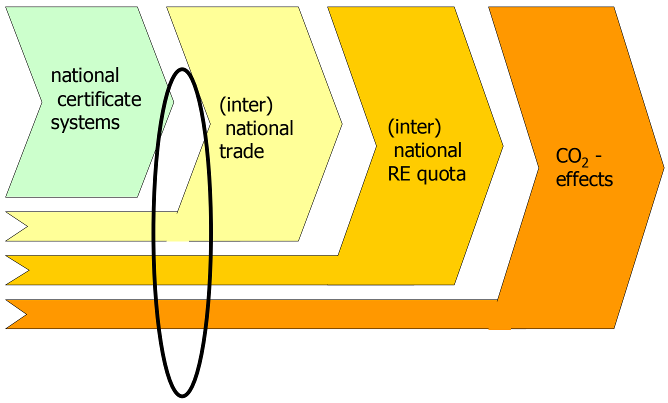

Figure 1.3 *The main perspective of RECS in the wider policy context*

Figure 1.3 situates RECS in the context of national and international environmental initiatives. Current activities are focused on the functional test of the international green certificate system, according to the organisational description in the following Chapters. The Test phase started in January 2001 in 6 countries. All related structures and documents are functional and available.

Harmonisation of different systems

The RECS discussions on the different national developments soon showed a lot of similarities, but also many structural differences between countries. A basic set of rules (the Basic Commitment) was designed, which, if these rules are integrated in the national/regional systems, will allow international certificate exchange.

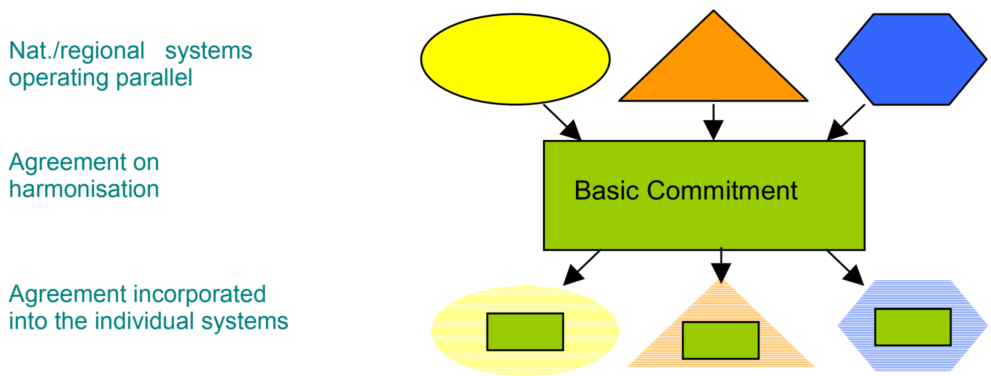

Figure 1.4 *Harmonisation of the national/regional certificate systems*

Around the set of basic rules (Basic Commitment) each country can create its own additional system, adapted to the national situation. The additional rules will not interfere with the Basic Commitment, or with the international compatibility. As an example: in the UK all renewable energy production will be sampled each 5 minutes, to register peak hour production. However, for the issuing of certificates one meter reading per month will do, since only production results count. Therefore, other countries do not join the UK example. This difference does not interfere with the final amount or kind of certificates that will be released to a generator.

International harmonisation

On the basis of the principles mentioned above it is possible to design certificate systems in very different ways. It is not possible to guarantee an internationally exchangeable certificate yet. Only if a minimum set of rules is included in all systems international harmonisation will be realised. The RECS Basic Commitment (BC) intends to offer a set-up for the required minimum set of rules. The BC also determines the checks/audits that are needed to verify that a given quantity of green energy has really been generated.

To guarantee and co-ordinate this uniform quality of the national systems and the certificates, an international association has been set up: the Association of Issuing Bodies (AIB). This association has the task of defining the BC and, where necessary, change it as required. IB's (in all countries/regions) that subscribe the RECS Basic Commitments are entitled to become member of the AIB and thus to influence the process.

The RECS Basic Commitment (BC)
The BC is the minimum set of rules and constraints for national (or regional) green certificate systems to be compliant to RECS. Additional rules can be added, depending on the local situation, to complete the national/regional Protocol.

The BC contains following elements:
definitions on objects, roles and events,
description of certificate issuing/ registration process,
description of the transfer of ownership and redemption of certificates,
description of the database for the registration of certificates,
description of the verification, auditing and reporting processes,
the information that is included in each certificate.

The latest version of the RECS Basic Commitment is available at the RECS website www.RECS.org. The first official release of the BC is added as Annex A to this report.

1.2 The RECS certificate system, process details

In this Chapter the life cycle of green certificates will be described on the basis of a process scheme. In Section 2.3, the key roles will be presented. Section 2.4 will elaborate on the costs and benefits.

Similarity in topics to tackle
A large number of similar questions arise in all countries that are developing certificate systems. These questions include:
- the definition of renewable energy,
- the information that has to be included in a certificate,
- the life span of a certificate,
- the best way to monitor generation of renewable energy and trade,
- the relation with CO_2 credits.

Just because these issues are so international, the processes/ systems initiated by RECS will here be described.

Principles of the certificate system
A certificate system must be transparent and must have clear rules. These rules will be laid down in a document, called the Protocol. The Protocol regulates a number of crucial issues related to the issuing and to the registration/monitoring of certificates. As indicated in Figure 1.3, RECS defined a minimum set of rules, the Basic Commitment, which should be integrated into each Protocol, to create a robust/ reliable system and to facilitate international exchange.

The transitions between several phases in the life cycle of a certificate need to be well understood. After all, a certificate is a virtual product denoted by a number. Copying of certificates is consequently easy. However, RECS yields a closed guarantee system in which double selling is excluded. Just like in a financial transaction an ‘amount’ is booked from an account A to account B. Without 'deleting' it from account A (to mention a simple mistake) that amount of money would double, which is naturally not acceptable. That is why certificates in a robust green certificate system will have determined phases in their life cycle. These process phases can best be explained with reference to Figure 1.5.

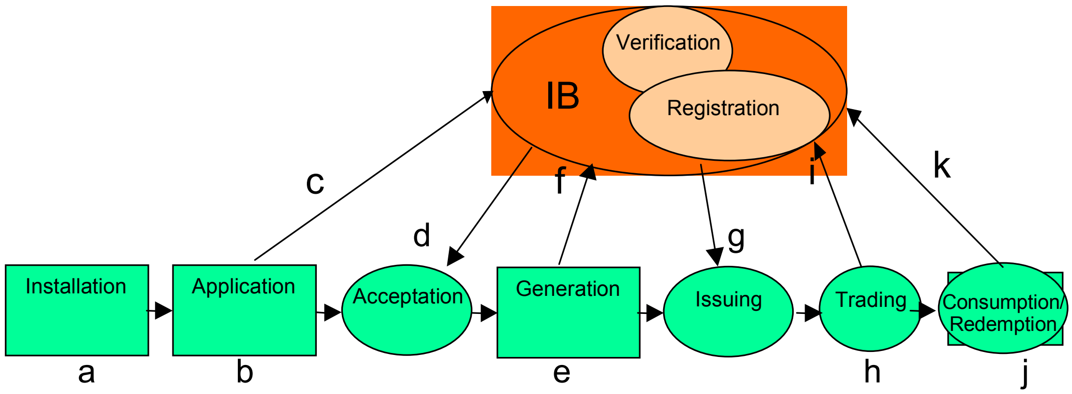

Figure 1.5 *Process phases in a certificate system*

Step a: Installation of devices for the production of green energy
The process starts when a generator produces electricity and when this production is metered. To be eligible for green certification the production unit will have to supply green energy, according to the definitions laid down in the Basic Commitments (BC) and in the local Protocol.

Step b: Applying for certificates
To become eligible the generator must take initiative and declare to the IB of its region or country the production unit to be renewable. The generator will have to take care, on its own expenses that the technical details of the installations are compliant to the BC, including the meters.

Step c: Initial verification of the Generator
The quality of the certificates is directly related to the verification of the whole process. As already mentioned the IB/CMO will verify the generator statements and the production units in a standardised way.

Step d: Acceptation of the generator
An independent Issuing Body (IB) will check the declaration statement and - if everything is correct - register the generator in the Central Registration Database (CRD). Another issue to verify is, how much state support (and of what kind) the Production Devices receive, which would (partly) exclude them from participation in RECS. The IB is now ready to start the issuing of green certificates for the production, on the basis of meter readings. Both the declarations and the meter readings will be checked, on behalf of the IB, by a Central Monitoring Office (CMO). The IB and the CMO will be elaborated on Chapter 3.

Step e: Generation
The generator can start to generate electrical energy for which, from now on, green certificates will be given.

Step f: Ongoing verification of the Generator
The meter reading on which the certificates are based can be accomplished by staff of the CMO or by personnel of local of energy companies (grid operators). In the latter case, random checks (by unannounced visits) will be carried-out by CMO-staff.

Also the compliance of the installation to the Basic Commitments will be verified in this random way.

Step g: Issuing and registration of the certificates
The certificates will be added to the generators' account by the CMO (which is in fact an executing office of the IB).

Each green certificate in the RECS system gets a unique number and is recorded in the Central Registration Database by the IB/CMO.

Step h: Trading of certificates
Once a certificate has been registered with the CMO, it can be sold against (varying) market prices. This can be interesting for several reasons for the market players and can influence in a positive way the development and implementation of renewable energy. However, these go beyond the scope of this document, which describes only the mechanisms of the certificate system.

Step i: Trading of certificates: verification and registration
New owners will also need an account with the CMO. Keeping the administration on transfer of certificates inside the CMO (IB) prevents error or fraud in the certificate flow. Only if the certificate trade grows beyond certain limits, the amount of work for the CMO can become a problem. In that case, the transfer can be administered by Production Aggregators. These are bank like institutions, registered and controlled by the CMO, at least for their activities with certificates.

Step j: Using the certificates (redeeming)
Certificates can also be 'redeemed'. This means that the certificates are withdrawn from the market as if they were destroyed. It can be compared to stamping a bus ticket. The IB/CMO affirms that the certificates have been 'redeemed' and release a declaration to the owner. With this declaration the owner can demonstrate that the certificates were redeemed for him/her and is thus entitled to the rights, which are related to consumption and which will differ per country (like fulfilling an obligation, tax refunds etc).

Step k: Redeeming the certificates: verification and registration
Within the RECS system this is done by the IB/CMO. The IB/CMO does not literally destroy the certificates (i.e. the unique numbers), but transfers them from the trading account to the redemption account so that the certificate can not be brought into circulation anymore. Verification can be accomplished by checking the certificate numbers during transactions (each or at random).

1.3 The RECS certificate system, role details

After outlining the events during the life cycle of certificates, in the previous Chapter, we will now examine the structure of a Renewable Energy Certificates System and the roles of the different organisations. Also the roles can best be explained with reference to an earlier presented diagram, see Figure 1.6.

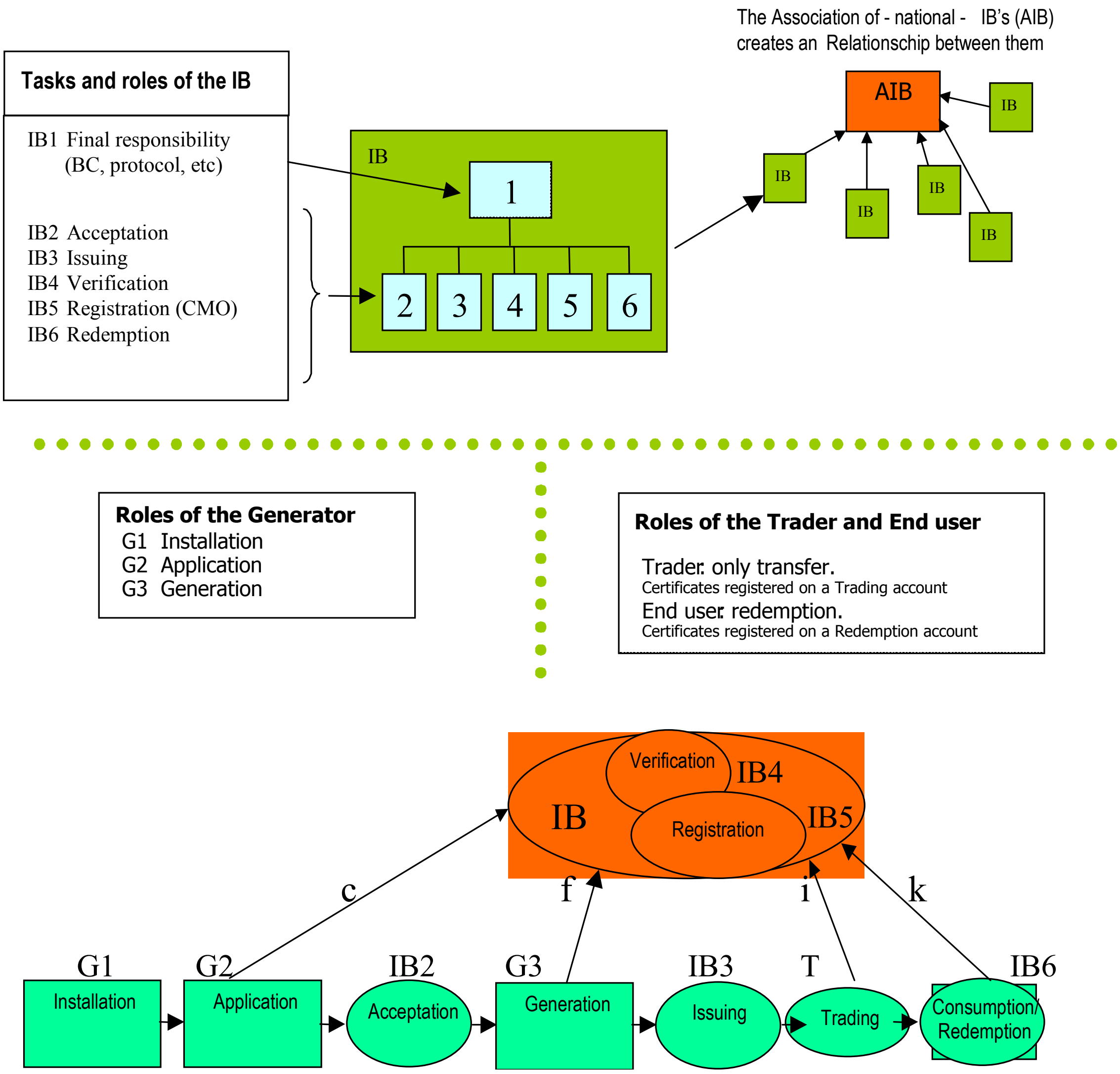

Figure 1.6 *Roles in a certificate system*

Role IB1; Formal Issuing body

The Issuing Body (IB) is an independent organisation that controls the whole process of the issuing, ownership transfer and redemption of green certificates within a service area (which will typically be a nation or region). The IB can be compared with a Central Bank, which manages the lifecycle of money inside a country and on its turn has to comply with supranational banking systems. In the RECS system the supranational level is formed by the Association of Issuing Bodies (AIB), which will be elaborated on later in this Chapter.

The IB consists of two main levels, as depicted in the text box & tree structure on the upper left side:

- The formal part of the IB (IB1), with the final responsibility for the rules, constitutional matters, contacts with the AIB etc.
- The executing part (IB2 - IB6), consisting of the various offices that fulfil the functions that were described in section 2. A central role (IB5) in this executing part takes the Central Monitoring Office (CMO), responsible for the Central Registration Database (CRD).

The IB is independent and will not take part in the market under any circumstances. The IB is the key organisation within the green certificate system, which highly determines the credibility and hence the effectiveness of the system. It is - among others - responsible for the following tasks:

- determination of the issuing (IB3), ownership transfer and redeeming procedures (IB6),
- licensing of Generators and Production Aggregators (PA’s),
- acceptation (IB2) and verification (IB4) of the players’ compliance with the rules, according to ISO-14000 standards,
- promotion of the public acceptance of the green certificate system (IB1).

The executing levels (2 - 6 in Figure 2.5) are part of the IB but can (as they carry out specific functions) be separate organisations. For example, the IB could be a Ministry and the CMO a national standardisation-institute. However, within the certificate system they represent one single body. So, they will have access to the same documents and databases.

The CMO and the verification department (IB4) must have a distributed presence on the territory. This will inevitably lead to a considerable workload and may ask for many local offices. The main idea, however, is that it acts as one single body, the IB. Regarding to data processing, this integration will work in the same way as with a bank, which has many offices but only one database.

Role AIB; Association of Issuing Bodies
This is the super-national body to which every organisation should adhere in order to be allowed to be an Issuing body of the Renewable Energy Certificates System. The basic international rules (Basic Commitment) are laid down by this Association of Issuing Bodies, national Issuing bodies can define additional rules in the National Protocol, as long as these don’t contradict the Basic Commitment.

The tasks of the AIB are:
- defining the Basic Commitment (BC),
- verifying the activities of the IB’s,
- increasing the influence and the application of the Certificates, for example as redemption for CO_2 obligations.

The IB’s and the AIB are responsible for the regular functioning of the green certificate systems. Green certificates represent a rather abstract ‘product’ and it is easy to loose the credibility of it. Thus, IB’s and the AIB are entitled to impose sanctions to actors inside the system, which don’t comply with the Basic Commitment or the (regional or national) Protocol. In this case they will initially give an admonition. If the actor doesn’t adequately respond to this, the IB will react with rather severe measures. The IB can exclude the actor from the system, transferring its tasks to other organisations. Furthermore, the IB can take legal steps for a claim of compensation, in case of damage. If an IB is not complying with the Basic Commitment, the AIB can take the same steps regarding this IB, as an IB does with other RECS actors.

Role G1-G3: Generator
Generators are the owners of the production units that generate renewable energy. The generators have to take initiative themselves to realise and finance the installations to produce energy, including the meters that will enable them to quantify the produced energy and thus the certificates they can obtain. They also have to take care for application. Therefore, they must send a Renewable Energy Declaration (RED) to the IB of there own region/country. In this RED the generator declares that its installation meets the renewable energy qualification and how much state financial support it receives. The former fact is important for classification of the produced energy and to control if it is genuinely renewable. The latter fact recognises the need to limit the certificate price of the certificates from renewable energy sources that did already get other financial support.

Production Aggregator (PA)
It is not sure whether these bank-like institutions are necessary in a system that hasn't a very significant volume of certificate transactions. If they are introduced, they will keep green certificate accounts for their customers (generators and other market parties). Therefore, the PA's must obey the Basic Commitments and the national Protocols.

When certificates change owner within one PA, a simple internal transfer operation suffices. If the new owner has an account with another PA in the same region/country, the competent IB is notified, by means of a form, signed by the PA manager and the new owner. If the new owner is outside the territory of the IB, then two IB's/CMO's will be involved. In this way, the flow can be adequately monitored with minimum involvement of the IB.

Role T: Traders and Exchanges
Traders own green certificate accounts and buy/sell certificates for commercial reasons. This can bring them profit as the value of certificates can change in time and place. To name some examples, if consumers or producers are obliged to show a certain amount of certificates at 31 December of some year and they don't have them, they will be eager to pay a higher price on the certificate market. Exchange centres may facilitate the trading process.

Role E: End users
End users of certificates are those actors, which will 'consume' the certificates, so that they can't be used anymore. This means that the certificates are withdrawn from the market as if they were destroyed. Within the RECS system this is done by the IB/Redemption department (block 6), the certificate is then 'used/consumed'. The IB/CMO does not destroy the certificates (i.e. the unique numbers), but *transfers* them from the normal trading account to a redemption account so that the certificate can not be brought into circulation anymore. It can be compared to stamping a bus ticket. The IB/CMO affirms that the certificates have been 'redeemed' and release a declaration to the owner. With this declaration the owner can demonstrate that the certificates were redeemed for him/her and is thus entitled to the rights, which are related to consumption and which will differ per country (like fulfilling an obligation, tax refunds etc).

1.4 Costs and benefits

Experience of the Dutch Green Label system
In The Netherlands EnergieNed made an estimate of the costs and the cost savings of the Dutch Green Label system. If every Energy distribution company should be forced to realise their target in their own service area, the total costs for the distribution sector would have been approximately 55 million Euro/year. As a consequence of the possibility of trade, induced by the Green Label system[1], this was only 33 million Euro/year. A yearly saving of 22 million Euro or 40 % was the result. The calculation was based on a rough estimate of the cost curves for renewable energy in the service area of each Distribution Company, compared to an estimate of the overall cost curve for The Netherlands.

With regard to the set-up and yearly running costs of the Green Label system, KEMA estimates figures of about 1 million Euro and 300.000 Euro, respectively. Under this cost regime the Dutch pioneer green certificate system succeeded in yielding a cost/benefit ratio of 1/70.

[1] For a description and evaluation of the Green Label system in The Netherlands see Chapter 2.

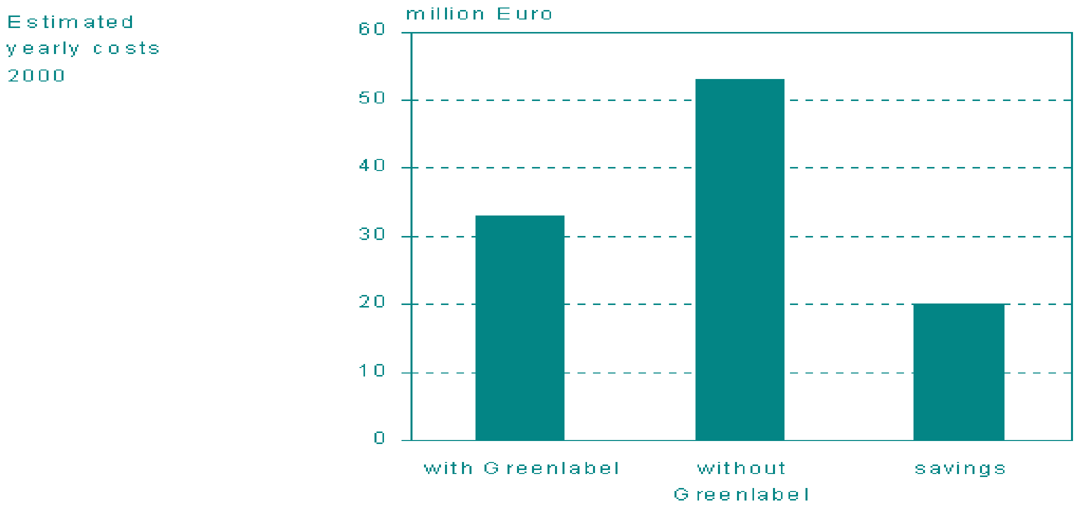

Figure 1.7 *Estimated cost savings of the Green Label System*

RECS Estimates
For the RECS Test phase a cost estimate overview is presented on the next page, together with a cost comparison to big volume (10 x), so that the influence of implementing the system on large scale can be seen.

The first column (reference) is an average cost estimate per country that participates in the test. The cost overview elaborates on both the initial costs and the yearly running costs for the Issuing Body and for the traders. It turns out that the average cost level per 'kWh', traded during the Test phase, will be about 0,2 Eurocent for the Issuing/monitoring activities and less than 0,1 Eurocent for the trade registration activities, based on an average certificate lifetime of 5 transactions. For the large scale (10x Test phase of RECS) these costs are 0,09 and 0,03 Eurocent, so about one half and one third of the costs for RECS.

All costs are based on costs in Europe. It must be emphasised that in China these costs may be different. Moreover, the beneficial effect of a large scale initiative on the employment should be taken into account. As seen in the table, a significant part of the increasing costs is for labour.

It should be noted that in Europe the national governments are expected to sponsor at least a part of the costs of the issuing/monitoring activities. This support is motivated by the fact that they want to place a guarantee system in the market anyhow and that they want to monitor renewable energy developments. Furthermore, the certificate structures will lead to experience that will facilitate management of their carbon credit agreements. Consequently the issuing/monitoring costs, or at least a substantial part of it, will not weigh on the users of the green certificate system.

For the RECS Test phase and a similar initiative on large scale, the following average costs per country are given:

Table 1.1 *Indicative system costs for green certificates*

	RECS [Euro]	10 times volume [Euro]
Initial establishment of the Issuing Body and its systems:		
Drawing-up of the national protocol (based on RECS draft)	10.000	10.000
Drawing-up of the statutes for the national IB (based on RECS draft)	5.000	5.000
Software development (issuing and monitoring; based on RECS draft)	40.000	40.000
General costs for the establishment	5.000	5.000
Unforeseen	10.000	10.000
Total initial costs Issuing Body:	*70.000*	*70.000*
Yearly running costs for the Issuing Body:		
Collecting monthly meter reading data for ca. 400 generators	40.000	400.000
Issuing of approx. 50.000 certificates	60.000	200.000
Checking of ca. 50 new Renewable Energy Declarations	10.000	50.000
Random checks	7.000	70.000
Monitoring of ca. 2000 trade transactions (ca. 50 certif./transaction)	20.000	80.000
Redeeming of ‘consumed’ certificates	7.000	30.000
Updating of the protocol	10.000	10.000
Management/ reporting	15.000	30.000
Total yearly running costs Issuing Body:	*169.000*	*870.000*
Yearly running costs Traders:		
Processing of 2000 trade transactions	20.000	80.000
Reporting to the IB	20.000	80.000
Updating of the systems	30.000	90.000
Total yearly running costs Traders:	*70.000*	*270.000*

Since each certificate in the RECS Test phase represents 1000 kWh, the amounts in the first column concern the issuing of green certificates for 50 mln. kWh renewable electricity per year per country and a yearly trading volume of 100 mln. kWh per country.

The running costs increase for some of the items in the second column ten times, other costs increase much less. This depends on the amount of ‘pure’ labour that is included in the item. This will increase in a linear way, while other activities will increase much less, because of a big share of system costs.

1.5 Conclusions

Crediting the environmental value of renewable energy generation (by means of green certificates) strongly motivates generators to register their production. This registration simplifies the monitoring of renewable energy developments and creates a solid basis for trade. A robust green certificate system will guarantee the renewable character of the generators, since only eligible production will be certified. It also will prevent double counting or double selling, since each production volume will be certified only once.

Experience gathered so far in The Netherlands and at European level (RECS) clearly shows that a green certificate system can only work properly when three conditions are met:

- availability of a robust organisation and software system (to issue, monitor and redeem certificates),
- actual need and demand in the energy market for the presented type of green certificates,
- general acceptance of the system by market actors, governments and interest groups.

The market demand topic and the public acceptance topic have a strong local character. However, the organisation and software system needed for a successful green certificate system will be more or less the same everywhere. Therefore, this report concentrated on the description of the RECS system, in particular the issuing/ monitoring part of it.

Within RECS a minimum set of rules (the Basic Commitment) has been drawn-up. Application of these rules is considered to be vital for a robust/reliable certificate system. As soon as these rules will have been integrated in the different national/regional systems, international certificate exchange will be possible. Around the Basic Commitment each country has freedom to create its own additional system, adapted to the local situation.

The description of all RECS process steps and all RECS roles, which is included in the Section 2.2 and 2.3 of the report, offer a useful backbone for everybody thinking about the start of a similar system. The cost estimate / cost experiences included in the report makes clear that the total costs of the green certificate system are marginal compared to the benefits. The experience of the Dutch green label system and of the RECS Test phase is that the costs amount 0,2 - 0,3 Eurocent per kWh. For large volume (ten times RECS), the fixed and running costs are about half these costs.

2. EXPERIENCES IN THE NETHERLANDS: THE DUTCH GREEN LABEL SYSTEM

2.1 Background

Between 1998 and 2000 a green certificate system was operational in the Netherlands. This green certificate system was called the 'Green Label System'. The organisational environment (structure of the electricity sector) of the Green Label system is based on the Electricity Law of 1989. The new Electricity Law of 1998 is bringing fundamental changes to the electricity industry structure and the Green Label System has been replaced by a different green certificate system in 2001. However, since the experience with the Green Label system has taken place in the pre-1998 Law situation the emphasis in this text will be on the structure of the Netherlands electricity sector during the 1990s as based on the 1989 Law. This is also more relevant for the situation in China, because the pre-1998 Law situation is far more similar to the situation in China than the post-1998 Law situation.

This Chapter has been written during the time the Green Label system was still operational. This means final evaluations are not being presented in this Chapter.

2.1.1 The structure of the Netherlands electricity sector during the 1990s

Size of the Dutch Power Sector

Total electricity consumption in 1999 was over 95 TWh. About 75 TWh was delivered via the public grid, the remainder was generated by industrial auto-generators in Combined Heat and Power (CHP) plants. Total public generation capacity is about 14 000 MW, whereas another 5000 MW of decentral CHP plants are installed. Almost 20% of the electricity consumption is being imported, mainly from Germany, but also from France and other countries. 2% of the electricity consumption comes from waste incineration plants, 1% from renewables.

Historical background

Historically local authorities (municipalities and provinces) owned the utilities in the Netherlands. There were substantial size differences between the utilities. The large utilities were vertically integrated, being a producer as well as distributor of electricity. Over the years several utilities started to co-operate on the production side and in the late 1980's some 15 vertically integrated electricity utilities existed. These companies were owned either by the local authorities of the larger cities or by the regional authorities of the provinces. They delivered electricity either directly to the end users or to local Distribution Companies that were owned by the local authorities of the smaller municipalities. In the late 1980's there were about 70 of these local Distribution Companies, which were often, but not always, horizontally integrated companies, delivering electricity as well as gas and water to the end users.

The 15 utilities that produced electricity collaborated on the national level in the form of the Dutch Electricity Generation Board (*Sep*). Sep, which was a daughter company of the Production Companies, was responsible for the national transmission grid and co-ordinated the planning for the construction of new power plants. Every two years Sep published a report containing a 20-year electricity demand forecast and a 10-year power plant construction plan, which had to be approved by the national government.

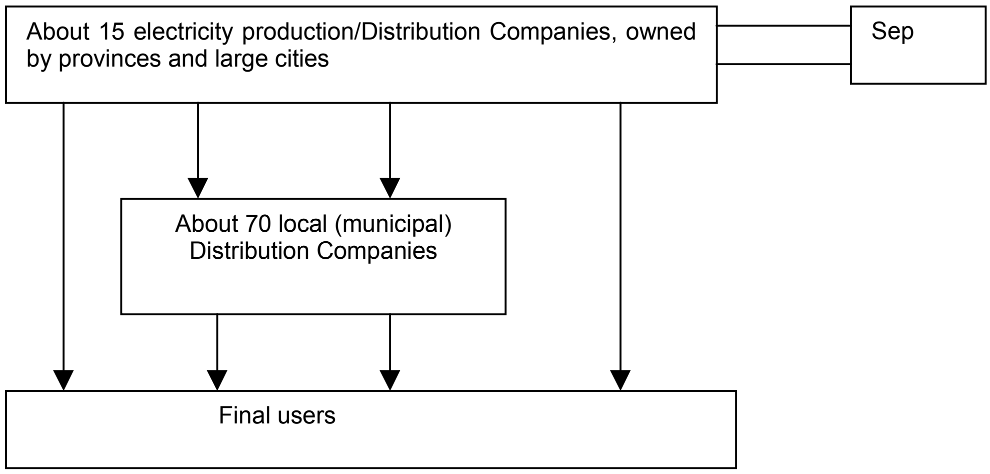

Figure 2.1 *Structure of Dutch electricity sector before 1989*

In the late 1980's several developments, such as a continuing number of mergers between the utilities and discussions on the conditions for and the degree to which outsiders could get access to the grid, lead to the restructuration of the electricity sector by the Electricity Law of 1989. The situation during the 1990s was based on this Law.

The 1989 Electricity Law

The most important aspects of the 1989 Law were:

- The separation between Distribution Companies and Production Companies in the electricity sector.
- The obligation for the Distribution Companies to accept electricity from Independent Power Producers (IPPs) (mostly at industrial sites) for a tariff based on the Distribution Company's avoided costs.
- The introduction of a tariff structure that allowed but tried to minimise price differences between the Production Companies and between the Distribution Companies.
- The possibility of horizontal shopping, i.e. the freedom of large end users to choose for another than their regional Distribution Company to purchase their electricity from, as well as the freedom of Distribution Companies to purchase their electricity from other Production Companies than their regional Production Company.
- The allowance to Distribution Companies to produce electricity by renewables and small scale Combined Heat and Power (CHP) plants. The law stated that Distribution Companies could bring into operation plants below 25 MW without consulting the Production Companies and plants up to 100 MW in consultation with Sep.

Production Companies

During the 1990s there were 4 electricity Production Companies: UNA in the north-west, EPON in the north and the east, EPZ in the south and EZH in the south-western part of the Netherlands. They co-operated in Sep, which was responsible for the transmission grid, the import and export of electricity, and the co-ordination of the production planning of the Production Companies. The 10-year construction plan had still to be approved by the national government.

Distribution Companies
Many mergers among the Distribution Companies took place during the 1990s. At the beginning of 1998 there were 19 electricity Distribution Companies. There were large differences between the sizes of the Distribution Companies. Some of them were small and still attached to one town or region, but most of them cover large regions, sometimes as large as the regions of the Production Companies. Most of these companies are horizontally integrated, although still mono-gas utilities exist. All the energy distribution utilities co-operated in their branch organisation EnergieNed.

Since 1997 several more mergers have taken place. In 2000 there are about 15 Distribution Companies left. The 5 largest Distribution Companies (NUON, Essent, Delta, REMU and Eneco) together currently have a market share of about 95%.

The tariff structure
The Production Companies were obliged to sell the electricity from the power plants first to the Sep for standardised fees, which reflect the production costs. The Sep levelled the costs of the different production plants and sold the electricity back to the Production Companies for one national basis tariff (LBT), which includes the coverage of Sep's own costs (a/o maintenance of the transmission grid). The Production Companies sold the electricity to the Distribution Companies for a slightly higher tariff than the LBT, reflecting their own transmission costs. These tariffs, the regional basis tariffs (RBTs), could be different between the Production Companies, but because of the competitive pressure, these differences turned out to be minor. Finally the Distribution Companies sold the electricity to the end users for a tariff in which the distribution costs were included.

Although the overall structure of the tariffs was regulated by Law, the details were filled in by the sector itself by internal negotiations (self-regulation). The Sep on behalf of the producers on the one hand and EnergieNed on behalf of the consumers on the other hand were the main negotiating parties.

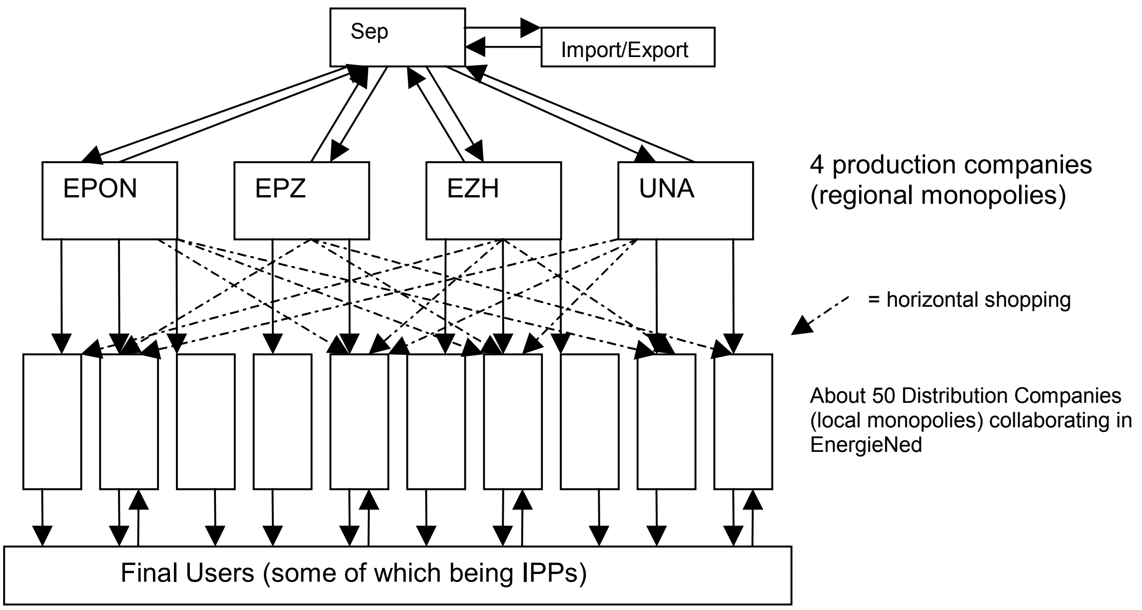

Figure 2.2 *Structure of the Dutch Electricity sector in the early 1990s, based on the Electricity Law of 1989*

Feed-in tariffs for electricity produced by IPPs
The Electricity Law of 1989 obliged the Production Companies to pay a compensation to Distribution Companies for the electricity produced by Distribution Companies or bought by Dis-

tribution Companies from IPPs (which they were obliged to accept). This tariff was based on avoided costs and consisted of a fixed part, reflecting depreciation costs on fixed assets, and a variable part, reflecting operation/maintenance and fuel costs. The level of the fixed part as well as the variable part depended on the character of the plant (base load, middle load or peak load).

Table 2.1 *kW and kWh compensations in 1997*

Kind of plant	[Hours/year]	[Dfl/kW/yr][2]	[Dfl/kWh]	Average compensation [Dfl/kWh]
Base load	>7000	260	0.046	0.081
Middle load	>2000 and < 7000	205	0.055	0.101
Peak load	< 2000	125	0.095	0.176

The tariffs paid by Distribution Companies to IPPs was a per kWh tariff and could be calculated assuming a certain amount of hours/year of contracted production.

2.2 Netherlands Renewable Energy Policy in the 1990s

2.2.1 Market penetration of renewables

The decision to implement the Green Label system was taken by EnergieNed in 1997. In that year the contribution of renewables in the Netherlands was as indicated in Table 2.2.

There were several definitions in use in the national discussion on renewable energy policy. The first is the definition given in the 'Action Programme Renewable Energy' (1997)[3] according to which sources are renewable if they '*are converted into secondary energy sources without making any demand on finite reserves'*. This definition includes wind energy, solar electric, solar thermal, geothermal, hydropower, biomass as well as acquifer energy storage, ambient heat delivered by heat pumps and waste incineration. Another definition has been put forward in the 'protocol on the monitoring of renewable energy', which has been established on the instigation of the Novem (the Dutch governmental agency for environmental and energy research) and EnergieNed. *Renewable energy is all energy in the form of electricity, heat or fuel that is generated by local renewable energy sources, after correction of possible use of energy for its generation*. The most important differences between the two definitions is that in the first definition incineration of non-organic waste, industrial heat pumps and import of renewable sources (e.g. from Norwegian large hydro-power plants) is included, which is not the case in the second definition. Therefore the first definition is called the 'broad definition' and the second definition the 'restricted definition'[4].

