GREEN CERTIFICATES MECHANISMS IN BELGIUM: A USEFUL INSTRUMENT TO MITIGATE GHG EMISSIONS

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ABSTRACT: Belgium is a Federal State divided in 3 Regions: Wallonia, Flanders and the Brussels Capital Region. Since wide competences have been transferred from the Federal State to the Regions, there are now 5 Green Certificates mechanisms on-going in Belgium, based on an obligation coupled with a penalty for the non achieved share of green power. In the Flemish Region, the systems are based upon the energy balance and use of fossil energy all along the supply chain that is then subtracted from the number of granted Certificates. In the Walloon Region, the system is based upon the avoided fossil CO_2 emissions with respect to a reference fossil plant. The system of the Brussels-Capital Region is based on the same principle than the Walloon one, with which it is compatible. As the systems are different in the three Regions, some technologies are encouraged in one Region and not in another one. Examples are given to illustrate and point out the differences between the five mechanisms. Even if the Green Certificates mechanisms differ from one Region to another, they appear to be a useful instrument in the frame of GHG mitigation.
Keywords: greenhouse gases (GHG), bio-energy policy, green electricity market

1 INTRODUCTION

Belgium is a Federal State consisting of 3 Regions: the Walloon Region, the Flemish Region and the Brussels-Capital Region. Since wide competences have been transferred from the Federal State to the Regions, there are now five Green Certificates mechanisms on-going in Belgium. The Federal policy level has only limited authorities in renewable energy policies. Its competences are restricted to offshore wind and to aspects related to high voltage grid.

In the frame of the Kyoto Protocol, the objective of Belgium is to reduce its greenhouse gas (GHG) emissions by 7.5% below its 1990 level by 2012. Furthermore, electricity sales are submitted to an obligation of 6% of renewable electricity by 2010 (see Table 1), to be achieved via targeted Green Certificates systems in each of the three Belgian Regions and on the Federal level. The obligation is coupled with a penalty for the non-achieved share of green power.

Table 1: Belgian objectives for electricity and heat consumption by 2010 [5]

%	2000	2005	2010
Electricity from Renewables***	2.6 (0.9)	3.7 (1.4)	8 (3.3)
Electricity from cogeneration**	3.4	6.3	15
Heat from Renewables****	6 (5.9)	6.5 (6.5)	9 (8.4)

* Figures in brackets: biomass share
** Not necessarily from renewables but integrated in the Green Certificates scheme
*** Total electricity consumption: 23 435 GWh in 2000, 24 300 GWh foreseen in 2010
**** Total lowheat consumption: 50 000 GWh in 2000 and foreseen in 2010

In the Flemish Region (Flanders), the two systems (Green and Cogen) are based upon the energy balance and use of fossil energy all along the supply chain that is then subtracted from the number of granted Certificates.

In the Walloon Region (Wallonia), the system is based upon the avoided fossil CO_2 emissions with respect to a reference being the combined cycle power plant firing natural gas with an efficiency of 55%. The Walloon regulatory body (CWaPE) has published a list of reference specific fossil CO_2 emissions of the whole supply chain for all fossil fuels as well as the major biomass resources. Some elementary operations have even been calculated for woody products (short rotation coppices, wood chips, wood pellets, etc.).

The system of the Brussels-Capital Region is based upon the same principle than the Walloon one, with which it is compatible.

The Federal system is limited to territorial waters and therefore to off-shore wind projects.

As the systems are different in the three Regions, some technologies are encouraged in one Region and not in another one.

2 BELGIAN CO_2 EMISSIONS

Yearly Belgian CO_2 emissions are about 150 Mtons CO_2. Due to its high number of industries, Flanders is responsible for the major part of these emissions (see Figure 1).

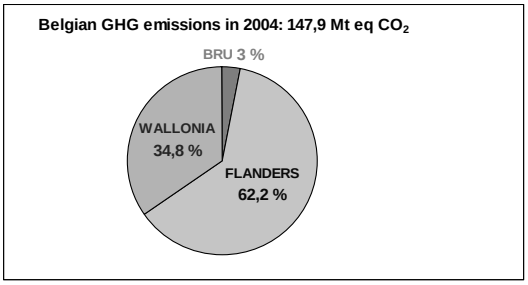

Figure 1: Belgian CO_2 emissions by Region [4]

Energy production, which mostly electricity production, is responsible for 21% of these CO_2 emissions (see Figure 2).

