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Regional Renewable Energy Certificate Systems: An International Review and Policy Implications for the Hong Kong-Guangdong Region

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REGIONAL RENEWABLE ENERGY CERTIFICATE SYSTEMS: AN INTERNATIONAL REVIEW AND POLICY IMPLICATIONS FOR THE HONG KONG-GUANGDONG REGION

PREFACE

This working paper is derived from the Honours Project titled "Regional Energy Collaboration for Sustainability: A Case Study of a Proposed Hong Kong-Guangdong Renewable Energy Certificate System", which was undertaken by the lead author for fulfilling the requirements of the Bachelor of Social Sciences (Honours) in the Department of Geography of Hong Kong Baptist University.

ABSTRACT

Renewable energy (RE) is a key to a sustainable future. At present, different types of RE policies are implemented to facilitate sustainable development. Among these policies, the renewable energy certificate system (RECS) has been increasingly adopted in developed countries to accelerate the deployment of RE. This market-based instrument has the strength of flexibility as it could be implemented in municipal, regional or even national scales.

Compared to some other cities, the progress of RE development is far from satisfactory in Hong Kong. However, in the last year, the consultation on the future fuel mix for electricity generation in Hong Kong provided an opportunity to study the feasibility of regional energy collaboration between Hong Kong and Guangdong. By integrating the concept of regional energy collaboration and implementation of RECS, a regional RECS could be an option to overcome local limitations and stimulate RE development.

This paper aims to examine the potential benefits for setting up a regional RECS between Hong Kong and Guangdong from the perspective of regional collaboration. We conducted desktop research and semi-structured interviews with seven representatives from major stakeholder groups, including a power company, environmental non-governmental organizations, academia, and a consumer advocacy organization. Based on our empirical data, we conclude by highlighting some considerations for the proposed system for the Hong Kong policy-maker should there be interest in facilitating regional energy collaboration.

1. INTRODUCTION

How to accelerate the deployment of RE has been an ongoing subject of study worldwide. Regional RECS is an innovative market-based instrument that could be adopted in a regional scale to achieve RE goals. The extent to which and how effective these policy innovations has remained under-studied.

The objective of this paper is to draw on international experiences to examine and identify key issues in the recent developments of RECSs, particularly those in the regional context, and to explore the policy implementations of the potential to develop a regional RECS between Hong Kong and Guangdong (HK-GD RECS) for Hong Kong policy-makers.

This paper is structured as follows. In Section 2, we examine RECSs from a theoretical perspective by introducing the definitions, key components and mechanisms of RECSs. We then provide an international overview of national and regional RECSs. This is followed by a detailed case study of the Norwegian-Sweden regional RECS, which can provide some insights on the key issues and lessons and contribute to the development of key considerations of the HK-GD RECS. In Section 3, we base on our in-depth semi-structure interview to discuss the potential benefits of and major barriers to the development of the HK-GD RECS. After exploring the feasibility of implementation, based on the context of Hong Kong and Guangdong, we discuss some of the main considerations for Hong Kong policy-makers if they decide to implement the HK-GD RECS.

This is a qualitative research. We conducted desktop studies and in-depth semi-structured interviews. We reviewed books, journal, papers, theses, government documents, newspapers, television programs and the local and overseas websites of governments, institutions and non-governmental organizations related to Hong Kong's electricity market, Guangdong's electricity market, Hong Kong-Guangdong RE development, RECS, and regional energy collaboration.

We conducted eight in-depth semi-structured interviews with representatives from four stakeholder groups including a power company, environmental non-governmental organizations, academia, and a consumer advocacy organization. We had invited eleven individuals from five groups of stakeholders for interviews. Eight of them agreed to be interviewed and the remaining three (two from government sector and one from power company) either rejected the invitation or did not respond. Seven interviews were conducted in face-to-face while one interview was conducted via telephone. Each interviewee was assigned a code as shown in the list of interviews. A list of the interviewees is provided in Table 8 on p.47.

2. RENEWABLE ENERGY CERTIFICATE SYSTEMS: AN ORETICAL DISCUSSION AND INTERNATONAL REVIEW

RECS is a highly complicated system which includes a lot of components that constitute an intricate mechanism. As the international experiences on implementing RECS are important for formulating the Hong Kong-Guangdong RECS, several national systems and two regional case studies are described in this section.

2.1. DEFINITIONS, KEY COMPONENTS, AND MECHANISMS OF RENEWABLE ENERGY CERTIFICATE SYSTEMS

To provide a comprehensive understanding on RECS, the definition, key components and mechanism of the system will be described in the following subsection.

