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Research Article

Study on Clean Development Mechanism, Quantitative and Sustainable Mechanism

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Aiming at the system and market problem of clean development mechanism (CDM), this study is carried out to establish the feasibility of certified emission reduction (CER) quantitative evaluation method and reserve mechanism in host country at the United Nations Framework Convention on Climate Change (UNFCCC) level. After the introduction of CER quantitative and sustainable mechanism, the amount of CER that can enter the market was cut to a quarter, which reduces about 75% of the expected CER supply. Market CER from the technology types of higher CER market share and lower support for sustainable development appears to have different degrees of reduction. As for the technology types of lower CER market share and higher support for sustainable development, the amount of market CER is maintained in line with prevailing scenario, and market CER supply becomes more balanced.

1. Introduction

During the first Kyoto commitment period, the CDM emerged to be the global currency for emissions trading, avoided more than 1.5 billion tonnes of CO_2 by over 7000 projects, and granted 5–13.5 billion USD to developing countries till 2012 [1]. CDM linked developing and industrialized country emission reduction efforts and provided a governance and accounting framework to assess the environmental integrity of offset projects. However, the CDM has not been without its critics, who have raised questions with regard to the additionality of projects, the mechanism's bureaucracy and transaction costs, and the majority of projects being concentrated in a few primarily emerging economy countries. Efforts to reform the CDM are underway, but at the same time, the global carbon market shows more interest to develop new offset mechanism, even being very similar to CDM, instead of directly using CER as an offset unit [2, 3].

While the Doha decision on Second Commitment Period under the Kyoto Protocol (CP2) confirmed the existence of the CDM until 2020, it did not address the issue of low demand or the oversupply under current CDM framework, thereby questioning the role of the CDM as a catalyst for private sector investment in climate change mitigation [4, 5]. In order to better facilitate the reformation on supply side as well as promotion in demand side of CDM and also considering the protection of existing CDM projects in an interim measure, it is very necessary to explore more options to upgrade design of CDM [6]. In particular, new instrument and components are needed to evaluate divers cobenefit from each CDM projects and enable the cobenefit to become a part of the value of CERs, instead of only emission

Table 1: Demand forecast of national carbon offset in non-Annex I countries during the period 2008–2012 [13].

Potential demand from industrialized countries ($MtCO_2e$)		Potential supplies ($MtCO_2e$)		
Country or entity	Kyoto assets demand		Official target*	
EU	**1,293**	Potential GIS	>**1,500**	
Government (EU-15)	**428**	Ukraine	**500–700**	
Private sector (EU ETS)	**865**	Russian Federation	200	
		Czech Republic	120	
		Other EU-10	600	
Japan	**300**			
Government	100			
Private sector	200			
Rest of Annex B	51	CDM & JI	**1,573**	Range: **1,500–1,658**
Government	46	CDM	**1,273**	**1,250–1,301**
Private sector	5	JI	**300**	**250–357**
Total				
Government				
Private sector				

*These numbers correspond to the amounts of AAUs governments intend to sell. They are much lower than the whole amount of excess AAUs, now estimated at more than 10 billion tCO_2e over the first commitment period, with Russia accounting for half, Ukraine one-quarter, and Poland one-fifth.

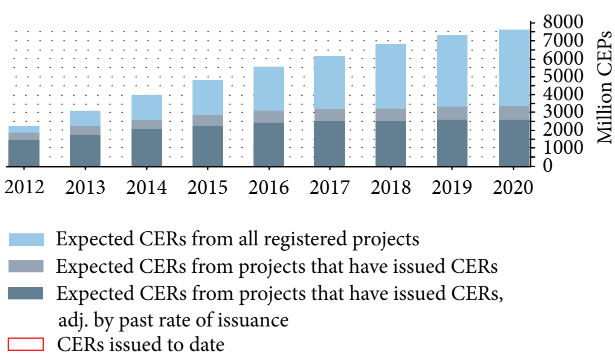

Figure 1: CER production forecast during the period 2013–2020 made by UNFCCC [14].

reduction. With such features, the amount of CER that is allowed to enter carbon market will be able to be adjusted in a quantitative way, according to its contributions to sustainable development and supply potentials [7–9].