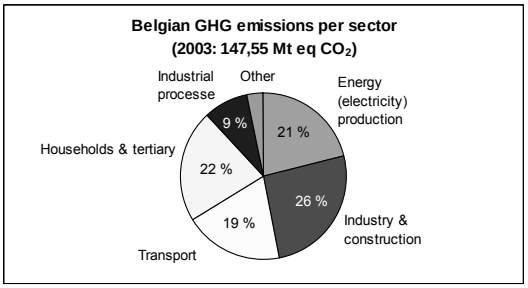

Figure 2: Belgian GHG emissions by sector [3]

3 PRINCIPLES OF THE BELGIAN GREEN CERTICATES MECHANISMS

In 1999, the Directive 96/92/CE regarding the organisation of the electricity market has been transposed to Belgium, allowing the provision of a mechanism stimulating renewable electricity: Green Certificates systems based on an obligation (quota) and penalties for the part of non-produced green power. Since competences regarding energy are attached to Regions, 5 different Green Certificates mechanisms are running in Belgium: 2 different in Flanders (1 Green, 1 Cogen), 1 in Wallonia, 1 in Brussels and 1 at the Federal level.

The following principles are common to all Belgian Green Certificates mechanisms:

- A growing obligation or quota (percentage) of renewable power production is based on the yearly electricity sales for each power supplier (high consumers are partially exempted, except for Cogen Certificates in Flanders);
- Penalties are applied for the share that is not covered by the Certificates (x € per missing GC);
- Certificates can be exchanged on the market between green producers and suppliers needing them to meet their quota;
- Regulatory bodies in each Region grant the Certificates and survey the market;
- Certified bodies inspect the green power plants and the bio-fuel resources.

The principles of the systems are summarized in Figure 3.

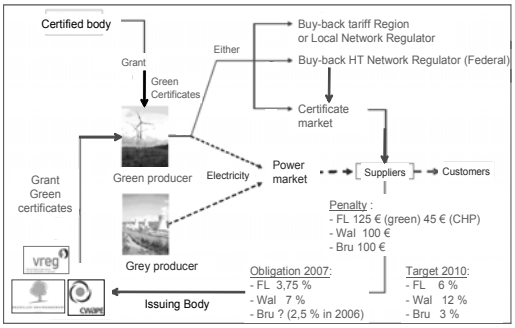

Figure 3: Green Certificates systems in Belgium

Three issuing bodies (VREG, CWaPE and Brussels Environment) are responsible for the certification of the generating units as well as the grant of the Green Certificates, respectively in Flanders, Wallonia and Brussels. The suppliers which cannot present the requested amount of Certificates according to their sales in a considered period are fined with a penalty of respectively 125 €, 100 € and 100 €. The obligation increases every year such that 6% of renewable power is obtained for whole Belgium by the year 2010, as imposed by the RES-Directive. The 2007 quotas are 3.75% in Flanders, 7% in Wallonia and still need to be decided for Brussels (it was 2,5% in 2006).

The details of the existing Green Certificates systems are presented in Figure 4, including realisations up to now and market value.

FLANDERS	2002	2003	2004	2005	2006	2007	2008	2009	2010
Obligation (%)	0,5%	1,2%	2%	2,5%	3%	3,75%	4,50%	5,25%	6%
Obligation (GC x 1000)	250	600	1.000	1.250	1.500	1.875	2.250	2.625	3.000
Generated GC x 1000	150	292	544	966	1.429				
Penalty	€ 75,00	€ 100,00	€ 125,00	€ 125,00	€ 125,00	€ 125,00	€ 125,00	€ 125,00	€ 125,00
Market value	€ 79,04	€ 92,62	€ 110,93	€ 109,78	€ 105,14				
WALLONIA		**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Obligation (%)		3%	4%	5%	6%	7%	8%	9%	12%
Obligation (GC x 1000)		701	945	1.195	1.449	1.710	1.976	2.247	3.030
Generated GC x 1000		622	715	823	1.074				
Penalty		€ 75,00	€ 100,00	€ 100,00	€ 100,00	€ 100,00	€ 100,00	€ 100,00	€ 100,00
Market value		€ 84,38	€ 91,74	€ 92,09	€ 91,56				
BRUSSELS			**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Obligation			2%	2,25%	2,50%	*to be determined*			
Generated GC x 1000			3,5	8,0	*8,8 (first trimester)*				
Penalty			€ 75,00	€ 75,00	€ 75,00	€ 100,00	€ 100,00	€ 100,00	€ 100,00