2.1.1. DEFINITIONS

RECS is a market-based instrument for trading renewable energy certificates that are non-tangible and tradable commodities to prove that one megawatt-hour of electricity was generated from eligible RE resources (Golini, 2005; Environment Protection Agency, 2008; Office of Energy Efficiency & Renewable Energy, 2010; Sustainable Prosperity, 2011). A renewable energy certificate (REC), also known as a green certificate, tradable green certificate, renewable energy credit, alternative energy credits or green tag, could represent the renewability attribute of the electricity (Nico et al., 2005; Bertoldi and Huld, 2006; Gillenwater, 2008; Environment Protection Agency, 2008; Office of Energy Efficiency & Renewable Energy, 2010; Sustainable Prosperity, 2011). It is issued by a third party to producers and can be sold together with the actual electricity or sold independently (Nielsen and Jeppesen, 2003).

2.1.2. KEY COMPONENTS

Based on our literature review, a total of thirteen components can be specified as the general structure of RECS. These can be categorised into three main types: the setting of RE goals, institutional entities and the setting of market rules. Goal setting is a general direction for the development of RE in a country and it is a necessity for leading a government towards a sustainable future. Institutional entities are executive and administrative bodies that establish, regulate and monitor the entire system. The setting of market rules guides and specifies the operation details of RECS for stakeholders. We will discuss the thirteen key components as follows. Table 1 below is a summary of the key components in a RECS.

(a) Renewable Energy Goal Setting

i. Renewable Energy Target

A renewable energy target is a direction of RE development, which is set by a government in order to increase a certain proportion of power generated from RE sources in the overall energy mix (Nielsen and Jeppesen, 2003; Nico et al., 2005; Environment Protection Agency, 2008), and/or increasing the total installed capacity of RE (Sustainable Prosperity, 2011).

(b) Institutional Entities

i. Executive Body

The executive body is a government entity which is liable to set up a RECS and formulate the legal framework of the entire system (Nielsen and Jeppesen, 2003). It is also responsible for setting up the criteria of RE certification, determining quotas for obligated actors, formulating rules and regulations of issuing, trading, redeeming and monitoring certificates, as well as appointing executors and monitors (Nielsen and Jeppesen, 2003).

ii. Issuing Body

The issuing body is an independent organization responsible for issuing and redeeming of RECs (Nielsen and Jeppesen, 2003; Nico et al., 2005; Bertoldi and Huld, 2006; Sustainable Prosperity, 2011). However, sometimes the issuing body may only have an internet-based issuing platform. (Nico et al., 2005).

iii. Monitoring Organization

The monitoring organization is usually a government authority responsible for registering, monitoring and approving the trading of RECs (Nielsen and Jeppesen, 2003). It monitors the compliance of obligated actors with reference to specific quotas (Nielsen and Jeppesen, 2003). It also checks whether the total production of RE claimed by producers is in proportion to the number of issued RECs (Nielsen and Jeppesen, 2003).

(c) Market Rules

i. Obligated Actor

The obligated actor refer to market players who must demonstrate that a certain amount of electricity are supplied from RE sources by submitting a specific number of RECs to the authority so as to achieve the RE quota under RECS (Golini, 2005; Sustainable Prosperity, 2011).

ii. Quota

The quota is a number that requires the obligated actor to generate or purchase a certain amount of electricity generated from RE in a given year (Bertoldi and Huld, 2006; Sustainable Prosperity, 2011). The quota is commonly expressed in the form of absolute amount in kWh, in MW or by percentage (Nico et al., 2005).

iii. Eligible Resources

The eligible resources are RE technologies or resources which are eligible for certification under RECS (Nico et al., 2005). Technical specification of each type of RE may be specified by a government and generally it covers a wide range of RE resources. However, it is important to note that some RE resources, such as large-scale hydro, may be excluded or require additional improvements due to environmental considerations (Golini, 2005; Sustainable Prosperity, 2011).

iv. Treatment of Existing RE Plants

Different countries, under their own systems, have diverse treatments on existing plants. The major consideration of the treatment is based on the objectives of the system, whether aimed at increasing newly installed RE capacity or increasing penetration of RE (Nielsen and Jeppesen, 2003). Generally, only new RE installed capacity is eligible for certification and most exiting RE plants are excluded so as to increase incentives on additional RE capacity (Nico et al., 2005; Sustainable Prosperity, 2011).

v. Period of Validity

"Period of validity" refers to the number of months or years that RECs can be valid for demonstrating the compliance with obligation (Nico et al., 2005). Any certificates beyond this period would become invalid and cannot be circulated further. The length of validity would also affect the price of RECs, as well as determine the allowable banking period (Nico et al., 2005).

vi. Banking and Borrowing

Banking and borrowing are flexible mechanisms which can be built in RECS (Golini, 2005; Sustainable Prosperity, 2011). Banking allows RECs to not be consumed in the current compliance period and to be banked in an account and used for compliance with obligation at a later period (Nico et al., 2005; Nielsen and