Furthermore there is a list of renewable energy sources that are eligible for transfer of Regulatory Energy Tax funds (see below), which constitutes a 'de facto' definition. This list is:

- wind energy
- solar energy
- small-scale hydropower (<15 MW)
- biomass-electricity (but not as co-fired with synthetic waste)
- biogas.

[2] A Dutch guilder (Dfl) equals 0.45 Euro (per definition) or 0.41 US $ (August 2000).

[3] The 'Action Programme 1997-2000 Renewable Energy - Advancing Power' (Actie Programma 1997-2000 Duurzame Energie In Opmars), better known as Action Program Renewable Energy was published in 1997 by the Minister of Economic Affairs as a consequence of the renewable energy targets, mentioned in the Third Energy White Paper of 1995 (see section 1.2.2).

[4] In 1999 the official definition was updated and brought more closely to the restricted definition. Industrial heat pumps are excluded from the definition and waste incineration is only included for 50%, being the estimated organic part of waste in incineration plants.

Table 2.2 *Dutch situation in 1997 for renewable electricity*

	[MW]	[TWh]	% of domestic electricity consumption (96.1 TWh)	PJ avoided	% of domestic energy consumption (2945 PJ)
Wind	325	0.45	0.47%	3.8	0.13%
Solar PV	4.4	0.01	0.01%	0.09	0.00%
Hydropower		0.1	0.10%	0.9	0.03%
Waste incineration		2.1	2.19%	17.9	0.61%
Landfill gas		0.1	0.10%	0.9	0.03%
Domestic biomass	0	0	0	0	0
Import biomass	0	0	0	0	0
Import renewable electricity	0	0	0	0	0
Total		2.76	2.87%	23.9	0.8%

If non-electricity options are included (such as domestic open heards fired by wood) then the percentual contribution of renewables to the domestic energy consumption defined by the broad definition is about 1%. The largest contribution from renewables comes from waste incineration, a source that is not included in the restricted definition. The current contribution of renewables in the sense of the strict definition to the Dutch energy consumption is negligible.

2.2.2 Renewable Energy Policy Targets

Renewable energy targets in the form of a prospected share of renewables in the Dutch energy mix were formulated officially for the first time by the national government in the Third Energy White Paper that was published in December 1995[5]. The main target with regard to renewables is a share of 10% of renewable energy in 2020. According to calculations of the Netherlands Energy Research Foundation, published in the 'National Energy Outlook 1995-2020[6]', published in 1998, this translates to a share of renewable energy in the power mix of about 17%.

The Kyoto-agreements on Climate Change in 1997 have been translated in proposals for real measures in the White Paper on Climate Change in 1998 (part 1) and 1999 (part 2)[7]. The Dutch target of a reduction of 6% with regard to 1990 levels means a reduction of 50 Mton CO2-equivalents with regard to the baseline scenario. At least 25 Mton will be reduced by domestic measures. One of these measures is renewable energy. Within this policy framework a target of a share of 5% of renewables in the energy mix has been set for 2010. Assuming that this translates in a similar manner into a renewable electricity share, this means a target of about 8% renewable electricity share.

5 An Energy White Paper is an important policy document in Dutch politics. It generally lays down the principles for further energy policy measures and legislation. The first Energy White Paper was published in 1974 in reaction to the first oil crisis of the 1970s. Diversification of resources, energy efficiency and research in renewable energy sources were the important principles. The Second Energy White Paper appeared in 1980, in reaction to the second energy crisis of the 1970s. It is known as the Coal White Paper, since its main focus was on how to enlarge the share of coal in the energy mix to save domestic natural gas resources, a policy that was soon abandoned (after 1985), but still resulted in the construction of the world's largest coal-gasification demonstration plant. The Third Energy White Paper of 1995 anticipated on liberalisation of energy markets, and took into account environmental concerns related to the production and use of energy.

6 The ECN Business Unit of Policy Studies publishes National Energy Outlooks on behalf of the Ministry of Economic Affairs every 4 years. For that reason it has developed an extensive set of interconnected energy models (the National Energy Outlook computing system).

7 Part 1 of the Climate Change White Paper is concerned with measures for domestic greenhouse gas emission reduction, whereas part 2 focuses on non-domestic measures (Joint Implementation and Clean Development Mechanism).

Dutch renewable energy targets in the context of the European Union

In the European White Paper on Renewable Energy (1997) an indicative[8] target was set of raising the renewable share of the energy mix from 5% in 1995 to 12% in 2010. Following this target the Commission recently has proposed indicative targets for the share of renewables in the electricity mix for each of the Member States. For the Netherlands a 12% share in 2010 is proposed, substantially higher than the 8% just mentioned.

Table 2.3 *Energy-related policy targets in The Netherlands*

Subject	Target [%]	Year	Policy Document
Renewables	3	2000	Third Energy White Paper 1995.
	5	2010	White Paper on Climate Change Policy, part I, 1998.
(Indicative target of EU for NL)	12	2010	Draft Directive on the Integration of Renewable Energy Sources in a Liberalised Energy Market.
	10	2020	Third Energy White Paper, 1995.
	17 (electricity)	2020	National Energy Outlook (calculations).
Greenhouse gases (Kyoto)	-6 (1990)	2010	Kyoto-agreements, 1997.

2.2.3 Renewable Energy Stimulation Measures

Regulatory Energy Tax

Since 1997 domestic consumers pay a Regulatory Energy Tax (REB) on their electricity consumption. This tax was introduced with the aim to enhance energy-efficient behaviour. The general idea of this tax is that it is fiscally neutral: the introduction of this tax was accompanied by a lowering of the general income tax. The philosophy is behind this is that those who consume less energy than average would gain, and those who consume more than average loose. It is agreed within the government that the income from the Regulatory Energy Tax should be about 3.4 billion Dfl in 2001.

Since 1997, the Regulatory Energy Tax has increased considerably (see Table 2.2) and it will increase further.

[8] 'Indicative' here means that these targets are not binding. It is a common way for the European Commission to formulate policy. For binding targets the unanimous agreement of all Member States is necessary. By stating indicative targets, which of course are less robust, the Commission avoids an explicit voting on this issue, whereas it hopes that the targets will at least function as a guideline in Member States' own policy making. In practice this is indeed the case.

Table 2.4 *Increases in Regulatory Energy Tax over the years*

	1996	1997	1998	1999	2000	2001
Natural gas (ct/m^3)						
0-800 m^3	0	0	0	0	0	25.67
800-5000 m^3	3.2	6.4	9.53	15.98	20.82	25.67
5000-170000 m^3	3.2	6.4	9.53	10.44	11.44	12.44
170000-1 million m^3	0	0	0	0.71	1.54	4.37
Over 1 million m^3	0	0	0	0	0	0
Electricity (ct/kWh)						
0-800 kWh	0	0	0	0	0	12.85
800-10000 kWh	2.95	2.95	2.95	4.95	8.2	12.85
10000-50000 kWh	2.95	2.95	2.95	3.23	3.54	4.27
050000-10 million kWh	0	0	0	0.22	0.48	1.31
Over 10 million kWh	0	0	0	0	0	0

1 Dutch guilder = 0.454 Euro. To convert to Eurocents divide by 2.20371. 1 Euro = 0.9 US$

The consumers pay the tax to the utilities, which have to transfer it to the Treasury. An exception is made for electricity generated by renewables according to the list of renewable energy sources, mentioned in section 1.2.1. Utilities may transfer part of the tax (until now always equal to the rate that applies for the group that consumes between 10 000 to 50 000 kWh (e.g. 3.54 cents/kWh in 2000)) to the producer of renewable electricity, instead of transferring it to the Treasury.

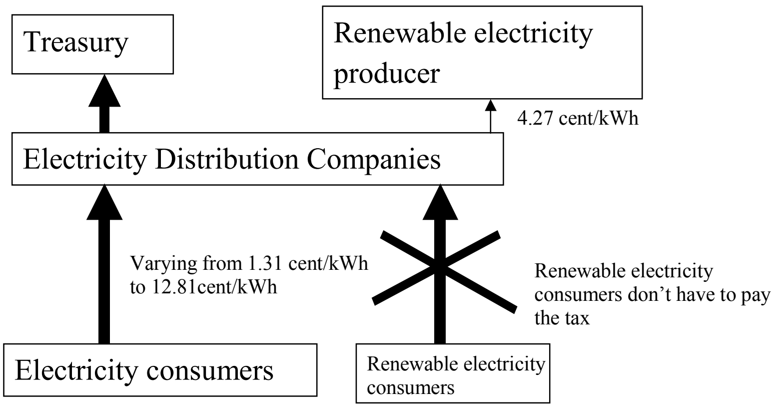

Figure 2.3 *Regulating Energy Tax and Renewable Energy (figures for the year 2000)*

An extra stimulus for renewables is the decision of the government that since January 1999 consumers who buy renewable electricity (under the same definition) do not have to pay the Regulatory Energy Tax. This rule of exception increases the profitability of renewables even more.

Accelerated Depreciation of Environmental Investments (VAMIL)

The VAMIL scheme, implemented since 1997, allows investors in environmental technologies (defined explicitly by a VAMIL-list) to depreciate their investments against taxable profits freely (i.e. also in the first year). This leads to fiscally lower profits in the earlier phases of the lifetime of the investment, and fiscally higher profits towards the end of the lifetime of the investment. The result is a reduction on investment of about 10%. All renewable energy technologies are included in the VAMIL-list.

Energy Investment Relief Scheme (EIA)
Since January 1997 for investments technologies that are explicitly defined on a qualifying list (including renewable energy technologies) can be deducted from the taxable profit at a rate varying from 40% to 52% of the total investment (with a maximum of Dfl 50 million per investment). In this way the EIA is almost a straightforward subsidy. The size of the subsidy is the product of the EIA-rate and the level of the profit tax (between 35% and 40%). This means a subsidy of between 14% and 21%.

Green funds
A green fund is a fund that invests money in environmental beneficial projects, which includes renewable energy. Since 1997 private persons investing in a green fund are exempted from tax on the interest income from that fund. Under the current tax system in the Netherlands this comes down to return on investments criteria that can be about 50% lower than for other investments. Because of Green Funds renewable energy projects can get a loan for interest rates 2 % points lower than average loans.

2.3 Implementation of the Green Label System

2.3.1 The Environmental Action Plan 1990-2000 of the Energy Distribution Sector

The Environmental Action Plan (in Dutch *Milieu Actie Plan* or *MAP*) started in 1990 as a coordinate action between the government and the distribution sector to promote energy efficiency and renewables[9]. The goals of the MAP are the reduction of 17,7 Mton CO_2 and 0,4 billion acid equivalents (NO_x and SO_2) with regard to the 1990 situation in the year 2000. Since 1991 many measures have been taken, including the promotion of CHP, insulation, energy-efficient light bulbs, high-efficiency boilers and renewables. The resources, required for funding the planned measures, come partly from the government (270 million/year between 1991 and 1993 and 150 million/year since then) and partly from the energy distribution sector. The main part of the sector's own financial support comes from a special levy (the MAP-levy) that varies between 0.5% and 2.5% (with a mean of 1.8%) on the energy bill. This MAP-levy does *not* cover the total electricity consumption of almost 95 TWh per year. Firstly about 20% of the electricity consumption comes from auto-production in industry. Secondly large consumers (about 33% of the demand, partly overlapping with auto-producers) are exempt from paying the MAP-levy. The total volume of electricity for which a MAP-levy was applicable was about 53 TWh in 1995, which is a little bit more than the half of the total electricity consumption (and about 70% of the electricity sold via the public grid). The total budget of the MAP has been in the order of Dfl 300 million/year.

2.3.2 Renewable Energy in the Environmental Action Plan

The Environmental Action Plan plays an important role in the stimulation of renewables. Of the 300 million Dfl/year about 70 million/year went to the stimulation of wind energy, the most important renewable energy source (within the strict definition) in the Netherlands. Most companies stimulated wind energy by offering feed-in tariffs for electricity from wind power above standard prices. However, not in every region the same tariff was offered. Some companies offered 15 cents/kWh (15-year contracts), others only 11 cents. For big projects the investor had to negotiate every time again. The legal minimum feed-in tariff was based on a calculation of

[9] The MAP is the outcome of a 'covenant' between the Electricity Distribution Sector and the Dutch Government. Covenants are a policy tool widely used in Dutch policy. The general idea is that the Government restrains from further legislation, as long as the industrial counter party reaches the desired targets in its own way. In 1990 the Government and the Electricity Distribution Sector, represented by EnergieNed, concluded a Set of Agreements, in the line of the Third White Paper, which was turned into concrete detailed targets, plans and financing in the MAP. The general 'penalty' if covenant targets are not reached is that the Government introduces legislation that will enforce industry to do what it.

the avoided costs for the production of electricity (including a variable part for economising on fuel and a fixed part for economising on capital investments in conventional plants). It was set at 8.1 cents/kWh for wind turbines and at 7.9 cents/kWh for PV-installations. Since 1996 an extra 2.95 (3.54 cents/kWh in 2000) cents/kWh was added, being the rate of the Regulating Energy Tax that Distribution Companies could transfer to the producer of renewable electricity.

2.3.3 The Green Label System: Burden Sharing of a 'Voluntary Obligation'

The Decision Renewable Energy

On 30 January 1997 the Workgroup Renewable Energy of the MAP-Working Group of the Members of EnergieNed (the association of Distribution Companies) took the Decision on Renewable Energy. This Decision meant that the scattered approach of the first 7 years of the MAP towards renewable energy was replaced by a common approach. The main elements of the Decision were:

- A target was set for the total amount of renewable electricity to be produced or supported by the Distribution Companies.
- This target was set in line with the government policy objectives of the Third Energy White Paper and was set at 3.2% of the total amount of electricity for which the MAP-levy is applicable, based on 1995 figures, to be reached in the year 2000. In absolute terms this target meant 1700 GWh, almost a doubling with regard to the production of 900 GWh renewable electricity in 1997.
- This target should be reached for the lowest overall costs possible. Since the opportunities for the production of renewable energy differs substantially per region (see e.g. Figure 2.3), the distribution sector decided to implement an internal green certificate trading system.
- EnergieNed, the branch association of the distribution sector, was asked by its Members to implement the trading system before 1 January 1998.

Characteristics and principles of the Green Label System

EnergieNed succeeded in setting up a green certificate system before 1 January 1998. It asked KEMA[10] to build the necessary software. These are the key characteristics and principles of the Dutch system, as agreed upon by the distribution sector (members of EnergieNed) in December 1997.

- The overall target of 1700 GWh in the year 2000 is distributed over 19 Distribution Companies.
- The contribution to the overall target per company is based on the relative MAP-levy-related electricity sales in 1995.
- The individual company target can be reached by showing sufficient redeemable Green Labels by the end of the year 2000.
- A Green Label is a proof that 10 MWh renewable electricity has been produced and has been fed into the grid.
- Green Labels are only valid in the (calendar) year of production.
- The targets will be adjusted according to relative climatic variations in the target year; Relative in this context means e.g. that the target of a utility that has no Green Labels from wind turbines, will not be influenced by variations in the wind regime.

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[10] KEMA originally was the electricity standards and research organisation of the energy sector in the Netherlands, and has its premises on the same location as Sep and EnergieNed. Today it is an independent research organisation, although still with strong links with the energy sector.

- Starting in 2000 a penalty will be applied to those Distribution Companies that will not be able to show sufficient Green Labels at the end of the year 2000[11].
- This penalty consists of the obligation to buy green labels from other companies with a surplus of Green Labels against the market price + 50%.
- As long as the Green Label system exists, the penalty procedure will be started after the end of every year.

EnergieNed has made an estimate of the cost savings of the Green Label system. If every Distribution Company has to reach their target in their own region, the total costs for the distribution sector is estimated at 55 million Euro/year. With the possibility of trading, induced by the Green Label system, this is only 33 million Euro/year, a saving of 22 million Euro or 40 %. This calculation is based on a quick estimate of cost curves for renewable energy in the region of each Distribution Company and the corresponding costs per utility to reach the target, added up. This is compared with an estimate of an overall cost curve for the Netherlands and the corresponding overall costs for all utilities.

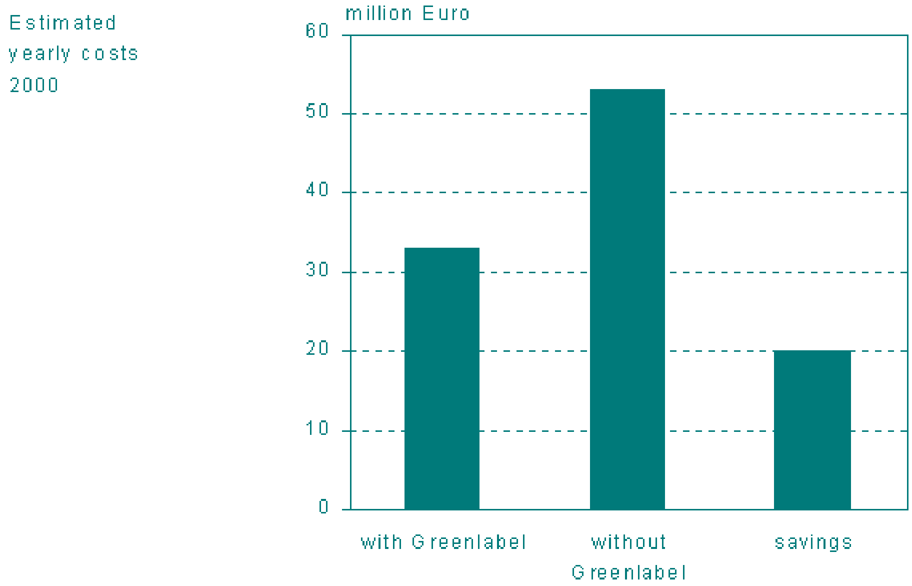

Figure 2.4 *Estimated cost savings of the Green Label System*

[11] Although the original targets were only set for the year 2000, the system is set up in such a way that also after the year 2000 it could remain in operation. The energy utilities will in principal continue the Green Label system as long as the institutional environment allows it. This means a/o that there can be no competition from foreign companies (without an obligation) on the relevant electricity market. With the current plans on liberalisation this means that the system could continue at least one more year (see section 5).

2.3.4 The Mechanics of the Green Label System

Issuing of Green Labels

KEMA has developed software (called 'Labelaar') that is provided to every Distribution Company. With this software a Distribution Company can issue Green Labels according to their meter readings. A Distribution Company is the only organisation allowed to issue Green Labels in their region. Every month the number of Green Labels produced by a production site is communicated to the owner of the production site (in case the utility itself is not the owner) and to the central registration databases that is managed by KEMA on behalf of EnergieNed. For verification purposes it is only allowed to issue Green Labels for electricity that is also eligible for the transfer of Regulatory Energy Tax money (see section on policy measures). Each Green Label is coded as follows:

[*country of origin*] {2 characters} [*year of production*] {two figures} [*issuer code*] {four figures} [*type of renewable energy*] {two figures} [*serial number*] {six figures}.

Example:

- *NL 99 2641 00 120678*

The producer is not directly represented in the code. However, his data are linked to the serial number and stored in the central database. Data linked to the serial database include the exact location of the production site, the period in which the production took place and the actual owner of the Green Label.

Registration and trade of Green Labels

The information related to the issuing of a Green Label is put into an input file and was sent to KEMA (per e-mail). KEMA performs several consistency checks (see section on verification procedures) and stores the Green Labels in the central database. When Green Labels are traded, both parties communicate the transactions to KEMA. KEMA checks whether the Green Labels are still valid.

The Green Label system just registers transactions. There is no Green Label trading place. For the moment the market has been estimated to be too small to set up a Green Label Exchange.

Redemption of Green Labels

Green Labels can be redeemed anytime. The Distribution Company can do this by indicating in the Labelaar input file that they want to redeem the specified Green Labels. They can redeem Green Labels for their target, but also for covering their green electricity sales[12] (if they have decided to sell green electricity in addition to their target) or for direct sales of Green Labels to third parties. The last case is regarded as a normal trade transaction, with the exception that the owner is not one of the Distribution Companies. In principle the owner of the Green Label can still resell the Green Label to one of the Distribution Companies during the validity period. In the case of redemption for the target or for green electricity sales the Green Labels are earmarked as being redeemed. Every Distribution Company has an account indicating the remaining Green Labels needed for the target and an account of the Green Labels they own available for redemption or trade. At the end of every year, the Green Labels that have not yet been redeemed, are redeemed automatically by KEMA.

Verification procedures

KEMA performs a set of standard consistency checks. With regard to issuing this is for instance the question whether the producer is known and whether his/her data are consistent with earlier data. This means for instance that the same wind farm site cannot have produced twice as much

[12] About green electricity see two sections below.

Green Labels than the month before if there was less wind that month. With regard to trade and registration KEMA checks whether the certificate is still valid (right year, not owned by someone else, not yet redeemed). With regard to the target they check whether the target is met.

The number of Green Labels issued by the Distribution Company is not verified directly. Originally it was the intention that the inspectors of the Treasury, who verify the amount of electricity for which Regulating Energy Tax money can be transferred to the renewable energy producer, would simply compare their figures with the Green Labels issued by the Distribution Company. However, the Treasury has decided that it was not their duty to verify systems not implemented by the government. This means that at this moment there is not an appropriate verification on the number of Green Labels issued. Large-scale fraud however, would immediately come to the attention, because then the number of Green Labels issued and the total amount of Regulating Energy Tax transferred would differ substantially. In that case the whole system would loose its credibility, and that is in the interest of no one. Although this 'social mechanism' seems to prevent fraud at the moment, it is generally acknowledged that a more robust verification procedure will be needed in a next system.

Application of penalty

The software to calculate the penalty or bonus per utility has been written and has been fictively used at the end of every year (1998, 1999). Results of these exercises have not yet been published. The year 2000 was the first year for which the penalty was really applied. Debates on how to interpret the rules exactly have been going on during the whole year of 2001. As yet (end of 2001) there is no public information on how the settlements between the companies have proceeded.

Green Electricity in the Green Label System

Since 1996 a number of utilities offer customers the choice to buy Green Electricity (also known by names as Eco Electricity or Nature Electricity). Green Electricity is bought by consumers on a purely voluntary basis. These consumers have to pay a surplus price. In return the utility guarantees that the amount of green electricity consumed by the final user over a year is matched by an equal amount of renewable electricity produced or bought by the Distribution Company itself.

The surplus customer price for the customers varies per utility, but on the average it is 0,08 Dfl/kWh. The Distribution Company guarantees the green electricity consumer that the money raised by the selling of green electricity will be invested in the construction of new renewable production capacity. Independent organisations (WWF and a regional Environmental Federation) control whether the utilities do not sell more green electricity than they have produced or bought. The total amount of green electricity sold has risen from 2 GWh in 1995 to at least 625 GWh in 2000. About 145 000 households (on a total of about 6 million households) and 700 firms currently buy green electricity. In the region of Eindhoven the local Distribution Company (one of the smaller ones) claims to be selling green electricity to 20% of its household customers.

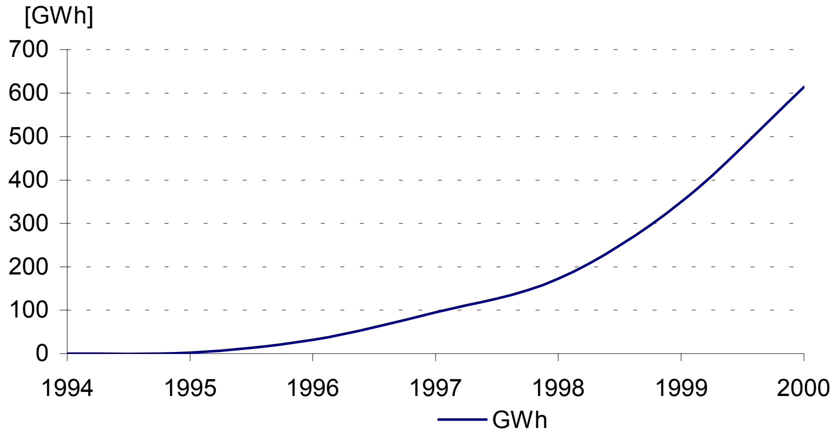

Figure 2.5 *Green Electricity Sales in the Netherlands*
The sales figures of the year 2000 are based on existing contracts at 1 January

The principle of additionality
As been indicated above, the sales of green electricity are covered by Green Labels. With the growth of green electricity sales the discussion on *additionality* of voluntary green electricity demand becomes very important. The basic question is whether Green Labels used for green electricity sales should be produced on top of the obligation, or whether they could be part of the obligation. In the latter case, if all Distribution Companies would add their voluntary demand sales to their target according to the Decision Renewable Energy, then the total amount of Green Labels required at the end of the year 2000 is not equivalent to 1700 GWh, but will be 1700 GWh plus at least 530 GWh. Most Distribution Companies say they maintain the principle of additionality (they agree that green electricity sales should be on top of their obligation), but not all do, or are not clear about it. This opaque situation has led to a lot of discussions. The Dutch government and the controlling NGOs (WWF) all ask for a clear stance on the additionality principle.

2.4 Experiences so far

Growth of Renewable Electricity Production 1990-1999
Figure 2.6 gives the growth of electricity production by renewable energy sources between 1990 and 1999 and the total deficit with regard to the target. What can be seen is that since 1997 the growth of domestic renewable electricity production has slowed down. The start of the Green Label System in 1998 doesn't seem to have helped in this respect. Figure 2.7 shows however that the number of planned renewable electricity projects has considerably grown.

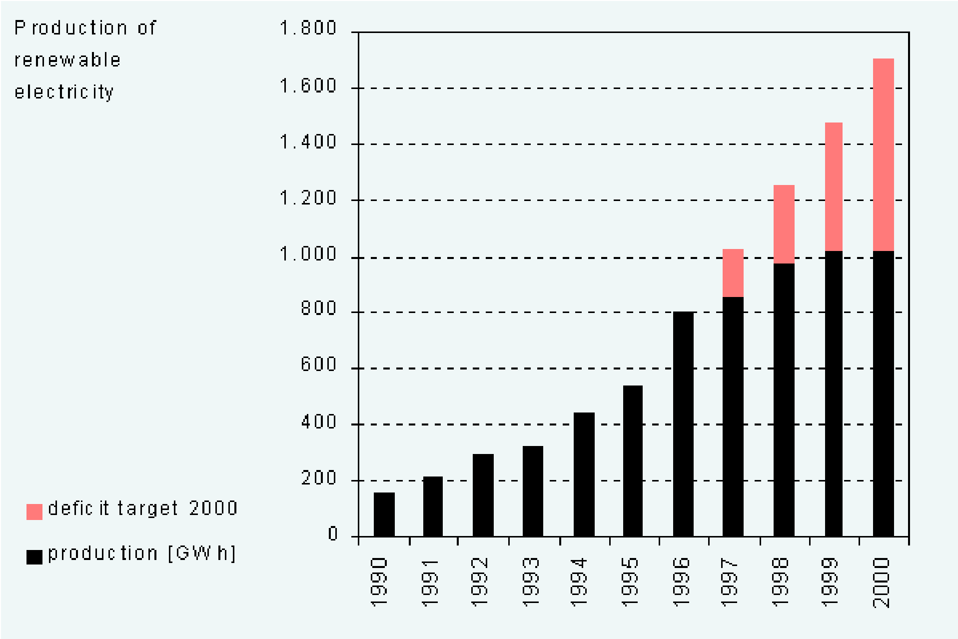

Figure 2.6 *Growth of Renewable Electricity Production*

Preliminary figures of 2000 show that about 1400 GWh of renewable electricity has been produced in 2000 and 200 GWh has been imported (Table 2.5).

Table 2.5 *Supply of RE in NL in 2000*

	[GWh]
Co-firing of biomass in coal plants (production sector)	177
Green Label Obligation for Distribution sector	620
Green Labels used for green electricity consumers	625
Import	193
Total	1615

These figures show that, although the target has not been reached, that during the Green Label System years, the production of renewable electricity has grown considerably.

The main reason why not enough production of renewable electricity has come on-line is the complex planning procedure. Getting the necessary construction permits for renewable energy plants from the local authorities, and especially for wind turbines, has been proven to be very difficult. Although surveys show that the majority of the people living near to planned wind turbine projects is in favour of them, those who are not often start painstaking and long legal procedures. The main objections against wind turbines are distortion of the landscape and, especially for natural areas, the danger of bird killing. Getting a construction permit sometimes can take between 3 to 10 years.

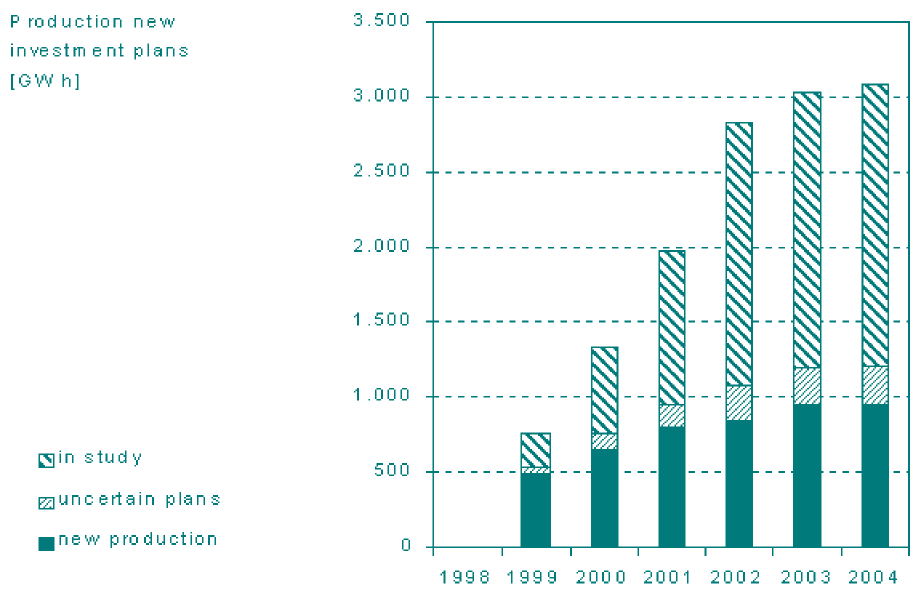

Figure 2.7 *The Average Future Production of Planned Renewable Electricity Projects*

Planning problems are less pregnant for biomass installations. The production of Green Labels by biomass installations (biomass, biomass co-firing and landfill gas in Figure 2.8) therefore has doubled between 1998 and 1999. The main share of the production however still comes from wind energy, but that might change soon.

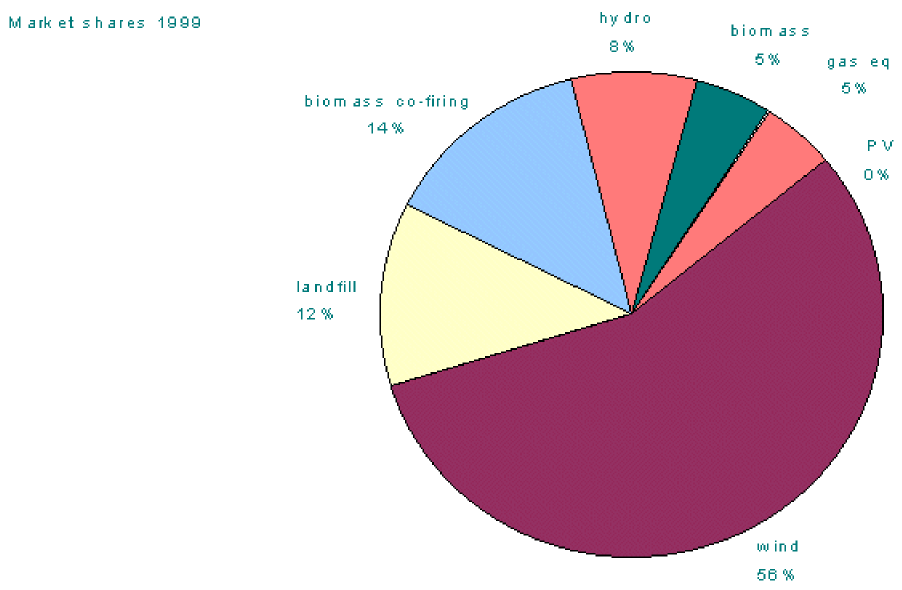

Figure 2.8 *Market Shares Production Green Labels by Source 1999*

Table 2.5 *Contribution of new bio-energy plants to the Green Label production*

Project under construction and operational in 2000	Power [MW]	1997 [Gwhe]	1998 [Gwhe]	1999* [Gwhe]	2000* [GWh]
Landfill gas and Anaerobic Digestion		200	216	220	220
Stand alone combustion					
Small scale industrial wood	1.5			10	10
Cuyck, PNEM, green power from wood	24				175
Lelystad, NUON, nature power from forestry	1.3				10
Cocombustion in coal fired power plants					
Nijmegen/EPON, pulverised wood	20	37	100	100	140
Amer/EPZ, sludge	5		30	30	30
Maasvlakte/EZH, biomass pellets	15			100	100
Amer/EPZ, gasification of old wood	30				200
Amsterdam/UNA, sludge	15				100
Total		*237*	*346*	*460*	*765*

* estimation based on 7000 hours of operation per year

The difference between actual production and future-projected production shows that a Renewable Portfolio Standard system should take into account the time lag between investment decisions and actual production of renewable electricity. Also in countries where planning procedures take shorter time (as might be the case in China) there will be some time lag between investment decisions and coming on-line of renewable electricity production facilities. Taking into account the time in a design of an RPS can be done by allowing flexibility in compliance and by announcing the scheme well before it starts.

The Price of Green Labels

At the early stages EnergieNed made an estimate of the price of Green Labels. The most expensive option that is needed to cover the 1700 GWh obligation (the marginal option) was expected to cost about 16 cents/kWh, i.e. if all the fiscal investment incentives (VAMIL, EIA, Green Funds) are taken into account. The electricity from renewable energy plants is worth 8.1 cents/kWh (the legal minimum) + 2.95 cents/kWh (the transfer of the regulating energy tax in 1997) = 11.05 cents. To cover the costs of the marginal option, the Green Label should be worth at least 16-11.05 = 4.95 cents/kWh.

In the first year of the Green Label system this figure was guiding the market, and prices paid for Green Labels were in that order of magnitude. However, due to the shortage on the market prices rose during 1999. Producer chat room discussions on the Internet indicated that a price for the total package of Green Labels and renewable electricity was in the order of 17.5 to 18 cents/kWh. On the other hand the eco-tax transfer tariff has risen from 2.95 cents/kWh to 3.54 cents/kWh, which has reduced the Green Label price accordingly. This means that currently Green Labels cost about 6 cents/kWh.

The geographical price differences that existed before the Green Label system have almost been disappeared. This is the consequence of the fact that producers indeed tried to sell their Labels outside the area of their own Distribution Company.

Price transparency

Most contracts are long-term bilateral contracts. Therefore the transparency of the market is not very high, meaning that actual prices are not really known. The absence of a sufficiently liquid and transparent spot market is due to the fact that no one needs Green Labels immediately. This would only be the case if the Compliance Period is almost ending. Since the first real Compliance Period is the year 2000, there has as yet been no drive to buy or sell Green Certificates immediately. Also there is no facilitating trading place for Green Labels.

The Creation of Green Labels produced in Other Countries
Because of the domestic planning problems, several Distribution Companies have decided to import green electricity from other countries, e.g. to cover their green electricity sales. The first import of a Green Label took place in early 1999 when Energy North West[13] made a contract with National Wind Power from the United Kingdom. ENW bought the right to issue Green Labels of the production of a wind turbine in the UK. Another company, NUON has invested in wind farms in the UK, Germany and China(sic!) for which they issue Green Labels. With their counter-investor in China they have agreed that all the 'greenness', including the marketing rights etc. of the renewable energy production of the Chinese wind farm belong to NUON.

These activities of course have invoked a lot of discussions in the Netherlands, but there is no definitive outcome yet of this debate.

2.5 Lessons learned

The Green Label system has taught several lessons about how to set up a green certificate system. Being a learning-by-doing experience several flaws in the design of the Green Label system became apparent, flaws that can easily be avoided in other green certificate systems that take the lessons of the Green Label system into account. The lessons learned can be divided in three categories:
1. Lessons learned with regard to the general approach.
2. Lessons learned with regard to the creation of demand for certificates.
3. Lessons learned with regard to trade in certificates.

2.5.1 General lessons

The Principle can be put in Practice
The Green Label system has shown that the principle of separate markets for electricity and 'greenness' can indeed be put into practice. Undeniably the Green Label system has added substantially to the financial viability of new projects. Prices paid for renewable electricity were higher than before in the Netherlands. Currently there are hardly any obstacles anymore from a financial point of view for an investor to extend his investments in low-cost renewable energy projects. The shift from wind energy projects to biomass projects shows that planning problems for one resource do not hamper renewable energy development too long, as long as other options (that might be a little bit more expensive) are available that are less vulnerable for planning procedures.

Flanking Policy (planning) Important
The difficulties to reach the target with the lowest cost options, despite prices that are high enough, shows that flanking policy to remove non-economical barriers for the penetration of renewables is very important. In the Netherlands such a flanking policy is especially important with regard to the streamlining of getting construction permits from the local authorities for wind turbines. The Dutch government has announced that indeed it wants to focus more on planning policy.

Green Certificates are a Good Tracking System
Another positive lesson learned is that the registration software of the Green Label system makes it possible to exactly track where the greenness of a once renewably produced kWh remains. It avoids the possibility of double counting. If more countries had such a system, the control on the import and export of green electricity would be far more easy, than on the basis of contracts and/or physical flows of electricity.

[13] ENW merged with NUON during 1999.

A Renewable Portfolio System Should be Announced well Before the Start Date
Because of the time lag between investment decision and actual production of green certificates, the introduction of an RPS system and its rules, should be known one or two years before it actually starts. This leaves obligatory actors and investors the opportunity to anticipate on the start of the system.

This idea is currently being followed in the Texas RPS system. The rules (including level of mandatory shares, penalties, possibilities of banking and borrowing) have been published early 2000 and the system starts on 1 January 2002. Currently several obligated parties have issued Requests For Proposals for renewable energy project developers and the first contracts are being made.

Verification Weak in Dutch Green Label System
In the Dutch Green Label system there has not been an appropriate verification on the number of Green Labels issued. Large-scale fraud however, would immediately come to the attention, because then the number of Green Labels issued and the total amount of Regulating Energy Tax transferred would differ substantially. In that case the whole system would loose its credibility, and that is in the interest of no one. Although this 'social mechanism' seems to prevent fraud at the moment, it is generally acknowledged that a more robust verification procedure will be needed in a next system. This means that an independent organisation (e.g. National Computing Chamber, or the General Inspection Service of the Treasury) should be appointed as the Verification Body. Verification should not only include verification of procedures, but also control of the production installations: do they really produce energy from renewable energy sources? Can they prove that? Etc.