Figure 4: Obligations and Realisations of the GC'S systems in Belgium

The suppliers have the possibility to generate the Certificates with their own assets or purchasing them at a market price. It is important to note that Walloon and Brussels Green Certificates are exchangeable while there is no mutual recognition with the Flemish ones.

The utilities might use their generated Green Certificates for their own purposes if they are also suppliers, to sell them on the market or to sell them at a guaranteed price either to the high-tension network operator (federal level), or to the distribution network operator (regional level) or to the Region itself (Wallonia only). The guaranteed values are presented in Table 2 according to the renewable source.

Table 2: Buy-back tariffs (€/GC)

Type	Belg	FL	Wal
Off-shore wind	90	N/A	N/A
On-shore wind	50	80	65
Hydro	50	95	65
Solar	150	450	65
Biomass	20	80	65

The Green Certificates are granted on the base of a detailed definition of the acceptable renewable energy sources according to each Region. The definitions are given in Figure 5.

BEL	Based upon sustainable development Sustainable development *"All non-fossile non-nuclear energy source that meets the needs of the present without compromising the ability of future generations to meet their own needs."* PV, Wind, Geothermal, Biogas, Biomass accepted
FL	Tide&Wave, Hydro < 10 MWe, Biomass according to a)-d) a) vegetable products from agriculture and forestry; b) litter and manure; c) sorted organic-biological waste; d) unsorted organic-biological waste (MSW) with min. 35 % energy recuperated
W	CHP and Hydro < 20 MWe included
Bru	Hydro < 10 MWe Biomass = organic waste from agriculture and forestry

Figure 5: Definition of the renewable energy sources. (BEL: valid for all Regions, FL for Flanders only, W for Wallonia and Bru for Brussels)

Regarding bioenergy, the calculation of the number of granted Certificates per generated MWh is based upon:

- The amount of energy used for the production and transportation of the biomass, in Flanders;
- The related CO_2 emissions on the base of a LCA analysis, in Wallonia and Brussels.

This means that biomass is not considered as fully neutral for the Green Certificates systems in Belgium, as it is in the European Emission Trading Scheme for CO_2 emissions.

4 GREEN CERTIFICATES SYSTEMS IN FLANDERS

Since 2002, Flanders has opted for two separate Green Certificates systems: one for green electricity promotion and one for quality cogeneration plants promotion. Green Certificates are related to the amount of produced green power, while Cogen Certificates are granted on the basis of the Primary Energy saving.

Green and Cogen Certificates are issued monthly but the quota of Certificates returns to the issuing body (VREG) annually.

4.1 Green Certificates in Flanders

In order to receive Green Certificates, a power plant has to satisfy several criteria:

- It must produce electricity from renewable energy sources;
- The green energy production must be measured by the grid manager;
- It must provide an inspection report.

The number of granted Green Certificates is based on the net green electricity production. The fossil energy necessary to operate the plant, transport and prepare the biofuel is subtracted.

1 GC in Flanders = 1 NET MWh Green Electricity

Coal power plants are widely present in Flanders. Thanks to the Flemish Green Certificates system, co-firing biomass with coal is possible in this Region since Green Certificates will be granted for the part of electricity produced from renewable sources.

An example can illustrate this system. Let us take a coal power plant, with an efficiency of 38%, co-firing wood pellets from Canada.

Each ton of wood pellets contains 4.7 MWh_{PE}, which produce 1.79 MWh_{el} in this plant. According to the Flemish Green Certificates system, the energy necessary to operate the plant, transport and prepare the biofuel has to be subtracted. In this case, it is:

- Electricity consumption for pelletizing: 100 kWhe/ton;
- Electricity consumption for drying: 6 kWhe/ton;
- Train transport: 700 km per train or 108 kWhp/ton;
- Sea transport: 750 ton diesel/40 000 tons or 232 kWhp/ton ;
- Total: 446 kWh/ton.