Jeppesen, 2003). As for borrowing, it allows the current obligation to be met by the future generation of renewable electricity (Nico et al., 2005). These mechanisms can increase the flexibility of the certificate in a system and it can be used as a measure to stabilize the fluctuating prices of the certificate caused by the unstable supply of RECs or intermittency of RE (Nielsen and Jeppesen, 2003).

vii. Import and Export

Some RECSs allow obligated actors to import or export RECs from/to other countries/states. However, the transfer of RECs is subjected to the restriction of local governments or is limited by the differences in two RECSs (Sustainable Prosperity, 2011). Therefore, the import or export of RECs mostly occurs in those countries/states with similar RECSs (Sustainable Prosperity, 2011).

viii. Minimum Price and Maximum Price

A minimum price, which is guaranteed by the government, refers to the lowest price of a REC as designated in a policy or law. A maximum price refers to the highest price of a certificate that limits the costs of compliance with obligation (Nico et al., 2005; Golini, 2005; Sustainable Prosperity, 2011). In short, a guaranteed price is a shot in the arm for stakeholders, especially the investors in RE, as it can ensure the investment in a healthy and profitable way and demonstrate the government's determination for long-term RE development (Nielsen and Jeppesen, 2003; Sustainable Prosperity, 2011).

ix. Penalty for Non-compliance

A penalty refer to the fine that paid by obligated actors if their obligation is not met (Nielsen and Jeppesen, 2003; Nico et al., 2005). Penalties mainly exist in compliance markets and are absent in voluntary markets. The cost of penalty is usually at the same level as the maximum price of a REC designated in a policy or law in a way to ensure obligated actors take responsibility should they fail to meet their obligation (Nielsen and Jeppesen, 2003; Golini, 2005; Sustainable Prosperity, 2011).

Table 1. Key components in a RECS (Bertoldi and Huld, 2006; Environment Protection Agency, 2008; Golini, 2005; Nico et al., 2005; Nielsen and Jeppesen, 2003; Sustainable Prosperity, 2011)

Types	Key Components	Explanations
(a) Goal Setting	i. Renewable Energy Target	• Set by a government • Increase a certain proportion of power generated from RE sources in the overall energy mix • Increase the total installed capacity of RE
(b) Institutional Entities	i. Executive Body	• Setting up RECS • Formulating the legal framework of the entire system
	ii. Issuing Body	• Issuing and redeeming of REC
	iii. Monitoring Body	• Registering, monitoring and approving the trading of REC
(c) Market Rules	i. Obligated actor	• Market players • Must demonstrate a certain amount of electricity supply is generated from RE sources • Submitting a specific number of RECs to the authority
	ii. Quota	• A number or percentage required by the obligated actor to generate or purchase a certain amount of electricity generated from RE in a given year
	iii. Eligible resources	• RE technologies or resources • Eligible for certification under RECS
	iv. Treatment of existing RE plants	• Most exiting RE plants are excluded • In order to increase new installed capacity of RE
	v. Period of Validity	• The number of months or years that RECs can be valid to demonstrate the compliance with obligation
	vi. Banking and Borrowing	• Banking allows RECs to not be consumed in the current period and be used for compliance at a later period • Borrowing allows the current obligation

		to be met by the future generation of renewable electricity
vii. Import and Export	•	Allow obligated actors to import or export RECs from/to other countries/states
viii. Minimum Price and Maximum Price	•	Minimum price is guaranteed by government, and refers to the lowest price of RECs
	•	Maximum price refers to the highest price of a certificate that limits the costs of compliance with obligation
ix. Penalty for Non-compliance	•	The fine that is paid by obligated actors if they do not meet their obligations

2.1.3. MAJOR MECHANISMS

RECS is a highly complicated system and the existing systems implemented in different countries are variable and dynamic. Thus, it should be noted that the following description is a generalized mechanism of RECS.

In general, RECS is mainly based on three institutional entities (executive body, issuing body, monitoring body), three market players (producers, obligated actors, voluntary consumers) and two markets (REC Market, electricity market). Also, there are four phases (establishment and formulation, issuing, trading, monitoring) that can be generalized in the system. The mechanism is illustrated in Figure 1.