Considering the limited capacity of carbon market for offset units, the share of CERs enlarged for those projects with higher cobenefit but lower potentials of supply. In the meanwhile, CDM under reformation should be considered to suit for demand in emerging ETS in both industrialized countries and developing countries. Following this concept, this paper is trying to develop such updated mechanism to enable us to differentiate between CERs as per their features, by dividing each CER issued into two parts, for reserve and for market. It is envisaged that the new mechanism is able to dynamically adjust the ratio of market CER from the issued CERs based on technology type, so that it is able to automatically control the supply potential of CER from different technologies according to its contributions to sustainable development and a real-time market share [10–12].

As a demonstration, this paper tested the effect of this new mechanism by using real data of CDM projects in CDM-pipeline. It can be found that the share of controversial CERs, for example, CER from destruction of chemical gases or large scale, hydro remarkably shrunk and the total volume of CER supply can be downsized.

2. Problem Analysis of CER Market

2.1. Absolute Overplus Risk of CER. According to supply and demand analysis of flexible mechanisms (CDM, joint implementation (JI), and assigned amount unit (AAU)) under the Kyoto Protocol during the period 2008–2012, the demand amount of the first commitment period is 1.64 billion tons, while the potential supply amount (CER, emission reduction unit (ERU), and AAU) has reached more than 3 billion tons (CER accounting for half of which, as shown in Table 1).

Considering that AAU cannot be used for the second commitment period of Kyoto Protocol, carbon offsets during the period 2013–2020 will be mainly based on CER and ERU. Combined with domestic emission reduction mechanisms of current non-Annex I countries, World Bank in the "2012 Global Carbon Market Trends Report" forecasts that during the period 2013–2020 the demand for carbon offset of non-Annex I countries worldwide can add up to approximately 2.7 billion tons, for which EU demand for carbon offsets accounts for 1.6 billion tons or less (as shown in Table 2).

According to the CER supply forecast made by UNFCCC in March 2013 for the second commitment period of Kyoto Protocol (from 2013 to 2020) up to 2020 CDM projects may generate CER accumulated up to an amount between 2.5 billion tons and 7.5 billion tons (as shown in Figure 1, not containing the program of activities (PoA)). Excluding the

Table 2: Demand forecast of national carbon offset in non-Annex I countries during the period 2013–2020 [13].

Country (group of)	Assumption	Potential demand ($MtCO_2e$)
Australia	Carbon price mechanism, cap in line with target of 5°/b below 2000	348
EU-27, Iceland, Liechtenstein, and Norway	20% below 1990, with differentiation EU ETS and effort sharing	1,635*
Japan	Between 25% and below 1990	≤539
New Zealand	NZ ETS: 10% below 1990	77
North America	Western climate initiative (WCI): limited to California and Québec, with international offsets allowed in California only	94
Switzerland	20% below 1990, with ETS and other measures	2.3–12.8
Total	≤2,706	

Notes: for detailed assumptions see Annex 8: assumptions for estimates of potential demand for offsets from non-Annex I countries.
*Already accounts for an inflow in the European Union Emission Trading Scheme (EU ETS) of 865 million CERs and ERUs during Phase II.

CER generated before 2012, the newly added CER supply of the second commitment period is expected to reach about 1 to 6 billion tons.

During the first commitment period of Kyoto Protocol (KP-1), CER supply and demand were basically balanced, with a slight excess subject to the impact of AAU. Due to the lack of existing demand, CER supply capacity will exceed demand in the second commitment period of Kyoto Protocol (KP-2). Theoretically the maximum amount of excess supply capacity can reach 3.3 billion tons.