The reader shall note that electricity is considered here like it was a primary energy source.

Those 446 kWh need to be subtracted from the electricity production of each ton of pellets, which leaves 1.79 – 0.446 = 1.34 MWh_{el} per ton of pellets substituted to coal.

The number of granted Green Certificates will then be:

1GC = 1.34/1.79 * Electricity produced from pellets

This means that every MWh_{el} produced from pellets receives 0.75 GC.

4.2 Cogen Certificates in Flanders

Quality cogeneration plants must save at least 5% of Relative Primary Energy (RPE), calculated as follows:

$$\text{RPE saving} = \frac{E/\eta_E + Q/\eta_Q - F}{E/\eta_E + Q/\eta_Q}$$

Where:

- E/η_E represents the energy necessary to produce the same amount of electricity in a reference power plant than in the cogeneration plant;
- Q/η_Q represents the energy necessary to produce the same amount of heat in a reference boiler than in the cogeneration plant;
- F represents the amount of energy really consumed by the cogeneration plant.

The number of granted Cogen Certificates is then:

1 Cogen C = 1 MWh Primary Energy (PE) saved

And PE saving = $E/\eta_E + Q/\eta_Q - F$

5 GREEN CERTIFICATES SYSTEM IN WALLONIA

Started in 2003, this system is based upon the avoided CO_2 emissions. One Green Certificate is granted for every 456 kg of CO_2 avoided.

Practically, the number of granted Certificates depends on the amount of green electricity produced multiplied by the CO_2 saving rate, τ:

$$\#GC = E * \tau$$

This rate is calculated as follows:

$$\tau = \frac{E_{ref}/\eta_{Eref} + Q_{ref}/\eta_{Qref} - C_{bio}/\eta_{Ebio}}{E_{ref}/\eta_{Eref}}$$

Where:

- E_{ref} is the amount of CO_2 emitted by a reference power plant;
- η_{Eref} represents the efficiency of this reference power plant;
- Q_{ref} is the amount of CO_2 emitted by a reference boiler producing the same amount of heat than the green plant, with:
  $Q_{ref} = \eta_{Qbio}/\eta_{Ebio} * CO_{2ref}/\eta_{Qref}$
- η_{Qref} represents the efficiency of this reference boiler;
- C_{bio} is the amount of CO_2 emitted by the green electricity installation;
- η_{Ebio} represents the electrical efficiency of the green electricity installation.

The reference used is a steam & gas power plant with an efficiency of 55% for the electricity component and a natural gas-fired boiler with an efficiency of 90% for the heat component.

Based on detailed LCA analysis, the Walloon regulatory body (CWaPE) has published a list of reference specific fossil CO_2 emissions of the whole supply chain for all fossil fuels as well as the major biomass resources [1]. Some elementary operations have been quantified for woody products as well (see Table 3).

Table 3: References CO_2 emissions used in Wallonia for the GC's calculation

❖ NON FOSSILE	$kgCO_2/MWh_p$
▪ wind/solar/hydraulics	0
▪ organic biodegradable matters	0
o milling / chopping	4
o transport on max. 200 km	5
o transport on more than 200 km	25
o drying	10
▪ corn crops	22
▪ wood	23
▪ wood pellets with residues from the forestry	30
▪ cultivated wood (short rotation coppices)	45
▪ rapeseed oil	65
▪ bio-diesel	80
❖ FOSSILE	
▪ natural gas	251
▪ gasoil	306
▪ light fuel oil	310
▪ heavy fuel oil	320
▪ coal	385

The reference installation for electricity being a natural gas power plant with an efficiency of 55%, it gives 251 $kgCO_2/MWh_p$ divided by 0.55 = 456 $kgCO_2/MWh_{el}$.

Different examples can illustrate this system. Let us take a wood chips-fired power plant with an efficiency of 35%. In this case, since there is no cogeneration, the calculation of τ is simplified as shown to the following expression:

$$\tau = 1 - \frac{C_{bio}/\eta_{Ebio}}{E_{ref}/\eta_{Eref}}$$

According to the CO_2 emissions references (see Table 3), wood chips production emits 23 kg CO_2/MWh_p and 5 kg CO_2/MWh_p for their transport. The CO_2 saving rate is then:

$$\tau = 0.82$$

This implies that every MWh_{el} produced in this wood chips-fired power plant will receive 0.82 Green Certificate.