2.5.2 Lessons with regard to the creation of demand

Long-term Security Necessary
The Dutch experience has shown that most investors prefer long-term contracts instead of short-term large profits. The obligatory actors (the buyers of certificates) are only willing to provide such investor security, if they themselves can be certain enough that there will be a long-term demand for green certificates. That means that a system that only runs for 3 years is not enough.

Currently most Distribution Companies try to establish demand security by developing the voluntary market. A renewable obligation provides of course a far more stable environment as long as it is a long-term RPS, with a guaranteed size of the market. Any RPS system implemented by a government should take this aspect into account. This means that the scheme provides security for at least 10, but preferably 15 years after the political target year.

This lesson has been taken up for instance in the design of the UK RPS. The last target year being 2010, a mandatory share at least equal to the one in 2010 will continue to exist at least till 2025.

Flexibility in Compliance Needed
Because of the time lag between investment and actual production of Green Labels and also because of the climatic variation of wind, water and solar input, more flexibility in compliance is needed. This can be done in two ways: by *banking* (e.g. extending the validity period of a certificate by an extra year) and by *borrowing* (e.g. by allowing a slight leeway on the obligation and allow obligated parties to catch up in the next year).

2.5.3 Lessons with regard to trade in certificates

System Design Should Include Creating a Green Certificate Trading Place

The Dutch Green Label market was estimated to be too small to create a Green Label Exchange. However, in practice this meant that almost only bilateral contracts were made between producers and Distribution Companies, with sometimes long negotiation times, and that for newcomers it was difficult to know what the actual value of a Green Label really was. This lack of transparency did not stimulate trade, which hardly occurred. The lack of information also functioned as a barrier for investors, who like to know the possible value of their investments.

Several companies are currently developing or delivering software for internet-based green certificate trading places. These include the Automated Power Exchange (APX) of California (for the Californian and Texan market), M-Co from New Zealand (for the Australian market) and Natsource in New York/London (an international broker). Another environmental market that has been in operation since 1998 is the market in the UK in Package Recovery Notes (PRNs). PRNs are proofs that a certain amount of waste has been recycled and can be used by the manufacturing industry to comply to their obligation to recycle a certain percentage of their packages. This market is operated by the company OM Environment.

Intermediate Compliance Periods needed

The relative lack of trade between Distribution Companies is, besides a lack of transparency on the price, also due to the fact that no real Compliance Period has happened yet. Until now, at the end of every year, no penalties had to be paid yet. It is expected that during the last months of 2000 more trade will occur. If 1998 and 1999 had been real Compliance Periods, with a penalty applied, then more trade would have occurred (and may be more effort would have been put in getting new renewable energy projects in place).

It is also the experience of OM Technology in the PRN spot market mentioned above that most spot market trade occurs during the end of the Compliance Period. The appropriate length of the Compliance Period is a balance between creating transparency by a spot market and the avoidance of too many administrative burdens. From a policy point of view, a year is an appropriate length of a Compliance Period. Experience in the PRN spot market shows that every year the spot market is used more and more. Green certificate trade experiments at the University of Amsterdam indicate that a Compliance Period of one year does not have a major impact on trading in the earlier parts of the Compliance Period.

Climate Correction maybe not best Approach

To account for different climatic conditions in each year (especially wind), the final obligation in the year 2000 will be corrected afterwards for wind conditions. This factor introduces an extra market uncertainty, since now it is not known exactly how many certificates are needed. In a long-term RPS it can be expected that over the whole period wind conditions will be average. A better way to deal with climatic variations is to allow to a certain extent banking and/or borrowing of certificates.

Internationalisation Necessary

The Dutch market still is too small to form a real working liquid and transparent market. Internationalisation of the Green Label system would solve a lot of problems related to liquidity and transparency, and would also be a solution for the typical Dutch planning procedure problems. These problems are far less in countries as Denmark, Germany and Spain. Also big projects (such as large offshore wind farms) could come on-line without flooding the market immediately.

This last lesson might be not relevant for China, since the Chinese electricity market is more that 20 times larger than the Dutch MAP-related electricity sales and the proposed mandatory share of at least 5% is much higher than the current 3% target in the Netherlands. This means that a lot of difficulties related to the relative small market size in the Netherlands will not occur in China on the long run and might only occur in the beginning.

2.6 The future of green certificates in the Netherlands

The Green Label system will continue at least till the end of the year 2000. What will happen afterwards is not sure. The new Electricity Act of 1998 foresees a liberalisation of the Dutch electricity market in several steps. Since February 1999 all the large electricity consumers are liberalised. Furthermore the government considers seriously accelerating the pace of liberalisation. Probably every consumer will be liberalised per 1 January 2004.

The government has announced that per 1 July 2001 they plan to liberalise the green electricity market for 100% and introduce a green certificate system that will replace the Green Label system to support this. Within the Electricity Law the legal basis for such a system has been given by a provision that the government can, if they consider that necessary, introduce an obligation on final consumers, with a green certificate system.

From a Mandatory Share to Supporting Renewable Energy Consumption by a Price Signal

Although the Parliament is in favour of an obligation (mandatory market share) for consumers, the Minister however wants to rely on the growing voluntary demand. She wants to support voluntary demand by continuing the exemption of green electricity consumption from the Regulating Energy Tax. Whether in the longer term still no obligation will be introduced is not 100% certain. Members of the Parliament have announced that they might prepare a Renewable Mandatory Share Bill themselves.

Remaining Questions

There are several uncertainties with regard to the future Dutch green certificate system.

First of all the exemption of the Regulating Energy Tax for green electricity sales until now has been controlled by the Treasury on the basis of renewable electricity production figures and on the basis of contracts; and *not* on the basis of Green Labels (which are not conceived as not having a legal basis). The Treasury does not seem to be too willing to change their control behaviour, since it believes that the current practice is satisfactory. In early 2001 the Tax Service seemed willing to accept the exemption from the Regulating Energy Tax on the basis of certificates, but not yet the production subsidy coming from Regulating Energy Tax-funds.

Another problem is that currently for the Treasury the Distribution Companies are subject to the Regulating Energy Tax and not the final consumers per se. This means that the Regulating Energy Tax production credit cannot be cashed if a renewable energy producer sells his green certificates directly to the final consumer.

Currently there is a shortage on the market to satisfy the combined demand from voluntary green electricity sales and the target of the Distribution Companies. Demand in 2000 will be at least 1700 + 625 = 2325 GWh, whereas production is about 1400 GWh. However, if there is no obligation anymore, starting from January 2001, then the target demand disappears and only the voluntary demand is left. This means that, at least initially, there is an oversupply of about 700 GWh on the market. Those companies that have not maintained the additionality principle (against the government's wishes) will not be hurt, since their purchase and own production match the voluntary sales. However, the companies that have maintained the additionality principle will be punished.

2.7 Conclusions and recommendations

2.7.1 Conclusions

The following conclusions can be drawn:

- A Renewable Portfolio Standard can work in a non-liberalised Market

Although in most countries where RPS systems are being introduced, this happens within the framework of liberalising electricity markets, the Dutch example of the Green Label system shows that it is perfectly possible to have an RPS working in a non-liberalised situation. The Green Label system worked in a similar organisational structure as currently in China.

- Lessons learned might be helpful for design of Chinese RPS system

In introducing an RPS, China can benefit from lessons learned in other countries on design and implementation. Most useful for China would be lessons that have a potential application in China. The lessons learned in the Netherlands, especially with respect to the Green Label system are believed to be in particular relevant for China. Institutions in the Netherlands are in general willing to share their experiences.

- Existing software can be transferred and adapted for China

The software developed for the Green Label System, currently being considered by a number of European Union Countries interested in Green Certificate Trading as the basis for an international EU trading system, might also be useful for China when introducing an RPS. This would avoid a lot of mistakes made by the early developers and would enable to design software that is compatible enabling possible future co-operation. Also other organisations and companies in the world (US, Australia/New Zealand) develop similar software.

2.7.2 Summary of Recommendations for a Chinese RPS system

- Announce the details of the Chinese RPS system well before the start of the system.
- Review existing software for Green Certificates registering and trading and consider adopting existing European/Netherlands software for use in China.
- Enhance investor security by extending obligation to at least 10/15 years after target date
- Compliance period of 1 year.
- Provide flexibility in compliance to obligation by allowing a certain extent of banking and borrowing.
- Set a simple penalty fee.
- Develop a clear and solid Verification Procedure.
- Create a green certificate trading place (internet).
- Make a clear decision on the additionality principle: Voluntary sales of green electricity should be in addition to the obligation.

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3. ORGANISATION AND ADMINISTRATIVE SOFTWARE NEEDS FOR GREEN CERTIFICATE SYSTEMS

3.1 Introduction

The Government of China is currently working with the World Bank to prepare a major programme to increase the development of renewable energy in China. One of the policy options the Government of China considers is the instrument of tradable green certificates.

A consortium of consultants from the Netherlands has been asked by the World Bank to provide the Government of China with information and experiences on tradable green certificates.

At the moment there are two Tradable Green Certificate (TGC) systems 'in the air': the Green Label system in the Netherlands and the Renewable Energy Certificate System (RECS) in Europe. The Dutch system started in 1998 and was implemented as part of the Environmental Action Plan of the energy distribution sector. RECS started last year and has participants from all over Europe.

This report describes in brief the following:
- the requirements for a tradable certificate system,[14]
- the organisation of such a system,
- the software to be used in that system,
- recommendations for implementation in China.

3.2 Requirements for a tradable certificate system

– *What is a Tradable Green Certificate System?*

A tradable green certificate system, is a system in which production of renewable electricity receives a certificate that can be sold. The green certificate is a piece of evidence that a certain amount of electricity has been produced by a renewable energy source. The certificate is issued by an independent organisation to the producer of the renewable energy. The producer can sell the certificate on a market, separate from the electricity market. The revenues provide extra income, in addition to electricity sales, to cover the incremental costs of renewable energy production.

In more detail, Figure 3.1 shows what actually happens: a renewable energy source produces electricity. The meter at the producers' location registers how much electricity is produced. This amount of electricity can be sold at the electricity market. Furthermore the amount of produced electricity also represents a certain amount of green certificates, which can be issued by an Issuing Body. The owner can trade with the certificates on the TGC market.

[14] Requirements for a tradable certificate system are independent of a particular country.

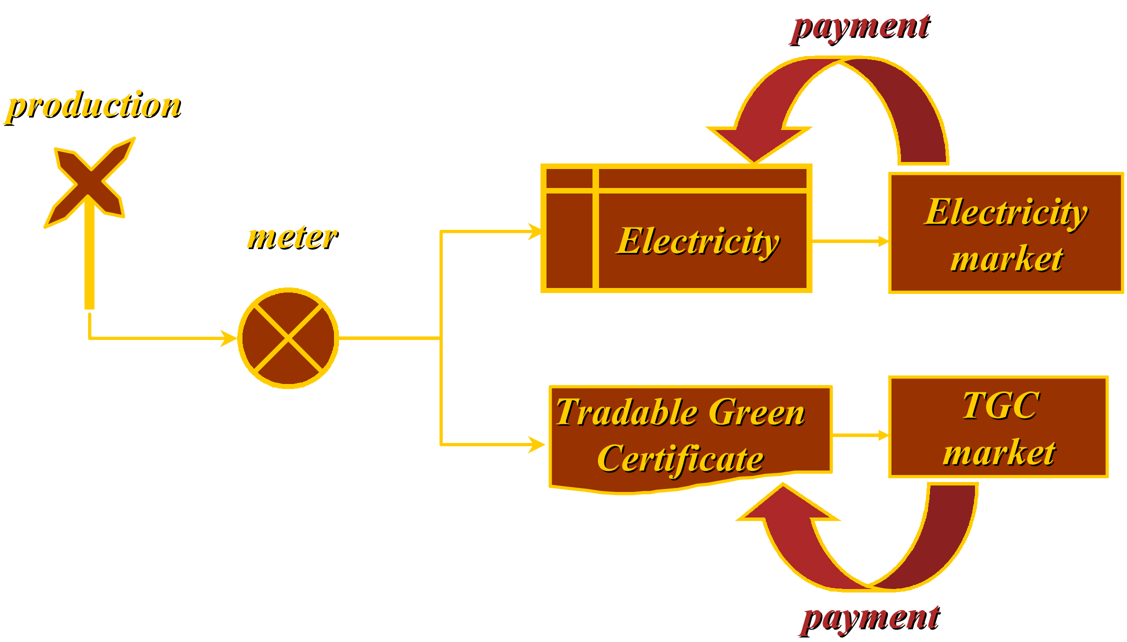


Figure 3.1 *The market of electricity and tradable green certificates*

Figure 3.2 shows the primary processes within a tradable green certificate system: acceptance of the renewable energy producer, production of electricity, issuing of the certificate, trade the certificate and the redemption of the certificate. There are two other functions that supports these primary processes: the registration and verification of all processes.

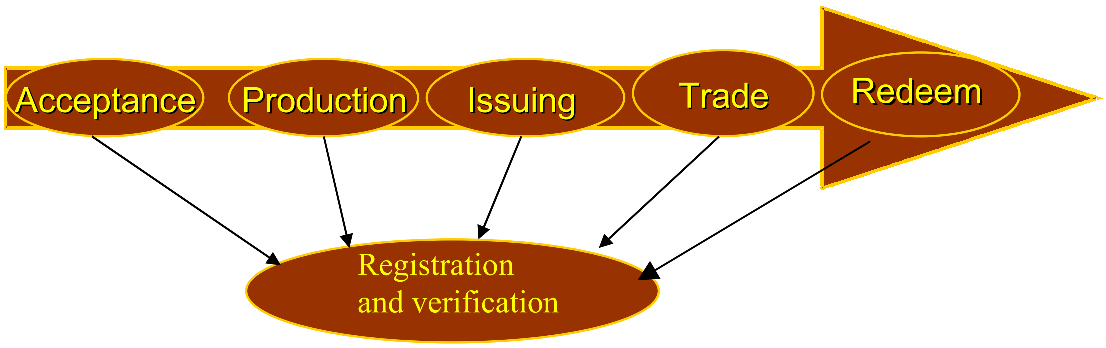
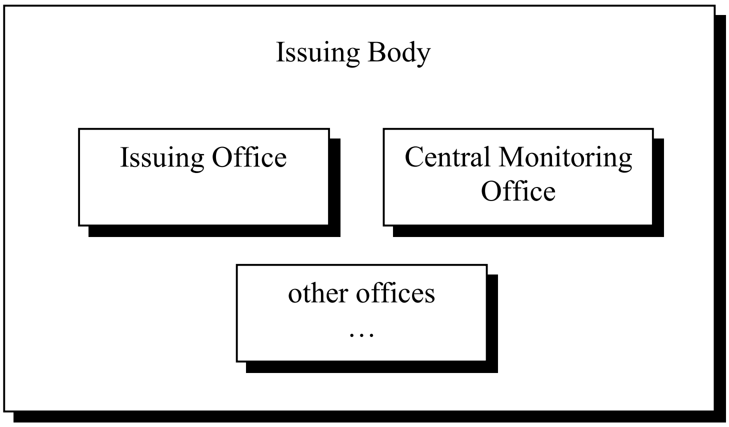


Figure 3.2 *The elements of a tradable green certificate system*

The Issuing Body (IB) is the organisation responsible for setting up a tradable green certificate system. The Issuing Body has several responsibilities. Besides setting up the system, the Issuing Body is also responsible for issuing of certificates and registration of all actions. These tasks can be fulfilled by two executive offices:

- an Issuing Office (IO) for the issuing of green certificates,
- a Central Monitoring Office (CMO) for registration of certificates.

It is necessary to separate these two tasks to prevent certain risks (such as incorrect use of certificates, disappearance of certificates in a 'black' circuit, conflict of interests between issuing, registration and verification). Chapter 3 addresses the different tasks in more detail.



- *What is required to run a tradable green certificate system?*

The introduction of a tradable green certificate system requires the following elements:

- clearly defined rules for the system (a 'protocol'),
- an organisational framework for the system,
- administrative software to issue and register certificates,
- a market with supply and demand.

- *Rules*

Every TGC system needs clearly defined rules for the system. Such rules have been developed for:

- the Dutch Greenlabel system (the rules are given in the 'Protocol Monitoring Green Labels' and the 'Decision on Renewable Energy'),
- the European Renewable Energy Certificate System (the set of rules are documented in the 'Basic Commitments'[15]).

These sets of rules can form an example for a protocol of the Chinese system.

- *Organisational framework*

TGC system requires clearly identified organisations to run it successfully. The tasks and responsibilities of these organisations are described in the rules of the system. Section 3.3 gives more detail on the organisational framework.

- *Administrative software*

The required procedures to run the system include the necessary software. It defines how and when green certificates are issued, and how they are registered. Section 3.4 describes the software, which is available within the European Renewable Energy Certificate System (RECS). This software can be regarded as the standard for running the administration of tradable green certificate systems.

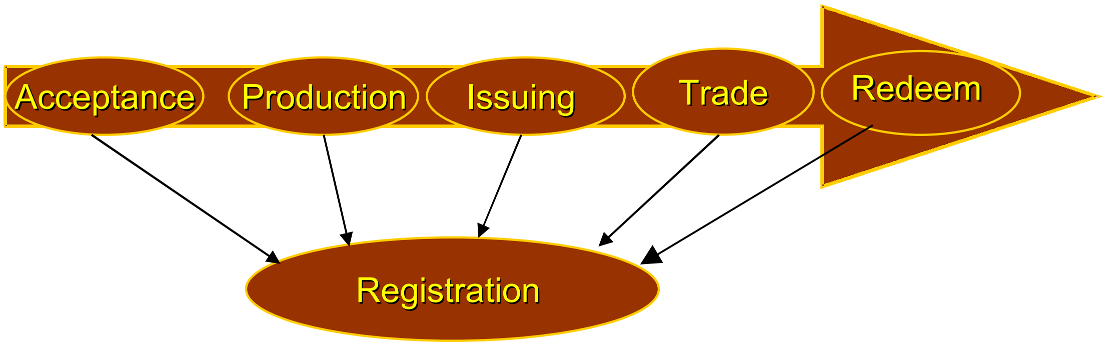
- *Market with supply and demand*

A certificate system works only when there is sufficient demand. How the demand for certificates can be organised for China, will be described separately. The way demand is created has some implications for administrative procedures and software. However, our current European software standard can deal with all possible ways to organise demand.

[15] This document can be found at http://www.recs.org.

3.3 Organisation of a tradable certificate system

The primary processes within a tradable certificate system are: acceptance, production, issuing, trading, redemption and registration.



For each of these processes tasks can be defined for the involved actors, which will be described in this section.

Overall organisation (tasks executed by the Issuing Body):
- propose rules,
- operate the TGC system,
- internal control and verification of the TGC system.

Acceptance (tasks executed by producer, trader and Issuing Office):
- apply to the Issuing Body to be recognised as a renewable energy producer,
- apply to the Issuing Body to be recognised as a trader,
- acceptance of renewable energy producers and traders.

Production (tasks executed by the producer):
- agree with the rules of the Issuing Body,
- request certificates from the Issuing Office,
- report transactions to the Central Monitoring Office.

Issuing (tasks executed by the Issuing Office):
- approve and register the amount of electricity generated,
- make and issue tradable green certificates,
- report to the Central Monitoring Office.

Trading (tasks executed by accepted traders):
- trade in registered certificates,
- report transactions to the Central Monitoring Office,
- agree with the rules of the Issuing Body.

Redemption (tasks executed by the end-user):
- report certificates for redemption to the Central Monitoring Office,
- agree with the rules of the Issuing Body.

Registration (tasks executed by the Central Monitoring Office):
- register all accepted participants,
- register all certificates issued,
- register mutation of ownership of certificates,
- register the status of the traded certificates,

- give information to the Issuing Body,
- provide statements on redemption.

Figure 3.3 shows the primary process with the supporting functions.

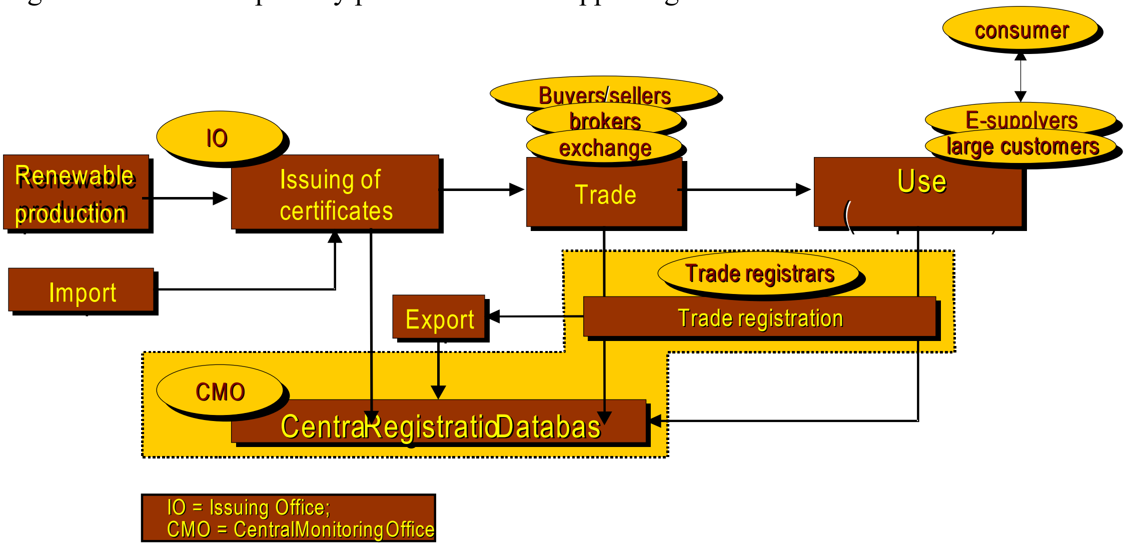


Figure 3.3 *The primary process with supporting functions*

3.4 Software for a tradable certificate system

In Section 3.3 we described the organisation and tasks of the different actors in a tradable green certificate system. A large part of the work and tasks of these actors can be supported with software tools. In the RECS system the necessary software has been implemented and works satisfactory. In this Chapter we describe available software illustrated with windows-screens. Figure 3.4 shows schematically the software modules available within the RECS system.

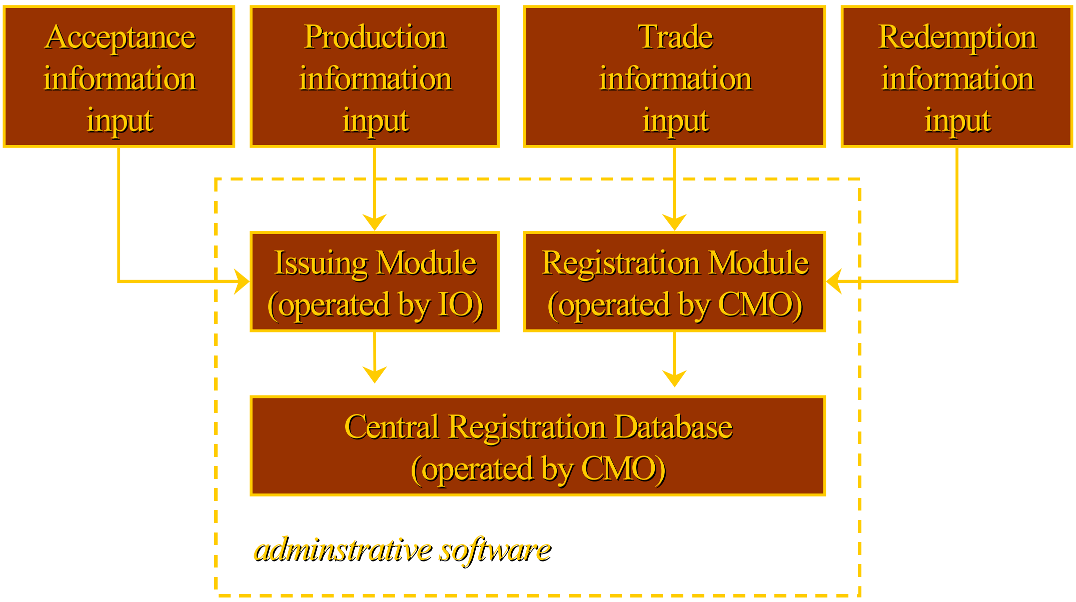


Figure 3.4 *The set-up of the administrative software and its required input*

The Central Registration Database forms most important element of the administrative software of a tradable green certificate system. For each participant in the certificate system, the Central Monitoring Office keeps an account in this database on which certificates can be deposited or withdrawn. Deposits on the account can occur through issuing of certificates (if the account is

owned by a producer) or by buying certificates. Withdrawals can occur by selling or redeeming certificates.
The Issuing and Registration Modules are two software packages that provide user-friendly access to the Central Registration Database.

3.4.1 Production of renewable energy

Within a tradable green certificate system, the producer of renewable energy has to submit information of his production site to the Issuing Office before any certificates can be issued. The Issuing Office will process this information on the produced amount of renewable energy using the Issuing Module of the administration software. Hence the Issuing Office can, after some checks, issue certificates to the producer. Figure 3.5 shows this schematically.

The amount of energy produced is registered through meter readings. This figure can be sent either automatically to the administration software of the Issuing Office but also as a request form.

To ensure that the amount of electricity that is certified corresponds to the actual amount of electricity, which is generated, the Issuing Body may order that audits are carried out.

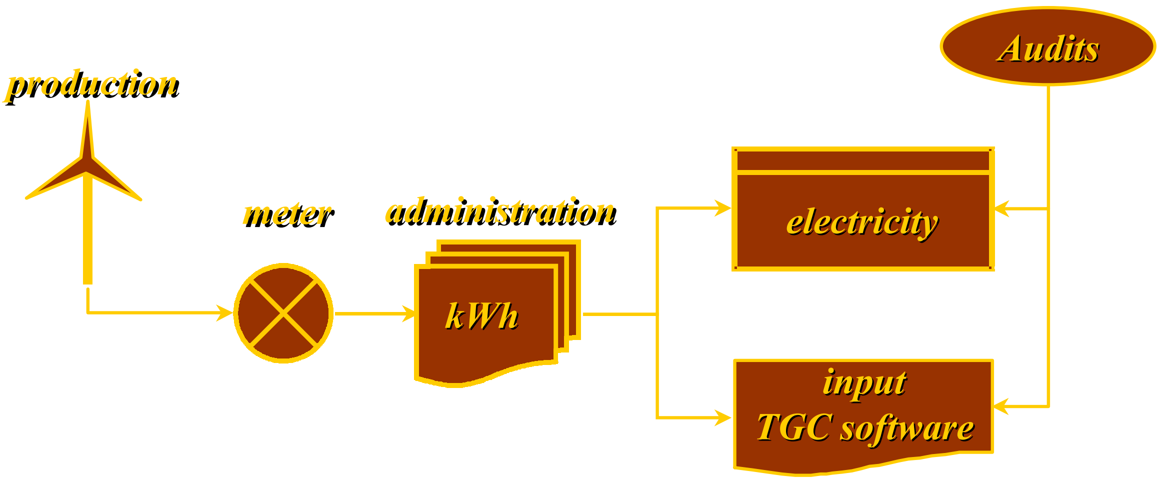


Figure 3.5 *Issuing tradable green certificates - step 1*

3.4.2 Issuing green certificates

The Issuing Body is responsible for issuing certificates. The actual administrative work of this responsibility is carried out by an Issuing Office, which operates the issuing module available in the RECS software.

The Issuing Office has to:

- accept and register renewable energy producers before any certificates are issued,
- issue certificates following production of renewable electricity,
- report the identification numbers of certificates to both owners and Central Monitoring Office.

Accept and register production devices

As we described in Chapter 3, one of the tasks of the producer is to submit an application to the Issuing Office in order to be accepted as a registered participant in the system. If the application is accepted, the Issuing Office registers all relevant information on the producer and on the production device.

The Issuing Module of the software provides the Issuing Office the functionality for managing the production device data:

- register the name and address of the owner of the production device,
- register the number of the certificate account on the Central Registration Database on which certificates for the production device will be deposited,
- create a new registered production device and issue a unique identification number for this device,
- enter the relevant data on this device into the database of the system (the data are entered from accepted application form, *see Figure 3.6),*
- record the date on which the registration took place.

In case the production device has been modified after acceptance and a notification has been received by the Issuing Office, the following actions can be handled by the software:

- update of the registered information on the production device,
- re-register the production device,
- record the date on which the modifications in the production device took place,
- record the date on which the re-registration took place.

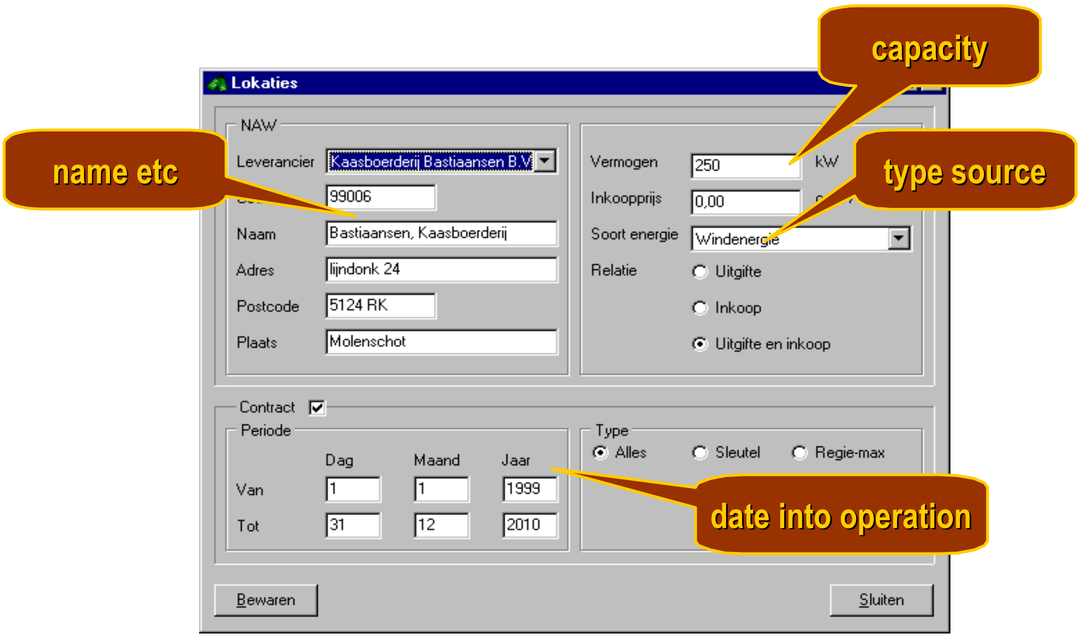


Figure 3.6 *Illustration of the screen on which data on the production device can be entered*

Issuing certificates

In order to issue certificates, the Issuing Office requires information on the electricity production of a registered production device in a particular month. These meter readings, in combination with the identification number of the production device, can be supplied in two ways:

- in an input file in which the meter readings are given (the file may be prepared by the network company, which reads the meters),
- using a request form on which the meter readings are specified.

The Issuing Office enters the information into the Issuing Module of the RECS software. The Issuing Module subsequently handles the complete process of issuing certificates for a production device. On receipt of meter readings for a given month and production device, the Issuing Module performs the following checks (see Figure 3.7):

- is the production device known and registered by the system,
- what was the last period over which certificates have been issued for this production device,

- is there an amount of electricity generated in previous periods, which has not yet been settled for this production device,
- is the produced quantity of renewable energy within the feasible limits of the production device,
- is the amount of electricity generated in this period sufficient to issue a certificate,
- how many certificates can be issued for this production device.

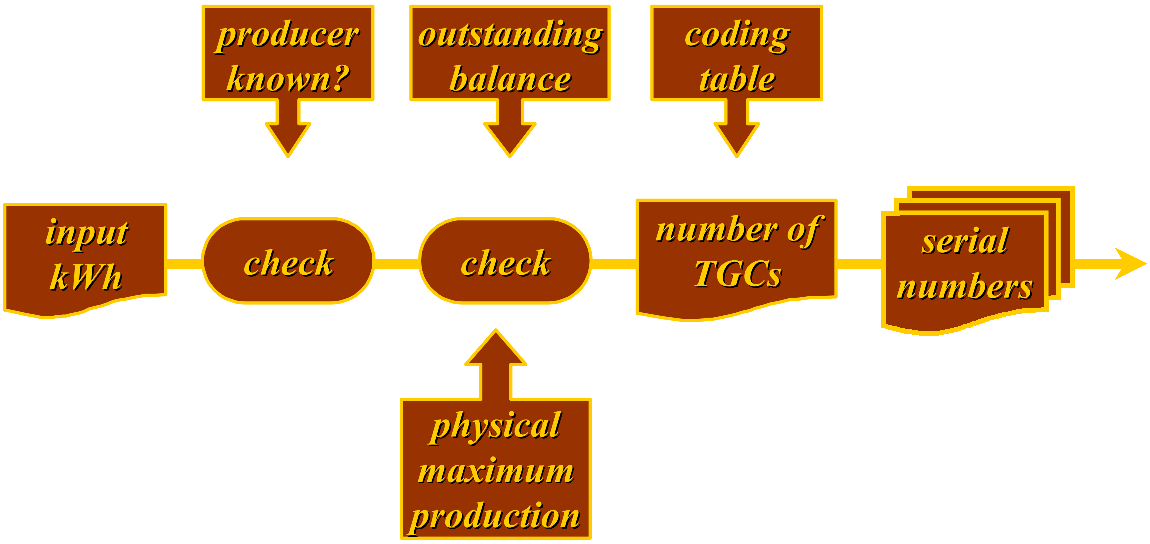


Figure 3.7 *Issuing Tradable Green Certificates - step 2*

In case these checks have been passed in good order, certificates are issued according to the amount of electricity produced. Also the outstanding balance of electricity production for each production device is updated. Figure 3.8 shows the screen, which enables an administrator of the Issuing Office to prepare the data to issue certificates for a particular production device with manual data entry based on a request form. In case input files with data are received by the Issuing Office the issuing process runs automated.

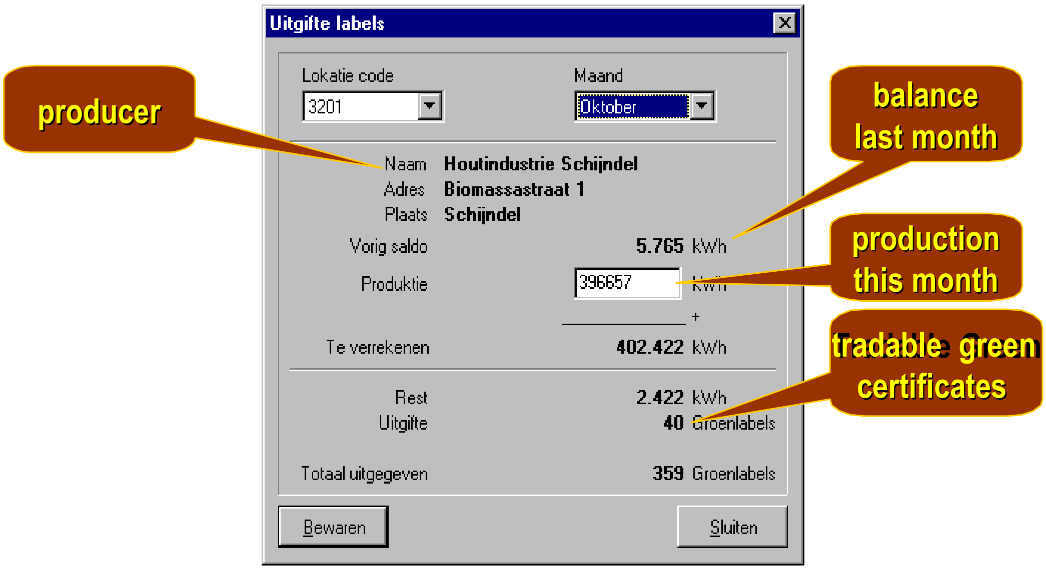


Figure 3.8 *The screen enables an administrator to issue certificates for a particular production device with manual data entry based on a request form*

To allow verification by the administrator of the Issuing Office of all data, certificates are not issued immediately following data entry (regardless whether data were entered manually or automatically from an input file). All data entered are stored on a separate data sheet for inspection by the administrator to ensure that these are correct. In case errors are observed (e.g. apparent typing errors), corrections can be made manually.

When all data have been found to be in good order, the administrator can update the database and certificates are issued for each production device for which production figures have been entered. The module performs the following actions:

- each certificate is given a unique identification number (see the appendix for the rules for assigning this unique identification number)
- each certificate is registered on the name of the owner of the corresponding production device and assigned to his account on the Central Registration Database.

Reports on issuing

The Issuing Office provides information to owners of production devices, the Issuing Body and the Central Monitoring Office.

For owners of production devices the software prepares the following statements:

- an overview of registered data on the production device following acceptance by the Issuing Body (one initial registration and updates upon modifications),
- a monthly overview of the amount of certificates issued (and the identification numbers assigned) and the balance of any outstanding amount of electricity production not settled yet.

The software produces the following general data reports, which are available for the Issuing Body:

- the amount of certificates issued and its distribution over various renewable energy sources,
- the amount of electricity for which certificates could not yet be issued,
- the number of production devices registered and its distribution over various renewable energy sources,
- the details of all production devices,
- the number of owners of production devices and their details,
- the period in which certificates have been issued,
- how many modifications have taken place in registered production devices and when these modifications took place.

For the Central Monitoring Office, the software prepares at regular intervals the following input, which is incorporated into the Central Registration Database:

- identification numbers of all certificates issued,
- names and identification numbers of the owners of these certificates,
- names and other relevant details of owners of recently accepted production devices,
- data on recently accepted production devices.

3.4.3 Trading green certificates

All participants in a tradable green certificate system can buy or sell certificates. As a result of these trades, the ownership of certificates changes. Since the ownership of a certificate is registered centrally in the database of the Central Monitoring Office, owners are required to notify this office when ownership of a certificate should be transferred to another participant as a result of a trade deal. To maintain the reliability of the system as a whole, the Central Monitoring Office will then change the ownership registration of the certificate.

For each participant in the certificate system, the Central Monitoring Office keeps an account on which certificates can be deposited or withdrawn. Figure 3.9 shows how the balance of that account is affected by trade transactions:

- certificates can be deposited through purchases of tradable green certificates and increase the balance of the account[16]
- withdrawals decrease the balance of the account and can result from
  - selling certificates to other participants,
  - redeeming certificates for given reasons.