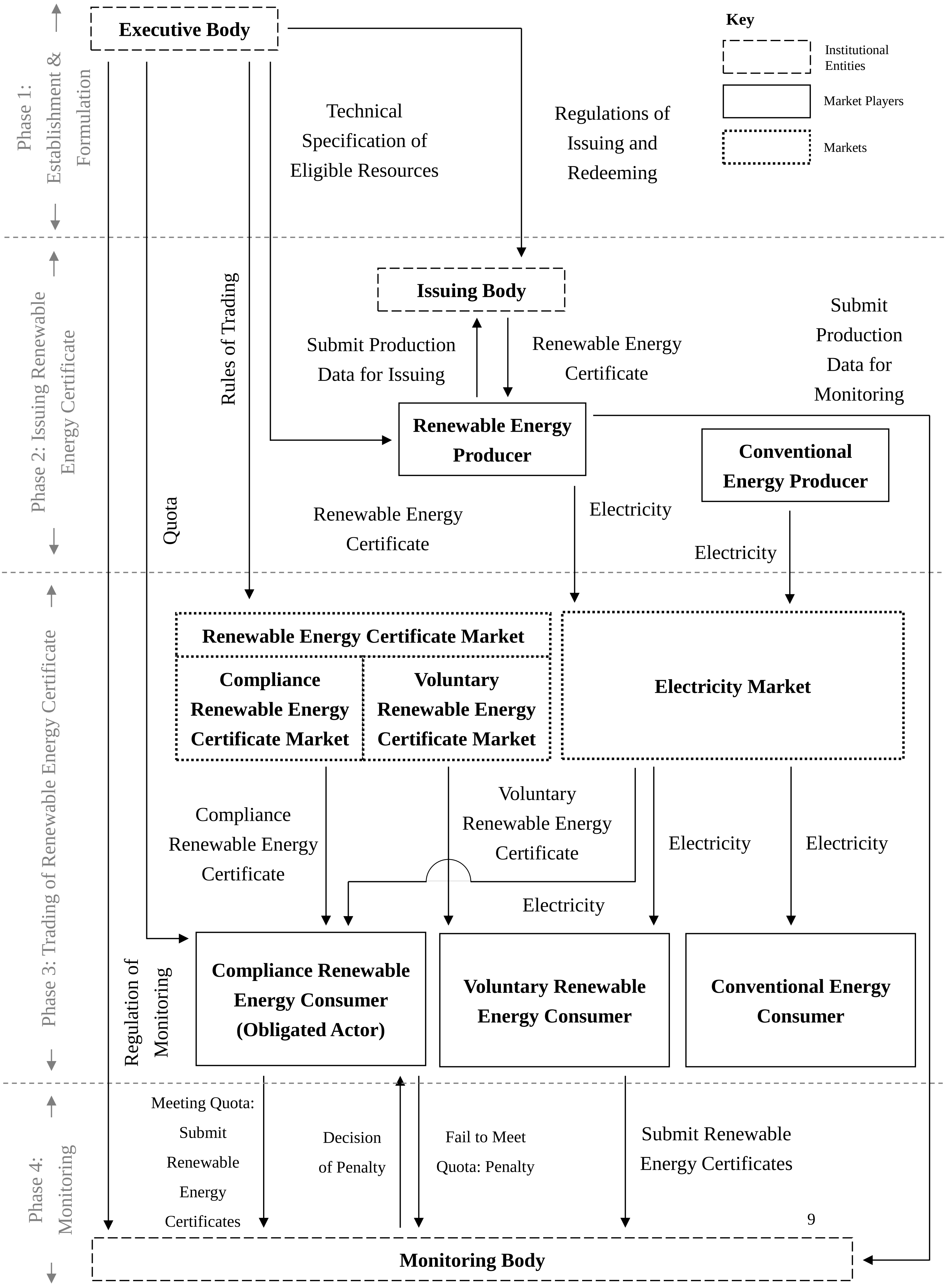
The first phase is the establishment and formulation of RECS. It begins with institutional entities, namely the executive body, issuing body and monitoring body (Nielsen and Jeppesen, 2003). The executive body will first formulate rules and regulations for the issuing body, monitoring body, producer and REC Market, and set up a quota for the obligated actor (Bertoldi and Huld, 2006; Nielsen and Jeppesen, 2003). Once all the regulations and quotas are set, other institutional entities, market players and markets will be functional according to the commands from the executive body (Sustainable Prosperity, 2011).

The second phase is the process of issuing. In order to be eligible to receive RECs, a producer is required to produce electricity from eligible RE resources specified by the executive body (Bertoldi and Huld, 2006; Sustainable Prosperity, 2011). Once electricity is generated, that producer needs to submit its production data to the issuing body for the procedure of issuing the REC and to the monitoring body for verifying the production technologies and the total RE production claimed by the producer (Sustainable Prosperity, 2011). Afterwards, the issuing body will issue a corresponding number of certificates to the producer based on the actual amount of RE generated by the producer (Sustainable Prosperity, 2011). Once the REC is received from the issuing body, the producer would start to distribute the REC and electricity to the REC market and electricity market respectively (Sustainable Prosperity, 2011).