But in the case of a sawmill valorising its by-products in a wood chips-fired power plant, CO_2 emissions for fuel production can be reduced to 4 CO_2/MWh_p (chopping emissions only), with no transport emissions, and:

$$\tau = 0.97$$

In this situation, every MWh_{el} produced will receive 0.97 Green Certificate.

Beside power alone production, cogeneration of biomass is a technology strongly supported by the Walloon Green Certificate system, as shown in the following example. In a wood chips-fired CHP plant with an electrical efficiency of 35% and a heat efficiency of 50%, where all the heat generated is really used to replace traditional heat, τ becomes:

$$\tau = \frac{251/0{,}55 + (0{,}5/0{,}35 * 251/0{,}90) - (23+5)/0{,}35}{251/0{,}55} = 1{,}69$$

This means that, in this wood chips-fired CHP plant, every MWh_{el} produced receives 1.69 Green Certificates.

While cogeneration is highly encouraged in Wallonia, the example below shows why, on the contrary, co-combustion is not profitable with this Green Certificates system.

Let us take a coal power plant, with an efficiency of 41%, considering co-firing with wood pellets. Table 4 calculates the value of the CO_2 emissions saving rate, τ, with different biomass ratios (the energy content of coal is 7.56 MWh/ton and pellets 4.7 MWh/ton). One can see that τ remains negative until a share of 70% of pellets in mass, which means that no Green Certificates will be granted below that mix.

Table 4: τ values when co-firing different mass ratios of pellets with coal

Mass ratio	Bioenergy ratio	τ
10%	6%	-0,94
20%	13%	-0,80
30%	21%	-0,66
40%	29%	-0,50
50%	38%	-0,33
60%	48%	-0,14
70%	59%	0,07
80%	71%	0,30
90%	85%	0,55
100%	100%	0,84

As a consequence, the Belgian electricity producer Electrabel chose to convert one of its coal power plants in Wallonia (Les Awirs, Unit 4) into a 100% pellets fired-power plant, with an efficiency of 34%. Since wood pellets are imported from various countries (Canada, Poland, etc.), an additional 25 $kgCO_2/MWh_p$ has to be integrated in the calculation of the CO_2 saving ratio, τ. That gives the following value: $\tau = 0.65$.

Every MWh_{el} produced in this power plant receives consequently 0.65 Green Certificate.

Since the installed capacity of this power plant is 80.3 MW_e, it has a production potential of 562,100 MWh_{el}/year and 343,489 Green Certificates per year [7].

Table 5 below gives typical CO_2 saving ratios for different renewable technologies and fossil CHP in Wallonia. It underlines the influence of this Green Certificates system which strongly supports the most efficient and environmentally friendly technologies.

Table 5: Profit for every MWh_{el} produced from different renewable technologies or fossil CHP

Technology	CO_2 saving rate τ	Average GC price in 2006	Profit (€/green MWh_{el})
PV, Hydro, Wind	1	91,56 €	91,56
Biomass for electricity	0,65		59,51
Oil cogeneration	0,17		15,57
Natural gas cogeneration	0,28		25,64
Biomass dual-fuel cogen	1		91,56
Biomass cogen (farm biogas, rapeseed)	1,5		137,34
Biomass cogen (wood, landfill gas)	2		183,12

6 GREEN CERTIFICATES SYSTEM IN THE BRUSSELS-CAPITAL REGION

Started in 2004, the system in the Brussels-Capital Region is the same as the Walloon one, which it is compatible, providing the following exchange rate:

$$1\ GC_{Wallonia} = 1\ GC_{Brussels} * Penalty_{Brussels} / Penalty_{Wallonia}$$

Today, it means that 1 Walloon Green Certificate is worth 75 € / 100 € = 0.75 Green Certificate from Brussels.

7 FEDERAL GREEN CERTICATES SYSTEM

The Federal policy level has only limited authorities in renewable energy policies. Its competences are restricted to offshore wind and to aspects related to high voltage grid.

Off-shore wind parks projects are currently under consideration but one can already wonder what impact this kind of project would have on Regional markets since it is evaluated that the first project would receive 900,000 Green Certificates the first year, which represents almost half of the total current yearly amount of Green Certificates (see Section 8, below).