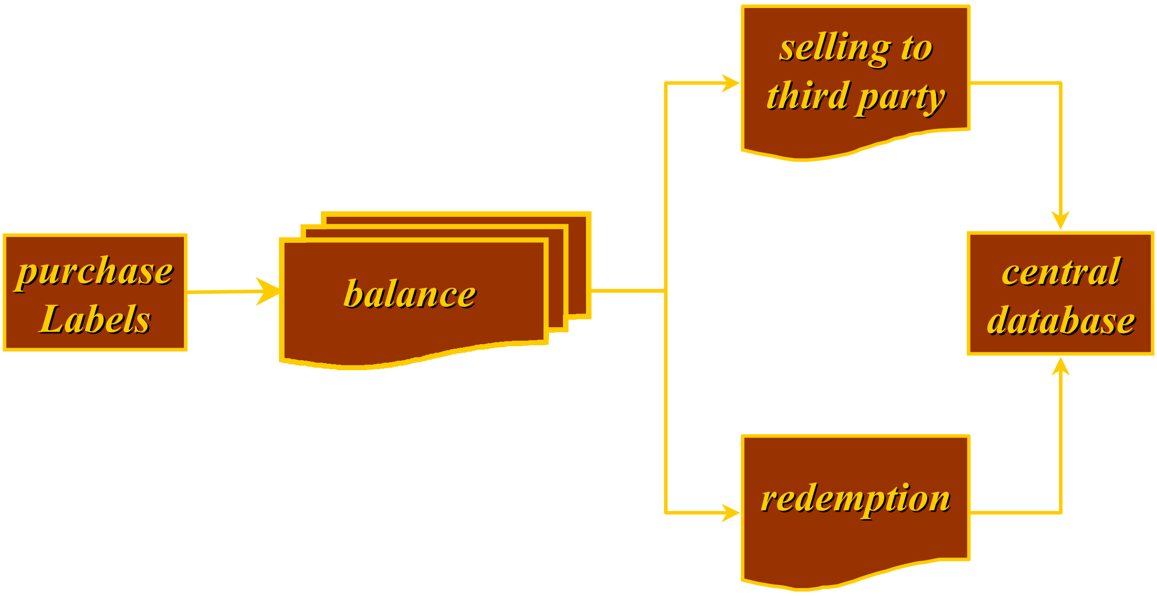


Figure 3.9 *How trade affects the balance of the certificate account of a participant in a tradable green certificate system*

Figure 3.10 shows an example the account of a participant. For each account the following data are registered:

- the owner of the account,
- the total amount of certificates currently present,
- the dates on which certificates are deposited or withdrawn through buying and selling,
- the total amounts of certificates which have been deposited or withdrawn,
- the identification numbers of certificates.

[16] If the account is owned by a producer of renewable electricity, then its balance also increases when certificates are issued and deposited.

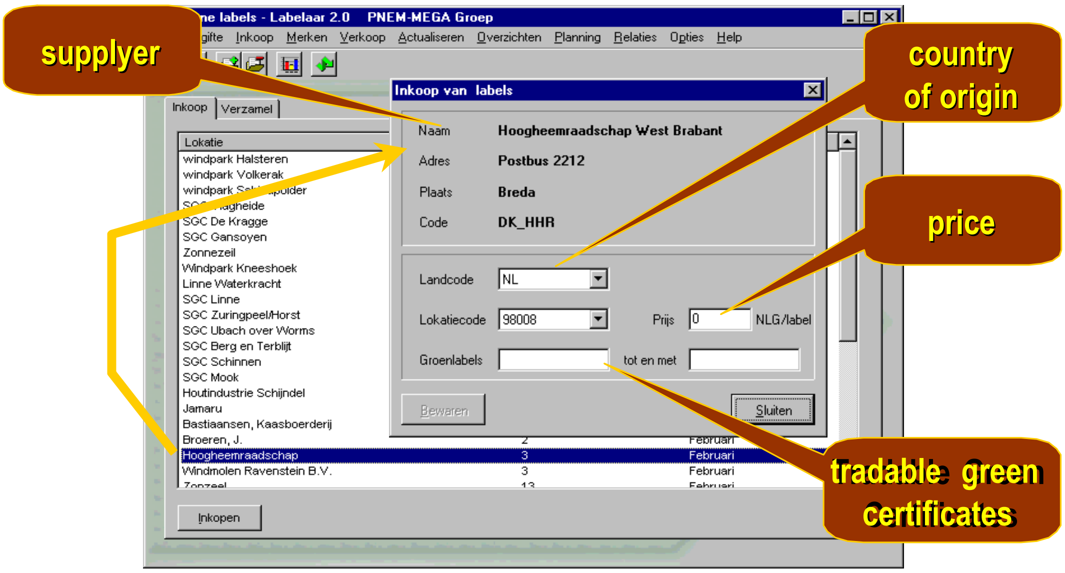


Figure 3.10 *Registration of purchase of TGCs*

When a trader is accepted by the Issuing Body, he or she can actually trade with registered certificates on his or her account. Any transaction made has to be reported to the Central Monitoring Office, where the ownership of the certificate will be transferred from the selling to the buying party. Orders for the transfer of certificates from one account to another can be given only by the selling party.

Transfer of ownership

On receipt of a request for transfer of certificates by the owner, the data from the request have to be entered into the Registrar Module (see Figure 3.11). This part of the software performs subsequently the following actions:

- checks the validity of the certificates:
  - have the certificates been issued and are they present in the Central Registration Database,
  - are the certificates still available for transfer (i.e. not redeemed, not exported, not blocked).
- checks whether the certificates are actually registered on the account of the owner (i.e. the selling party),
- checks whether the buyer has an account on the Central Registration Database,
- transfers the tradable green certificate from the seller's account to the buyer's account,
- reports the transfer to the Central Registration Database.

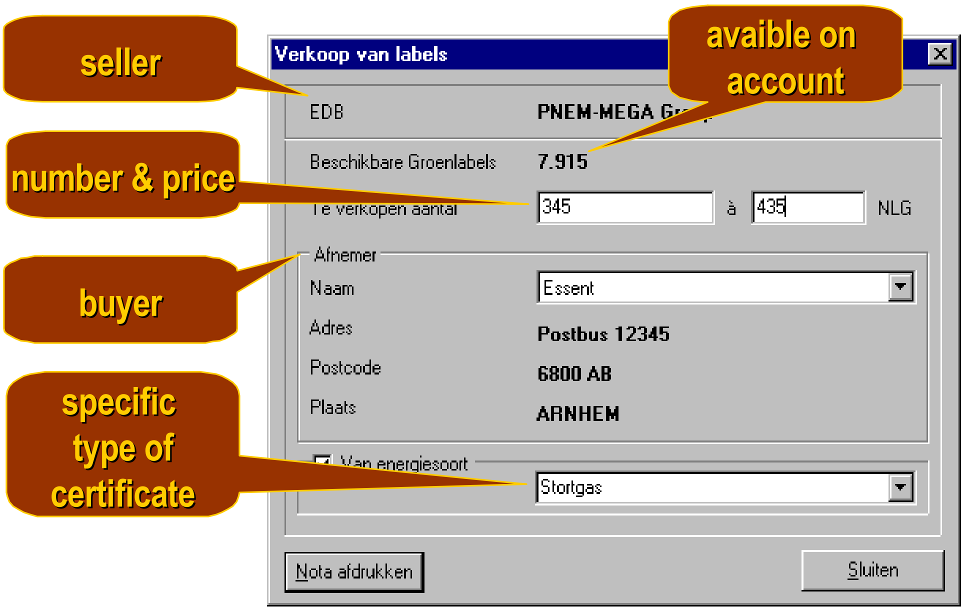


Figure 3.11 *Selling to third parties*

All owners of an account on the Central Registration Database will receive an account overview when a change in their account has taken place. An example of such an overview is given in Figure 3.12.

Account owner <Name> **Reference** <id-number account owner>
<Address>
<City>

Date <dd-mm-yyyy>

Overview Tradable Green Certificate account for <month/year>

Last balance <number> **Tradable Green Certificates reported on** <dd-mm-yyyy>

Bought <number> **Tradable Green Certificates**

Sold <number> **Tradable Green Certificates**

New balance <number> **Tradable Green Certificates**

See specification print for full details

Figure 3.12 *Example of an account overview*

Import and export of certificates

On receipt of a request for export[17], the registration module:

- checks the validity of the certificates,
- marks the certificate as exported,
- reports the export of the tradable green certificate to the seller,
- reports the export to the Central Registration Database,
- transfers the certificate to the buyer's account.

[17] Cross-border trade is an important element of the European RECS system. For China, import and export could, however, be excluded from the official design of a tradable green certificate system. The procedures used can, on the other hand, form the basis to manage and administer trade in certificates between provinces in China.

On receipt of a tradable green certificate exported from another domain (see Figure 3.13), the registration module:

- sends an import request to the Central Registration Database, operated by the Central Monitoring Office, which is responsible for checking the status of the exported tradable green certificate,
- on receipt of acknowledgement from the Central Registration Database, the Central Registration Database transfers the tradable green certificate to the buyer's account.

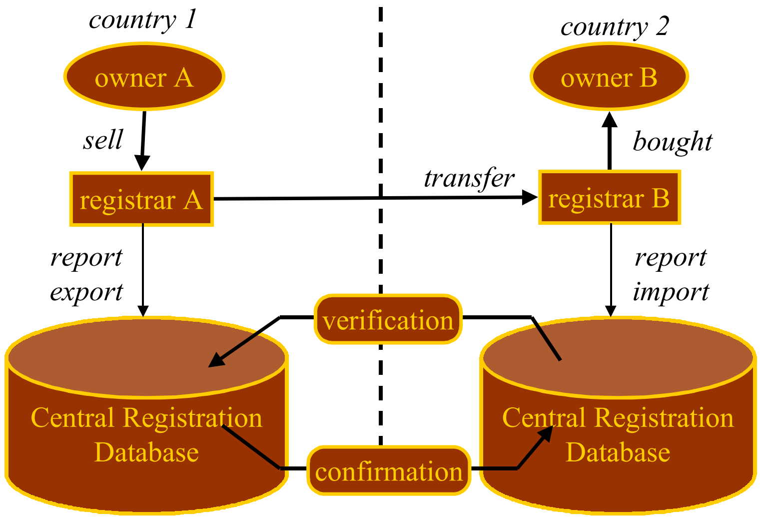


Figure 3.13 *Example of import and export of certificates*

3.4.4 Redeeming green certificates

At any given moment, an owner may want to use his certificates for a particular purpose. There can be many reasons to use certificates and these may include for instance:

- meeting a voluntary target or an obligation for renewable energy set by the government,
- selling of green electricity by an electricity supplier to its customers as part of a green pricing programme,
- obtaining tax credits from the government,
- fulfilling environmental policy of a company,
- etcetera.

We will not deal with the way in which the demand for certificates can be organised and how under such a policy redemption would take place exactly. Here, we will focus on the administrative handling of redemption through the use of software for two reasons:

- The administrative procedures are more or less the same regardless of the way in which nature demand for certificates is organised.
- Our software is capable of handling redemption, which can be ordered by owners for a number of reasons.

To redeem certificates the owner of these certificates has to submit a request to the Central Monitoring Office. This request contains the following information:

- the amount of certificates he wants to redeem,
- optionally he may also specify particular identification numbers,
- the reason for which he wants to redeem certificates.

On receipt of a request for redemption, an administrator uses the Registrar Module of the RECS software to handle the order (see Figure 3.14). The software performs the following actions:

- checks the validity of the certificates:
  - have the certificates been issued and are they present in the Central Registration Database,
  - are the certificates still available for transfer (i.e. not redeemed, not exported, not blocked).
- checks whether the amount on the account of the owner is sufficient to cover the order,
- in case the owner has specified particular identification numbers, it checks whether the certificates are actually registered on the account of the owner,
- marks the certificates as redeemed and records the reason for which they have been redeemed,
- reports the redemption to the owner and to the Central Registration Database.

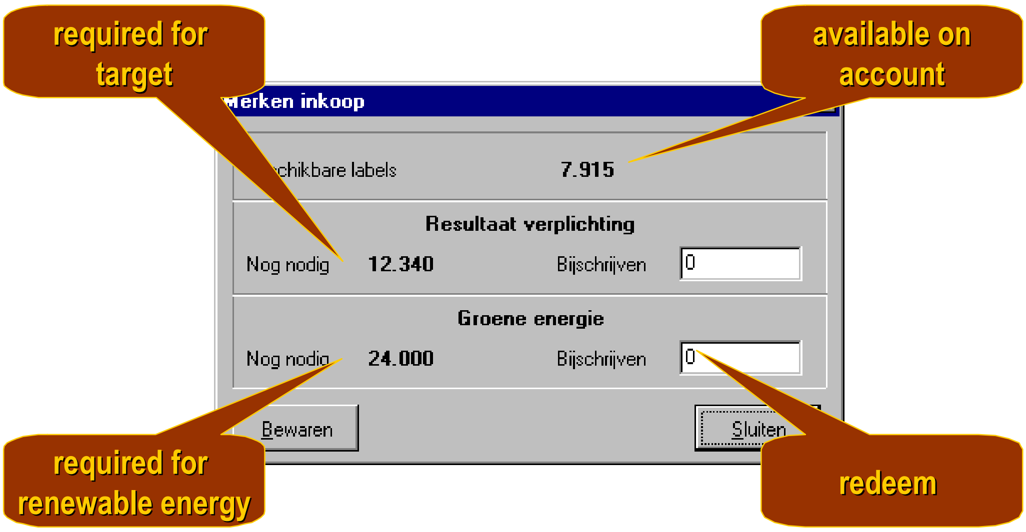


Figure 3.14 *Screen to handle the redemption of TGCs from the account of an owner for several purposes*

3.4.5 Central Registration Database

The Issuing Body is required to verify the three processes, which are crucial in the TGC system: issuing, trade and redemption. The administration for this verification is enabled by the Central Registration Database, which is operated by the Central Monitoring Office.

The main task of the Central Registration Database is to:

- register participants,
- register certificates issued,
- transfer the ownership of certificates,
- redeem certificates,
- verify functions performed by the Issuing and Registrar Modules,
- verify and confirm the validity of import and export,
- monitor activities in the TGC market,
- report regularly on the numbers of tradable green certificates issued, imports and exports, and redeemed.

Figure 3.15 shows the registration process schematically. The verification procedures take place in the central database. Errors are detected and shown in monthly reports. In case the demand for certificates is created by a target for certain participants, these monthly reports also provide information if these participants meet their targets. If targets are not met, sanctions could take place on the basis of this information.

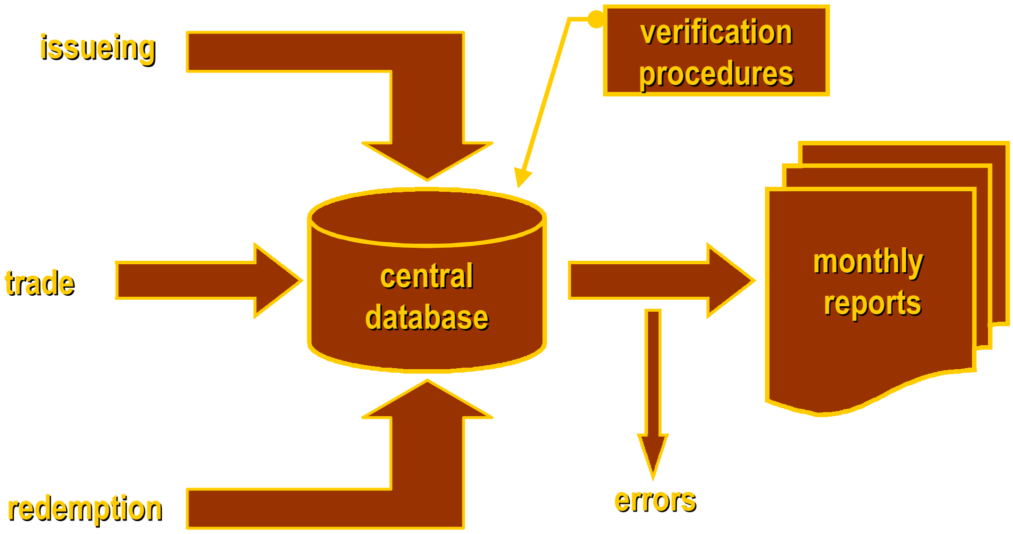


Figure 3.15 *Central registration*

The registration of certificates takes place in analogy with bank accounts:
- Each participant has its own account on which certificates can be deposited or withdrawn.
- The Central Monitoring Office sends account statements to all participants (producers, traders and end-users),
- Changes in the Central Registration Database take place only when orders concerning the transfer of certificates have been received from the owner of the certificate.

All certificates are marked when issued with the status identifier 'transferable' in the Central Registration Database. These certificates can be transferred to the account of another owner when an order for such a transfer has been received.

The status identifier may change in the following cases:
- When an owner has given an order to redeem the certificate. It will be marked in the Central Registration Database as 'redeemed'. Certificates marked as redeemed are no longer transferable to any other owner.
- When an owner has given an order to export the certificate. It will be marked in the Central Registration Database as 'exported'. Certificates marked as exported are no longer transferable to any other owner.
- When the Issuing Body has given an order to mark the certificate as non-transferable. It will be marked in the Central Registration Database as 'non-transferable'. Certificates, which are marked as such are no longer transferable to any other owner.
- When the Issuing Body has given an order to mark the certificate as temporarily blocked. It will be marked in the Central Registration Database as 'blocked'. Certificates, which are marked as such, are not transferable to any other owner as long as the blocking period has not been lifted by the Issuing Body. When the Issuing Body agrees to lift the blocking period, the status is reset to 'transferable'.

The software is designed such that it is easy to implement a billing systems based on the number of certificates issued or traded or on the number of transactions.

The Central Registration Database performs ongoing plausibility checks on incoming data. Irregularities, which are detected in the incoming data, are recorded in a log-file, so that errors can be traced to their source.

3.5 Recommendations for implementation

In this Chapter we give a set of recommendations for the implementation of a tradable green certificate system in China.

The introduction of a tradable green certificate system in China requires important decisions in the energy policy of the government of People's Republic of China. Elements of such a decision concern:

- design the rules for this tradable green certificate system,
- set up the organisation and infrastructure for this system,
- organise the demand for certificates.

To introduce a tradable green certificate system China can use the approach of *learning by doing*. This approach of learning by doing offers several advantages:

- it enables a quick start of,
- it can build on experiences from elsewhere,
- it offers flexibility in its development by adapting to lessons learned,
- it allows a gradual expansion into a fully developed system.

The roadmap for an introduction based on learning by doing may look as follows:

- start a pilot project in a selected number of provinces limit this pilot project, at its beginning, to the following processes:
  - issuing certificates to the production of renewable electricity,
  - registering these certificates.
- use the Basic Commitments of the European RECS as the basis for the set of rules for this pilot and adapt where appropriate to the legal and economic situation in China
- use the administrative organisation and software we described in this report as the starting point to build a system in the selected provinces
- expand the system over time by adding
  - policy to create demand for certificates,
  - trade in certificates,
  - more provinces in China.

In setting up a tradable certificate system, properly functioning administrative software plays a crucial role. The European software we described in this report can be regarded as a standard for such a system. It covers all functionalities to cover all administrative processes and run a reliable operation.

In its present form, the European version of the software can help to start a pilot project to implement a tradable certificate system in China. For smoother implementation a translation of all screens and help files from English into Chinese is required. Depending on the requirements of the government of China, possibly some minor modifications are necessary regarding:

- the size of the renewable electricity certificate (now 1 MWh, but a larger size may seem more practical in China)
- the list of renewable electricity technologies, which is covered.

Also, the way in which demand for certificates is organised has some implications for the administrative software. At present, however, our current European software standard can deal with all possible ways to organise demand and forms of redemption. The present functionalities for redemption will, therefore, be sufficient for use in a pilot project.

According to our preliminary estimates, the handling and storage capabilities of the European software version will be adequate for a pilot project. When a pilot project is started, it is important to investigate the scale in China:

- how many producers of renewable energy will participate,
- how much energy do they produce on a monthly and annual basis,
- how many provinces take part in this project.[18]

Finally, to arrive at a fully Chinese version of the administrative software for a tradable certificate system, the following steps should be taken in due course:

- a design phase in which standards and functionalities of the software are set specifications are written and a contractor for building the software is selected,
- actual building of the software according to the design specifications and testing of the product after completion,
- finally, implementation of the software itself and the training of all people and organisations involved.

[18] The present European version can handle a limited amount of certificates which is tuned to the renewable production of countries such as France and Germany (about 100 million certificates of 1MWh). In case the production in China exceeds this amount, modifications are required. Possible solutions are:

- within the organisation of the tradable green certificate system: make use of central monitoring offices per province, which limits the information that should be registered.
- enlarge the size of the green certificate (now 1 MWh) up to a more practical size.

4. REBUS CHINA TRAINING MANUAL

4.1 Introduction

This manual explains the backgrounds and working of the REBUS analysis framework. REBUS stands for Renewable Energy Burden Sharing.

The background of this analysis framework lies in the European Union Renewable Energy policy. At the level of the European Union a policy target for renewable electricity has been formulated (22 % in 2010), and the question is how this overall target can be equally divided among the 15 EU Member States. A division of targets has been proposed recently. This burden sharing process is of course a political process of negotiation. Within this political process an analytic framework, such as the REBUS framework, can be a helpful tool. The relation of the EU and its Member States is somewhat similar as the relation between the Central Government in China and its provinces. Therefore the REBUS framework has been adapted for China, and this manual explains its workings.

An important part of the political process will be the question what policy targets are to be reached by the proposed renewable energy policy. One of those targets could be a fair sharing of the cost burden of the renewable policy. This leads to the question of what is perceived as 'fair'. The REBUS model provides different 'fairness rules', or 'equity criteria', and their consequences can be analysed.

An important condition of renewable energy policy is often that the target is reached in a cost-effective way. An important means to reach this cost effectiveness is to introduce the possibility of trading. In the REBUS analytic framework it is assumed that trading occurs through the trading of green certificates, and not of the physical electricity itself.

The REBUS framework consists of the REBUS-spreadsheet model and various spreadsheets to calculate so called renewable energy cost-potential curves. The idea is that every province has different natural circumstances, leading to different possibilities of producing renewable energy for different costs. This relation has to be determined for each province, and is presented in provincial cost-potential curves. These cost-potential curves are the major input of the REBUS-model, and often the most difficult part of the whole REBUS analytic framework. There are several ways to construct cost-potential curves. The theoretical best way is also the most time-consuming and difficult one: determination of all the sites where renewable energy can take place in each province. A more general, top-down, approach, based on general statistical data, will be used in this manual. However, also this approach takes time, and needs explanation.

This manual will explain how cost-potential curves can be constructed and also how the REBUS model works. This will be done each time by first explaining the background, followed by a description of the concrete implementation in the different spreadsheets of the REBUS analytical framework.

Section 4.2 will explain the theoretical background of Burden Sharing options. In section 4.3 the structure of the different interacting spreadsheet models that form the REBUS analytical framework will be explained and special attention will be given to how to calculate costs for renewable energy production. Section 4.4 will explain how estimations of renewable potentials can be made in general. Section 4.5, 4.6 and 4.7 will go into more detail of the potential estimation for China with regard to wind energy, solar energy and biomass energy options. Section 4.8 explains the working on the REBUS-spreadsheet.

4.2 Theory of Burden Sharing options

4.2.1 Introduction

The potential of achieving maximum cost effectiveness on the scale of China can be reached through the possibility of trading. The advantage of trading green certificates instead of green electricity is that no physical barriers exist to this trading. Trading opportunities exist because of different values of green certificates in each country. In each country this value depends on the possibilities within a country to produce green electricity (the supply curve) and its target (the demand curve). This means that national target setting is a crucial aspect for international trading of green certificates. The combination of national targets and the respective supply curves also determines the total cost burden in each country. This raises the question how cost can be equally shared among the provinces of China and what an approach of equal burden sharing would mean for national target setting.

In this Chapter a conceptual approach will be put forward that deals with the question of equal burden sharing and the consequences of such an approach for national target setting[19]. The approach assumes that cost is the main consideration for decisions with regard to the deployment of renewable electricity in each country. Another assumption is that renewable electricity potentials and their cost can be known in a comparable way per country. The approach only takes direct cost into account. It will be illustrated by assuming an *imaginary community of three nations/provinces*, each with their own characteristics in terms of population, Gross Domestic/Provincial Product, total electricity demand and renewable electricity supply curves. The consequences on burden sharing and target setting of four different burden sharing rules will be shown. These burden-sharing rules are:

1. equal relative targets (in % of total electricity consumption),
2. equal marginal cost,
3. equal cost per capita,
4. equal cost per unit GDP.

The consequences of these four burden-sharing rules will first be elaborated for a situation without trade between the countries. Next the effects of free trade will be discussed. Finally for the last two burden-sharing rules, ‘equal’ national targets will be determined by taking into account the effects of trade.

In Section 4.2.2 the characteristics of the imaginary community of three countries will be explained. In Section 4.2.3 the difference of taking minimal total cost for the consumer or minimal total production cost as a starting point for a burden sharing analysis will be discussed. In the Sections 4.2.4 and 4.2.5 burden sharing with and without the possibility of trade will be treated. Section 4.2.6 will give the conclusions of this Chapter.

4.2.2 Characteristics of the countries

The imaginary community consists of three countries. They can be characterised as follows (see Table 4.1). Country A is a rich country with a relatively small population that consumes 100 TWh electricity per year. Its renewable potential is low, and its renewable electricity production possibilities are relatively expensive (Figure 4.1). Country B is an average country with respect to size of population and GDP. Its renewable potential is large and the possibilities it has are relatively inexpensive (Figure 4.2). Country C can be characterised as relatively large and poor, whereas its renewable energy potential is medium (Figure 4.3).

[19] The approach that will be described in the remainder of this Chapter has recently been implemented in an ECN model called REBUS (REnewable BUrden Sharing).

Table 4.1 *Characteristics of the countries*

Country	Size of population [million]	Gross Domestic Product Total [b$]	Per cap. [k$]	Total [TWh/year]
A	10	200	20	100
B	20	150	7.5	180
C	30	100	3.33	120
Total	60	450	7.5	400

Figures 4.1 to 4.4 show the supply curves of renewable electricity of each for the three countries and for the community as a whole. Each curve only covers 25% of the total electricity consumption and the vertical axes are assumed to be the same scale. The vertical axis represents the reference price for electricity. In this case it is assumed that even the cheapest options are more expensive than this reference price.

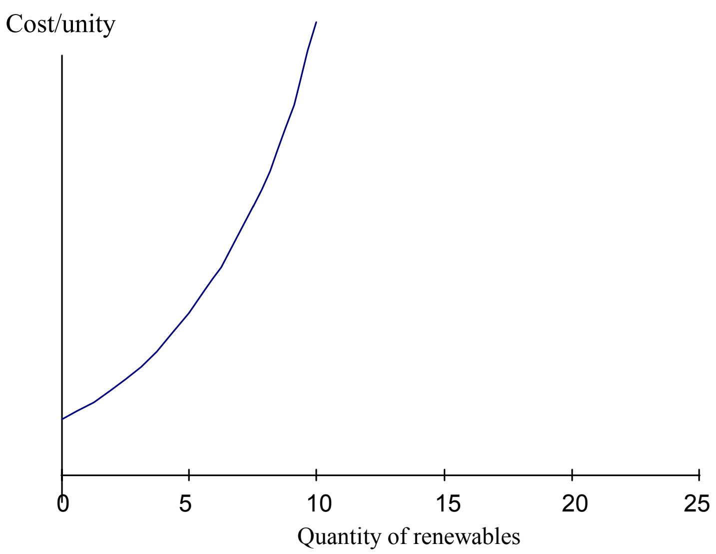


Figure 4.1 *The renewable electricity supply curve of Country A*

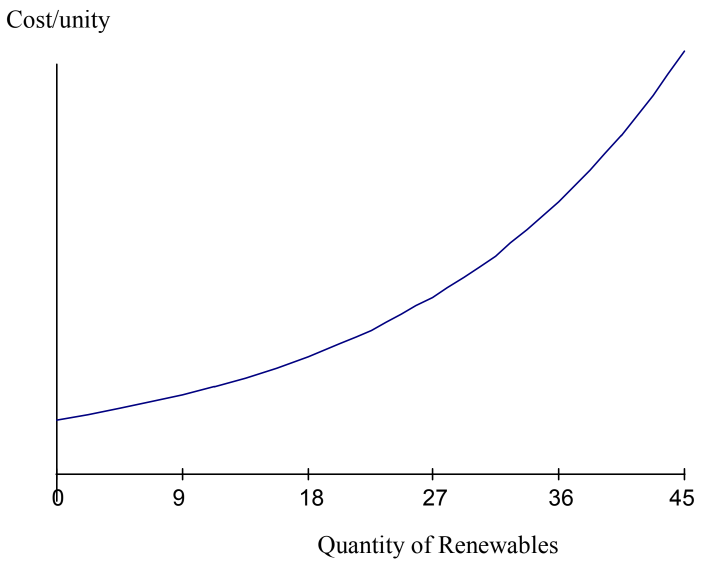


Figure 4.2 *The renewable electricity supply curve of Country B*

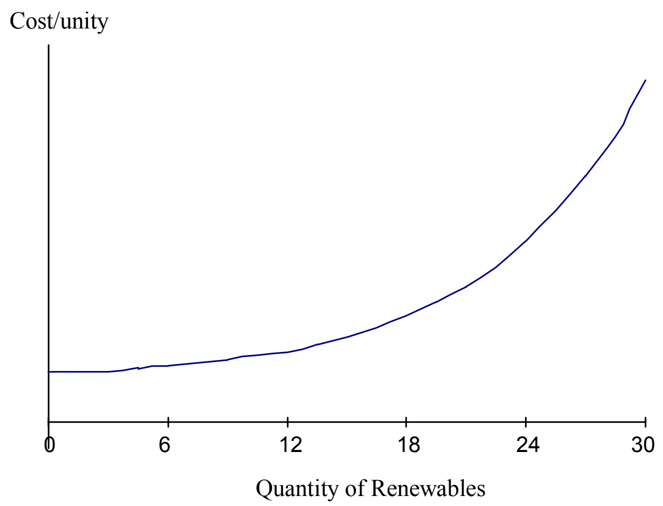


Figure 4.3 *The renewable electricity supply curve of Country C*

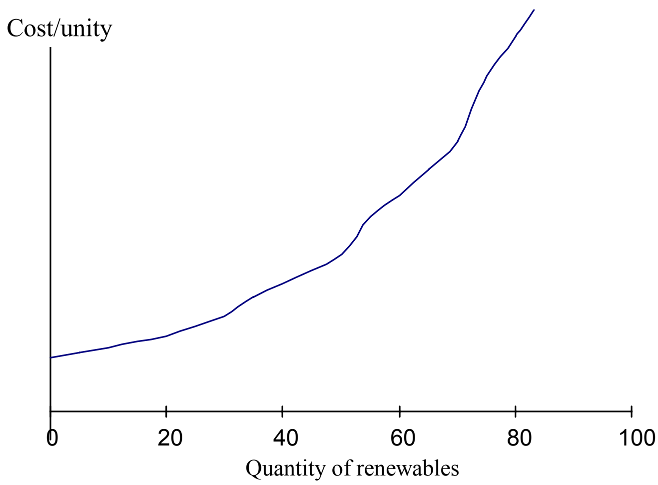


Figure 4.4 *The renewable electricity supply curve of the whole Community*

4.2.3 Total Cost

The community as a whole consumes 400 TWh of electricity per year. Suppose a target is set to produce 50 TWh (=12.5% of total electricity consumption) by renewable sources in a certain year in the future. If the countries collaborate well (e.g. by introducing a system of tradable certificates), they will develop the most inexpensive options in the community, which will result in total cost as indicated in Figure 4.5.

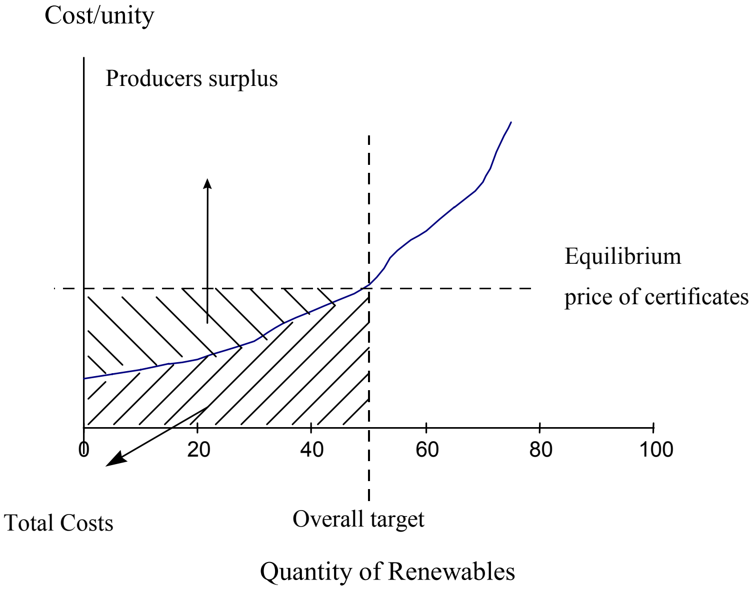


Figure 4.5 *Total cost and size of the green electricity market in the whole Community*

The point at which the target and the supply curve cross will determine the equilibrium price for trade of certificates. The shaded area under the supply curve until the target value represents the *total production cost* of reaching the target. If in all countries the market of certificates is created by an obligation on the part of the consumers, and the consumers have no possibility of producing the certificates themselves, then the potential profit on the certificate market for producers of green certificates can be indicated by the area above the supply curve and below the equilibrium price line (*the producers surplus*). Both areas together, equalling the target amount times the equilibrium price then represents *the total cost for consumers* of reaching the target.

4.2.4 Burden sharing: total cost for the consumer

If in each country the obligation will be put on the consumers, and the countries want to distribute the burden equally among their inhabitants, then an equal relative target of 12.5% of the consumers' electricity consumption seems fair, at least at first sight. Those who consume more electricity will pay more and those who consume less, will pay less. However, Countries B and C will probably not agree, because of the large income differences with Country A. Persons in Country A are, on the average, 6 times as rich as persons in Country C and 2.7 times as rich as people in Country B. One could argue that this would mean that the target for people in Country A should be 6 times as high as the target for people in Country C and 2.7 times as high as for people in Country B.

This assumption results in the following set of equations:

$$TREC_A/TEC_A = (GDPcap_A/GDPcap_C)*TREC_C/TEC_C$$
$$TREC_A/TEC_A = (GDPcap_A/GDPcap_B)*TREC_B/TEC_B$$
$$TREC_A + TREC_B + TREC_C = TREC_{TOTAL}$$

where

$TREC_X$ = Targeted Renewable Electricity Consumption of Country X
TEC_X = Total Electricity Consumption of Country X
$GDPcap_X$ = Gross Domestic Product per capita of Country X
$TREC_{TOTAL}$ = Targeted Renewable Electricity Consumption of the Community

Solving this set of equations for the three countries, using the figures of Table 4.1, results in a renewable electricity target for Country A of 26,7 GWh (26,7%), a target for Country B of 18 GWh (10%) and for Country C of 5,3 GWh (4.3%).

4.2.5 Burden sharing: Total cost of production

The assumption that in every country the obligation will be put on the consumer might not hold. In our imaginary Community we assume the principle of subsidiarity applies. This principle implies that the Community only provides general policy frameworks, whereas within this general framework the individual countries keep their freedom to make their own choices. Some of the countries for instance might not want to put the obligation on the consumers, but rather on the producers or suppliers of electricity. Such a choice would have disadvantages, but it has some advantages as well. Since producers and suppliers are able to make ‘make-or-buy-decisions’, they will choose to produce their own renewable electricity as long as the cost of doing this will be lower than the cost of buying green certificates on the international green certificate market, i.e. as long as their own marginal cost will remain below the equilibrium price. In that case total cost in a country will be limited to the total production cost (see Figure 2.5) plus possibly an amount that is imported from other countries (if trade is allowed). Another consequence of this subsidiarity principle is that countries might decide not to reach their target by a direct obligation but by other policy measures, such as premium feed-in tariffs, bidding systems, or capital subsidies. In such a case it will be difficult to assess what the burden per country will be, and how it will be distributed. What remains is the knowledge about the minimal production cost that could be achieved. In the third place, even if the obligation is on the consumers in all three countries, the possibility exists that a substantial part of the consumers will be able to make ‘make-or-buy’-decisions, e.g. by participating in wind power corporations, by exploiting small-scale hydropower plants, or by putting solar panels on their roofs. In such a case much of the consumers will provide, as self-producers, in their own certificates, and the total cost for consumers will get close to the total production cost. Also it can be imagined that one of the countries decides not to implement an obligation, but to leave reaching the target to the market in the belief that there will be enough customers, be it individual consumers or enterprises, that will be willing to buy ‘green electricity’. In such a case suppliers might want to maximise their sales by a product differentiation strategy. Low-cost green electricity, e.g. hydropower or (organic) waste incineration, might be offered against lower prices to specific customers than higher-cost green electricity, e.g. offshore wind to other customers. This means again that the cost for the consumer will get closer to the total production cost.

For all these reasons it is not evident that the ‘total minimal burden’ to be distributed will either be given by the sum of the shaded areas of Figure 4.5 (total cost for the consumer) or by the shaded area below the supply curve (total production cost). The consequences of taking the former as a starting point have been elaborated in the foregoing section. In the remainder of this Chapter the latter will be taken as a starting point.

4.2.6 Burden Sharing Without Trade

In this section we will start with a situation without any trade of green electricity or green certificates. This will serve as a point of reference and comparison for the analyses in later sections that take the possibility of trade into account.

Equal target rates

Suppose it is decided that each of the three countries will have to produce an equal percentage of their electricity consumption by renewable energy sources. Figure 4.6 shows the consequences for each country. The intersection of the supply curves with the target is the point that represents the marginal cost for each country, which differ substantially from each other. For Country A it is even not possible to reach the target. Moreover the shaded areas, which represent the total cost per country, differ substantially as well. Since there is no trade, options will be developed that would not have been developed if the Community had been regarded as one country. This means that the total cost for the Community as a whole is not minimised.