The third phase is trading. There are two existing types of REC markets, namely the “Compliance REC Market” and “Voluntary REC Market” (Sustainable Prosperity, 2011). The main differences of these markets are their market players and types of REC. “Compliance REC Market” is targeted for the obligated actor who is subjected to quotas specified by the executive body and the type of certificate transacted in this market is called “Compliance REC” (Sustainable Prosperity, 2011). As for the “Voluntary REC Market”, the major market player is a voluntary consumer who is not subjected to any quotas or obligations but the consumer voluntarily purchase eligible RE as a means of supporting RE development (Environment Protection Agency, 2008; Sustainable Prosperity, 2011). Hence, the certificate traded in this market is called “Voluntary REC”. Once an obligated actor or a voluntary consumer pays money to a producer, the obligated actor or the voluntary consumer will receive the electricity and corresponding type of certificate (Environment Protection Agency, 2008).

The fourth phase is the step of meeting obligations by submitting REC. An obligated actor will submit RECs to the monitoring body for meeting the quota as specified by the executive body (Bertoldi and Huld, 2006; Nico et al., 2005; Sustainable Prosperity, 2011). The obligated actor would be penalized if it fails to meet the quota (Nielsen and Jeppesen, 2003; Nico et al., 2005). The voluntary consumer can submit certificates to the monitoring body as a proof of purchasing or using RE from eligible renewable resources (Environment Protection Agency, 2008; Office of Energy Efficiency & Renewable Energy, 2010; Sustainable Prosperity, 2011)

Figure 1. The mechanism of a RECS (Environmental Protection Agency, 2008; Nico et al., 2005; Office of Energy Efficiency & Renewable Energy, 2010; Sustainable Prosperity, 2011)



2.2. AN OVERVIEW OF GLOBAL EXPERIENCES

The RECS has been widely adopted in western countries. By studying the current practice of RECS, it can provide a wider perspective on how these countries utilise the system as an instrument to facilitate RE development. For this purpose, a total of eight RECSs are selected for our case studies. These systems are well-developed since they have a relatively long history of development on RECS. All of the basic information of the systems are summarized in Table 2 based on the components of a system as categorised in the previous section.

When comparing the implemented systems in different countries and states, there are several similarities and differences. In terms of similarity, all selected systems are identically implemented with supporting legal frameworks (Australian Government - ComLaw, 2014; Colorado Secretary of State, 2014; Danish Parliament, 1999; Department of Regulatory Agencies, 2014; Legislation.gov.uk, 2014; Legislative Counsel of California, 2002; LOVDATA, 2011; Notisum, 2012; Public Utility Commission of Texas, 1999, 2014; Texas Constitution and Statutes, 1999; The Swedish Parliament, 2014). Also, most of the systems belong to the compliance market and obligations are usually designated to electricity suppliers and consumers (Clean Energy Regulator, 2014; Danish Parliament, 1999; Gov.uk, 2012; LOVDATA, 2011; Swedish Energy Agency, 2012). Moreover, the executive body, issuing body and monitoring body in selected systems are mainly governmental entities (Clean Energy Regulator, 2014; Danish Parliament, 1999; Gov.uk, 2012; Norwegian Ministry of Petroleum and Energy, 2012; Ofgem, 2014; Swedish Energy Agency, 2012), except for some countries which have designated an internet-based online platform as an issuing body (The REC Registry, 2014; Western Electricity Coordinating Council, 2012).

As for market rules, treatment of existing RE plants, banking and borrowing, certificate size and the price of certificate are almost the same. Nearly all selected systems set restrictions on existing electricity plants for certification, allow “banking” of certificate and prohibit “borrowing” (California Public Utilities Commission, 2012; Clean Energy Regulator, 2014; Climate Change Authority, 2012; Colorado Secretary of State, 2014; Danish Energy Agency, 2001; Department of Energy & Climate Change, 2012; Golini, 2005; Legislative Counsel of California, 2002; LOVDATA, 2011; Ofgem, 2014; RECS International, 2013; Swedish Energy Agency, 2012). Also, the size of the certificate among the selected systems are mostly based on one megawatt hour per certificate and most of them do not have any regulations on the maximum or minimum price of each certificate (California Public Utilities

Commission, 2012; Clean Energy Regulator, 2014; Colorado Secretary of State, 2014; Danish Energy Agency, 2001; LOVDATA, 2011; Ministry of Enterprise, Energy and Communications, 2013; Norwegian Water Resources and Energy Directorate, 2014; Public Utility Commission of Texas, 1999, 2014; Swedish Energy Agency, 2012; Texas Constitution and Statutes, 1999).