According to the forecast of carbon emission scenarios in 2020 during the Copenhagen Climate Conference COP15, under different binding emission reduction scenarios, global greenhouse gas emissions will reach about 49–56 billion tons/year by 2020, which should be controlled at 40 billion tons under the 2°C target. Therefore, global emissions by 2020 should be decreased by 16 billion tons/year with the 2°C target (no binding emission reduction scenario). If more stringent binding emission reduction mechanisms are formed at Conference of COP15, global emissions by 2020 require further reduction of 9 billion tons/year or more (as shown in Figure 2).

Supposing 2013–2020 average emission reductions per year up to 9 billion tons/year, there have been totaled 72 billion tons of emission reductions during the eight years. On the supply side, in accordance with the UNFCCC forecast new supply of CER during 2013–2020 can reach 6 billion tons, accounting for 8% emission reduction mandate with the 2°C target (under strict-constraining mechanism scenario).

In a strict-constraining mechanism scenario, most of the emission reductions are required to carry out under the total carbon emissions control (cap-and-trade) in various regions, while the total control and carbon trading systems usually set an upper limit for the carbon offsets usage (about 8–10%). So even though a binding global emissions reduction agreement was formed in 2015 with a higher emission reduction target, the carbon offset demand may not be able to consume all of the CERs generated by CDM projects.

According to the emissions reduction assignment under the 2°C target, even though the broader and deeper global emissions reduction agreement can be formed before 2015, the global CER supply capacity is still difficult to be fully digested. Therefore, there is an absolute excess risk of CER.

2.2. Reflecting-Reduction-Cost Incompetency of CER. In addition to lack of demand, the CDM design also results in the current crisis of CDM. Existing CDM allows different types of projects to provide the market with undifferentiated credits (CER) in accordance with the CO_2 reduction equivalent, ignoring the key differences between different types of technology, such as emission reduction potential and cost differences, as well as different contribution to sustainable development.

Ignoring these differences leads to the domination of projects with the lowest emission reduction costs and largest emission reduction potential (e.g., hydrofluorocarbon (HFC)), which can only operate effectively with a large CER demand. Once the demand is insufficient, it will produce "bad money drives out good money" effect: the falling of CER price will result in the maximum damage to projects with higher additional emission reduction costs and smaller emission reductions, while projects with larger emission reduction and lower emission reductions costs can continue to generate CER. In the above scenario, except for a few projects receiving excessive subsidies, the emission reduction willingness of most participants including the host countries will be damaged, giving rise to the unsustainability of the current CDM system.

3. The Significance of CDM Quantifying to Sustainable Reform

3.1. Empowering CDM Host Countries to Intervene with International Carbon Market. In the market, developed countries have quota reserves such as EUR and control on trading rules, with the ability to dominate the CER prices and demand. As the supply side, host countries do not have the national CER reserves and are in the lack of market intervention to drastic fluctuations of CER prices, which is not beneficial for business and national CER revenue rights.

Although the UNFCCC is considering how to control the CER supply, political risk exists when certain methodological