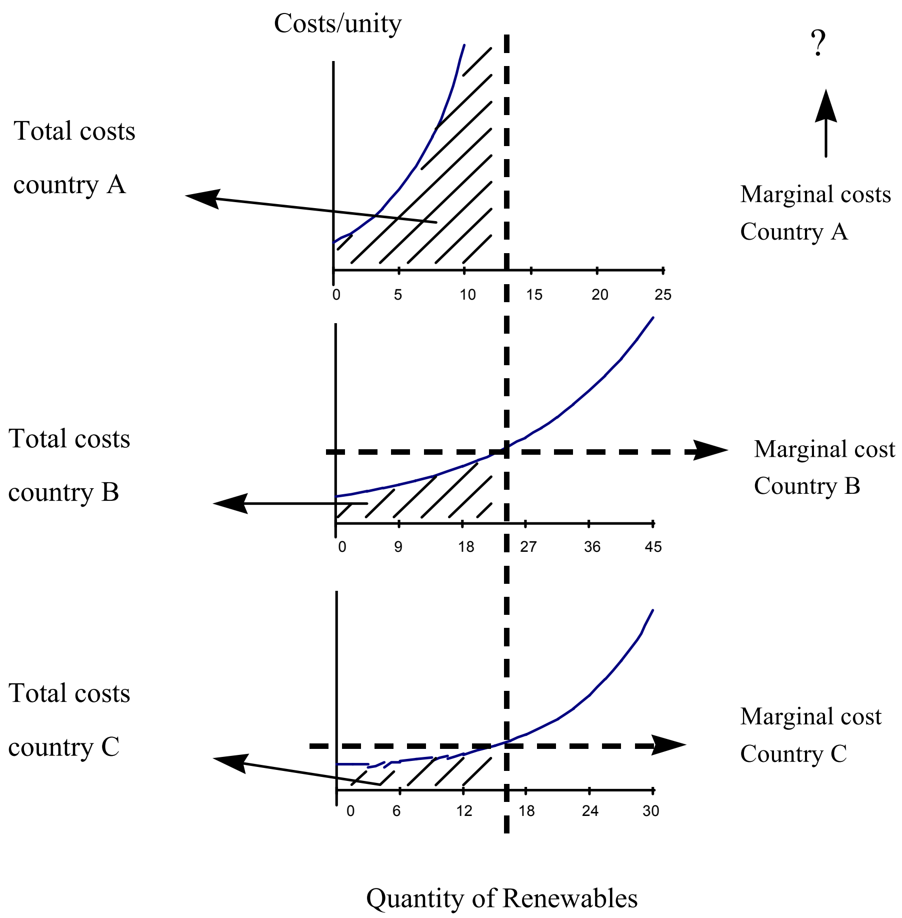


Figure 4.6 *Equal targets per country*

Equal marginal cost

The only way in a situation without trade to get rid of the disadvantage of not having minimal total cost for the Community as a whole is to divide the targets in such a way that marginal cost are equal (Figure 4.7). The marginal cost for each country will then equal the equilibrium price level as given in Figure 4.5. As Figure 4.7 shows the cost for each country will be distributed very unequally.

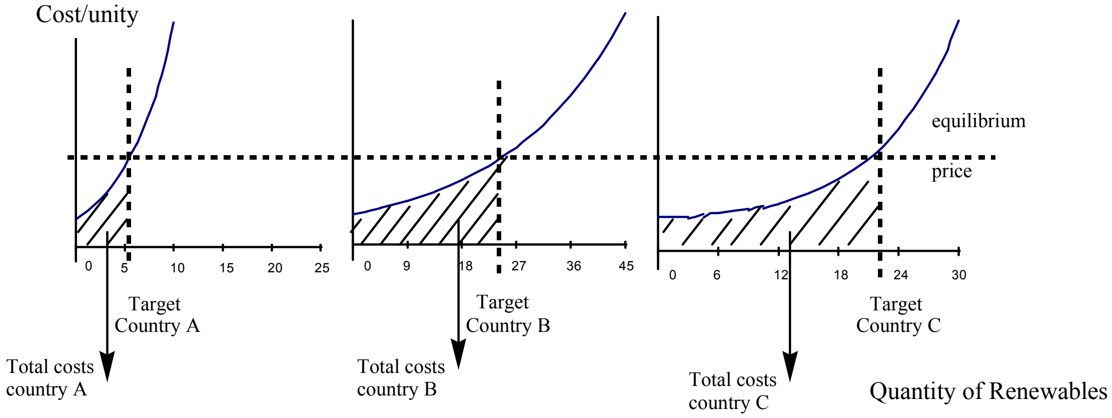


Figure 4.7 Equal marginal cost

Equal total cost

One way to remove an unequal distribution of cost over the three countries is to take equal burden sharing as a starting point and subsequently calculate the resulting targets and marginal cost in each country. In theory and practice different equity criteria exist. This implies that a 'fair' distribution of the burden can be made in different ways (i.e. the decision on which equity criterion to apply will be a political one). In Figures 4.8 and 4.9 two examples are given. In Figure 4.8 the size of population of the different countries is taken as a base for burden sharing. In Figure 4.9 the Gross Domestic Product is taken as a base for burden sharing. Comparing the area for the two cases makes clear that different concepts of 'equity' can make a very substantial difference.

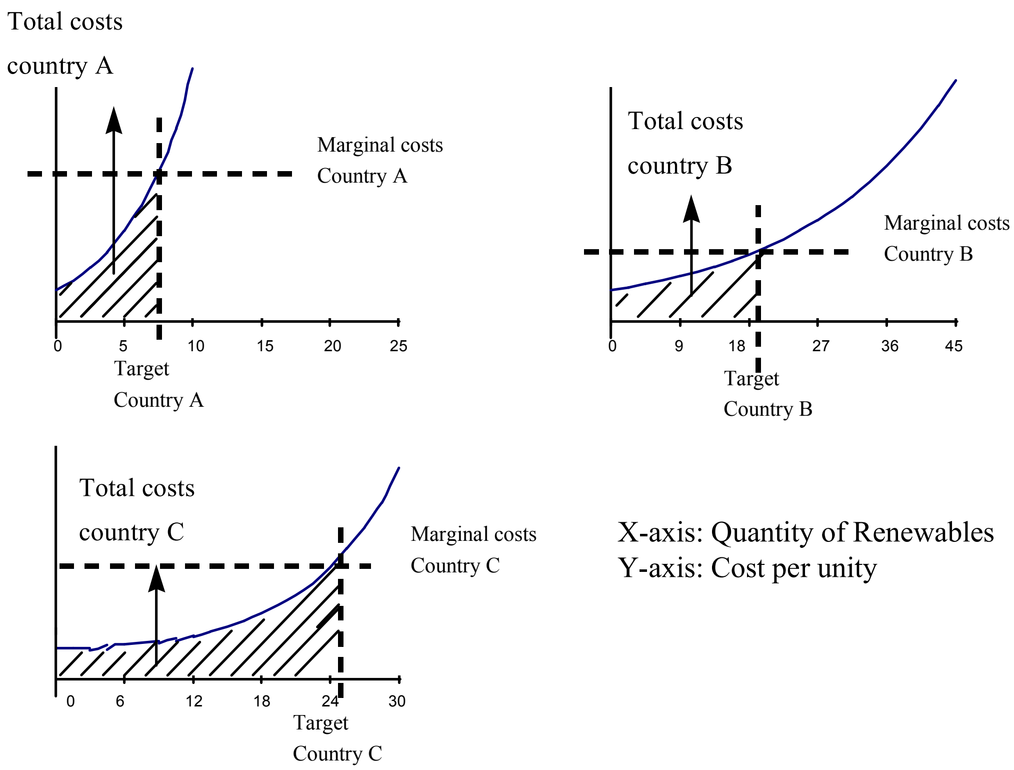


Figure 4.8 *Equal cost per capita*

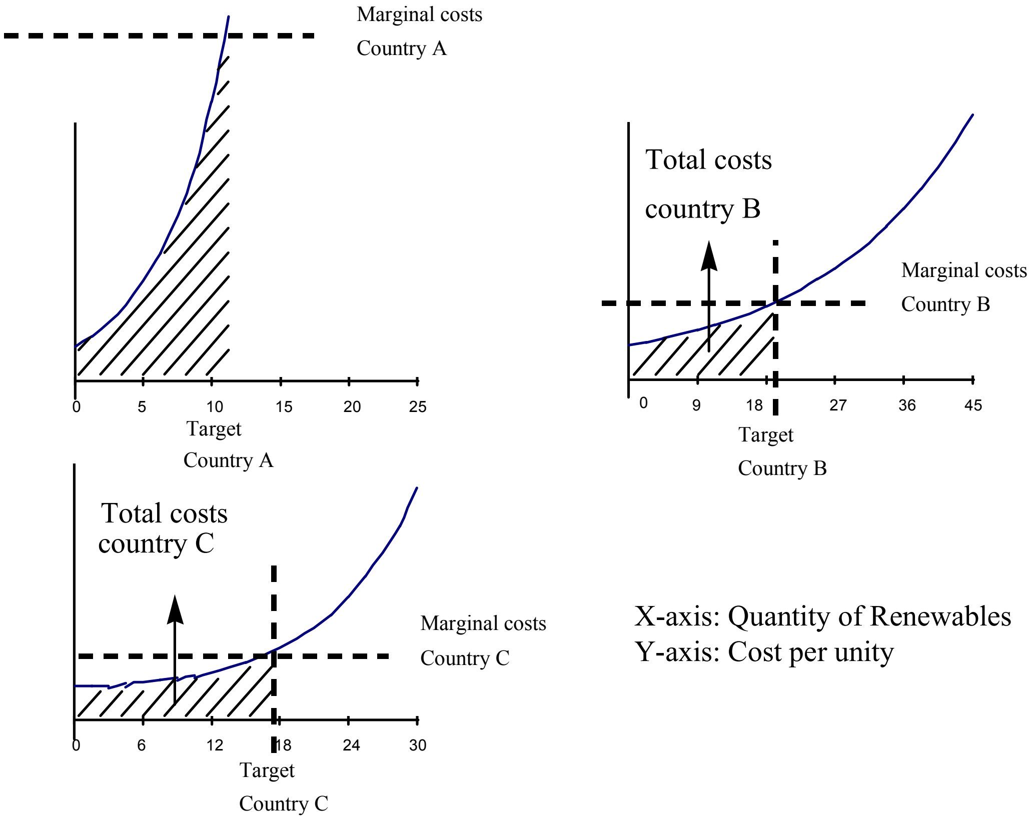


Figure 4.9 *Equal cost per unit GDP*

4.2.7 Burden sharing with trade

In both cases of the foregoing section equal burden sharing is ensured since it is taken as the starting point (of course depending how one sees ‘equity’). In neither of the cases, however, minimal costs for the community are attained because options will be developed that would not have been developed if the Community had been regarded as one country. This disadvantage can be dealt with by allowing trade. Trade will have beneficial consequences for all three participating countries, as can be seen in Figure 4.10.

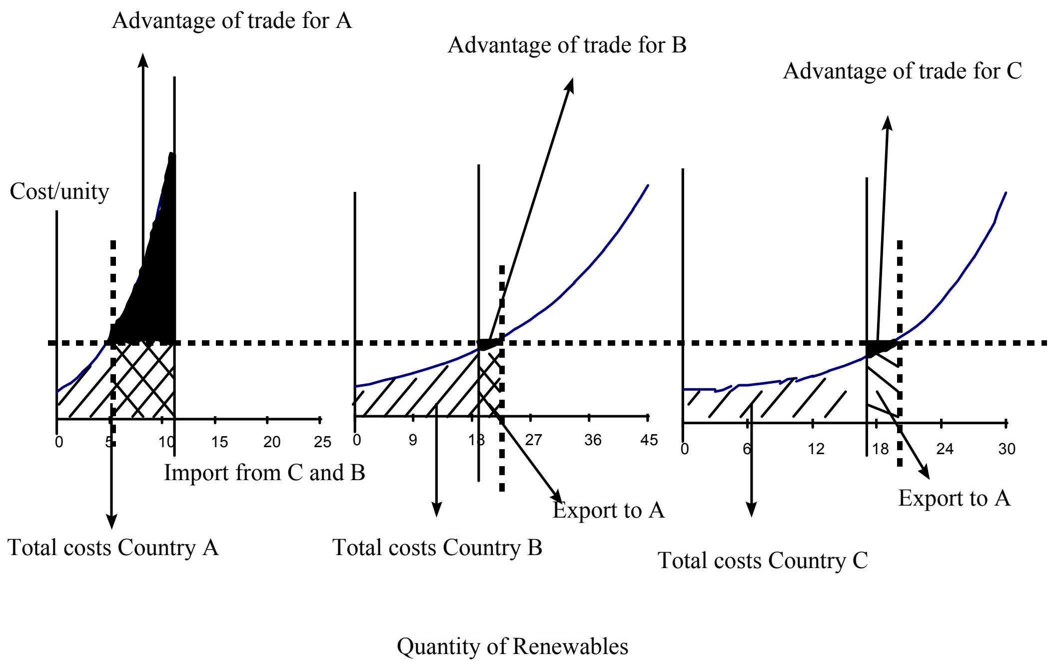


Figure 4.10 *The effects of trade in the case of 'equal cost per unit GDP'*

In Figure 4.10 the targets are equal to those resulting from an 'equal cost per unit GDP'-approach without trade (see Figure 4.9). The black-shaded areas in Figure 4.10 represent the advantages of trade for each country. In the case of Country A this represents cost savings. The options within country A that are below the equilibrium price have been developed, but for the remainder of its target Country A is importing certificates from Country B and C. These two countries develop more options than required for reaching their target, but they are able to sell the extra certificates to Country A against the equilibrium price. Since their production cost are lower than the equilibrium price, they make a (small) profit on these sales (represented by the black shaded areas).

Figure 4.10 shows that the effects of trade might be more beneficial for one country than for the other. Country A is profiting more from the possibility of trade than the other two countries. The result is that in Figure 4.10 the total cost per unit GDP in each country is not equal anymore. To get an equal burden sharing the targets of each country could be readapted in such a way that the total cost for each country, per unit GDP (or per capita, depending on the equity criterion chosen), is equal. This is illustrated in Figure 4.11.

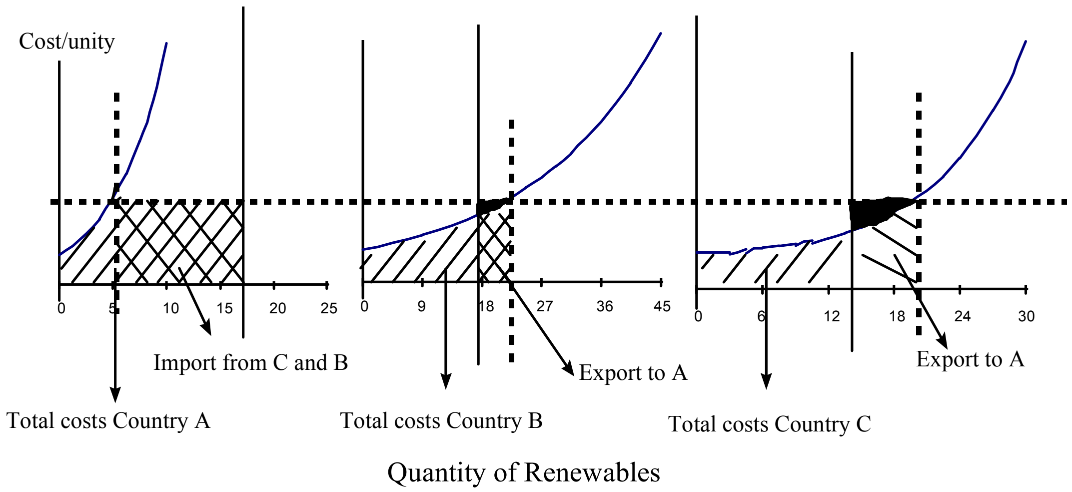


Figure 4.11 *Distribution of targets after having taken the effects of trade into account ('equal cost per unit GDP')*

The net total cost of each country are equal to the production cost of the options developed in each country plus cost from import minus the revenue from exports. In Figure 4.11 these cost are supposed to be equal on a per capita basis for each country. With regard to Figure 4.10 the target of Country A has been enlarged, whereas the target of Country B remains the same and the target of Country C has been reduced.

4.2.8 Conclusion

Different ways exist to derive national targets from an overall target. Depending on the equity criterion applied, the effects of trade taken into account and if total cost of consumption or production are to be considered, results in different reduction targets per country. Table 4.2 summarises the characteristics of the burden sharing rules that have been discussed in this Chapter.

Table 4.2 *Characteristics of different burden sharing rules*

Burden definition and possibility of trade	Burden sharing rule	Equal burden sharing	Equity base	Minimal cost
	equal relative targets	Yes	kWh consumed	Yes
Consumption cost/trade	equal cost per GDPcap	Yes	GDP/cap	Yes
	equal relative targets	No		No
	equal marginal cost	No		Yes
Production cost/no trade	equal cost per capita	Yes	size of population	No
	equal cost per unit GDP	Yes	GDP	No
	equal relative targets	No		Yes
Production cost/effects of trade	equal marginal cost	No		Yes
	equal cost per capita	No		Yes
	equal cost per unit GDP	No		Yes
Production cost/trade into account	equal cost per capita	Yes	size of population	Yes
	equal cost per unit GDP	Yes	GDP	Yes

The combination of equal burden sharing and minimal total cost is reached only in the first two and in the last two cases. Whether these cases are perceived as equal, depends on the equity criterion one prefers, and as such will remain a political decision. Another issue to be decided on is whether total cost for the consumer or total cost of production should be taken as a basis for burden sharing. Although the former seems more simple and straightforward, the latter might be preferred in situations in which provinces adhere to the subsidiarity principle and prefer to reach their target in their own way. For both approaches the consequences for each province in the China can be calculated for different burden sharing rules, given that appropriate renewable electricity supply curves for each country are available.

4.3 The REBUS-China model structure

4.3.1 Introduction

The REBUS-China model is a combination of different Excel spreadsheets. There are 3 main parts:

- satellite sheets for each renewable resource,
- the REBUS framework,
- REBUS-CHINA itself.

These sheets are all linked to each other, that means that modifications should be carried out carefully.

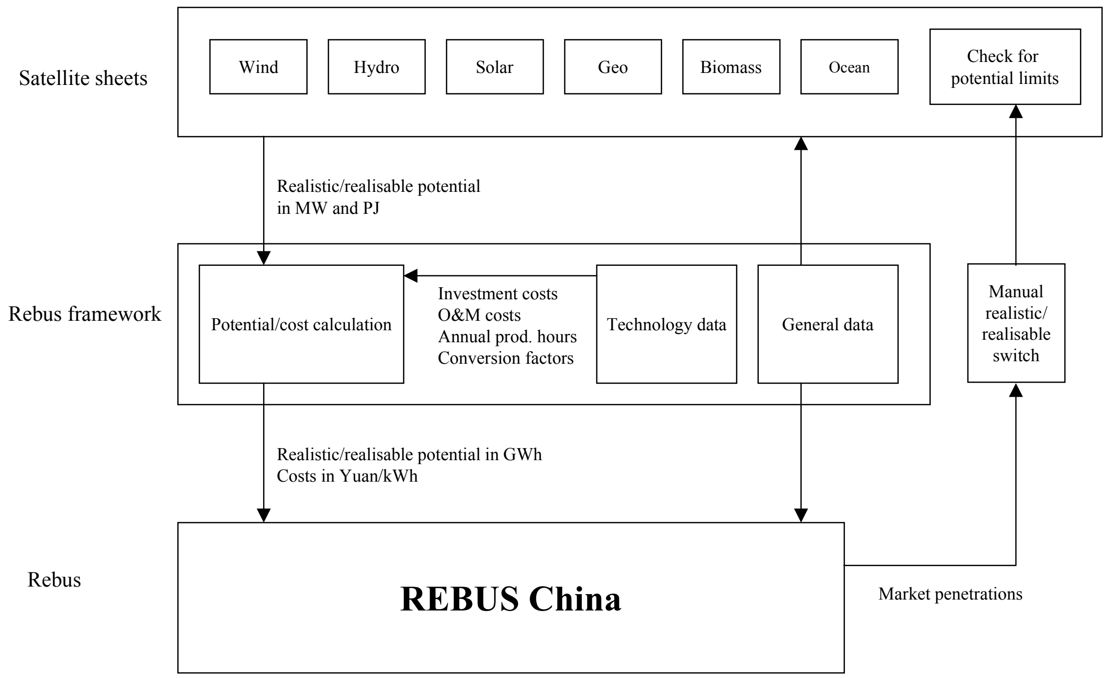


Figure 4.12 *REBUS-China modelstructure*

4.3.2 Satellite sheets

There are as many satellite sheets as there are main sources of renewable electricity energy (RES-E). Within the sheets a subdivision of these sources have been made. The main sources are:

- wind energy: onshore and offshore,
- hydro energy: small and large hydro,
- solar energy: PV and solar thermal power,
- geothermal power,
- biomass: agricultural residues, forestry residues, organic waste and mixed waste
- ocean energy: tidal energy, wave energy, ocean current energy, temperature difference energy and salt difference energy.

In every satellite the potential is calculated. These are realistic or realisable capacity potentials in MW and flow potentials in PJ for biomass and waste (for the definition of capacity and flow potentials: see section 4.4). The potentials for biomass and waste are given in PJ, since the source is usually expressed in PJ. All the other potentials in satellite sheets are expressed in MW.

There is no particular format for the satellite sheets, since it depends on the available data, which method can be used. But for every satellite sheet the result of the calculations must be a list with the provinces and their potentials, either in MW or in PJ. These potentials are used as input for the Framework, and they are therefore linked to the Framework.

The satellite sheets use general data from the REBUS Framework (subsheet 'China general'), such as number of inhabitants, land areas or cattle stock for example. The use of these data is not always necessary: if for example the *realistic* potential of geothermal energy in MW in a certain province is known, this can be put directly into the appropriate place either in the satellite sheet or in the Framework.

4.3.3 REBUS framework

In the Framework all the data from the satellite sheets are collected, and recalculated to obtain output data, which will be the input for REBUS-China. These are the cost potential data expressed in GWh and yuan/kWh. To be able to calculate these data, the potentials from the satellite sheets have to be recalculated. The recalculation takes place with the aid of technology data, cost data and specific province data and is performed on one datasheet per province. The structure of the framework is given in Table 4.3.

Table 4.3 *Structure of the Framework*

Subsheet	Description	In/output
China general	General data on China	
Resources	RES-E definitions (see Table 3.1)	
Potentials	Potential data from (linked to) the satellite sheets	Input[1]
Harmonised data	All technology data not dependent on situation per province	
Non-harmonised data	Technology data dependent on situation per province	
Province sheets	Per province a data sheet on which cost/potential data is calculated	
Curves	Overview of all cost/curves as generated by the province sheets	
To REBUS	Output of the cost-potential data to REBUS (linked)	Output[2]

1) Input from the satellite sheets.
2) Output to REBUS-China.

In the data sheets (harmonised and non-harmonised) a technology has to be chosen to convert the power or energy potential into electrical energy, this takes place in the province sheets:

- The MW power potentials are calculated into GWh via an average annual production time.
- The PJ energy potentials are calculated into GWh via a conversion factor belonging to a biomass technology.

Apart from the conversion factor from primary into electrical energy an average annual production time is needed for the biomass technologies as well.

Technology data needed to calculate costs are shown in Table 4.4.

Table 4.4 *Technology data needed per technology*

Data	Expressed in
Investment costs	[yuan/kW]
Fixed Operation and Maintenance costs	[yuan/kW/year]
Variable O&M costs	[yuan/kWh]
Fuel costs	[yuan/GJ]
Annual production hours	[h/year]
Conversion factor	[%]
Economic lifetime	[year]

All the technology data must have a harmonised and can have a non-harmonised part. The harmonised part is equal for each province, the non-harmonised part can be differently defined per province. The non-harmonised part is used to express regional differences between provinces, such as different labour costs, or higher investment for specific locations.

The subsheet 'Harmonised data' in the Framework is reserved for the harmonised data. These data are needed according to Table 4.4, for every technology and every band.

The non-harmonised data are collected in the subsheet 'Non-harmonised data'. For every province the non-harmonised data part can be entered here.

For further information on calculating cost-prices and how the harmonised and non-harmonised data are used see section 4.4 of this manual.

Bands

Each subdivision of the main source of RES-E is divided into at most 4 different bands. Each band can be defined with different characteristics. These bands are also defined in the satellite sheets. If for example a technology is defined with three bands in the framework, the corresponding satellite sheet must generate also three bands, in MW or PJ.

Some of the band characteristics are shown in Table 4.5. Definitions can be chosen in such a way that it reflects the cost structure of a technology. For wind and solar energy for example, the difference in wind speed or solar radiation regimes determines the cost price, rather than differences in investment costs. However for the biomass and waste potentials the conversion technology determines the costs. Therefore it is possible in this case to define different technologies in the bands. On the other hand: costs of hydro, geothermal and ocean energy can be determined by the differences in investment costs, simply because not every site can be exploited at the same costs.

Once a band is defined in the subsheet 'Resources' in the Framework, the grey colour (see Table 4.5) will disappear, this will also happen for the bands on all the province sheets. The definitions in the subsheet 'Resources' are not linked to any other sheet, except for the grey colour coding and the names of the definitions. This sheet has only administration purposes, thus no calculations or whatsoever are performed with the definition names.

Table 4.5 *Band definitions*

Sources		*Band 1*	*Band 2*	*Band 3*	*Band 4*
Wind	Wind onshore [m/s]	< 4	4 - 6.5	6.5 - 7.5	> 7.5
	Wind offshore [m/s]	< 7	7-9	9-11	> 11
Hydro	Small hydro (<10 MW)				
	Large hydro (>10 MW)				
Solar	Photo voltaics [$kWh/m^2/y$]	< 1400	1400 - 1600	1600 - 1800	> 1800
	Solar thermal electricity				
Geo	Geothermal electricity*	Low investment	Medium investment	High investment	
Biomass	Agricultural residues	Rice husks	Stalks		
	Forestry residues	Residues			
	Organic waste	Digestible	Combustible		
	Mixed waste	Landfill gas current locations	Landfill gas annual stream	Incineration of annual stream	
Ocean energy	Tidal energy				
	Wave energy				
	Ocean current energy				
	Temperature difference energy				
	Salt difference energy				

* Not defined in the Framework yet: only mentioned as example of an investment dependent band definition.

4.3.4 Realistic/realisable loop

The output of REBUS-China has to be checked for the maximum potential per technology for China as a whole (see section 4.4). This maximum potential will be based on maximum world wide market growth rates per technology. Although a certain technology might have a large market penetration in one or more provinces due to relatively low costs, the sum of the penetrations over all provinces cannot exceed this maximum potential. The maximum potential is based on the assumed share of the world market for China.

The world wide market potential for the renewable technologies can be calculated via a maximum growth rate of the industry of around 30% over a long period of time. Some technologies have shown this growth rate over a long period of over 10 years, such as video-recorders, mobile phones or Internet applications. It is assumed that the renewable technologies will not exceed this maximum growth rate.

The first run of the model system has to be done with *realistic* potentials. At this point the maximum potential is disregarded. After the first REBUS-China run, the market penetrations based on *realistic* potentials are known. At this point these resulting potentials have to be calculated back into the MW format with the aid of annual production hours. The sum of these resulting potentials in MW per technology has to be compared with the maximum potential for China. All the exceeding realistic potentials have to be set to zero, beginning with the most expensive, to obtain the *realisable* potentials per province. After this, the model combination has to be run again. In Figure 4.13 this method is shown. For the definition of *realistic* and *realisable* potential see Section 4.4.

Since it is not known in advance if the resulting potentials from the next run will stay under the maximum potential, these steps have to be repeated until all market penetrations remain under this maximum potential. This has to be done manually, since the framework has not yet this functionality.

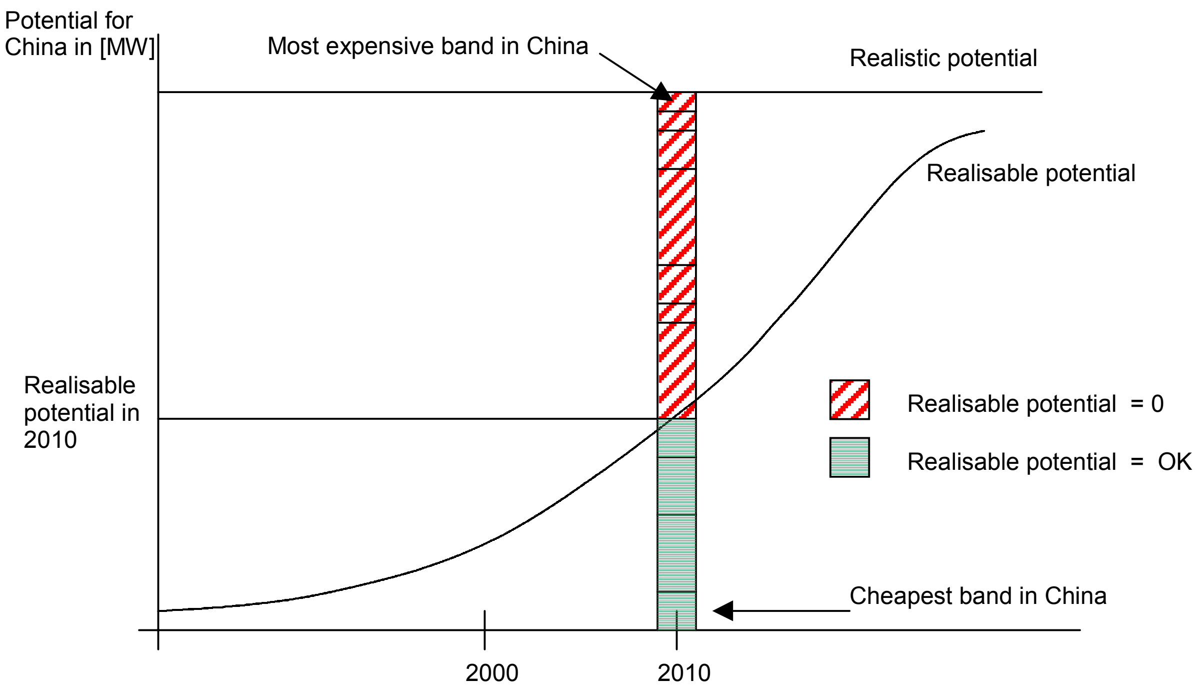


Figure 4.13 *Realistic/realisable potential for a certain technology.*

4.4 Renewable Energy Cost and Potentials

4.4.1 Bottom-up and top-down approaches

Although a bottom-up approach to determining renewable energy potentials (e.g. by using GIS-systems) is the best, this approach is not taken in this manual, because of the time-consuming character. A bottom-up approach would consist of the following steps:

1. Define criteria for appropriate sites.
2. Determine sites.
3. Determine potential for each site by studying the site on the location.
4. Add all the potentials to get to a total.

The top-down approach will be used here, which roughly consists of the following steps:

1. Use general statistics for an estimation of theoretical or technical potentials.
2. Multiply these potentials with a factor between 0 and 1 to account for physical and social hurdles to get a realistic potential.
3. Take into account the time horizon of the target and the implications this has for the total amount of a renewable energy for the whole of China (realisable potential).

Since the REBUS-China model will calculate with a certain target year (2010), all the cost and potential data must have values as foreseen for that target year.

4.4.2 Potential definitions

Many potential studies indicate different potentials for the same country. This is not only because of calculation differences, or different approaches. Also not always the same potential is taken. Some potential estimations are highly theoretical and hypothetical. What we aim for is to produce potentials that are realistic and realisable in the timeframe from now to the year of the target (that means from early 2001 to the end of 2010). To avoid confusions we will very precisely define what we mean by different kinds of potentials.

The first division we make is between energy flow potentials (in short flow potentials) and technology conversion capacity potentials (in short capacity potentials):

- A *flow potential* is the energy included in a certain energy flow. For example the energy included in the wind, biomass resources etc.
- A *capacity potential* is the potential in terms of MW of the conversion technology.

In both categories we can define:

- theoretical potential
- technical potential
- realistic potential
- realisable potential.

A *theoretical flow potential* is all the energy included in an energy flow in the whole of a province. For example all the solar radiation falling on the surface of a province in one year. Or all the energy in the wind that blows in a province during one year.

A *theoretical capacity potential* is calculated by assuming that conversion plants of a renewable energy technology cover the whole province surface. For example if the total surface of a province is 10000 km^2 and per km^2 2.5 MW of wind can be placed, then the theoretical capacity potential is 2.5 MW x 10000 km^2 = 25000 MW.

A *technical flow potential* is all the energy in included in an energy flow from which the unavailable flows are deducted. For example: all the biomass residues from agriculture, minus that what is used for other means.

A *technical capacity potential* is calculated by assuming that conversion plants of a renewable energy technology cover the whole of the available areas for that technology within a province. Available areas comprise the total area of the province minus the unavailable areas. For example, unavailable areas for wind energy include (large parts of) urban areas and wild and remote areas.

A *realistic capacity potential* is calculated by multiplying the technical capacity potential by a factor between 0 and 1. This factor can be derived from experience. For example the current Danish capacity is about 2000 MW. It is estimated that eventually the onshore capacity could double to 4000 MW without inducing too much social resistance and taking into account other barriers. This capacity means that wind turbines will cover about 5% of the land that is in principle available. A factor of 0.05 to calculate the realistic potential from the technical potential seems to be a good estimate.

A *realistic flow potential* is calculated by multiplying the technical flow potential by a factor between 0 and 1. For instance for biomass, limiting factors can be the distance of the available material to potential conversion sites; or the losses in transport; or the competition with other uses, not yet taken into account, etc.

A *realisable capacity potential* takes into account what part of the realistic potential can be deployed given the fact that the world-wide production of conversion technologies cannot grow faster over a longer period than by a maximum of about 30% a year. This means for example that a realistic potential in China for wind energy could be larger than 200 000 MW. But if the world-wide capacity in 2010 is not more than let's say 150 000 MW, and part of this capacity is installed in other parts of the world, it is not realisable for China to install more than a certain part of (for instance 50 000 MW) the total in China. Assuming that first the most cost-effective sites will be developed, this means that the realisable potential in low-wind provinces is zero, even if the realistic potential is higher. It also means that in wind-rich provinces the realistic potential might be realisable (growth rates of wind energy deployment in Spain for example have been higher than 100% during some years).

A *realisable flow potential* takes into account that it takes time to develop the market from zero to its full realistic potential. The development of landfill gas in the Netherlands has taken about 20 years, to get from zero deployment to the current level that is close to 100%. This means that also in China it cannot be expected that in 2010 more than 40 to 50 % of the realistic flow potential will have been deployed.

The main difference between realistic potentials and realisable potentials is *that realistic potentials are time-independent* whereas *realisable potentials are time-dependent* (see Figure 3.2).

4.4.3 Calculating the realisable potential for REBUS

Since the REBUS model is run for a certain target year, we finally need to determine the realisable potentials (in terms of kWh) of each renewable energy technology. This done first by calculating first the realisable capacity potential (in MW) or the realisable flow potential (in terms of PJ). An example how this is done is given in Table 4.6.

Table 4.6 *Determination of realisable potential for on-shore wind per province*

Capacity potential	*Flow potentials*
Theoretical = total land area in province x 2.5 MW per km^2 ↓	Theoretical
Technical = total available land area = total area - (urban area + lake areas + remote areas) x 2.5 MW per km^2 ↓	Technical
Realistic = factor (e.g. 5%) x technical potential ↓	Realistic
Realisable To get realisable potential the following steps are taken: • Translate realistic capacity potential in amount of GWh/year (see later). • Take this as the first input in REBUS-model. • Run REBUS-model. • Determine how much wind (MW) in the whole of China is taken up by REBUS-calculations. • Determine how much capacity can be installed at maximum in the whole of China. • If first-run REBUS output is higher than maximum, set the potential in the higher-cost locations at zero. • Re-determine potentials per province.	Realisable

Several things become clear from Table 4.6:

- Not all potential have to be worked out to get to the realisable potential. In the example all the flow potentials are not interesting. Also the theoretical potential does not need to be calculated.
- To get the realisable potential deserves some extra work and attention. However, this is the only consistent way to get there.
- For some technologies (e.g. biomass technologies) the realisable potential is not very different form the realistic potential, for instance because the realistic potential is only a factor 2 or 3 higher than the current level. There is no reason to believe that a doubling or tripling in deployment cannot be reached in 10 years, if the economic incentives are right.
- As the time horizon of the exercise moves on (e.g. 2030 instead of 2010) the realisable potential gets closer to the realistic potential and the two could be considered identical. However, we are focussing on 2010 and the difference between realisable and realistic potential is a real issue.

The calculated MWs (or PJ's) will form the input for the calculations of the cost-potential curves.

4.4.4 Wind energy potentials estimation

Onshore wind energy potential definition

The potential of wind energy is a capacity potential, as outlined in Table 4.6. A wind turbine can be placed anywhere, but the wind regime at that place determines the annual energy output. Higher mean wind speeds mean higher productions with the same installed power. Therefore the available space per province for placement of wind turbines should be combined with the different wind regimes in that province. This is done in the satellite sheet 'China wind.xls', in the subsheet 'Onshore wind'. The values in this sheet are based on first estimates, further research to be performed in China is highly desirable to establish more accurate values. Please note that when available area is mentioned, this means that the available area as foreseen in the *target year 2010* is meant.

Wind bands

The wind regimes are defined in bands, to express the different annual energy yield being dependent on the *annual mean wind speed*. These bands definitions are shown in Table 4.5. The choice of these different bands depends on the overall wind regime over China. In Table 4.5 is assumed that this onshore regime has mean wind speeds between approximately 3 m/s and 9 m/s. When more detailed information is known, the band definition can be changed in the satellite sheet on wind energy by the user of the REBUS model combination.

Available area

Next step is the determination of the available area per province for every band. That is: what area per province has an annual mean wind speed lying within a band? In the first rough estimate made within this project a starting point was the amount of agricultural area per province. It was therefore assumed that no space for wind turbines was available in urban, forestry, lake or remote areas. Although this may not be true, more detailed research need to be done to determine the real available area (bottom up method). The areas in the different bands were determined using the 1999 White Book on New & Renewable Energy in China.

Power density

When the available area is known, the technical wind power potential needs to be determined. This can be done by a factor called the wind-power density. It determines how many wind turbines with a certain power can be placed on a square km, without disturbing each other. In this case the power density is taken to be 2.5 MW/km^2, corresponding to European values found for onshore wind farms. The power density can be multiplied by the available area per province per band to obtain the total power capacity potential.

Availability factor

According to several experiences in Europe, especially in the Netherlands, not all the power potential can actually be achieved, although the area might be available. In some cases there will be a strong public opposition against the placement of wind turbines (NIMBY effect), in other cases issues such as land use policy will prohibit the exploitation of wind turbines. Therefore the total capacity potential will not be the technical potential.

Offshore wind energy potential definition

To calculate the offshore wind energy potential the same method as for onshore wind can be used. The available area will be the available sea area, which is assigned to a certain province. This area must not include other user functions, such as ship lanes or military drill grounds. The next step is to divide this area according to wind speed regimes offshore and to assign bands to these regimes (see Table 3.2). These regimes have to be determined by wind energy experts.

Technology limitations must also be taken into account: for example conventional offshore foundations for wind turbines can only be placed in relatively shallow waters (maximum depth 50 m).

The power density offshore can be around 5.5 MW/km^2, according to the Dutch situation. The availability factor is here assumed to be 100%.

Energy yield

To be able calculate the energy yield of the wind turbines, the average annual production hours at full power have to be known according to the wind speed regime in the band definitions. In general, the annual production time increases with the annual mean wind speed, but other factors such as the Weibull shape factor, availability and transmission losses are also important. The appropriate data on wind speed regimes in the Chinese provinces need to be provided by wind energy experts.