On the other hand, different systems have different names for certificates but normally most of the names consist of the term “certificate” or “credit” (Bertoldi and Huld, 2006; Environment Protection Agency, 2008; Gillenwater, 2008; Nico et al., 2005; Office of Energy Efficiency & Renewable Energy, 2010; Sustainable Prosperity, 2011). Moreover, the RE target and quota among the systems vary and most of the targets and quotas are “conservative”; only Denmark proposed an aggressive target for achieving an entire energy supply by RE by 2050 (Danish Energy Agency, 2014).

Moreover, the eligible resources vary in different systems. Most systems accept solar, wind, hydro, tidal, wave and geothermal energy as an eligible RE resource for producing electricity and receiving RECs while other resources, such as waste, biomass and landfill gas, are generally not qualified for RECs (Golini, 2005; Sustainable Prosperity, 2011). It should be also noted that some countries or states may restrict the maximum installed capacity of specific RE resources, especially hydro. Only the installed capacity ranging from fifteen hundred kilowatts (Sweden) to thirty megawatts (California) of a hydropower plant is eligible to receive RECs due to environmental consideration (Swedish Energy Agency, 2012; California Public Utilities Commission, 2009).

Furthermore, other market rules, including validity and penalty, are diverse among these systems. Only certificates in Australia, Denmark, Sweden and Norway have permanent validity while other selected countries or states limit the validity of the certificate between one year and five years (Ofgem, 2014). The penalty costs among these systems also vary. Australia, United Kingdom, Denmark, Texas, California and Colorado have a fixed price on the penalty while Sweden and Norway only set the penalty in the form of a percentage (LOVDATA, 2011; RES Legal, 2014).

In brief, all these systems are targeted to facilitate the RE development but they are different in their system setting and implementation. No uniform goal setting, institutional entities, obligated actors and quotas, and market rules can be found in the case studies.

Table 2. An international review of RECSs in major nations

Country / States		Australia	United Kingdom	Denmark	Sweden	Norway	United States		
							Texas	**California**	**Colorado**
Year of the Start-up		2001	2002	1999	2003	2012	2002	2011	2004
Type of Market		Compliance	Compliance	Compliance	Compliance	Compliance	Compliance	Compliance, Voluntary	Compliance
Name of System		Renewable Energy Target	Renewables Obligation	Green certificate scheme	The green electricity certificate system	Electricity Certificate System	Texas Renewable Energy Credit Program	California Renewables Portfolio Standard	Renewable Energy Standards
Name of Certificate		• Small-scale Technology Certificates • Large-scale Generation Certificates	Renewable Obligation Certificate	Green certificate	Green Electricity Certificate	Electricity certificate / Elcertificates	Renewable Energy Credit	Renewable Energy Credit	Renewable Energy Credit
Goal Setting	Renewable Energy Target	• Large-scale Renewable Energy Target: 41,000 GWh by 2020 • Small-scale renewables: 11,000 GWh by 2020	Meeting 15% of the UK's energy demand from renewable sources by 2020	Entire energy supply is to be covered by renewable energy by 2050	Increase the electricity production from renewable energy sources by 25 TWh relative to production in 2002 by 2020	Increase the renewable electricity production by 26.4 TWh from 2012 to 2020	10,000 MW in-state renewable generation capacity by 2025	33% energy demand from renewable sources by 2020	30% energy demand from renewable sources in 2015-2019
Institutional Entities	Executive Body	Department of the Environment	Department of Energy and Climate Change	The Minister of Environment and Energy	Swedish Energy Agency	Norwegian Ministry of Petroleum and Energy	The Public Utility Commission of Texas	The California Public Utilities Commission	Department of Regulatory Agencies
	Issuing Body	The REC Registry	Office of the Gas and Electricity Markets	The system operators (Energinet.dk)	Svenska kraftnät	Statnett	The Electric Reliability Council of Texas	Western Renewable Energy Generation Information System	Western Renewable Energy Generation Information System
	Monitoring Body	Clean Energy Regulator	Office of the Gas and Electricity Markets	The Danish Energy Agency	Swedish Energy Agency	Norwegian Water Resources and Energy Directorate	The Electric Reliability Council of Texas	The California Energy Commission	Department of Regulatory Agencies
Market Rules	Obligated Actor	Electricity retailers	Electricity suppliers	Electricity consumers	• Electricity suppliers • Certain types of electricity end	• Electricity supplier • Certain types of electricity end	• Investor-owned utilities • Retail suppliers • Municipally-	Electric retail sellers • Investor-owned utilities • Electric service	• Investor-owned electric utilities • Municipal-owned electric