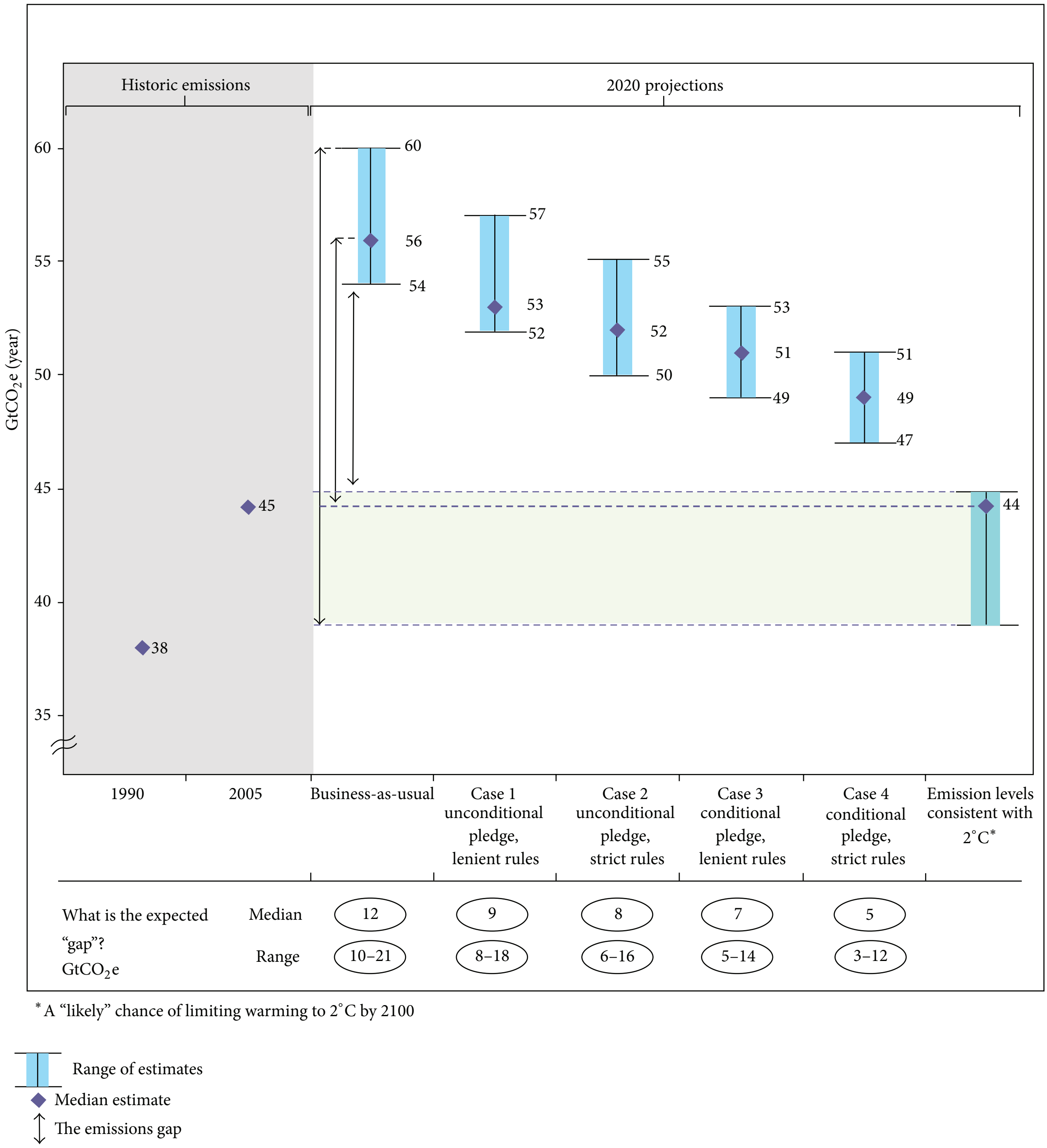

Figure 2: Comparison of expected emissions in 2020 with the emission levels consistent with a "likely" chance of meeting the 2°C limit [15]. The figure compares the expected emissions in 2020 resulting from the four pledge cases with the emission levels consistent with a "likely" chance of meeting the 2°C limit. The median estimates and range of estimates (20th to 80th percentile) are shown. The gap between expected emissions and the 2°C levels is given above in each case.

projects are prohibited to continue registering or issuing at the UNFCCC level. Especially for the chemical gas projects such as HFC, the management calls for further prudence. As these chemical gases have enormous greenhouse gas potential, if the ban of CDM leads to such projects ceasing the destruction of chemical gases and resuming direct emissions, global efforts to reduce emissions will be greatly weakened. Thus adopting tools to adjust and quantify CER supply at the UNFCCC level and recognizing the differences of various CER are not only much easier to implement compared to the administrative measures of "a clean cut," but also conducive to encouraging the promotion of more diversified emission