To be able to perform calculations with the Framework the following annual production hours are assumed, based on an educated guess (for the band definitions: see Table 3.2):

Table 4.9 *Annual production time wind energy*

Band	Annual production hours [h]	
	Onshore	Offshore
1	500	1800
2	1200	2700
3	2200	3500
4	2700	3800

All the data in the Table are harmonised data, for the non-harmonised production time per province further research need to be done.

Costs

According to the 1999 White Book on New & Renewable Energy in China the cost price of wind turbines in China is around 8500 yuan/kW. The fixed O&M costs for onshore wind energy are usually 2.5% of the investment costs per year (Dutch situation), while the fixed O&M costs for offshore wind energy are usually taken to be 3.5%. Variable O&M costs can be assumed to be zero. Other costs must also be taken into account: costs for the foundation (onshore as well as offshore) and costs for grid extension an connection for example. The share of the turbine costs in the total investment costs is on average 60% for onshore wind energy and 30% for off-shore wind energy (Dutch situation).

Lifetime of modern wind turbines can be 20 years.

4.4.5 Solar energy potentials estimation

Solar PV potential definitions

The potential of solar PV cells is dependent on the available area in the target year for installation of these cells. This method is similar to wind energy potential determination. Question is where the available place can be found. The method to be used depends on available data. In this manual two methods are discussed. The first method is comparable to the method used for wind energy: what is the fraction of the urban area per province, which can be used to install PV, cells. In this case it is assumed that the potential is related to urban area since the data on urban area is known. In reality however PV cells can be installed everywhere in open air. The second starts with a different perspective: what is the total roof area on buildings available for installing PV cells. In this case an assumption is made on the available roof area per province.

Urban area

Starting point is the amount of urban area per province. Next step is to divide the total area per province into the solar radiation bands. Assumed is furthermore that the urban area is equally distributed over the province. Together with the power density of 100 W_p/m^2, this will result in the theoretical potential of solar PV.

A next assumption is the amount of urban area actually available for PV cells. This is the difficult part, since it not known in detail, which areas are available for PV in a city. These areas can be roofs of residences and other buildings, some areas in public gardens or other unused areas for example. It is assumed here that 1% of the total urban area per province is available for PV (5% is mentioned in the satellite sheet for solar in the subsheet 'Solar PV area'). This means a realistic potential of around 610 GW_{peak} for total China.

Note that this is an example of a top-down approach.

Roof area

Here the starting point is the amount of roof area per province on residences for example. Needed is the average number of people per house, to get the total number of houses (or roofs) per province using the population per province. If a power occupation of 200 W_{peak} per roof is assumed, the resulting potential can be described as theoretical potential. If furthermore is assumed that the roof areas are proportional divided over the province, the potentials per band can be determined.

With an assumption on the amount of roof area available per house the realistic potential can be calculated. These calculations are all performed in the satellite sheet for solar energy, subsheet 'solar PV house'. This method can be described as a bottom up approach.

The total resulting PV potential for China using this method was found to be 3.7 GW.

Energy yield

For both methods it is necessary to know the distribution of solar radiation over China. From the 1999 White Book on China New & Renewable Energy a rough estimate of this distribution can be known. Next step is the definition into bands. In the Framework the following band definition is used (see Table 4.5):

Table 4.10 *Solar radiation bands*

Band	Solar radiation [kWh/m²/a]	Annual production hours [h]
1	<1400	1560
2	1400 - 1600	1800
3	1600 - 1800	2040
4	>1800	2280

To calculate the annual average production hours the following data has been used:

Power density of a PV cell in 2010: 100 W_{peak}/m^2
Efficiency of a PV cell in 2010: 12%

Costs
According to the 1999 White Book on China New & Renewable Energy the investment costs of solar PV cells are expected to be 12,500 yuan/kW_{peak} in 2010, whereas the current (1999) costs are 35,000 yuan/kW_{peak}, or 44,000 yuan/kW_{peak} selling price. O&M costs can be assumed to be less than 250 yuan/kW_{peak} per year.

4.4.6 Biomass potentials estimation

A first rough biomass resource estimation and technology description are made based on data available at the ECN. Several different resources of biomass will be distinguished. This distinction is made on differences in source type e.g. waste versus residues and different conversion to electricity options. For example, some biomass resources are suitable for combustion and some resources should be digested. Based on these two criteria three different resource types are distinguished. These are:
1. agricultural and forestry residues
2. manure
3. mixed waste.

Resource data are based on available databases as e.g., the FAO-statistics, China's State Statistical Bureau (SSB) reported for 1949-90, and some information on the new renewable policy in China.

Technology data are based on the Dutch situation. These where gathered recently (Zeevalkink and Van Ree, 2000) and represent the 2000 situation. These data are not necessarily representative for China. Especially the cost data should be considered as a rough estimate based on Dutch figures.

Residue resources
Agricultural residues
Agricultural residues are widely available in China. In many cases they are already used for heat production and therefore not available for electricity production. But there is a potential of residues available not used anyway now. In some cases statistics on amount of residues are available, (for example bagasse from sugarmills) but in most cases estimations have to be made based on agricultural production statistics.
In those cases the next method is used for calculation of the available residues:
1. Make an inventory of the most production for the most important crops (tons).
2. Define the amount of residues related to the crop (specific data for all crops).
3. Define which part of the residues is used for other purposes and therefore will never be used as energy source.

Because the large amount available the production of rice husks is considered a special category. Maybe bagasse is another special category, but because of limited data availability not defined that way so far.

Current data in the model are based on:
1. Production statistics for the regions in China for rice, wheat corn and soy, these crops cover around 90% of the agricultural production in China.
2. The residue production per ton of crop is assumed per crops (Diamantidis and Koukios,2000; El Bassam, 2000). Wheat 1,1 ton res/ton crop, rice 1 ton husks and 1 ton stalks per ton crop, maize 1 ton/ton and soy 1,5 ton residues/ton crop.
3. Because of the use of residues for soil improvement and as cooking fuel, it is assumed that 50% of the stalks is available for electricity production.

The choice of these assumptions is relatively arbitrary and requires some more analyses. Especially yield and other uses of residues might be very region-depending. These data are absolutely necessary in order to get insight in the true potential of agricultural residues.

Forestry residues
Forestry production is known for some of the Chinese regions. Data for the roundwood production were found. The amount of residues can be estimated from this production figures, because the direct relation between roundwood production and amount of residues. This method is used for the calculations of the forestry residues. An update containing all Chinese regions is required to make the database useful.
The analyses of the potential resources in PJ requires the next steps:
1. Find the roundwood production statistics (result in CM).
2. Calculation the tonnage, assuming that each Cubic Meter of roundwood has 0,52 Ton of dry matter (DM) (*Welling and Scharai-Rad*, 1999) (result in Mton).
3. Per ton of roundwood 0,51 ton of sawnwood residues are produced (result in Mton).
4. In case these data are unavailable assume a production of 0,5 ton residues per hectare forestry (result in Mton).
5. Heating value of the wood residues is 15 GJ/ton DM (result in PJ).

This is the technical potential. Due to a lack of information no assumptions were made for the percentage available for electricity production.

Example
In case the roundwood production is known the next calculation is used. For Heilongjiang with a roundwood production of 13,5 CuM, we and up with 13,5 CuM x 0,52 Ton/CuM x 0,51 ton residues/ton roundwood x 15 GJ/ton residues = 53,7 PJ potential forestry residues.

Conversion technology for residues
Residues are used in both gasification and combustion plants. Combustion is so far the best developed technology for electricity production. Co-firing in coal-plants could be an alternative, but it is questionable if the technological disadvantages could be easily tackled.
For this database incineration technology is considered and data were used that represent the Dutch situation (Zeevalkink and Van Ree,2000). Costs do represent the *European* situation and are converted from Dutch guilders to Chinese yuans. The data are:
- technology: fluidised bed incineration,
- lifetime: assumed is 25 years,
- capacity: 25 $MW_{e,}$
- costs: 2850 Yuan/ $kW_{e,}$
- conversion efficiency: 30%,
- fixed O&M annual 4% of investment. = 110 Yuan/ kW_e /year,
- variable O&M: not considered,

- fuel price: residues are considered to be for free,
- low estimate of transportation costs 25 Yuan/ton = 1,7 Yuan/GJ input.

Farm slurries resources

The second biomass resource available for energy production is manure. The availability depends on the cattle, pig and poultry stock, the manure production per animal. Because both wet and dry manure can be converted to electricity an analyses of both is made. Wet manure (mostly around 90% water) is bested converted by anaerobic digestion. Relatively dry manure is best converted by combustion.

The next method is used to define the potential:

- Animal stock per province, data were available for 1997 and 1996.
- Animals were ordered into classes (large ruminants, small ruminants and large and small non ruminants).
- The manure production per animal is assumed (Gerlagh and Gielen, 1999).
- The amount of manure used for other purposes is assumed. (75%, therefore 25% for energy).
- The gasproduction per ton wet manure is assumed to be 50 m3 CH4/ton wet manure.
- The heating value of the dry manure is assumed to be 10 GJ/ton dry manure.
- Combustible is assumed only 25% of the sheep-goat manure and all chicken manure.

Table 4.2 *Data on manure production and energy*

Manure production	[ton wet per head per year]	[ton dry per head per year]	[m^3 CH_4 per ton wet]	[GJ/ton dry]	[% available for energy]	[% combustible]
Cattle, horses (large rumin.)	13,30	2,50	50	10	25	0
Sheep+goats (small rumin.)	1,00	0,20	50	10	25	25
Pigs (non-rumin.)	1,10	0,13	50	10	25	0
Chicken (non-rumin.)	0,02	0,01		10		100

Conversion technology for manure

Energy production out of manure is based on digestion or combustion. Digestion is a non-thermal process that fit best for relatively wet manure streams. Combustion is only profitable in case of dry manure and therefore only used for manure that is relatively dry in itself.

Digestion

Digestion of manure is a well-known process for the production of gas. The potential gas production from manure depends on the stock, the manure production per head and the gas production per m^3 wet manure available. Numbers and production of manure in wet tons are required data to calculate the potential for digestion.

For anaerobic digestion the next data are assumed:

- capacity 30 kW_e farm system,
- capital costs 28.000 Yuan/kW_e,
- O&M: 6% of investment (mainly labour),
- fixed: 3% of investment 900 Yuan/kW_e,
- variable: Assuming 2000 hours/year 0,44 Yuan/kWh(electric),
- fuel costs: cost of catering the manure almost 0 in case of husbandry, which is the main source. 0 Yuan/GJ input,
- heating value gas: 20 MJ/m^3,
- efficiency electricity generation: 20%.

Incineration
Incineration technology is the same used for agricultural and forestry residues.

Mixed Waste
Resources
The third stream considered is waste. It is questionable if energy from waste must be considered renewable but at least it is profitable to gain energy out of waste streams. In case waste statistics are available the data collection is relatively straightforward. Until these data are available the REBUS model uses estimations based on the population numbers and overall waste collection data for China. Overall waste available in China is estimated at 107,5 Mton. This waste is considered to be available for landfill and landfill gas production. Annual increase of waste produced is assumed to by 9%. It is assumed that incineration of waste will increase to 5% in 2010. The heating value of the waste is assumed to be 4,2 MJ/kg (Chapter VI, renewable energy).

Waste is nowadays dumped in landfills. This leads to the production of landfill gas that can be used for electricity production. This option is also available for future waste. Another energy generating option is incineration. This is, especially when low air-emissions are required, relatively complex and expensive.

Technology
Landfill
The landfill gas production depends on the organic matter of the waste. Because the low heating value found in literature it is assumed that the waste is very wet (over 50%), with an organic compound of 30% of the dry matter. In that case the gas production gas per m3 waste is 25 m^3 of landfill gas with a CH4-concentration of 60%. The landfill gas production is spread over 25 years with a maximum after 10 years. This means that potential calculated will only be reached 10 years after start of the landfill. The product is landfill gas that can be used in a gas engine. The electricity is produced with a gas engine. The technical characteristics of the gas engine are:

- capacity: 1 MW_e,
- efficiency 20%,
- capital costs 4500 kfl/ MW_e = 12.000 Yuan/ kW_e,
- fixed O&M: 36.000 Yuan/ kW_e /year,
- variable: not considered,
- fuel costs: 0 Yuan/GJ. People have to get ride of their waste.

Incineration
In case we assume the Dutch waste incineration plants the costs are extremely high, based on a free-in price of 175 NLG/ton (470 Yuan/ton) paid by the supplier of the waste. Therefore the incineration will only be cost effective in case the consumer pays to get ride of his waste. Dutch data for waste incineration, including strict gas-cleaning are:

- capacity: 40 MW_e,
- efficiency: 26% (2010),
- investment costs: 20.000 DGL/ kW_e = 52.000 Yuan/kW_e,
- fixed O&M-costs 20 NLG/ kW_e = 55 Yuan/kW_e,
- variable not considered,
- fuel costs: It seems unrealistic to count with a negative fuel price, therefore 0 Yuan/GJ.

4.4.7 Cost price calculation

To calculate the cost price of RES-E, the levelised cost method is used. The levelised cost method is based on equal annual costs for the generation of electricity. Main parts of these costs are the annual capital costs and the annual O&M costs. The annual capital costs are calculated with an annuity factor, based on the interest rate and the economic lifetime. Data needed to calculate the cost price are shown in Table 4.3.

Table 4.3 *Data to calculate cost prices*

Data	Expressed in	Variable
Investment costs	[yuan/kW]	I
Fixed Operation and Maintenance costs	[yuan/kW/year]	O_{fix}
Variable O&M costs	[yuan/kWh]	O_{var}
Fuel costs	[yuan/GJ]	F
Annual production hours	[h/year]	h
Conversion factor	[%]	c
Economic lifetime	[year]	L

Calculation takes place with the addition of the harmonised and non-harmonised data for all variables, except the interest rate. Thus:

- $I = I_{non\text{-}harmonised} + I_{harmonised}$
- $h = h_{non\text{-}harmonised} + h_{harmonised}$

etc.

Formula for calculating the costs price in yuan/kWh:

$$Cost\ price\ =\ O_{var} + \frac{a\,I + O_{fix}}{h} + \frac{F}{c\,(1000/3.6)}$$

For the variable definitions: see Table 2.1. For non-biomass and non-waste sources the fuel cost part is obviously zero. Please note that the investment costs and fixed O&M costs must be given in yuan/kW and not in yuan/MW for example, since the cost price is expressed in yuan/kWh.

The annuity factor *a* can be calculated as follows:

$$a\ =\ \frac{r}{1-(1+r)^{-L}}$$

With:

a	the annuity factor
r	the interest rate (can be set in the subsheet 'China general' in the Framework)
L	economic lifetime of the technology

The MS-Excel function for calculating the annuity factor: =PMT(interest, lifetime, -1)

4.5 The REBUS model

This Chapter describes the REBUS spreadsheet model. Section 4.5.1 provides an introduction that briefly mentions the background of the REBUS model and the main questions that can be answered by the model. Section 4.5.2 deals with the design of the REBUS model, including a list of all worksheets included in the model. The inputs of the REBUS model are discussed in Section 4.5.3, after which Section 4.5.4 discusses how to operate the REBUS model. This section contains important information on what data can or may not be changed, and provides a detailed description of at which location what kind of data should be specified. Section 4.5.5 concludes with the possible extensions of the REBUS model.

4.5.1 Introduction

The REBUS model quantifies the impact of trade in burden sharing mechanisms (e.g. green certificates) and the implementation of different rules to setting regional and (inter)national targets for the share of renewable electricity consumption or production. Results are obtained for a range of so-called burden sharing options that reflect differences in economic, social and geographical possibilities to increase the share of renewables in individual geographical regions. The REBUS model furthermore analyses the impact of other supporting mechanisms for renewable electricity on the effects of a Tradable Green Certificate system.

The REBUS model is used to support the world-wide increase of renewable energy. The REBUS model is a framework that can be used for determining the most equitable distribution of costs (burden sharing). With this, key policy makers, industrial stakeholders and consumers are provided with guidelines to make decisions that reflect this equity.

The main questions that can be answered by the REBUS model include:

- What are the costs of realising (inter) national or regional targets for RES-E?
- What will be the expected price of tradable green certificates in the region?
- What are the cost benefits of interregional trade in tradable green certificates?
- What it the impact of applying different burden sharing rules to achieving RES-E targets?
- Which technologies are likely to penetrate in the coming years on the basis of cost-effectiveness?
- What is the effect of changes in the cost or potential of individual technologies on the penetration of this technology and on the resulting costs of achieving renewable electricity targets?
- What are the effects of other national or regional supporting policies on the certificate price and the costs of achieving targets?

4.5.2 Design of the REBUS model

General design and application

The REBUS model is designed as an EXCEL spreadsheet calculation tool. Given the individual curves for the costs and potentials of renewable electricity options in each geographical region under study and given the targets set for achieving certain shares of RES-E in total electricity production or consumption, the REBUS model determines the costs of achieving these targets for each region individually. Moreover, the REBUS model determines the price of Tradable Green Certificates in the market, assuming that some of the regions have implemented such a joint system with the objective of lowering their overall costs of achieving the targets.

Given cost/potential curves for RES-E per region, the REBUS model:

- Calculates the RES-E cost/potential curve for the whole region
- Determines the costs of achieving renewables electricity targets, for individual countries or regions and for a number of co-operating countries or regions that have formulated joint renewable electricity targets.
- Determines the TGC price given a division of targets or a burden sharing rule.
- Calculates the benefits of interregional trade.
- Determines the optimal realisation of RES-E production in each individual region.
- Identifies the optimal trade between regions.
- Identifies import or export certificates for each individual region.

The REBUS model can be operated for a number of options to distribute the overall Chinese target to individual targets. Furthermore, the model can be operated for a number of so-called burden sharing options, i.e. different ways of redistributing the total costs of achieving the targets set. The calculation options currently included in the model are specified in Chapter 2.

For each case the model will determine for each individual region:

- direct costs of renewable electricity,
- the least-cost opportunities for renewable electricity,
- the price of Tradable Green Certificates in China,
- regional target shares of renewable electricity,
- total costs or benefits of achieving targets,
- net trade in Tradable Green Certificates,
- net benefits of implementing a 'bubble concept' in the whole region.

The individual worksheets

The REBUS model contains the following worksheets:

- Notes: Provides general notes on the operation of the REBUS model. All this information is included (and elaborated) in this report.
- Burden sharing: The calculation sheet of the model
- Input cost curves: Input sheet for the cost/potential curves
- Calculate curves: Automatically generates the cost curves per country that are required for the model, based on the data specified in the sheet 'input cost curves'
- Results targets: Listing of targets for individual regions in the selected cases compared to the least-cost division of targets.
- Report-A: Report of the results for the chosen calculation case for specified targets
- Report-B: Report of the results for the chosen burden sharing option
- Graph potentials: Graphical presentation of the potential of renewable electricity in each individual region, specified per technology
- Graphs curves additional: Graphical presentation of the cost/potential curve for each individual region, specified for only additional potentials (i.e. additional to the realisation of RES-E in the base year)
- Graphs curves total: Graphical presentation of the cost/potential curve for each individual region, specified for the total potentials (i.e. including the realisation of RES-E in the base year)
- Curve China additional: Graphical presentation of the cost/potential curve for China, specified for only additional potentials (i.e. additional to the realisation of RES-E in the base year)
- Curve China total: Graphical presentation of the cost/potential curve for China, specified for the total potentials (i.e. including the realisation of RES-E in the base year)
- Result graphs: Graphical presentation of selected calculation results
- Data: Input sheet for the exogenous input data required for the REBUS model, excluding the cost/potential curves.
- Regions: The Chinese regions and model abbreviation used in the spreadsheet.

4.5.3 Inputs of the REBUS model

Generally, the inputs of the REBUS model can be divided in two categories: the cost/potential curves as described in Chapter 3 and a set of exogenous data. The cost/potential curves must be specified in the worksheet 'input cost curves'. The majority of exogenous data must be specified in the worksheet 'Data'. Input data should be specified at the indicated areas that are coloured blue. Naturally, it is most convenient to specify the input data by means of a direct link between the REBUS model and the REBUS framework, so that when changes are made in the data included in the REBUS framework, these are automatically incorporated in the REBUS model.

Cost/potential curves

The main inputs for the REBUS model are the so-called cost/potential curves. These curves specify the cost and realisable potentials renewable electricity supply for a broad range of renewable electricity technologies (and for each technology for different technology bands) in each of the regions specified in the model. A detailed explanation of these cost curves is included in Section 4.4.

The spreadsheet is based on a specific format of marginal cost curves that if most often used for (model) calculation and analysis: average marginal cost. The shape of the costs curve is thus a stepped cost curve, where for a range of potential renewable electricity technologies, the total realisable potential of this technology is specified at given average marginal costs. When sufficient detail on the type of technologies and specific technology bands (see Chapter 3) are included, this simulates the actual marginal cost curves of renewable electricity production.

To be able to determine the overall TGC price, the cost curves of individual regions must be added to one overall cost/potential curve for the whole region. For this, the individual cost/potential curves should be defined so that the vertical axis (representing the price of RES-E options) is identical for each curve[20]. This means that the curves have to be redefined if they are originally not specified in this format. This redefinition is automatically carried out in the sheet 'calculate curves'.

The redefinition of cost curves contains the following steps:

- All price levels are listed that occur in the individual cost/potential curves.
- Each individual cost curve is redefined by specifying the corresponding potential for each of these price levels. The corresponding potential of renewables is defined on the basis of the original cost/potential curve of the individual region.
  Note that this process may be carried out since the original cost/potential curves are defined as stepped curves that present the average costs for a certain potential.
- A maximum number of steps is defined for the redefined cost curves. The model automatically generates the optimal choice of steps.
- The extended individual cost/potential curves are redefined for this optimal choice of steps.

This complex procedure for the redefinition of cost/potential curves is carried out for two reasons. First, as was explained before, to be able to add up individual cost/potential curves to formulate one cost/potential curve for the whole region. Second, to limit the calculation time of the REBUS model.

Reference price

Next to the cost/potential curves, the REBUS model includes the possibility to specify a reference electricity price, i.e. the market price for the physical product electricity. If this option is used, the costs calculated by the REBUS model represent the additional costs of renewable electricity supply, i.e. in addition to the reference market price for electricity. Note that in this case we may speak of the real price for tradable green certificates, representing only the 'green

[20] For the theory on specifying a cost/potential curve by adding up individual cost/potential curves, see Paragraph 5.2.

aspect' of renewable electricity supplies. If the reference market price is not specified, the costs calculated by the REBUS model represent the total cost of renewable electricity generation, thus the costs for the physical power as well as the costs for the 'green aspect' of renewable electricity. The calculated TGC price is then the sum of the actual price of green certificates and the market price for electricity.

There are three possibilities to specify the reference electricity price:
1. Single reference electricity price for the whole geographical region under study, simulating one internal electricity and certificate market in the whole region.
2. A specific reference electricity price for each individual region.

Exogenous input data
For each individual geographical region identified in the model, the following information should be specified in the worksheet 'Data':
- Renewable electricity production in the base-year [GWh].
- Total electricity consumption in the year 2010 [GWh].
- Total population in the year 2010 [million people].
- Gross Domestic Product in the year 2010 [in Yuan 2000].
- (If available) Renewable electricity target for each individual region [share of electricity consumption in the year 2010].

Other exogenous input that *must* be specified:
- The overall target for renewable electricity consumption for the whole region. This should be specified in cell C34 of the sheet 'burden sharing'.
- The (marginal) cost of the existing RES-E potential in the base year. This should be specified in cell B7 of the sheet 'calculate curves'.

Price effects of renewable electricity policies
- The REBUS model includes the possibility to analyse the price effects of supporting policies for specific renewable electricity technologies. An example of such a policy is a technology subsidy or a feed-in tariff for e.g. PV production.
- If the user wants to analyse effects of stimulating measures, the direct price effect on the reference electricity price should be specified. This can be specified for each individual region, for each technology. The information should be specified in the worksheet 'input cost curves' in cells B65-AG104.

4.5.4 Operation of the REBUS model

This section describes the operation of the REBUS model. Please read this section carefully before you start operating the model system. Furthermore, please realise that the REBUS spreadsheet model uses many formulas and macros. The user should be very cautious before changing the content of any cell. In general, the user according to the given specification may fill in the cells that are coloured blue. The content of other cells should NOT be changed unless the user has full knowledge of its impact. Changing the content of these cells could make the model inoperable or affect the reliability of the calculation results.

Introduction
Before the operation of the spreadsheet is explained, a number of observations must be made on the underlying assumptions of the REBUS model. The analysis in the REBUS model is based on the following assumptions:
- There is an international or interregional market for electricity.
- There is an international or interregional market for tradable green certificates or other burden sharing mechanisms that serve to redistribute the costs of achieving renewable electricity targets.

- The total costs of achieving an overall target are at a minimum point when full trade in certificates is allowed.
- There is perfect competition, both on the electricity market and on the certificate market.
- Total consumption of electricity in the target year is known, and renewable electricity targets are set.
- Demand of electricity and certificates is inelastic of the price of certificates.

Starting calculations

The REBUS model is designed in such a way that calculations are carried out automatically once the required input data is specified. The user should specify the exogenous input data as described in) Section 4.3. Then, the user can determine what case to calculate. The model calculations are executed in the worksheet 'burden sharing'. Figure 4.14 presents the order of steps that should be followed to operate the REBUS model.

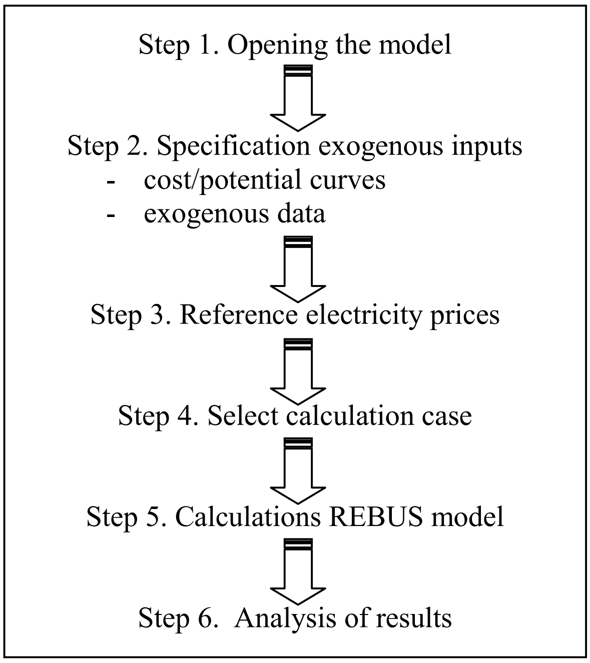


Figure 4.14 *Scheme on starting calculations in the REBUS spreadsheet model*

The different steps in operating the REBUS model are explained in more detail below. User specifications are identified with ⇨.

Step 1: opening the REBUS model

The REBUS spreadsheet model for China will opened by opening the xls file 'REBUS China.xls'. When opening the REBUS spreadsheet model two questions are asked. The first question concerns the macros that are included in the model. To protect against viruses, the Excel software always asks whether a workbook is from a trusted source and thus whether the macros should be enabled or disabled. To be able to operate the REBUS model, the question whether the macros should be enabled should be answered positively. If not, the model will not work adequately or the Excel software will give an error message.

⇨ Select 'enable macros'

The second question is whether automatic links should be updated. The REBUS model automatically generates input data from the REBUS framework. If no changes are made in this REBUS framework, select No. Otherwise select 'Yes'.

⇨ Select 'Yes' if changes are made in the REBUS framework.

⇨ Select 'No' if no changes are made in the REBUS framework.

When selecting ‘Yes’, sometimes the location of the linked file should be specified. In that case, one should specify the location of the REBUS framework.

Step 2: specification of exogenous inputs
As is described in section 3, the main inputs to the REBUS model concern the specification of a range of exogenous data inputs and the cost/potential curves. The cost/potential curves should be specified in the worksheet ‘input cost curves’. Data should be specified in rows 9 to 58 for each individual region. These regions are formulated in the columns C to FJ. In the original model format this is automatically generated from the REBUS framework spreadsheet, where these curves are specified. This automatic link can be overruled by directly specifying data in the rows mentioned.

⇨ Specify the cost/potential curves in the worksheet ‘input cost curves’ in rows 9-58 and columns C-FJ. If cost/potential curves are specified in the REBUS framework, do NOT enter any data since the input is generated automatically.

Important note: After specifying new curves, <u>always</u> press the main button to generate the cost curves in the format required by the REBUS model!!! This main button is included in the worksheet ‘input cost curves’, cell A6.

Next, exogenous data should be specified in the worksheet ‘Data’. This concerns regional gross domestic product (GDP), population and expected consumption in the year 2010, as well as the reference amount of renewable electricity production in each region in the base year of calculations. If available, also the renewable electricity target (as a share of electricity consumption) for each individual region in the year 2010 should be specified.

⇨ Specify electricity consumption in the year 2010 in worksheet ‘Data’, cell B10-B42.
⇨ Specify GDP in the year 2010 in worksheet ‘Data’, cell N10-N42.
⇨ Specify total population per region in the year 2010 in worksheet ‘Data’, cell H10-H42.
⇨ Specify the renewable electricity consumption in each region in the base year in worksheet ‘Data’, cell E10-E42.
⇨ (If available) Renewable electricity target for each individual region (share of electricity consumption) in the year 2010.

- Two additional exogenous inputs that *must* be specified:

⇨ Specify the overall target for renewable electricity consumption for the whole region in the worksheet ‘burden sharing’, cell C34.
⇨ Specify the (marginal) cost of existing RES-E potential in the base year in the worksheet ‘calculate curves’, cell B7.

Step 3: Reference electricity prices
As was explained in section 3, the REBUS model includes the possibility to specify a reference electricity price, i.e. the electricity production price for the physical product electricity. This reference price is used to compare the costs of electricity production from RES-E with the costs of electricity production that would be made if a standard power production unit would be installed. If this option is used, the user of the model must specify this reference price. Note that there are two possibilities to specify the reference electricity price, based on the availability of data:

1. One reference electricity price for the whole geographical region under study, simulating one internal electricity and certificate market in the whole region.
2. A specific reference electricity price for each individual region.

⇨ Specify the reference electricity price for the whole region in the worksheet ‘input cost curves’, cell B4.
⇨ (if available) Specify reference electricity prices for individual regions in row 60 in the cells indicated by the colour blue. If no data is entered, the reference electricity price for this specific region is set equal to the reference electricity price for the whole region.

Step 4: Select calculation case

The REBUS model can be operated for a number of so-called calculation options. These options include different ways to distribute the overall Chinese target to individual targets. These target options are included in the so-called case A, which is calculated in the worksheet 'burden sharing' in rows 34-50. Next these calculation options include different ways of redistributing the total costs of achieving the targets set. These burden sharing options are included in the so-called case B, which is calculated in rows 54-72. The use should indicate which calculation option should be executed in cell B34 or B54 of the worksheet 'burden sharing'.

The present model includes the following target options in case A:
1. Flat minimum rate, i.e. a similar target for each individual region.
2. Specified targets for each individual region, for instance based on regional governmental policies or (inter)national agreed targets.
3. Individual regional targets based on equal targets per capita.
4. Individual regional targets taking into account national RES-E potential.
5. Individual regional targets based on equal growth in the share of RES-E for each region.

⇨ Specify the required calculation option in case A in worksheet 'burden sharing', cell B34.
⇨ In case of using option 2: specify specific targets per region in worksheet 'Data', cells L51-L83.

Case B recalculates the individual regional targets when the total costs of achieving the overall target for renewable electricity are divided according to a certain burden sharing criterion. The present model includes the following burden sharing options:
1. Redistribution of targets at equal costs per unit of GDP.
2. Redistribution of targets at equal costs per capita.

⇨ Specify the required calculation option in case B in worksheet 'burden sharing', cell B54.

Burden sharing options used: (1) equal costs/gdp, (2) equal costs/capita.
⇨ User specification case B: choose burden sharing option in cel B54.
⇨ User specification case B: set overall target in cel C34.

Step 5: Calculations REBUS model

The main calculations of the REBUS model are executed in the worksheet 'burden sharing'. For each of the calculation cases this worksheet contains a number of intermediate and final results. These are presented in rows 35-50 for case A (target options) and rows 55-72 for case B (burden sharing options) for each of the individual regions (columns c-fj). Table 1 lists these intermediate and final results.

Table 4.11 *List of intermediate and final results included in the worksheet 'burden sharing'*

Description included in the model	Explanation
Equilibrium price	The optimal price of tradable green certificates when full trade is allowed.
Interpolation	Factor used to find the exact equilibrium price between the fixed price levels in the redefined cost curve.
Renewables at equilibrium price	The total amount of renewables within the region at the equilibrium price.
Share renewables before trade	The share of renewables in the total electricity consumption when the full target should be realised within the region itself.
Share renewables after trade	The share of renewables in the total electricity consumption when full trade is allowed.
MC renewables before trade	The cost of the last option needed within the region to satisfy the target.
Total reduction costs before trade	The total costs of achieving the target when the full target should be realised within the region itself.
Total reduction costs after trade	The total costs of achieving the target when full trade is allowed.
Trade: +/- = buying/selling certificates	The total amount of renewables traded by this region. A positive (negative) sign indicates that the region is a net buyer (seller) of certificates.
Trade	Total trade by this region as a share of its total target.
Costs per capita before trade	The total costs of achieving the targets per capita when the full target should be realised within the region itself.
Costs per capita after trade	The total cost of achieving the targets per capita when full trade is allowed.
Costs per capita of trade	The total costs of trade per capita.
Eff. gains per capita	The net benefits of trade per capita.
% GDP before trade	The total costs of achieving the targets as a share of GDP when the full target should be realised within the region itself.
% GDP after trade	The total costs of achieving the targets as a share of GDP when full trade is allowed.
Intermediate: total burden up to equilibrium price	The total costs of the realisation of renewables within the individual region up to the equilibrium price.
Resulting total renewables	The resulting amount of renewables paid for by the individual region. (i.e. realisation within the region plus/minus the amount of renewables traded).

The model user should note that if changes are made in the cost/potential curves, the cost curves should be re-formulated again in the format required by the REBUS model. This is automatically executed after pressing the main button, which is included in the worksheet 'input cost curves', cell A6. If this is omitted, the results are not accurate!

⇨ Press main button (worksheet 'input cost curves', cell A6) if changes are made in the cost/potential curves

Step 6: Analysis of results

The REBUS model contains a number of worksheets that provide a more user-friendly report on the calculation results. These include:

- Results targets, a listing of targets for individual regions in the selected cases compared to the least-cost division of targets.
- Report-A that reports on the results for the chosen target option (case A).

- Report-B that reports on the results for the chosen burden sharing option (case B).
- Result graphs that graphically presents a selection of the calculation results.

Next, some of the inputs are reported graphically. These include:
- Graph potentials, which graphically presents the RES-E potential in each individual region. The graphs are specified on a technology level.
- Graphs curves additional, which graphically presents the RES-E cost/potential curve for each individual region. The curve is specified for only additional potentials (i.e. additional to the realisation of RES-E in the base year).
- Graphs curves total, which graphically presents the total RES-E cost/potential curve for each individual region (i.e. including the realisation of RES-E in the base year).
- Curve China additional, which graphically presents the cost/potential curve for China. The curve is specified for only additional potentials (i.e. additional to the realisation of RES-E in the base year).
- Curve China total, which graphically presents the cost/potential curve for all RES-E for China (i.e. including the realisation of RES-E in the base year).

4.5.5 Model extensions

Interaction of a certificate system and other supporting mechanisms

As is explained in section 4.3, the REBUS model includes the possibility to analyse the price effects of supporting policies for specific renewable electricity technologies. This can be specified for an individual technology in a specific region. Table 4.12 provides a list of examples on policy cases and other model extensions (see below) that can be investigated by the REBUS model. Note that this list is not exclusive, thus that a long list of other cases can also be formulated.

Table 4.12 *List of policy cases that can be analysed in the REBUS model*

1. Ceiling on inter-provincial certificates Maximum percentage on the amount of certificates bought on the national Chinese market to comply with agreed targets at the provincial level. In other words, fixed minimum inner-province realisation of increase in renewable electricity production. For instance: ceiling of 50%
2. Inclusion/exclusion of certain provinces in the Chinese TGC system
3. Exclusion/inclusion large hydro or another technology from the TGC system
4. Interaction with specific provincial support schemes, e.g. investment subsidies
5. Interaction with specific technology support, e.g. special regulations for small hydropower
6. Impact of differences in reference electricity prices between regions

- To carry out a policy case, the exogenous inputs of the REBUS model should be changed manually.
- For policy cases that influence the potential of renewable electricity included in the TGC system (cases type 1 or 3), see first explanation *below (additional requirements on market potential of renewable technologies*).
- For policy cases that affect the number of regions participating in the TGC system (cases type 2), see second explanation below (*Reduction or extension of regions*).
- For policy cases on interaction with support schemes (cases type 4 or 5): Specify the price effect of supporting policies in the worksheet ‘input cost curves’ in cells B65-AG104.
- For policy cases that affect the reference electricity price, see step 3.

Additional requirements on market potential of renewable technologies
As was explained in Chapter 3 the cost/potential curves used in the REBUS model are specified on the basis of an assumed realisable potential for each technology in each individual region. This realisable potential takes into account the technical potential, the availability of land, public acceptability and planning issues. Furthermore, this realisable potential takes into account the capabilities of the renewable production industry such as a maximum growth rate on the production output. However, as is explained in Section 4.3, the definition of realisable potential does NOT take into account an overall limitation on the capabilities of the production industry within the whole region. To include this additional restriction, an iterative procedure of running the REBUS model and the REBUS framework should be executed as is indicated below.

Step a: specification of data in the REBUS framework.
Step b: running the REBUS model with original cost/potential curves.
Step c: changing cost/potential curves in the REBUS framework.
Step d: running the REBUS model with modified cost/potential curves.

Steps c and d should be repeated until for all technologies the sum of penetration in all regions does not exceed the maximum overall penetration specified.

Reduction or extension of regions
The current REBUS model for China is specified for 33 regions. However, it can also be used to analyse the effects of including additional regions or excluding certain regions in the burden sharing system. Extension or reduction of the number of regions is complex, and requires a good insight in the programming of the model and experience in changing macros.

In short, the following steps should be executed to extend the number of regions in the REBUS model:
1. For each new region, additional columns should be included in the worksheet 'input cost curves' and 'calculate cost curves', performing similar operations as for the other regions.
2. For each new region, 5 additional columns should be included in the worksheet 'burden sharing' that performs similar calculations as for the other regions.
3. The exogenous input data specified in section 3 should be extended with exogenous input data for the new regions. The format used for this input data should be identical to the format used for the existing regions.
4. All formulas used in the worksheet 'burden sharing' that use this exogenous data should be adapted to include the new regions. (in general the operating ranges should be extended, this concerns calculations made in column C and the calculation of the cost/potential curve for the whole region)
5. The automatic generation of cost curves should be extended for the additional regions. For this, additional macros should be written to copy and sort the inputs as specified in the worksheet 'input cost curves'. This concerns the macros COPY_DATA_X and SORT_COST_X, with the X indicating the ranking number of the region.
6. The following macros should be extended to included the additional input data for the new regions included: COPY_DATA_ALL and SORT_COST_ALL.
7. The reporting sheets and worksheets containing a graphical presentation of the inputs or results of model calculations should be updated to include reporting on the new regions.