					users and electricity users • Electricity intensive companies	users	owned utilities • Electric cooperatives	providers • Small and multi-jurisdictional utilities	utilities • Cooperative electric associations
Quota		• 2014 renewable power percentage (RPP): 9.87% • 2014 small-scale technology percentage (STP): 10.48%	• 2013/14: 0.206 ROCs for each MWh supplied to customers • 2014/15: 0.244 ROCs	At least 30% will be renewable energy in final energy consumption by 2020	Quota obligation per MWH of electricity sold or consumed: • By 2014: 0.142 • By 2015: 0.143 • By 2020: 0.195 • By 2025: 0.149 • By 2030: 0.076 • By 2035: 0.008	Quota obligation per MWH of electricity sold or consumed: • By 2014: 0.069 • By 2015: 0.088 • By 2020: 0.183 • By 2025: 0.176 • By 2030: 0.094 • By 2035: 0.009	The renewable energy capacity requirements for the compliance period beginning January 1: • In 2014: 5,000 MW of new resources • After 2014: 5,000 MW of new resources	• 25% of retail sales from eligible resources by December 31,2016 • 33% of retails sales by December 31, 2020	Investor-Owned Utilities • 30% of retails sales by 2020 Electric cooperatives • 10% of retails sales by 2020 Cooperative utilities • 20% by 2020
Eligible Resources	Solar	✓	✓	✓	✓	✓	✓	✓	✓
	Wind	✓	✓	✓	✓	✓	✓	✓	✓
	Hydro	✓	✓ (<20 MW)	✓ (<10 MW)	✓ (<1500 kW)	✓ (<1 MW)	✓	✓ (<30 MW)	✓ (<10 MW)
	Waste	✓	✓					✓	
	Tidal	✓	✓				✓	✓	
	Wave	✓	✓	✓	✓	✓	✓	✓	
	Geothermal	✓	✓		✓	✓	✓	✓	✓
	Biomass	✓	✓	✓			✓	✓	✓
	Landfill gas	✓	✓				✓		
	Other	✓	✓	✓	✓	✓		✓	✓
Existing Plants		✗	✗	-	✗	✗	✗	✗	✗
Certificate Size		1 MWh	Varied	1 MWh	1 MWh	1 MWh	1 MWh	1 MWh	1 MWh
Validity		Permanent	1 year	Permanent	Permanent	Permanent	3 years	3 years	5 years
Flexibility	Banking	✓	✓ (/w restriction)	✓	✓	✓	✓ (/w restriction)	✓	✓
	Borrowing	×	×	×	×	×	×	×	✓
Import/ Export		×	×	✓ (/w restriction)	✓	✓	✓	✓	-
Minimum Price/ Maximum Price		No regulation	No regulation	Min: 0.10/kWh Max: 0.27/kWh	No regulation	No regulation	No regulation currently	No regulation currently	-
Penalty		AUD$65 per LGC/STC not surrendered	£43.30	DKK 0.27 per kWh	150% of the weighed, average certificate value	150% of the weighed, average certificate value	$50 per MWh that is deficient	5 cents per kWh, up to $25 million per year	Maximum penalty per violation: $2000

(Sources: California Energy Commission, 2014; California Public Utilities Commission, 2012; Clean Energy Regulator, 2014; Climate Change Authority, 2012; Colorado Energy Office, 2010; Danish Energy Agency, 2000; Danish Parliament, 1999; Database of State Incentives for Renewables & Efficiency, 2014; Department of Energy & Climate Change, 2013; Electric Reliability Council of Texas, 2014; Gov.uk, 2012, 2014; Government Offices of Sweden, 2012, 2014; Institute for Energy Research, 2010; Legislation.gov.uk, 2014; Norwegian Ministry of Petroleum and Energy, 2012; Norwegian Water Resources and Energy Directorate, 2013; Notisum, 2012; Ofgem, 2014; Organisation for Economic Co-operation and Development, 2002; Public Utility Commission of Texas, 2014; RECS International, 2013; RES Legal, 2014; Swedish Energy Agency, 2012, 2014; The REC Registry, 2014; U.S. Department of Energy, 2014; Wiik, 2003)

2.3. TWO CASE STUDIES OF REGIONAL ELECTRICITY CERTIFICATE SYSTEMS

Apart from the national approach, RECS could also be implemented in regional scales. In the following, the common certificates market established by Sweden and Norway and the regional tracking systems adopted by the state of California in the United States will be used as examples to illustrate how a RECS could be introduced in regional approach.

2.3.1 THE SWEDISH-NORWEGIAN ELECTRICITY CERTIFICATE MARKET

Sweden and Norway have been sharing a regional electricity certificate market since 1 January, 2012 and the market is proposed to be discontinued by the end of 2035 (SEA & NVE, 2013). The cooperation between the two countries is developed on the basis of a common market for trading RECs instead of establishing a common RECS. In other words, both countries are still operating own domestic RECS and the certificates issued in either one of the countries are allowed to be exchanged through the common market. It is a new approach of establishing cooperation between two countries to develop renewable electricity (Ministry of Enterprise, Energy and Communications, 2013).