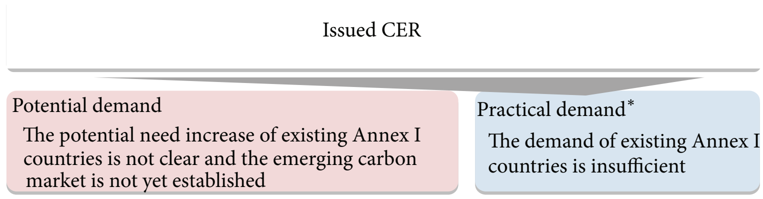

Figure 3: Relative excess scenario of current CER.

reduction technologies, thereby achieving the self-regulation and sustainability of CDM.

3.2. Enhancing Climate Negotiation Advantages of Host Countries by CER Reserves. CER reserves used for carbon offsets in domestic market by host countries or directly canceled as the quantified emission reduction contributions to host countries (similar to nationally appropriate mitigation actions (NAMAs)) can be taken as the measured, reported, and verified (MRV) responsibility for emissions reductions commitments to benefit developing countries in the climate negotiations [16]. Since CDM is a flexible mechanism that helps developed countries to offset emission reduction obligations and allows part of its reserves to be used in domestic market, it can provide a bargaining chip for developing countries in the climate negotiations, that is, to determine whether part of CER reserves would be used in domestic market based on the increase rate of emission reduction target committed by developed countries.

3.3. Empowering Host Countries to Interfere with CER Market by CER Reserves. Through this proposal, it is ensured that the large scale chemical gas projects will generate large CER reserves for host countries. When the quota/credit shortages lead to price rise in the future carbon market, host countries can supply CER reserves to the market. When there is an excess of quota/credit, host countries can continue reserving or use reserves for domestic emission trading scheme (ETS). Enabling host countries with reserve capacity can effectively restrain the speculative operations in the current buyer-country market and stabilize CER price volatility. This is a win-win outcome for the buyer and host countries.

3.4. Effectively Supporting Sustainable Development of Host Country by the Utilization of CDM. In addition, with the decreasing economic strength gap between developed and developing countries, differences of emission reduction obligations are being weakened. The role of CDM also needs to be adjusted, more suggestions declaiming that the CER should be transformed from cheap credits to offset emission reduction obligations of developed countries to a common emission reduction incentive tools. More than half of the CER amount is from chemical-gas-destruction projects, the majority of which is those CERs from relatively advanced developing countries, therefore, the disproportion of technology types and distribution of host countries cause that the CDM capability of supporting sustainability has being widely questioned. Support for sustainable development should be strengthened, and low-carbon technology transfer should be promoted. Only by CDM reformation that conforms to the trend of value foundation can the wider acceptance of CDM be strengthened.

Thus, by adding quantitative adjustment tools that can promote the contribution to sustainable development for current CDM system, host countries are able to comanage the CER market with Annex I countries at UNFCCC level and more capable of intervening with international market. Compared to maintaining the current situation of CDM, this improvement will be easy to accept within the framework of the UNFCCC.

3.5. Supporting the Emerging Carbon Market (ETS) by CER Reserves. There are currently more than twenty countries and regions establishing carbon markets (ETS), in which bilateral or multilateral trading mechanism with CER reserves can be introduced among host countries. That is, with excess CER, part of cheap CER can be used to start current emerging carbon markets in developed countries (e.g., Australia). In addition, when developed countries agree to increase the emission reduction commitments, host countries can provide initial liquidity for the domestic ETS to cover the illiquidity problem that brought about the single spot trading mode.