A reduction of the number of regions can be simulated by setting all inputs for a certain number of regions equal to zero, and by changing the formulas as mentioned in step 4 above.

ANNEX A. THE RECS-BASIC COMMITMENTS, RELEASE 1

A.1 Acknowledgement

This document sets out the basic concepts underlying the Renewable Energy Certificate System (RECS), and provides the minimum common set of definitions and criteria for the creation, issue, transfer and eventual removal from the market of RECS Certificates.

It has been prepared by its custodian, the Association of Issuing Bodies (AIB), in accordance with its Articles of Association and internal regulations as appropriate, and following consultation with the stakeholders in RECS. The associated intellectual property is vested in the AIB.

Rules that are supplementary to the Basic Commitment and apply to a domain are contained in a separate protocol.

The author of this document wishes to thank all contributors and particularly the members of the forerunner to the AIB, the Basic Commitment Working Group, for their constructive criticism and contributions:

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Article 1: Basic Commitment

1.1 The **Basic Commitment** (this document) is the minimum common set of definitions and criteria for the creation, issue, transfer and use as evidence of transfer of ownership and eventually removal from the market of RECS Certificates and may only be amended or added to by the Association of Issuing Bodies following a procedure of consultation in which the interests of Participating RECS Members are duly regarded.

1.2 Rules that are supplementary to the Basic Commitment and apply in one Domain only will be contained in the corresponding **Domain Protocol**.

Article 2: Definitions

2.1 **Renewable Energy** shall comprise all energy excluding fossil and nuclear fuels and electrical energy derived from these sources. Electricity produced from Renewable Energy sources is referred to in this document as **RES-E**.

2.2 Electrical energy shall be measured in megawatt hours, which shall be referred to in this document as **MWh**.

2.3 **Public Support** is any relevant direct or indirect support, whether from regional, national or international (for example European Union) public funds or comparable support schemes, excluding that provided by means of and relating to RECS Certificates.

2.4 A **RECS Certificate**:

a. Shall represent the entire benefit of RES-E over electricity from non-renewable sources. A Participating RECS Member and parties represented by it may not separately claim or confer rights or title to any element of this benefit;

b. Provides a record as specified in Article 3.14 of this Basic Commitment of the generation of a standard quantity of one megawatt hour (1MWh) of RES-E;

c. Shall remain valid until it has been redeemed;

d. Forms the basis of transfers of ownership between parties and title to it may change until it has been redeemed; and

e. All records relating to it including any transfer of ownership shall be retained by each of the parties to the transfer of ownership and by the corresponding Issuing Body for a period of not less than ten years after it has been redeemed, or so much longer as is required by the laws of the country in which it was issued.

2.5 An **Earmarked Certificate** specifies that Public Support has been received by the RES-E Generator for the associated Production Device or the electricity produced by it. Details of this support shall be maintained by the Issuing Body in accordance with Article 3.7.g.

2.6 A **Production Device** is a separately metered device or group of devices that generates electricity.

2.7 A **Consumer** of electricity is an end user of electrical energy.

2.8 An electricity **Transportation System** is a collective term for the electricity distribution and transmission systems, which together transport electrical energy from a Production Device to a Consumer.

2.9 A **Domain** will normally be defined by its geopolitical boundaries. Such boundaries may adopt or be different to those of the associated Transportation System, which may in some cases overlap geopolitical boundaries.

2.10 For each Domain, the corresponding Participating RECS Members shall appoint one **Issuing Body,** which shall:

a. Be the only such body that is responsible within that Domain for:

i. Ensuring that the Basic Commitment and relevant Domain Protocol are observed within its Domain in the creation, issue and redemption of RECS Certificates, and their use as evidence of transfers of RECS Certificate ownership;

ii. Inspecting, as set out in the Domain Protocol for the Domain in which that Production Device is registered, all RES-E Production Devices that wish to participate in RECS, including inspecting their metering equipment and any associated engineering, accounting and metering records in order to verify that they comply with RECS criteria as set out in the Domain Protocol and, where appropriate, approving and registering them for participation in RECS;

iii. From time to time, requiring the repetition of such inspection at its sole discretion in order to assure itself of continued compliance, confirming or removing such Registration as appropriate;

iv. Issuing, transferring ownership of and Redeeming RECS Certificates; and

v. Recording in a **Central Registration Database** (CRD) details of all issued RECS Certificates within its Domain including their current ownership.

b. Seek and gain recognition under such quality standards as the Association of Issuing Bodies considers appropriate.

2.11 If the Issuing Body outsources to an agent, then the Issuing Body shall remain responsible for the proper functioning according to the provisions to the Basic Commitment of that body as its agent, and the agent shall be subject to and will have the rights and responsibilities conferred by the relevant conditions of the Basic Commitment that apply to Issuing Bodies.

2.12 The **RECS Association of Issuing Bodies** is the international alliance of RECS Issuing Bodies and is responsible for approving and accepting all Issuing Bodies wishing to issue internationally acceptable RECS Certificates.

2.13 A **Generator** is a body engaged in the production of electricity by means of one or more Production Devices.

2.14 A **Renewable Energy Declaration** (or **RED**) shall be made by any RES-E Generator wishing to receive RECS Certificates for a specific Production Device to the Issuing Body with responsibility for the Domain in which this Production Device is located, and shall state that the Production Device produces RES-E.

2.15 Each Issuing Body shall be responsible for:

a. **Issuing** RECS Certificates for Production Devices within its Domain, including creating a corresponding entry in the appropriate Transferable Account on the CRD;

b. **Redeeming** RECS Certificates that it has Issued, including transferring the RECS Certificate from the appropriate Transferable Account for that RECS Certificate Owner on the CRD to the corresponding Redemption Account.

2.16 A **RECS Certificate Owner** is a body holding a transferable RECS Certificate, and shall use the RECS Certificate to provide evidence of ownership should it wish to transfer ownership to another party or otherwise Redeem it.

2.17 A **Production Aggregator** is a Participating RECS Member, which is bound by the rules of RECS and acts for one or more RES-E Generators.

2.18 **Registration** refers variously to the recording of transfers of ownership, the inspection and approval of RES-E Production Devices for participation in RECS, and the acceptance of the various bodies responsible for administering RECS.

2.19 A **Participating RECS Member** is a party that has been accepted into RECS by the relevant Issuing Body or the Association of Issuing Bodies as appropriate and agrees to be bound by the Basic Commitment and the relevant Domain Protocol for the Domain or Domains in which it is commercially active.

Article 3: Issuing of certificates

Overall responsibilities of an Issuing Body

3.1. Each Issuing Body shall explicitly identify the Domain or Domains within which the Domain team comprising the Participating RECS Members that are commercially active within the Domain or Domains have appointed it to issue RECS Certificates.

3.2. Only one Issuing Body shall issue RECS Certificates in any single Domain.

3.3. Issuing Bodies may not at any time hold title to RECS Certificates, nor may any body holding title to RECS Certificates be a subsidiary, parent or related undertaking or operate as or have any controlling financial interest in an Issuing Body.

3.4. Issuing Bodies may not at any time be a subsidiary, parent or related undertaking nor shall they operate as or have any financial interest in a Generator, the Production Aggregator or other market players.

Registration of a Production Device

3.5. A RES-E Generator or a Production Aggregator acting on behalf of a RES-E Generator wishing to receive RECS Certificates for the electrical output from a RES-E Production Device shall first gain Registration for that Production Device from the Issuing Body responsible for the Domain within, which the Production Device lies by making a Renewable Energy Declaration (or RED) to the Issuing Body. Any Production Device that is not so Registered may not be Issued with RECS Certificates.

3.6. A Renewable Energy Declaration shall state that the installation fulfills the criteria set out in this Basic Commitment and relevant Domain Protocol. The RED must have a period of validity limited according to the Domain Protocol for the Domain in which this Production Device is registered but will in any case be no longer than 5 years, after which time it must be re-submitted. Failure to do so will result in cessation of certificate issue for this Production Device. The criteria and the procedure for the RED may change over time.

3.7. A Renewable Energy Declaration shall include:

a. The name, address, contact details (including person responsible, phone, fax and e-mail) and Issuing Body for that RES-E Generator or of a Production Aggregator acting on its behalf;
b. The location of the Production Device;
c. The location and detail of the export and, where appropriate, import meter(s);
d. All possible sources of fuel to be converted into electrical energy by this Production Device, whether or not this is renewable, from the agreed list as set out in Annex I to this Basic Commitment;
e. The type of generation technology in place at this Production Device, from the agreed list as set out in Annex I to this Basic Commitment;
f. The installed capacity of this Production Device;
g. The date of commissioning of this Production Device;
h. Any schemes associated with any Public Support from the list set out in Annex 1 to this Basic Commitment that are or have been received in addition to RECS Certificates by this Production Device, together with an indication as to whether they are currently being received;
i. A guarantee that the RES-E Generator owning this Production Device will not during the period of its Registration and for the same unit of electrical energy receive certificates representing the benefit of renewable electricity generation from both RECS and another similar system;
j. A diagram showing the Production Device, the location of export meters used for metering its generation and of transformer substations at the plant site. If there are generating auxiliaries for the Production Device and/or import meters for metering their demand these shall be also shown on the diagram; and
k. Any additional information required by the Issuing Body as contained in the Domain Protocol.

3.8. Should any planned or unplanned change to a Production Device, including changes to any Public Support received by it, render the statements made in the RED inaccurate, then the corresponding RES-E Generator or the Production Aggregator acting on its behalf shall:

a. Inform the appropriate Issuing Body prior to planned changes coming into effect or immediately where such changes are unplanned; and
b. Not receive RECS Certificates in association with this Production Device other than in its original state until it has been re-Registered by the Issuing Body.

3.9. Each Production Device shall be assigned a unique identifier as defined in Article 3.14.c.

3.10. The current details as set out in the Renewable Energy Declaration (see Article 3.6) of each Production Device that has been Registered shall be made available in electronic form to each Participating RECS Member.

3.11. The Issuing Body shall publish clear and unambiguous procedures for the Registration of Production Devices. These procedures shall require that the RES-E Generator or the Production Aggregator acting on its behalf:

a. Completes and provides to the Issuing Body a RED;

b. Will permit the Issuing Body to inspect the Production Device and such records as it considers to be necessary to verify the authenticity of the RED and that such inspection may be conducted without prior announcement;

c. Requests an account on the CRD where the issued RECS Certificates for the Production Device will be deposited;

d. Discloses details of any past infringements of Domain or inter-Domain agreements regarding RECS Certificates and including the Basic Commitment and any Domain Protocol by itself or by any subsidiary, parent or related undertaking;

e. Provides details of an officially endorsed source of meter readings, the means of collecting these, approval for their collection and accepts liability for the delivery, quality and accuracy of these meter readings; and

f. Guarantees that all support schemes listed in Annex 1 to this Basic Commitment that are associated with this Production Device have been disclosed on the RE Declaration and that it will not during the period of its Registration and for the same unit of electrical energy receive certificates representing the benefit of renewable electricity generation from both RECS and another similar system.

3.12. If a RES-E Generator seeking Registration with RECS of a Production Device meets the criteria for participating in RECS then the Issuing Body shall accept the application.

3.13. If a Production Device belonging to a RES-E Generator has been Registered with RECS then the Issuing Body shall issue to that RES-E Generator such certificates as are supported by evidence of generation by that Production Device of a corresponding amount of electricity from renewable sources, as evidenced by appropriate meter readings and statements of the proportion of electricity from renewable sources.

Issuing of RECS Certificates

3.14. A RECS certificate shall exist as the following electronic record:

a. **Unique RECS Certificate number**: a certificate will be identified by a number that also identifies the Domain of origin - 30 numeric characters;

b. **Issuing body**: the identity of the Issuing Body (and the Domain) that issued the RECS Certificate. The AIB shall keep a list of recognised Issuing Bodies (this forms Annex I to this Basic Commitment) - 2 numeric characters;

c. **Production device:** A reference to the Production Device that generated the electricity of which details are publicly available (as set out in Article 3.10). The Production Device will be identified by a number that also identifies the Domain of origin - 18 numeric characters;

d. **Time of issuing**: The calendar year and month when the energy associated with this RECS certificate was fully delivered. Of the format CCYYMMDD - 8 numeric characters;

e. **Technology code**: a reference to the technology with which the electricity was generated (as set out in the list in Annex I to this Basic Commitment) - 2 numeric characters;

f. **Earmark**: an indication whether any Public Support is currently or has in the past been received, and of which further details are publicly available - one numeric character, where acceptable values are:

0 (zero) = No Public Support;

1 (one) = Public Support for investment in Production Devices that produce RES-E;
2 (two) = Public Support for the ongoing production of RES-E; and
3 (three) = Public Support for both the investment in Production devices that produce RES-E and for the ongoing production of RES-E; and

g. **Installed capacity**: the installed capacity of the Production Device that generated the electricity, in kilowatts - 7 numeric characters.

3.15. Only RES-E shall be eligible to receive RECS certificates, the quantity issued reflecting the amount of nett electrical energy generated as evidenced by meter readings adjusted by meter amendments and the outcome of any disputes. The nett electrical energy generation is the gross production minus demand of any generating auxiliaries and minus losses in the main generator transformers on the site of the Production Device. The frequencies with which meter data is monitored and RECS Certificates are issued shall form part of the Domain Protocol.

3.16. A Production Device may not during the period of its Registration with RECS and for the same unit of electrical energy receive evidence such as certificates representing the benefit of renewable electricity generation from both RECS and another system that similarly certifies the origin or represents the benefits of the associated renewable electricity.

3.17. On receipt of evidence of generation of a set quantity of electricity by a registered RES-E Generator either from that RES-E Generator or from a Production Aggregator acting on its behalf, the Issuing Body with responsibility for that Domain shall:

a. Issue a RECS Certificate to that RES-E Generator or Production Aggregator by creating an appropriate entry in the Transferable Account for that RES-E Generator; and
b. Inform the RECS Certificate Owner of the details of the Issued RECS Certificate.

By default, the first owner of a RECS Certificate shall be the RES-E Generator responsible for production of this RES-E.

3.18. The integrity of each RECS Certificate shall be maintained at all times:

a. Once it has been created, changes to a RECS Certificate shall not be allowed; and
b. The elements of the record associated with a RECS Certificate shall always be kept together in all data transfers.

3.19. All information contained in the RED that is not shown directly on the RECS Certificate shall be made available on application in writing from any body to the Issuing Body.

Article 4: Transfer of ownership of certificates

4.1. The manual and automated information systems implemented by an Issuing Body must be both robust and secure, and support ad hoc audit of the Issuing Body including enabling inspection of all transactions associated with all or specific RECS Certificates.

4.2. A RECS Certificate Owner wishing to transfer ownership of a RECS Certificate to another Participating RECS Member or, where applicable, the exchange effecting such transfer of ownership shall notify the Issuing Body that is responsible for the Domain in which the RECS Certificate is currently registered of the transfer of ownership of the RECS Certificate.

4.3. On receipt of a request to transfer ownership of a RECS Certificate from a RECS Certificate Owner or, where applicable, the exchange effecting such transfer of ownership, the Issuing Body shall:

a. Record the transfer of title in the Transferable Accounts of the parties to the transfer of ownership on the CRD, which shall provide evidence of title;
b. Retain all supporting documentation relating to transactions; and
c. Except as provided in Article 4.5, confirm such transfer to both parties to the transfer of ownership, where both parties to the transfer of ownership are situated within its Domain.

4.4. Transfer of ownership of RECS certificates may be through private, bilateral arrangements between parties or through an intermediary (for example, an exchange or brokerage).

4.5. The Issuing Body shall have sole responsibility for the import and export of RECS Certificates into and out of its Domain.

4.6. A Participating RECS Member (or, where applicable, the exchange acting for it) wishing to export a RECS Certificate from a Domain shall notify the Issuing Body for that Domain of the unique numbers of the RECS Certificates to be transferred, the destination Domain and the account number of the recipient in the Central Registration Database of that Domain.

4.7. On receipt of a request to export RECS Certificates the Issuing Body responsible for the exporting Domain shall:

a. Confirm the validity of the RECS Certificates;
b. Record the export in the Central Registration Database, amending the status of the RECS certificate to 'exported';
c. Send details of the exported RECS Certificates and the account number of the intended recipient in the Central Registration Database of the corresponding Domain to the Issuing Body of the importing Domain; and
d. Notify the seller that the RECS Certificates have been marked as 'exported' and transferred to the Issuing Body of the importing Domain.

4.8. On receiving details of the exported RECS Certificates and the account number of the intended recipient in the Central Registration Database of the corresponding Domain from the Issuing Body for another Domain, the Issuing Body of the importing Domain shall:

a. Confirm that the RECS Certificates received meet the criteria specified in the Domain Protocol for the importing Domain;
b. Transfer the RECS Certificates to the account of the recipient in the Central Registration Database;
c. Notify the recipient of the RECS Certificates of this transfer of ownership; and
d. Confirm the successful completion of the transfer of ownership to the Issuing Body of the exporting Domain, which shall in turn notify the seller of the RECS Certificate.

4.9. Should an exported RECS Certificate not meet the criteria of the importing Domain as set out in its Domain Protocol, then the Issuing Body of that Domain shall notify the Issuing Body of the exporting Domain. In such cases:

a. Such additional information as is required by the Issuing Body of the importing Domain shall be exchanged between the Issuing Bodies; or
b. The RECS Certificates shall be returned to the Domain of origin, the status of 'exported' cancelled, and the seller notified.

4.10. Any RECS Certificates Owner may retain or 'bank' its RECS Certificates for an unlimited period unless otherwise required by law.

4.11. Upon receipt of a request from a RECS Certificate Owner to issue a printed official RECS Certificate, the Issuing Body with which the RECS Certificate is currently registered will:

a. Transfer details of that RECS Certificate from the appropriate Transferable Account on the CRD for that RECS Certificate Owner to the corresponding Redemption Account, to indicate that ownership of the RECS Certificate is no longer transferable; and
b. Provide the RECS Certificate Owner with a printed copy of the RECS Certificate and confirmation that the RECS Certificate has been Redeemed.

4.12. Each Issuing Body shall maintain and make public a list of those schemes requiring RECS Certificates as evidence of compliance.

4.13. A RECS Certificate may be Redeemed for any of the following reasons:

a. Upon request from a RECS Certificate Owner for purposes that are agreed in its Domain context (e.g. to comply with agreement for the generation or supply of RES-E; to discharge an obligation to Government; in return for tax credits etc.);

b. To advertise the activities or products of a RECS Certificate Owner who requests that a RECS Certificate is redeemed; or

c. For any reason other than those listed above.

4.14. Upon receipt of a request from a RECS Certificate Owner to Redeem a RECS Certificate, the Issuing Body with which the RECS Certificate is currently listed shall:

a. Transfer that RECS Certificate from the appropriate Transferable Account on the CRD to the corresponding Redemption Account to indicate that the RECS Certificate has been redeemed and that ownership is no longer transferable;

b. Inform the RECS Certificate Owner of the details of the transfer, including the details held on the certificate, confirming in a declaration of redemption that the RECS Certificate has been Redeemed; and

c. Make available details of the RECS Certificate to the redeeming body and its auditors.

4.15. Where an Issuing Body finds and has supporting evidence to prove that a RECS Certificate being imported into or exported from its Domain contravenes RECS criteria as embodied in the Basic Commitment and the appropriate Domain Protocol or has been otherwise issued improperly, then it shall bring this to the attention of the other Issuing Body. Where the Issuing Bodies jointly are unable to resolve the problem then they shall bring this to the attention of the Association of Issuing Bodies, who will arbitrate in cases of dispute and whose decision will be final in all cases.

Article 5: Registration databases

5.1. Each Issuing Body shall:

a. maintain and make public records of each Production Device that it has at any time registered within its Domain including details of its Registration including, where appropriate, the original RED and any notifications of change to this RED during the period of its registration

b. maintain records in the CRD of each RECS Certificate that it has issued. These records shall include the current owner and transferability of the RECS Certificate.

Article 6: Verification, audits and reports

6.1. All parties to RECS shall:

a. observe the requirements of this Basic Commitment. Failure to do so shall be referred to the Association of Issuing Bodies, which may take such action as it considers necessary.

6.2. Each RES-E Generator shall:

a. periodically confirm that the claimed RES-E production is reflected in the physical meter reading.

6.3. Each Issuing Body shall be responsible for:

a. Performing ad hoc checks on Registered Production Devices to ensure that the corresponding RED correctly reflects the current state of the Production Device and to confirm that RECS criteria set down in the Basic Commitment and the relevant Domain Protocol are being observed. Should any abuses of the system be discovered then the Issuing Body shall take such appropriate action as it sees fit and inform the Association of Issuing Bodies should such abuse be capable of affecting the conduct of RECS Certificate transfers of ownership outside of the Domain of the Issuing Body;

b. Ensuring that the claimed RES-E production has actually taken place, and may demand ad hoc or scheduled access to all records and meters associated with

Registered Production Devices and require sight of documentation associated with the Public Support associated with the Production Device; and

c. Assuring the validity of REDs, claimed RES-E production, registration of transfers of ownership and Redemption of RECS Certificates; and for ensuring that the associated procedures are robust, effective, efficient and adequate.

6.4. Each Issuing Body:

a. Shall monitor all activity in the RECS market within its Domain;

b. Shall publish regular reports on the numbers of RECS Certificates issued, imports and exports and those no longer transferable as a consequence of redemption;

c. Shall publish regular reports on the functioning and efficiency of the market;

d. Shall report any instances of non-compliance with RECS rules by market player(s) to national and international competition authorities as appropriate and the Association of Issuing Bodies, which may take such action as is defined in the Domain Protocol.

Article 7: Investigations and modification requests and disputes

7.1 Any Participating RECS Member or Members may request the investigation of, or modification to, the operation of RECS:

a. Within the Domain within which it is commercially active, including without limitation modification of the Domain Protocol;

b. Outside of the Domain within which it is commercially active, including without limitation modification of the Basic Commitment.

Such request must include a detailed description, including an exact specification of any proposed modification of the Domain Protocol or Basic Commitment, and be passed in writing to the Issuing Body responsible for that Domain.

7.2 Each Issuing Body may:

a. With the approval of the Association of Issuing Bodies make such modifications to the Domain Protocol as are in its opinion necessary to the effective and efficient operation of the market and which will maintain compliance with this Basic Commitment;

b. Propose modifications to the Basic Commitment and the implementation of such proposed modifications shall be considered by the Association of Issuing Bodies (AIB).

7.3 On receipt of such a request as is specified in 7.1, an Issuing Body shall:

a. Consult with the Participating RECS Members within its Domain;

b. Decide whether the request is in its opinion reasonable and its consequences;

c. Inform the Participating RECS Member or Members whatever the outcome of this decision;

d. Notify in writing any requests that may have implications outside of its own Domain to the Association of Issuing Bodies, which will conduct any necessary investigations and institute proceedings to modify the Basic Commitment as necessary.

7.4 The Participating RECS Member or Members that raised the request may appeal to the Association of Issuing Bodies against any decision given according to 7.3REFMERGEFORMAT.

7.5 All actions set out in this Article 7 should be undertaken in accordance with the relevant Domain Protocol and the Articles of Association and rules of the Association of Issuing Bodies, where the Articles of Association and rules of the AIB shall take precedence.

A.2 Issuing Body Codes

Reference shall be made exclusively to the following list of eligible Issuing Bodies and their Domains.

The AIB shall keep a list of recognised Issuing Bodies (this forms Annex I to this Basic Commitment) - 2 numeric characters.

Table A.1. *List of Issuing Bodies*

Issuing Body Code	*Country Code*	*Issuing Body*	*Country*
-	AT	Not appointed	Austria
01	BE	Awaiting appointment	Belgium
02	DE	Ökoinstitut	Germany
03	DK	Eltra	Denmark (geographical area?)
04	DK	Elkraft	Denmark (geographical area?)
-	GR	Not appointed	Greece
05	IE	GCC	Ireland
-	ES	Not appointed	Spain
06	FI	Fingrid	Finland
07	FR	Observ'ER	France
08	IT	GRTN	Italy
-	LU	Not appointed	Luxembourg
09	NL	KEMA	Netherlands
10	NO	Statnett	Norway
-	PT	Not appointed	Portugal
11	SE	Svensk Kraftnat	Sweden
-	CH	Not appointed	Switzerland
05/12	GB	GCC	United Kingdom

A.3 Renewable Energy Sources and Generation Technology

Reference shall be made exclusively to renewable energy sources and generation technologies included in the following list:

Table A.2 *Renewable energy sources and generation technology*

Source	*Technology*	*Type*
Wind	Wind turbine	Onshore Offshore
Solar	Photovoltaic Thermal	
Energy from water[21]	Hydro power	
	Tidal energy	Onshore Offshore
	Wave energy	Onshore Offshore
Geothermal		
Biomass, using gasification and non-gasification technologies[22]		
	Energy crops	
	Forestry and agricultural by-products and waste	
	Biogas	
	Landfill gas	
	Energy from by-products and waste (with varying levels of filtration)[23]	municipal solid waste industrial by-products and commercial waste
	Sewage gas	

[21] Pumped hydro power is excluded.
[22] As defined in the Large Combustion Plants Directive and the Waste Combustion Plants Directive.
[23] Note that certificates will only be issued for the estimated non-fossil proportion of Energy from By-Products and Waste.

A.4 Earmarks

Reference shall be made exclusively to Public Support that has or is currently being received for investment in Production Devices that produce RES-E or for the current production of RES-E in addition to RECS Certificates, from the following agreed list:

Table A.3a *Public Support for investment in production devices that produce RES-E*

Country	*Abbrev.*	*Scheme*
DE	PVR	100,000 PV Roofs Programme Credit programme with reduced interest rates for PV plants owned by private households and SME (not valid for large utilities). Valid for applications until 2004. *Detailed criteria for eligibility and the volume of support will be made available to RECS.*
	Add	Additional RES Support Programmes Several regions (Länder) and communities have additional investment support schemes for PV, biomass and other RES in place. *The relevance of these schemes is much lower than the federal support schemes. A complete list of these schemes may not be available (and would be changing frequently), so it will probably not be possible to provide more details.*
	Note: *Especially for PV, different support schemes can be cumulated in rather complex ways.*	
NL	VAMIL	Early depreciation of investments. Applies to specific technologies which are listed. Scheme allows investments to deduct the full costs of their investment in the first year from the corporate tax they pay. Gives an effective reduction of investment costs of around 10%.
	EIA	Energy Investment Deduction. Applies to specific technologies, which are listed. Scheme allows investments to deduct 55% of the full costs of their investment in the first year from the corporate tax they pay. Gives an effective reduction of investment costs of 19% (since 2001, in previous years lower rates applied).
	GF	Greenfunds. Provide lower interest rates (up to 1.5%) for eligible projects.
	BSE	Decision on Energy Subsidies. Provides subsidy up to 30%. Support depends on technology.
	CO2	CO_2 Reduction Plan. Provides subsidies up to 30% of additional investment costs.
FI	I	Investment aid. This aid can vary from some per cents to about 30% depending on the feasibility of the production.
	Note: *There exists no obligatory system for renewable energy in Finland. The demand and production of green electricity are based purely on voluntary actions.*	
SE	I	Investment support scheme for small-scale hydro (<1,5 MW), biomass and wind. 15%-25%.
BE	I	Investment aid being given to renewables by the flemish government ‘Ecology-support’ for investments with a environmental benefits get the following support - large companies: 8% (end of pipe technologies) 10% (energy saving, including renewables) 12% (process-integrated) - small companies: 20% regardless the technology - pv: 50% by the flemish government + 25% by electricity-producers for the years 2000-2001 - solar heating: 625 € from the electricity sector (in the walloon region + another 625 € directly from the government)

Table A.3b *Public Support for current [ongoing] production of RES-E:*

Country	*Abbrev.*	*Scheme*
DE	REL	Renewable Energy Law (valid from 1. April 2000 on) Minimum prices for feeding in electricity from RES (wind, hydro <= 5 MW, biomass (excl. municipal waste) <= 20 MW, geothermal power, solar radiation <= 5 MW, landfill gas and sewage plant gas <= 5 MW). Minimum prices differ with generator rating and energy sources and for wind also with plant age and wind conditions on site. *A detailed list of the minimum prices will be made available to RECS.*
	FL	Feed-in Law (expired - valid until 31. March 2000) Minimum prices for feeding in electricity from RES (wind, hydro <= 5 MW, biomass (excl. municipal waste) <= 5 MW, solar radiation <= 5 MW, landfill gas and sewage plant gas <= 5 MW). Plants owned by utilities were not eligible for support. Minimum prices were related to average electricity prices and differed with generator rating and energy sources. *A detailed list of the minimum prices paid in the years from 1990 until the expiration of the FL will be made available to RECS.*
	Add	Additional RES Support Programmes Several regions (Länder) and communities have additional feed-in support schemes for PV, biomass and other RES in place. *The relevance of these schemes is much lower than the federal support schemes. A complete list of these schemes may not be available (and would be changing frequently), so it will probably not be possible to provide more details.*
	Note: • *The REL has replaced the FL. Therefore plants usually have received payments under the FL until 31.03.2000 and under the REL from 01.04.2000 on. It makes sense to include information on both schemes on the plant database.* • *Under the FL, plantes owned by utilities were not eligible for support. Under the REL these plants are entitled for support.* • *Especially for PV, different support schemes can be cumulated in rather complex ways.*	
IE	AERn	Alternative Energy Requirement Government supported competition. Successful applicants have 15 year power purchase agreement with ESB at agreed prices. Technologies supported are wind, hydro, landfill gas and biomass.
GB	NFFOn	Non Fossil Fuel Obligation All Obligation arrangements are based on the principle that Public Electricity Suppliers must contract for specified capacities of renewable energy generation in technology bands. Suppliers pay each renewable energy generator and agreed price for energy. The difference between market energy price and the agreed price comes from Fossil Fuel Levy that all suppliers pay as a percentage of sales of non-renewable electricity. Technology bands supported are/have been wind, hydro, landfill gas, municipal waste, energy crops, sewage gas. NFFO1 & 2 support schemes have ceased NFFO 3, 4 and 5 support schemes are active
	SROn	Scottish Renewables Obligation SRO1, 2 and 3 support schemes are active
	NI-NFFOn	Northern Ireland Non-Fossil Fuel Obligation NI-NFFO 1 and 2 support schemes are active
	CCL Exemption	Suppliers using renewable source electricity may avoid the Climate Change Levy payable on supplies of electricity. Only registered renewable energy generators qualify for this exemption.
NL	REB-36o	Support payment from the revenues of the energy tax for listed sources of renewables. Payment (2001) is 1.94 Euro-ct/kWh
	REB-36r	Support payment from the revenues of the energy tax for electricity form waste incineration. Payment (2001) is 0.97 Euro-ct/kWh

Table A.3b continued

Country	*Abbrev.*	*Scheme*
FI	II	Tax reduction in heat production. The tax is based on CO2 emissions from the production. Currently the tax is 102 FIM/tCO2. Biomass-based heat production is tax-free. The tax reduction for peat-based production is about 75%.
	III	Rebate of electricity tax. The refunds for biomass-based production and for wind power are 2.5 p/kWh and 4.2 p/kWh, respectively.
	Note: *There exists no obligatory system for renewable energy in Finland. The demand and production of green electricity are based purely on voluntary actions.*	
SE	II	Feed-in tariff for wind mills. The same amount as the normal energy tax for end-use customers.
	III	Feed-in tariff for small-scale production Devices < 1,5 MW.
BE	II	Fixed buy-back tariffs for renewables and CHP *The buy back obligation is placed on the producer or the supplier.*
	III	Extra tariff schemes of 1 BEF/kWh for solar energy, biogas and organic waste *The extra tariff is to be paid by the producer or the supplier of electricity who buys the electricity.*
	IV	Extra-tariff schemes of 2 BEF/kWh for hydraulic and wind energy with a capacity limited to 10 MW and fotovoltaic energy *The extra tariff is to be paid by the producer or the supplier of electricity who buys the electricity.*
	Note: Operating aid in Belgium is financed through private funds so it is not a public support scheme.	

ANNEX B. ANNEXES TO CHAPTER 3

B.1 Databases

The available software uses databases to gather information from or send information to. This appendix illustrates some of these databases or registers.

B.1.1 The tradable green certificate

Size and validity of certificate

- The standard size of a certificate is 1 MWh.
- The certificates shall remain valid until it has been redeemed.
- All certificates are marked when issued with the status identifier ‘transferable’ in the Central Registration Database. These certificates can be transferred to the account of another owner when an order for such a transfer has been received.

The status identifier may change in the following cases:

- When an owner has given an order to redeem the certificate. It will be marked in the Central Registration Database as ‘redeemed’. Certificates, which are marked as redeemed, are no longer transferable to any other owner.
- When an owner has given an order to export the certificate. It will be marked in the Central Registration Database as ‘exported’. Certificates, which are marked as exported, are no longer transferable to any other owner.
- When the Issuing Body has given an order to mark the certificate as non-transferable. It will be marked in the Central Registration Database as ‘non-transferable’. Certificates, which are marked as such, are no longer transferable to any other owner.
- When the Issuing Body has given an order to mark the certificate as temporarily blocked. It will be marked in the Central Registration Database as ‘blocked’. Certificates, which are marked as such, are not transferable to any other owner as long as the blocking period has not been lifted by the Issuing Body. When the Issuing Body agrees to lift the blocking period, the status is reset to ‘transferable’.

Structure unique coding of certificate

A tradable green certificate has a unique serial number, consisting of 5 codes:

- the country of origin,
- the year of issuing,
- the code of the issuer (only known by the central database),
- the type of renewable energy (see also table A1),
- and a serial number for each tradable green certificate produced.

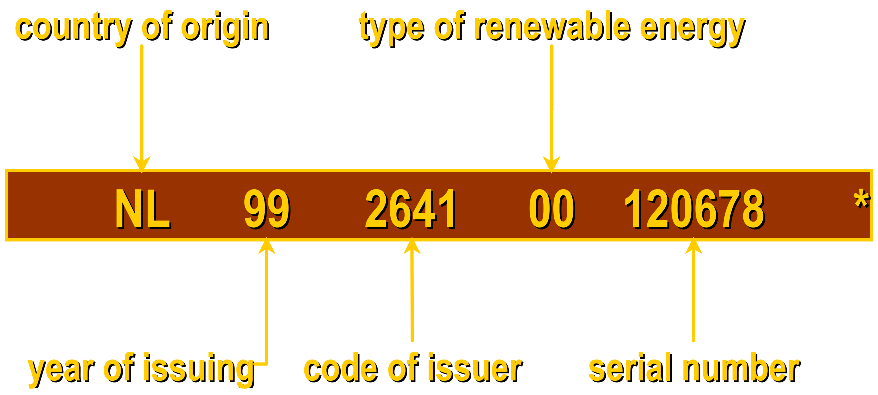

Table B.1 *Example of the coding table used to identify renewable energy sources (possibly to be adapted to the Chinese situation)*

Type of renewable energy	*Code*
wind energy	00
hydro	01
solar	02
wave / tidal	03
geothermal	04
biomass	05
waste	06

B.1.2 Register of production devices

Table B.2

Name of data field	*Coding*
identification number for the production device	unique number allocated in sequential order
account number where certificates should be deposited	see register of Generators (section 5.3)
production device details (name, address, contact details)	text field
meter details (location and detail)	number
	text field
renewable energy and generation technology	according to a specified list (see table A1)
possible sources of fuel	according to a specified list
installed capacity	number (in kW)
date of commissioning	dd-mm-yyyy
support schemes	according to a specified list

B.1.3 Register of Generators

Table B.3

Name of data field	*Coding*
account number of generator	unique number allocated in sequential order
generator details (name, address, contact details)	text field
issuing body or its agent	code number of the issuing body

B.1.4 Register of production registrar

Production registrars are within the responsibility of the Issuing Body. In case an IB decides to implement production registrars within its domain, a separate register of production registrars should be maintained. In that case the software contains a register with production registrars within the domain of the Issuing Body. The production registrar is identified by a unique digit code. The register contains name and contact information of the production registrar.

Table B.4

Name of data field	*Coding*
identification of PR	unique number allocated in sequential order
production registrar details (name, address, contact details)	text fields

B.1.5 Register of accounts

Separate accounts are created for each generator. The account is identified by a unique account number. Within the register of accounts the certificates are contained. The register contains a status field, which identifies the status of the certificates.

Table B.5

Name of data field	*Coding*
account number of generator	country code (ISO 3166-1) unique number allocated in sequential order
certificate	unique certificate identification number
certificate status	identifies the status of the certificate (transferable, exported, redeemed, non-transferable, blocked) see section A.1.1

B.2 Software and hardware requirements

The Issuing and Registration Modules require:

- Pentium-PC
- 32 MB memory
- 2 GB hard disk
- Windows 95 (or higher).

The Central Registration Database requires:

- Pentium-PC
- 64 MB memory
- 4 GB hard disk
- Windows NT
- Windows SQL database.

B.3 Training program for organisation and administrative software

B.3.1 Goal of the training programme

Background

The Government of China is currently working with the World Bank to prepare a major programme to increase the development of renewable energy in China. One of the policy options the Government of China considers is the instrument of tradable green certificates.
A consortium of consultants from the Netherlands has been asked by the World Bank to provide the Government of China with information and experiences on tradable green certificates.
As part of this agreement the World Bank has asked us to develop a training programme to transfer know-how and build capacity in China.

Training goals

This training programme has been developed with the following goals:

- increase the understanding of tradable green certificates,
- offer insight in the organisational requirements for such a system,
- build the capacity to run the administrative organisation of a system,
- provide hands-on experience in using suitable software.

Target audience

The contents of this programme is aimed at:

- energy policy experts of in national and provincial government,
- professionals working with organisations, which may possibly serve as the Issuing Body for a Chinese certificate system,
- employees of grid companies, which may play a role in supplying data to run a certificate system.

Programme

The programme will consist of 5 main items:

- general introduction into tradable green certificates,
- overview of organisation and tasks within a tradable certificate system,
- learn about administrative software to run such a system,
- get hands-on experience through several exercises,
- discuss implications and possibilities for China.

An overview of the contents and goals of each item can be found in the following Chapters.

Length of course

This intended length of this training course is 2 working days per session. In total we expect to organise a session in each province which is a candidate for a pilot project on tradable green certificate systems. In total, we expect to have 5 sessions in China in about 2 to 3 weeks time (depending on travel and logistic arrangements).

The course will be available from mid April 2001 (depending on the final delivery of the English version of RECS software, which will be used for training purposes).