8 RESULTS AND ACHIEVEMENTS

Figures 6 and 7 below show the number of issued Green Certificates in 2006, respectively in Flanders and in Wallonia. Figures for Brussels are not available at this time.

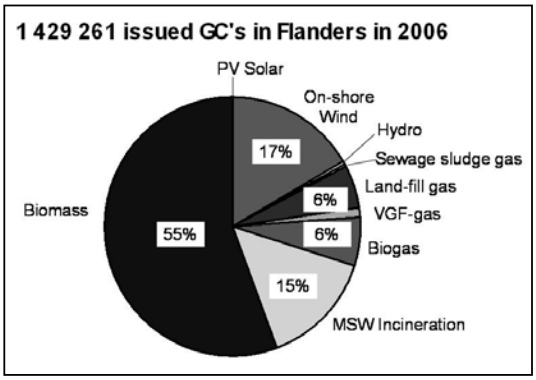

Figure 6: Number of Green Certificates issued in Flanders in 2006, by renewable source [6]

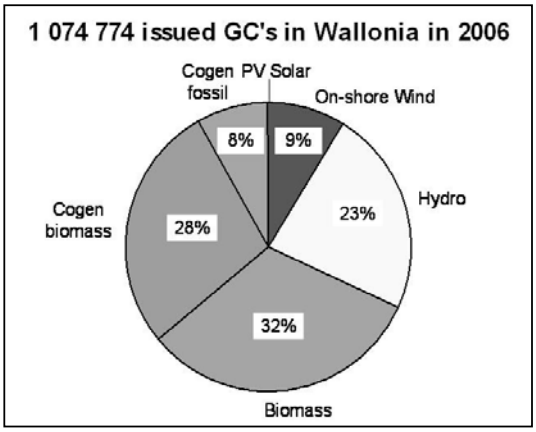

Figure 7: Number of Green Certificates issued in Wallonia in 2007, by renewable source [2]

From these two figures and from Figure 4, it is possible to make the following observations:

- Bioenergy is, in these 2 Regions, the most important source of Green Certificates: 83% for Flanders and 60% for Wallonia;
- Flanders has almost met its objectives since 95.3% of the obligation was fulfilled. The 70,000 missing Certificates represent fines of more or less 8.8 M€ (125 € per GC);
- Wallonia is still a bit below its obligation since 74.2% of the quota was issued. The fines for the 375,000 missing Certificates came to 37 M€ (100 € per GC);
- The 100% pellets power plant Les Awirs generates alone almost all the Walloon Certificates from biomass (see Section 5).

If one Green Certificate in Wallonia is issued for every 456 kg of avoided CO_2 emissions, it is possible to calculate that the Walloon Green Certificates system allowed the saving of 490,000 tons CO_2 in 2006.

The available figures for Brussels give 8,800 issued Green Certificates during the first trimester of 2006. An extrapolation would give 35,200 for the whole year, which represents a CO_2 saving of 7,600 tons CO_2 in 2006.

A detailed LCA analysis would permit to work out the exact amount of CO_2 saved for every Green or Cogen Certificate issued in Flanders. However, here, in order to be able to make some comparison, we chose to use the same ratio than in Wallonia. This means that the 1,429,261 Certificates issued in Flanders would have allowed the saving of 652,000 tons CO_2 in 2006.

This gives an evaluation of the total avoided CO_2 emissions in Belgium in 2006 of 1,149,600 tons CO_2. The GHG emissions due to electricity production represent 21% of the total Belgian emissions (see Figure 2). Regarding these figures, it is possible to assess that the Belgian Green Certificates systems allowed in 2006 an economy of CO_2 emissions due to electricity production of about 3.7%.

9 CONCLUSIONS

Because energy policies competences in Belgium are held by the Regions, five Green Certificates systems co-exist in this country.

Based on a quota of electricity to be produced from renewable energy sources, coupled with penalties in case of non achievement of the obligation, these systems appear to be useful instrument in GHG emissions mitigation.

Though different in some points, it is important to underline that these mechanisms present many common points and are based on the same principles. It is therefore hoped that in the future, these systems may be gathered in one common mechanism for the whole country, still based on the efficient quota-penalties system.

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