4. Design Concept of CDM Quantifying Sustainability Mechanism

The proposal intends to divide per ton CER into two parts based on CER shares of different types of technology and degree of contribution to sustainable development: CER directly accessing the market (market CER) and CER not directly entering the market and reserved by host countries (reserved CER). Excess short-term CER supply can be absorbed through the reserved CER mechanism of host countries; the ratio of reserved CER after issuance is decided by the adjustment factor at the UNFCCC level, thereby helping to enhance the advantages of host countries in the climate negotiations and establish the intervention capability to international carbon market.

The CER supply result is adjusted as shown in Figures 3 and 4.

After implementation of this proposal, international carbon market can help those CER generated by projects with greater contributions to sustainable development and lower

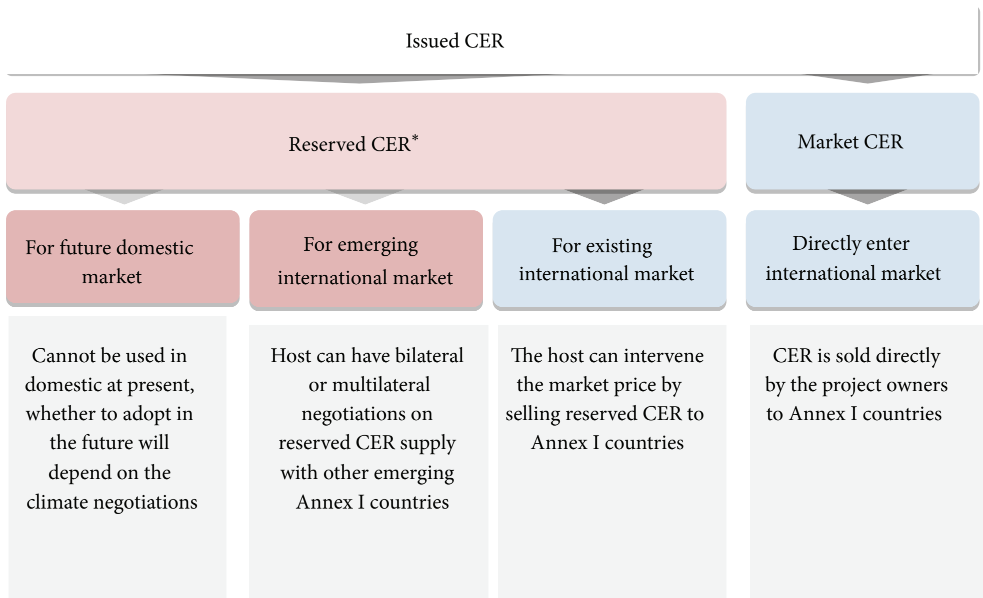

Figure 4: The scenario after implementation of this proposal.

share of CER to gain market advantage and to achieve long-term automatic adjustment. Due to more emphasis on technologies with larger contribution to sustainable development, this mechanism can enhance the value basis of CER.

In volume terms, the proposal will reduce CER market supply in the short run, while, in the long run, it will increase the intervention capability of the host CER reserves for the future international market. Moreover, it can improve and quantify the support of CDM to sustainable development and promote the equalization and diversification of CER in the technology distribution. The proposal design embodies the following ideas.

4.1. Proposal Principles at UNFCCC Level (Top-Down Approach). Implementation of this proposal reforms the quantitative and sustainable mechanism of CDM at UNFCCC level, to strengthen the status of UNFCCC and CDM and ensure the sustainability of CDM. The institutional reformation at the UNFCCC level (rather than the host country or the buyer country) is the most feasible way to limit the CER amount accessing markets by laws and regulations and to establish CER reserves of host countries.

4.2. Incentive Character of CDM in Limited Market Capacity. In this proposal, CDM market is seen as an incentive-subsidies market, which should emphasize the effectiveness and diversity of motivation. In a CER market with limited demand, CER market share among different countries and different types of technology should be more evenly distributed, avoiding long-term focus on a certain type of projects. Meanwhile, the occupied CDM market share of mature emission reduction technologies should be weakened, so that the international carbon market can better promote the new technologies. Therefore, this proposal has designed the project incentive levels of CDM for various emission reduction technologies.