Course language
The language of this course and of all materials will be English. Translations into Chinese of presentations and of materials used should be provided by the World Bank separately.

Facilities
To conduct the course the following facilities are required:
- a conference room for each training session with projector facilities,
- several PCs to run the hands-on training part of the course (depending on the number of participants). The PCs should have Windows 95 or 98 installed and an Internet Browser.

B.3.2 General introduction on certificate systems

Background
The introduction of a tradable green certificate system requires a basic understanding of such a system among all levels of organisations involved. This course element gives the participants insight in the policy backgrounds and requirements. This will help them to comprehend the next, more important steps of this course:
- what kind of organisation is necessary for a tradable certificate system,
- what is the administrative work for such a system and how can that be handled.

Training goal
Increase the understanding of tradable green certificates.

Programme
The programme will consist of the following items:
- general introduction into tradable green certificates,
- benefits of tradable green certificates,
- short review of experiences in Europe,
- organisation of a tradable certificate system,
- creating demand for certificates,
- policy requirements.

B.3.3 Organisation & tasks within a tradable certificate system

Background
Setting up a successfully working certificate system demands a clear organisation and arrangement of tasks and responsibilities of all parties involved. This course element explains which tasks and responsibilities should be fulfilled and by whom. It also provides a brief introduction on managing and administering information.

Training goals
Offer insight in the organisational requirements for a system of tradable green certificates

Programme
The programme will consist of the following items:
- general overview of requirements,
- the role of government and of market players,
- organisation, tasks and responsibilities of the Issuing Body,
- tasks for an Issuing Office,
- tasks for the Central Monitoring Office,

- tasks for participants,
- tasks for other market players,
- which information is required in a tradable green certificate system

B.3.4 Learn about administrative software

Background

Before the participants will start with their hands-on experience, they will be offered an overview of the software, its functions and information requirements.

Training goals

Understand the software, which is required to run the administration of a tradable green certificate system.

Programme

The programme will consist of the following items:
general introduction into processes which have to be administered,
overview of information required in each step of the system,
software solutions available to run such a system,
step-by-step introduction into the process:
issuing of certificates,
transfer of certificates,
redemption of certificates.
performing audits and security checks.

B.3.5 Hands-on experience

Background

So far, all course elements have been 'theoretical'. In this element they will use their understanding to work 'live' with a demo version of the software which is used for the European RECS system.
This course element will be run with case studies:
several have been prepared in advance as the first instruction,
others will be constructed by participants in working groups aiming at
handling 'difficult' installations,
solving errors,
detecting fraude.

This course element requires a number of personal computers[24].

Training goals

Learn to work 'live' with a software package which is capable of running the administration of a tradable green certificate system

Programme

The programme will consist of the following items:
- prepare and approve applications of participants,
- register participants in the system,
- approve applications of participants,
- issue certificates to renewable energy production plants,
- handle errors or suspect applications,

[24] The number of PCs depends on the number of participants. The PCs require Windows 98 operating system and an Internet Browser to run the software.

- prepare transfer and redemption orders,
- verify and register these orders.

B.3.6 Discuss possibilities for China

Background
At the end of the course, participants will have an understanding of the requirements to build and run a tradable certificate system in China. The wrap-up session will focus on the possibilities to implement a system in China (at first, through a pilot project).

With the Chinese participants as experts, we will solicit opinions on the implications and necessary steps to prepare such a pilot project. The wrap-up session will be in the form of a round the table discussion (or possibly in smaller working groups depending on the number of participants in each training session).

Training goals
Get insight into the implications and possibilities to implement a tradable green certificate system in China

Programme
The programme will consist of a discussion round (possibly within working groups depending on the number of participants and their backgrounds) focussing on:
organising the administration and tasks within a tradable certificate system for China,
listing all information which is available to issue certificates,
listing all information which is not present, but should be available,
implementing the system and the organisation in a pilot project,
how much preparation time will be involved
how much staff effort is required
which steps have to be taken
estimating the size and amount of work to run the system ‘live’.

B.4 Hands-on experience

The available software is divided in two packages:

- RECS.exe: for the registration of production devices, generators and issuing
- RECScentral.exe: for the registration of traders, end-users and the central monitoring of green certificates.

The following case studies will give you more understanding of the European RECS system in 'live'.
Cases 1 to 3 consider RECS.exe.
Cases 4 to 6 consider RECScentral.exe.

RECS.exe: how to get started

1. Start the Renewable Energy Certificate Software by double-clicking on 'RECS.exe'.
2. Type in your name and password (the trainer will provide this).
3. Click on 'login'.

Now you're in the Issuing Module of the software. The screen shows three possible routes to follow (Figure B.1):

- devices
- generators
- issuing.

Figure B.1 *Opening screen RECS.exe*

Case study 1

In this case study, you will learn the following:

- to enter a new device in the database of the system,
- to correct mistakes in entries you made,
- to issue certificates for a production device,
- to register a production device,
- to create statistics from the data in the database.

Normally you will receive an application form, which the generator has filled in for you. Your trainer will provide with a copy of this form.
Now check if the form is complete and contains all the data, which are required. If you are convinced all data are present, then you can start entering data into the database.

Entering a new device in the database
Entering the data from the application form takes 2 steps:
- entering data of the owner of the installation,
- entering data of the production device itself.

Step 1: Entering data of the owner of the installation
Click on the button ‘Generators’.
You will see that a new screen opens.

Now click on the button ‘New’ in the bottom of the screen.
A screen to enter data opens (see Figure B.2).
Enter the appropriate data from the form in the fields.
If you have completed all fields: click the ‘OK’ button.

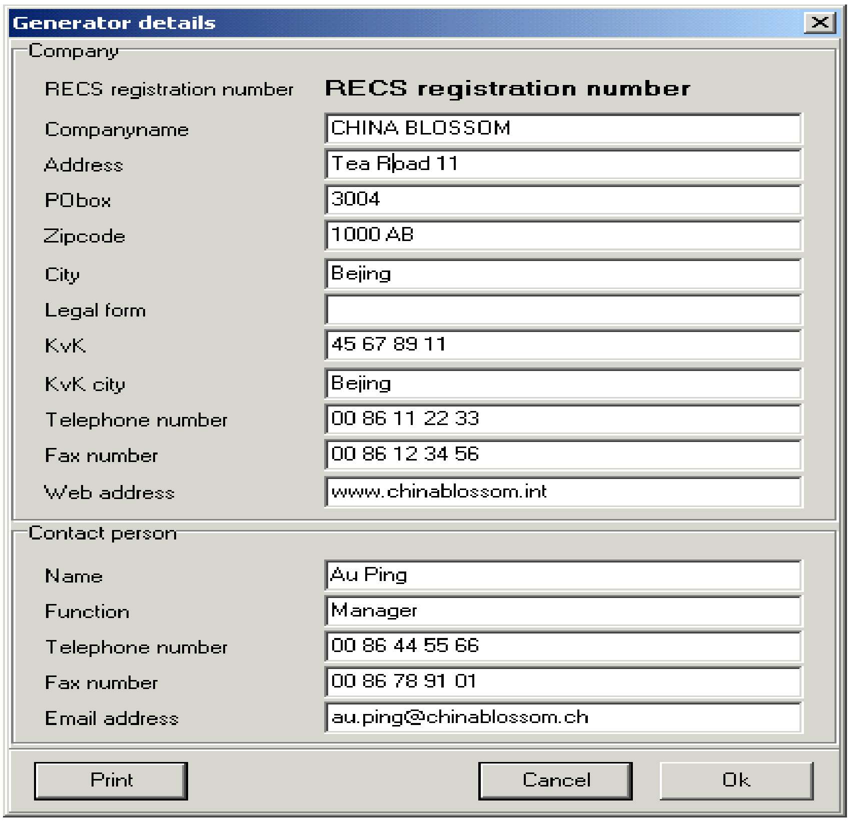

Figure B.2 *Generator details*

Step 2: Entering data of the production device itself
Click on the button ‘Devices’.
You will see that a new screen opens.
Now click on the button ‘New’ in the bottom of the screen.
A screen to enter data opens (see Figure B.3).
Enter the appropriate data from the form in the fields.
If you have completed all fields: click the ‘OK’ button.

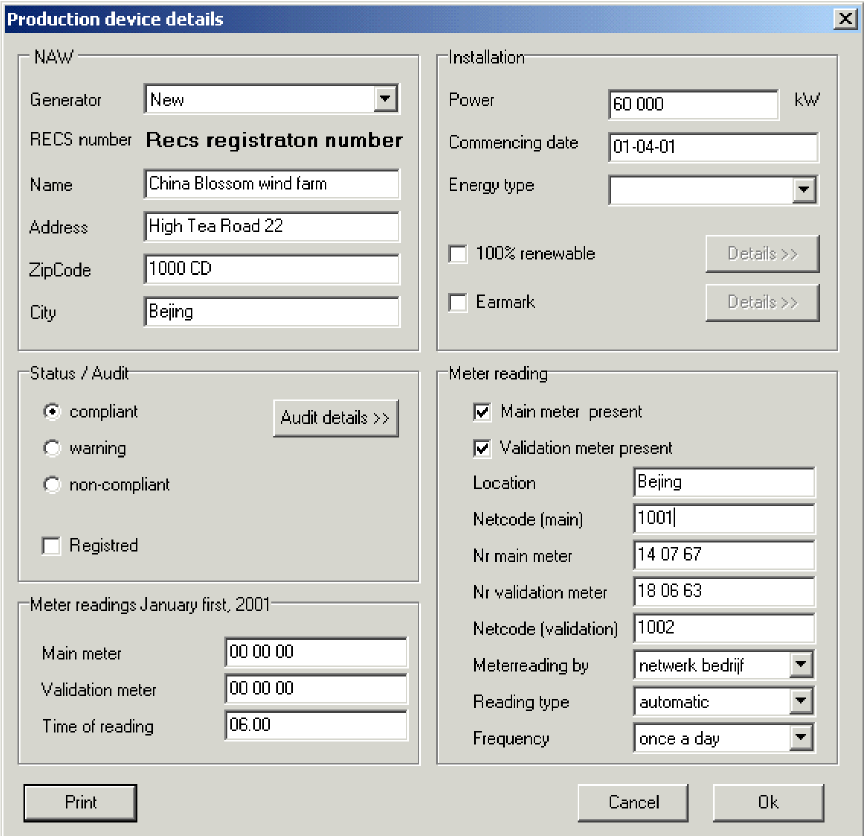

Figure B.3 *Production device details*

Correcting mistakes in data

Click in the main screen on 'Devices'. You have now an overview of all production devices present in the database. You will also see the new entry you made for the China Blossom Wind Farm. Check if the information you filled in is correctly given in the production devices overview. With the 'edit'-button you can change the data.

Click also on the 'Generator' button. You will now see an overview of all owners, which have been registered. The China Blossom Company should also be on the screen. Is the given information correct? If not, change the information with the 'edit'-button.

Issuing certificates

We will now go on to issuing certificates.

- Click on 'Issuing'.
- Enter a new issue: give the location code and the location name of the China Blossom Wind Farm (Figure B.4).
- Give the end of the period for which you want to issue certificates and give a meter reading.
- Press okay when ready.

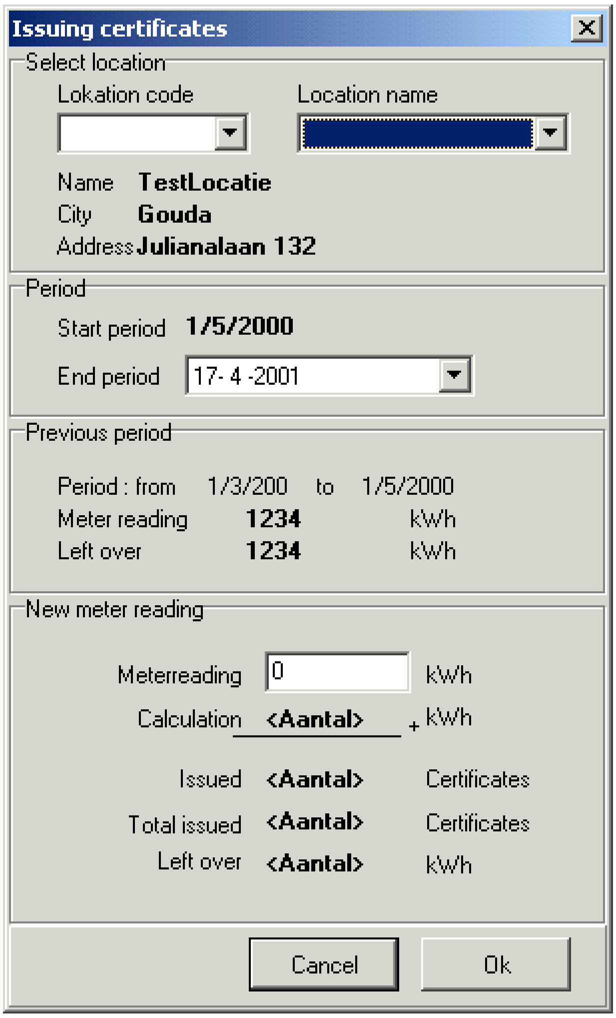

Figure B.4 *Issuing certificates*

Now you will notice issuing of certificates for the China Blossom Wind Farm is not possible! Why is that?

- Return to the production device screen.
- You will notice that the status of the device is not set on ‘registered’.
- Try yourself to change this setting - you will see that you cannot change it yourself because you need permission of your superior.
- Ask your trainer to set the status of the production device to ‘registered’.
- Now again try to issue certificates for your location.

Making statistics

With the ‘print’-button you will get several possibilities to print the following reports on issuing (Figure B.5):

- The cumulative number of certificates which have been issued since the start of the year.
- A monthly report on the number of certificates issued.
- A report which tells how many certificates have been produced by each type of renewable energy.
- A report for a specified production device.
- A report which tells how many certificates have a specific status.
- A report on the audit status of all production devices.

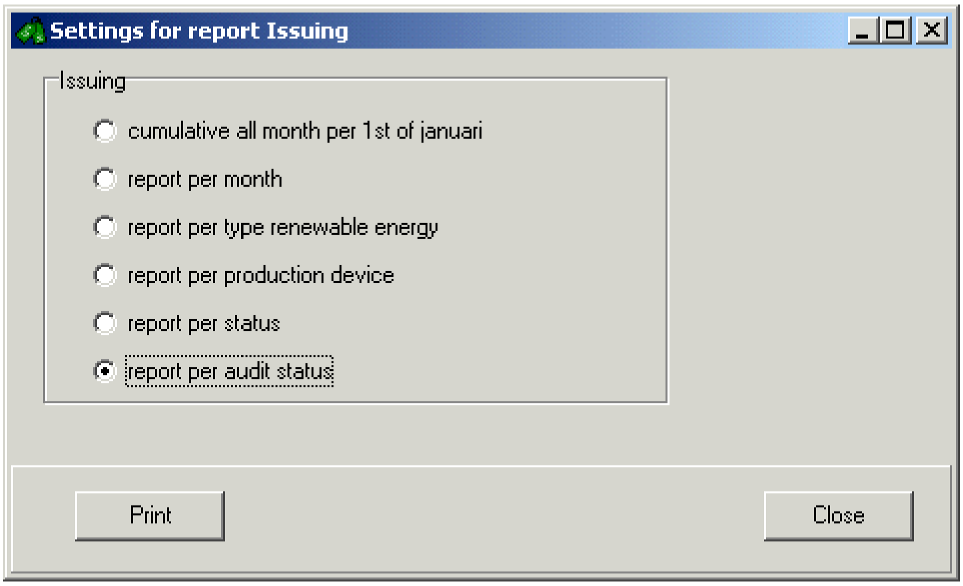

Figure B.5 *Print options*

Case study 2

In this case study, you will learn the following:

- to change the audit status of a production device,
- to understand what consequences this has for issuing certificates.

Your trainer will provide you with a copy of two audit report for two production devices.

Changing the audit status

Now do the following:

- Search the identification of the production device on the audit report.
- Click on 'Devices'.
- Select the production device from the list of all devices available.
- Double click on the record or click 'Edit'.
- Click on 'Audit details'.
- Type a summary of the audit report in the screen (see Figure B.6).
- If finished, click 'OK'.
- Search on the audit form if the audit status should be changed to 'warning' or 'non-compliant'.
- Select the radio-button 'warning' or 'non-compliant' on the screen with the details of the production installation (see Figure B.3).
- Click 'OK' to save your results.

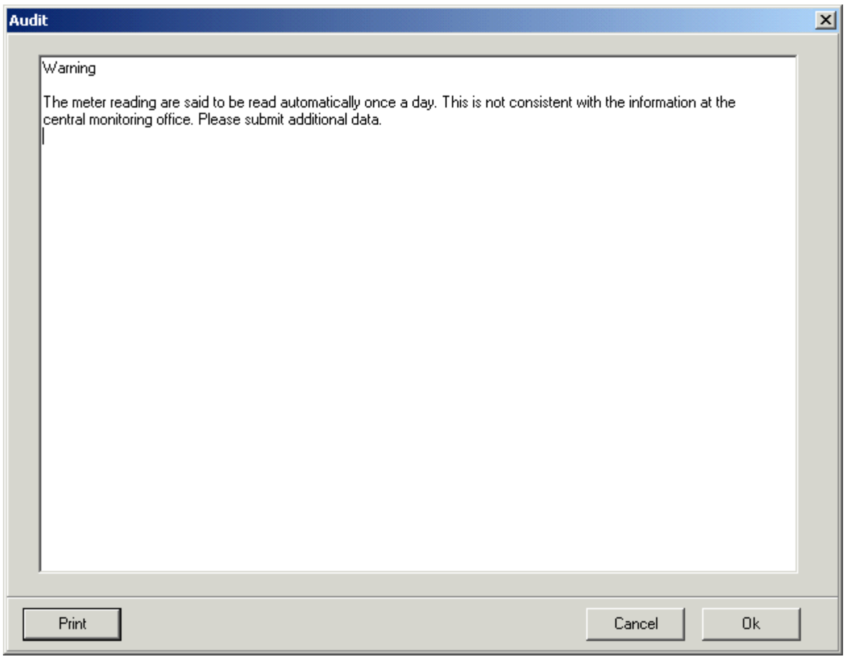

Figure B.6 *Audit details*

Understanding the consequences

- Try to issue certificates for the production installation for which you have changed the audit status.
- If you have entered 'warning':
  - you will see issuing is possible,
  - check reports (see Figure B.5),
  - select the reports 'status' and 'audit status',
  - what do you see on these reports?.

- If you have entered 'non-compliant':
  - you will see issuing is NOT possible,
  - check reports (see Figure B.5) and select the reports 'status' and 'audit status',
  - what do you see on these reports?
- Do you understand the differences?

Case study 3

(A) Enter four additional devices for two different types of renewable energy. You use the same company as the owner, but this company owns several production devices/locations. The production device overview now shows 4 new devices. The generators overview shows only 1 new company as owner.
The Issuing overview shows the five different locations of this company where renewable energy is produced.
Issue certificates for your four new production devices.

(B) Enter four additional generators, other than you're the company you added in exercise (A), each with one production device/location.
The production device overview now shows 9 devices. The generators overview shows five different companies as generators.
The Issuing overview shows the 9 different locations where renewable energy is produced.
Issue certificates for the four new generators.

RECScentral.exe: how to get started
1. Start the Renewable Energy Certificate Software by double-clicking on 'RECScentral.exe'.
2. Type in your name and password (the Issuing Body in your country will provide this).
3. 'Login'

Now you're in the RECS software for central monitoring. The screen shows five possible routes to follow (Figure B.7):
- accounts
- trace
- trade
- generators
- devices.

Figure B.7 *Opening screen RECScentral.exe*

Case study 4
(A) Enter a new account: fill in all the company details, information of the contactperson and the registration (Figure B.8).

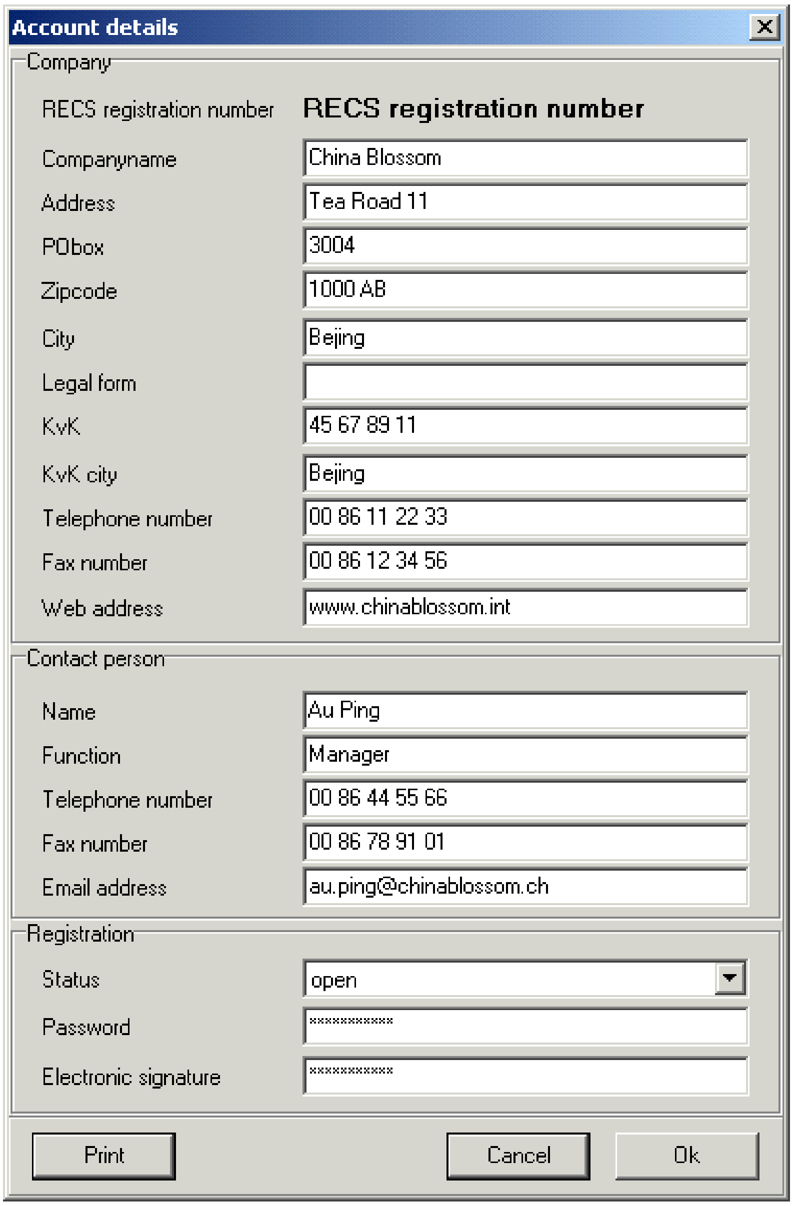

Figure B.8 *Account details*

(B) Fill in four additional accounts for four different generating companies.

Case study 5
Trace a production device by the certificate: press the 'trace'-button and all the information of the production device is given (see also Figure B.3).

Case study 6
Trade certificates: click the 'new'-button: fill in the buyers name and sellers name with their account numbers (Figure B.9; pick names from the original list of 5 accounts you made in case study 4).

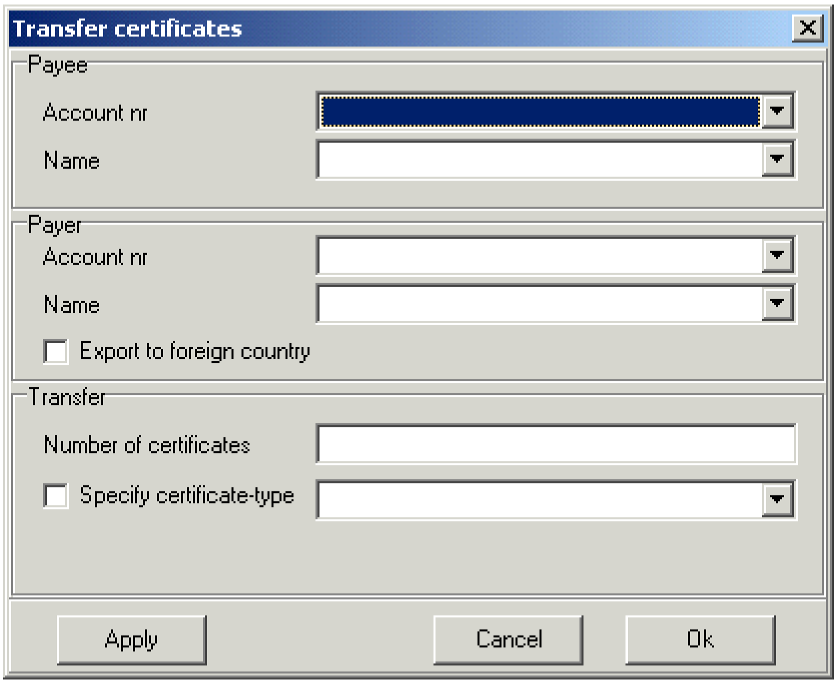

Figure B.9 *Transfer certificates*

- Check what happens if the buyer or seller does not have an account number.
- Check what happens if the number of certificates exceeds the available amount.

Press ‘apply’: ……..
Press ‘Ok’: a trade overview will be given for printing purposes.
Redeem certificates: click the ‘redeem’-button and give the name and accountnumber of the payee and the amount of certificates for redemption (Figure B.10).

- Check what happens if the payee does not have an account number.
- Check what happens if the number of certificates exceeds the available amount.

When pressing ‘generators’, an overview is given of all registered generators. Their details can also be given.
The same is possible for the production devices overview.

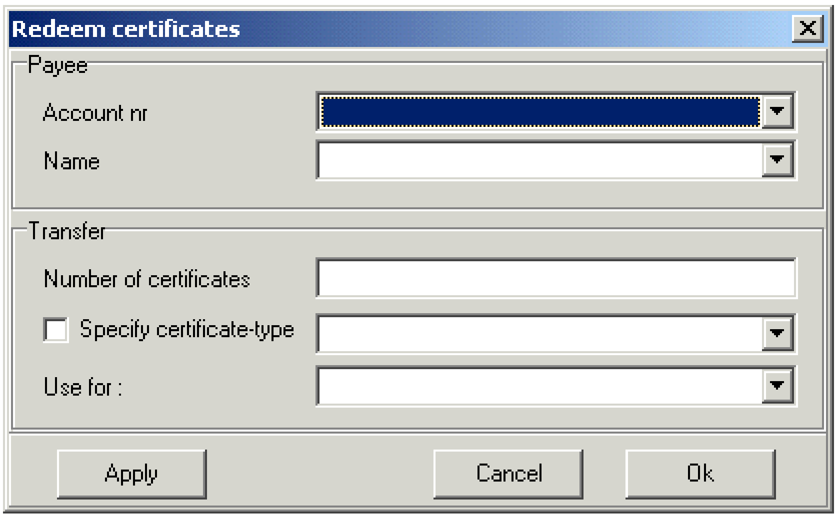

Figure B.10 *Redeem certificates*

ANNEX C. ANNEXES TO CHAPTER 4

C.1 Evaluation REBUS-training of Zhuan Xing

C.1.1 Introduction

Zhuang Xing from the Center for Renewable Energy Development (CRED) of the Energy Research Institute (ERI) of the Peoples Republic of China got a course in the use of the REBUS-model at the Netherlands Energy Research Foundation ECN in the Netherlands from 8-19 January 2001. This course has been part of a contract between the World Bank and ECN in the framework of the preparation for a large World Bank project that includes support to the Government of China to develop an adequate renewable energy policy for China.

The Renewable Energy Burden Sharing (REBUS) model is a spreadsheet model developed by ECN in the framework of an EU-sponsored project. The model can be used as a tool to investigate what the cost-effects of a certain distribution of targets for the consumption of renewable electricity are, given an overall target for the EU as a whole. This issue is similar to the current discussions in China of how to distribute the overall target for renewable electricity of at least 5.5% in 2010 over its different provinces. Within the framework of the World Bank project ECN adapted the EU-REBUS model for China and transferred this model and the knowledge how to use it during the training to Zhuang Xing from CRED.

An important input for the REBUS model are renewable electricity cost-potential curves for each Member State (in China for each province) of the Community of countries (provinces). To construct realistic cost curves for China was not a part of ECN's contract. However, ECN developed a framework (an Excel spreadsheet linked to a set of Renewable Energy technology spreadsheets) that helps to construct adequate cost-potential curves per province in a consistent way.

The two-week training consisted of one day of introduction, 4 days of training on how to construct cost-potential curves, and 5 days of training in the REBUS model itself. During the last week the REBUS China model was used to teach how the model is built. For teaching how to do analyses, which is how to analyse the results, the REBUS-EU model was used. This was due to the fact that many input data for China, which were sent to ECN just before the training started were not very good and led to infeasibilities in the calculations. These infeasibilities have been tackled by ECN during the last week resulting in a functioning version of REBUS for China. This version of REBUS-China clearly is not a tool for analysis yet, because the data are not yet realistic. However, it can show what kind of analyses can be done with the model if good data are available.

C.1.2 Evaluation

On the last day of Zhuang Xing's stay at ECN an evaluation discussion was held. Participants were, from ECN Gerrit Jan Schaefer (training co-ordinator), Manuel de Noord (teacher of the part on constructing cost-potential curves) and Monique Voogt (teacher on the REBUS model). Following are the main issues during this evaluation.

Zhuang Xing was satisfied with the general structure of the training. Both items, learning how to construct cost-potential curves as well as how to use the REBUS model itself were seen as very relevant and very important.

If Zhuang Xing had had one more day she would have liked to put some more time to doing the analyses, especially with the REBUS-China model.

If she had had one more day during the first week, she would have liked to construct on her own (as much as possible) cost-potential curves for more renewable energy technologies. During the first week she only constructed a cost-potential curve more or less independently for solar PV, while the wind and biomass curves were constructed with a lot of help from the ECN people.

Zhuang Xing indicated that, had she known better what to expect, she would have prepared better the necessary data. Now she knows better what kind of data is needed and understands why they are needed. Regretfully she didn't have enough time for a better preparation, also due to the very busy period at CRED before her arrival.

In general the training answered or exceeded her expectations. With regard to the cost-potential curves part she is now more confident CRED will be able to construct cost-potential curves for the provinces for China (if time and resources are available). What exceeded her expectations is that she had expected that she would be trained only in the use of the EU-model, whereas ECN had prepared a China model (although still with unrealistic data) as well.

On the question what Zhuang Xing thinks whether the REBUS-China model will be used in China, she answered that she considers this model (including the part on cost-potential curves) as very important for the preparation of an RPS policy in China. Given that resources are available, she is pretty certain that CRED will be very interested in using the model. The most challenging action will be the construction of realistic input data.

Zhuang Xing does not think she will be able to use the model without any help from ECN. This is true with regard to the cost-potential-curves part as well as with regard to REBUS itself. Manuel de Noord's impression is that she will need especially someone to discuss the methods of the construction of cost-potential curves, something to which Zhuang Xing agrees. With regard to the REBUS model itself, she would need most help in the analyses: what do the results calculated exactly mean, what questions do they answer, and how can relevant policy questions be answered with the model? Monique Voogt also thinks that once it comes to technical modifications (changing the macro's, running it only for a few provinces instead of for the whole of China, creating more steps in the cost-potential curves) Zhuang Xing will not yet be able to do that. Zhuang Xing agreed to this point as well.

The main conclusion is that if REBUS-China is to be used in China, a little bit more support will be needed from ECN. For this ECN and CRED will need to think about to incorporate this work in another project. This future support could consist of sending e-mails back and forward. However, a second training period like this one, on which Zhuang Xing can prepare herself better, now she knows how the model works in principle, would be preferable. Whether this is done in the Netherlands or in China does not really matter very much. An advantage of doing it in China would be that there is closer contact possible with Chinese renewable energy experts and general statistical agencies, from which realistic data can be drawn.

C.1.3 Round-up of the REBUS-training

Zhuang Xing has received the following items as part of the training:

- A CD-ROM with the REBUS-China (with the fake data that allow the model to work), the framework spreadsheet (with no data) and the available technology 'satellite' spreadsheets (with no data) (Caution: do not update the links when the model is opened. This will delete all the data in REBUS, so that it doesn't function anymore. If the satellite sheets and the REBUS-framework are filled in with good data, then the links can be updated)!

- A set of files including the Power Point presentations of the first day, providing the basic theoretical and practical background.
- A draft manual including descriptions of the background and the practicalities of the model.

ECN will still do the following:
- Prepare an updated version of the manual.
- Send the report on the EU results once it is ready (probably by March).

C.2 Training Report of REBUS Model

Zhuang Xing
Center for Renewable Energy Development of
Energy Research Institute in P.R.China

I was invited by Mr. G.J. Schaeffer in ECN to participate the RE model burden sharing (REBUS) training. It was respectively hold from 8-20 January 2001 at Petten and Amsterdam in the Netherlands, The training is aimed at learning the use of REBUS model for assessment on appropriate sharing China RE generation target in different provinces. It was my honour for being able to add the task. The benefit from learning REBUS model contains the following details.

C.2.1 The REBUS model

Introduction

The REBUS model is initiated by ECN central Policy Research. The target is how the European Union total RE generation can be equally divided among 15 EU member states. The level of EU renewable electricity target 21% has been formulated. The keystone question is the sharing principle and fairness. Several fairness sharing rules and criterions are produced by REBUS model, moreover can be provided for relevant consequence analysis.

In a cost-effective way, achieving renewable electricity target is the main role that RE policy taking. Their introduction to the market is the important way to meet cost benefit. The condition of the REBUS analysis framework established is underlying assumption on green certificates trading occurring.

The main REBUS model spreadsheet consists of renewable electricity potential spreadsheet, various spreadsheet to calculate technology cost, cost-potential curve spreadsheet and consequence analysis spreadsheet. The idea is that each province has different natural circumstance, leading to different possibilities for producing renewable energy for different cost. This relation has to be determined for each province, and are presented in provincial cost-potential curve. Theses cost-potential curve is the major input of REBUS model, and there are several ways to construct cost-potential curve.

The most important part of REBUS model is analysis framework of burden sharing. Theoretically, determining all renewable energy sites in each geographical province is very difficult. A top-down approach based on statistics datum will be used in the model.

REBUS model function and effects

Green electricity sharing target model using by cost-potential curve analyses and determine the way of national RE generation target appropriately divided in each province. REBUS model should reflect the impact of society, economic development, and quantify individual province renewable energy development target and distribution cost option.

Several different division cost option, the national overall green electricity target divided in each individual province, is set by REBUS model and based on calculating each provincial green electricity price. Each unit electricity price can be represented in uniform certificate. The different price to green electricity produced in each geographical province requires inter-provinces trading green certificates. For achieving provincial renewable generation target, in more general, low electricity price province will sell their certificates to the price high province requiring the purchase of green certificate. The flow direction of inter-province trading and cost can be calculated by REBUS model, and so can the provincial green electricity cost and per capital cost. Only based on a reference price replacing the green electricity market, can the addition cost of renewable generation be calculated. The reference price is different in each having different technologies province. The model itself can calculate the reference price, and also simulate the operation situation of green electricity market.

The REBUS model can calculate the electricity price against the cost-potential curves. The selection of green electricity production option for individual province is very significant impact of burden sharing calculation. It is assumed that the renewable generation target is equal implementation in each geographical province. The resource possibility of waste power generated in Shanghai is available, and the price is cheaper, so the cost of achieving RE generation target is lower, furthermore Shanghai can benefit from green certificate trading.

The REBUS model qualifies the impact of green certificate trading, and distribution overall Chinese target to individual target. The output of the model Determined by the model is in the following: national and individual province target, direct investment cost of achieving total target, least opportunity cost, green certificate price, cost and benefit of achieving target, net trade of green certificate trading, net benefit of national target replacing individual target.

C.2.2 Gains and benefits of leaning REBUS model

Thoughts and methods learn from ECN policy research

The effort of the renewable energy policy research in ECN is drawn from the utilisation of basic theoretic and advanced tool. Based on a number of detailed data supported, and scientific calculation methods, the model can quantify and analyse how to divide appropriately total Chinese green electricity target into each provincial target. In the course of exploring green electricity target, only when the different possibility of renewables electricity production in different natural geographical region has been considered should the technology and economic status of current and future various renewables electricity generation be taken into account. And then conclude with the potential and cost of national and individual province renewable energy electricity generation, so as to determine overall Chinese target. In burden sharing option, it's necessary to analysis the impact of social demands, economic bear ability and state planning and such factors on the effect of realisation green electricity target. For individual region, the price to renewable energy electricity can be formulated by utilising least marginal cost of achieving target, furthermore analysing the green electricity flow direction and trading status. Based on this experiences considered ideas and options for polices that would be appropriate in China, and made further policy research, so as to promote the feasibility and implementation of polices.

EXCEL software being a good calculation tool for the model

The REBUS model is designed as EXCEL spreadsheet calculation tool. The model contains a number of datum structure, abundant calculating methods, cost curve of different region, complicated data link model and elastic analysis options. Only using small part of EXCEL software functions, above of those requirement can be tackled. In addition to above advantages mentioned, the EXCEL spreadsheet is based on a specific format of the input and output datum that most often used for (model) calculation and analysis, which is easy for being consulted. And is established good communication between developers and operators. By means of using REBUS model, I realised that EXCEL is a good calculation and analysis tool, holding strong functions and which is very benefit to energy research. Besides a lot of formulas in EXCEL, extending to include vigorous macros is produced by the performance of VB contained. So as to Adequately meet and deal with small type model development and statistics work in energy research.

③ The application of REBUS model in China

The REBUS model development is aimed at the feasibility analysis of green certificate trading implementation in UN, the aim of model is reach in distributing the total UN green electricity target in the UN member states, researching the flow direction and trade status, and analysis the benefit of each member state from green certificate trading. Analysis the application of the model to China is starting from the aim of model development and model effects and structure and so on. The model executed is significant value for researching China green certificate trading. See specification below:

On the one hand, the model development object is open for European Union and the UN member states, which otherwise would not be able to afford to develop for China independently. Whereas, the relation of the UN and its member states is somewhat similar as the relation between the Central Government in China and its provinces. And the model framework construction is common, Therefore, it can be appropriate for China after the slightly modification.

On the other hand, the focus of the model research is involved green electricity issues. The UN made very early step in renewable energy development, many experiences and lessons relevant renewables electricity generation supported policies set and implementation can be shared. The green certificate trading regarded as one of efficient policies of promoting renewable energy electricity generation has been recognised. Comparing with the burden sharing of achieving Chinese target mechanism analysed by using the model, research objective is harmonised, content is similar, and the research method is upgraded. As a result of the different national condition between China and UN, and different particular attention laid, which can be reflected by analysing problem diversion, the difference is only expressed in the form of presented Parameter and selected options in the model. That is to say, the different can be solved by various datum described without revising the model.

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2001/2/20