4.3. Enhancing the Effect of Supporting Sustainable Development. Based on the compatibility of the existing methodology system (applicable to various types of emission reduction technology), to evaluate contribution of applicable technologies to sustainable development enables CDM to timely support those technologies with advantages in contributing to sustainable development.

4.4. Automatically Adjusting the Quantity of Various CER Entering the Market. Implementation of this proposal can automatically reduce CER market supply to mature project types (projects with large emission reductions and low emission reduction costs) and indirectly encourage projects with small emission reductions but great sustainable contribution to directly gain CER revenue through carbon markets, enabling emission reduction technologies gradually to decrease the proportion of CER entering the market with maturity improvement. Therefore, implementation of this proposal can automatically adjust the constitution of CER entering the market, thereby promoting the diversification and balanced development of CDM market.

4.5. Establishing CER Reserve Mechanism of Host Countries. The ratio of CER that is generated by each project type and can be used for reserving by host countries (the part that cannot directly enter the market) would be regulated at the UNFCCC level, with the host CER account established by the UNFCCC along the usage methods and conditions of this part of CER reserves. According to the emission reduction commitments of developed countries, host countries can set a proportion of CER reserves that can be used for host

Table 3: A test of the mechanism on current CERs issued from different technology types.

Parameters	M: marks (on contributions to sustainable development)	F_m: factor (derived from M ranking)	V: volumes (of accumulated issued CER for each type)	S: share (of each type CER in the total)	F_s: factor (derived from S ranking)	AF: adjusting factor (derived from F_m and F_s)	Volumes of market CER after adjusting	Shares of market CER from each type
Rationale of parameters	Inputs values, based on objective evaluations or model	$F_m = M_i/\text{average}\{M\, i{\sim}n\}$	Input values, based on actual data from UNFCCC	$S = V_i/\text{sum}\{V\, i{\sim}n\}$	$F_s = F_m/\max\{S_i, \text{average}\{S\, i{\sim}n\}\}$	$\text{AF} = \min\{1, F_{s_i}/\text{average}\{F_s\, i{\sim}n\}\}$		
Unit	**N.A.**	N.A.	$ktCO_2e$	%	N.A.	%	$ktCO_2e$	%
Wind	70	1.46	83,520	8.06%	18.06	78.9%	65922	26.35%
Hydro	20	0.42	107,682	10.39%	4.00	17.5%	18835	7.53%
Biomass energy	67	1.39	27,408	2.64%	33.44	100.0%	27408	10.96%
Methane avoidance	65	1.35	12,364	1.19%	32.44	100.0%	12364	4.94%
EE own generation	35	0.73	47,059	4.54%	16.03	70.0%	32961	13.18%
Landfill gas	40	0.83	30,074	2.90%	19.97	87.2%	26237	10.49%
Solar	70	1.46	166	0.02%	34.94	100.0%	166	0.07%
EE industry	40	0.83	2,089	0.20%	19.97	87.2%	1822	0.73%
Fossil fuel switch	35	0.73	35,598	3.44%	17.47	76.3%	27173	10.86%
EE supply side (power plants)	55	1.14	1,817	0.18%	27.45	100.0%	1817	0.73%
Coal bed/mine methane	50	1.04	16,559	1.60%	24.96	100.0%	16559	6.62%
EE households	100	2.08	135	0.01%	49.91	100.0%	135	0.05%
N_2O	5	0.10	217,632	21.00%	0.50	2.2%	4709	1.88%
Afforestation and reforestation	80	1.66	4,998	0.48%	39.93	100.0%	4998	2.00%
Fugitive	5	0.10	10,682	1.03%	2.50	10.9%	1165	0.47%
Cement	30	0.62	2,389	0.23%	14.97	65.4%	1563	0.62%
Transport	77	1.60	564	0.05%	38.43	100.0%	564	0.23%
EE service	90	1.87	6	0.00%	44.92	100.0%	6	0.00%
Geothermal	46	0.96	4,262	0.41%	22.96	100.0%	4262	1.70%
Energy distrib.	68	1.41	316	0.03%	33.94	100.0%	316	0.13%
HFCs	1	0.02	428,760	41.37%	0.05	0.2%	942	0.38%
PFCs and SF6	5	0.10	2,211	0.21%	2.50	10.9%	241	0.10%
CO_2 usage	20	0.42	10	0.00%	9.98	43.6%	4	0.00%
Tidal	80	1.66	—	0.00%	39.93	100.0%	0	0.00%
Total			1,036,302				250,169	

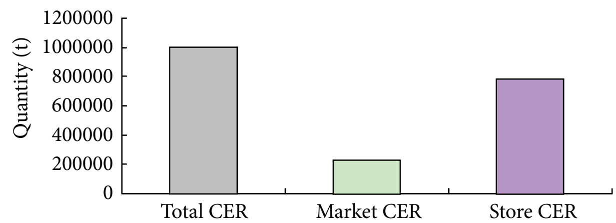

Figure 5: The scenario of reformed market CER and reserved CER [18].

Table 4: The CER proportion of all kinds of technology type before and after the reform.

Technology type	Issuance proportion before the reform	Issuance proportion after the reform
Wing power	8.06%	26.35%
Hydropower	10.39%	7.53%
Biomass	2.64%	10.96%
Waste-heat utilization	4.54%	13.18%
Landfill gas utilization	2.90%	10.49%
Alternative to fossil fuels	3.44%	10.86%
Coal mine methane utilization	1.60%	6.62%
N_2O	21.00%	1.88%
HFCs	41.37%	0.38%
Others	4.05%	11.76%

domestic market with the remaining reserves open for selling to international carbon market.

4.6. CER Reserves and the Intervention Capability of the Host Country in International Market. Host countries of CDM projects currently do not have CER reserve mechanism, so the CER pricing is entirely controlled by the buyer [17]. Thus, by UNFCCC-level rules, issued CER can be divided into two parts: CER entering the market and reserved CER by host countries. In that case, CER reserve mechanism of host countries can be established, which can transfer the current excess CER to national reserves, thereby transforming the current structure of CER solely being supplied by enterprises to the "dual track" of the state and enterprises. As the host governments reserve a large amount of CER, the interference on CER market price induced by speculation of buyer-market can be effectively curbed.

5. Expected Effect of CDM Quantifying Sustainability Mechanism

5.1. Significantly Cut the Traditional Expected CER under the Condition of Allowing Chemical Gas Projects to Enter the Market. After the introduction of CER quantitative and sustainable mechanism, the amount of CER that can enter the market was cut to a quarter, which reduces about 75% of the expected CER supply. The amount of cut CER is mainly from HFC and N_2O (reduced to 0.2% and 2.2%, resp.) destruction projects. However, HFC and N_2O destruction projects still can conduct CER trading in order to maintain necessary operation costs. Meanwhile, CER generated by those projects that cannot directly enter the market would be converted to reserved CER of the host country, which is managed by the host country (Figure 5).

5.2. Automatically Implementing the CER "Market Equilibrium Distribution" of Different Technologies. After introducing CER quantitative and sustainable mechanism, the amount of market CER from the technology types of higher CER market share and lower support for sustainable development appears to have different degrees of reduction. As for the technology types of lower CER market share and higher support for sustainable development, the amount of market CER is maintained in line with prevailing scenario. After the introduction of reform mechanism, market CER supply becomes more balanced. The expected change of share is shown in Table 3.

Among technologies in Table 3, those types in position of overwhelming majority are automatically adjusted, so that the market CER from those types declined differently according to their relative contribution to sustainable development. The effect of applying the mechanism in these technologies is summarized in Table 4.

Conflict of Interests

The authors declare no conflict of interests.

Acknowledgments

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