Such a market is officially recognized by both countries with the signing of the bilateral agreement named “A Common Market for Electricity Certificate” (Ministry of Petroleum and Energy, 2012). Under the agreement, the two countries acknowledged firmly on the benefit of a common market as it is advantageous for both parties “to promote renewable electricity production” and efficiently use RE resources, as well as allow better market functioning due to the larger market for investors and encourage higher liquidity (Ministry of Petroleum and Energy, 2012; SEA & NVE, 2013). Therefore, the authorities believed that a common market would help to increase renewable electricity production in a cost-effective way (SEA & NVE, 2013).

The two countries set a combined goal of producing new renewable electricity of 26.4 TWh by 2020 and each country is responsible for 13.2 TWh under the certificate system (Ministry of Petroleum and Energy, 2012). There is no fixed goal for each year. On average 2.93 TWh of new renewable electricity will need to be generated in both countries each year to achieve the goal by 2020. In 2013, the annual new renewable electricity production was higher than the above figure and a total of 6.2 TWh new electricity, which 5.3 TWh was generated in Sweden and 0.9 TWh was produced from

Norway, was generated by accredited electricity producers in the two countries (Energimyndigheten, 2014). However, as a common market between two countries, any adjustments on the goal of renewable electricity production may affect the demand and supply of electricity certificates in the common market. Thus, it shall be discussed by both countries as stated in the agreement (Ministry of Petroleum and Energy, 2012).

For handling the issues of the common market, Sweden and Norway designated their own institutions respectively, namely the Swedish Energy Agency (SEA) and the Norwegian Water Resources and Energy Directorate (NVE), to administrate their domestic electricity certificate system and to jointly manage the common electricity certificate market instead of establishing a joint agency (SEA & NVE, 2013).

Besides, Sweden and Norway assign *Svenska kraftnät* and Statnett separately to manage the online accounting systems for electricity certificate trading in the common market (SEA & NVE, 2013). Both institutions are responsible to publish the number of issued, sold and cancelled electricity certificates, as well as the average price of electricity certificates in each country on their websites (SEA & NVE, 2013).

As a common market, it is important for the two countries to reach an agreement for trading electricity certificates. Hence, Sweden and Norway signed the agreement to recognize the importance of common rules of trading in order to make the certificates circulation possible and compliance to the obligation in both countries:

> "The common market shall require each party to ensure that electricity certificates issued in one country can be used to comply with the electricity certificate obligation in the other country. (Article 3.1 Common electricity certificate market, Agreement on a Common Market for Electricity Certificates) "

With the consensus, trading electricity certificates in the Swedish-Norwegian Electricity Certificate Market is possible. In fact, Cesar or NECS, which are the online accounting systems for Sweden and Norway respectively, played the role of the common market. Electricity producers and obligated actors must own an electricity certificate account in order to proceed the transaction of certificates in the market (SEA & NVE, 2013). Trading electricity certificates in the market mainly occurs between obligated actors and electricity producers but it also includes traders (SEA & NVE, 2013). The intention of the traders is to purchase electricity certificates and sell certificates later at a profit (SEA & NVE, 2013). The SEA and NVE believed that traders could be conducive to even out prices on the market (SEA & NVE, 2013). In any case, trading is entirely the bilateral agreement between the seller and buyer and there are no regulations on the price of the certificate as it is determined by demand and supply (SEA & NVE, 2013). Certificates are transferred from a seller's account to a buyer's account once the transaction is completed and the buyer can utilize certificates to fulfill the individual obligation under domestic RECS (SEA & NVE, 2013).

According to NECS (2015) and CESAR (2015), approximately 48.3 million electricity certificates, which was equivalent to 48.3 TWh of renewable electricity, were traded through the Swedish-Norwegian Electricity Certificate Market between April 2014 and March 2015. 75% of electricity certificates were traded within Sweden or Norway while 25% of certificates were traded cross-nationally. Among the cross-national trading, almost 70% of the certificates came from Sweden while 30% came from Norway. Comparing with the two previous obligation periods, although the total trading volume slightly decreased in the period of 2014-2015, the volume of cross-national trading largely increased from 11% in the period of 2012-2013 to 25% in 2014-2015. Figure 2 illustrates the effectiveness of the common market for Sweden and Norway in regional trading of RECs.

Figure 2. The trading volume of electricity certificates in the Swedish-Norwegian Electricity Certificate Market between April 2014 and March 2015 (NECS, 2015; CESAR, 2015)

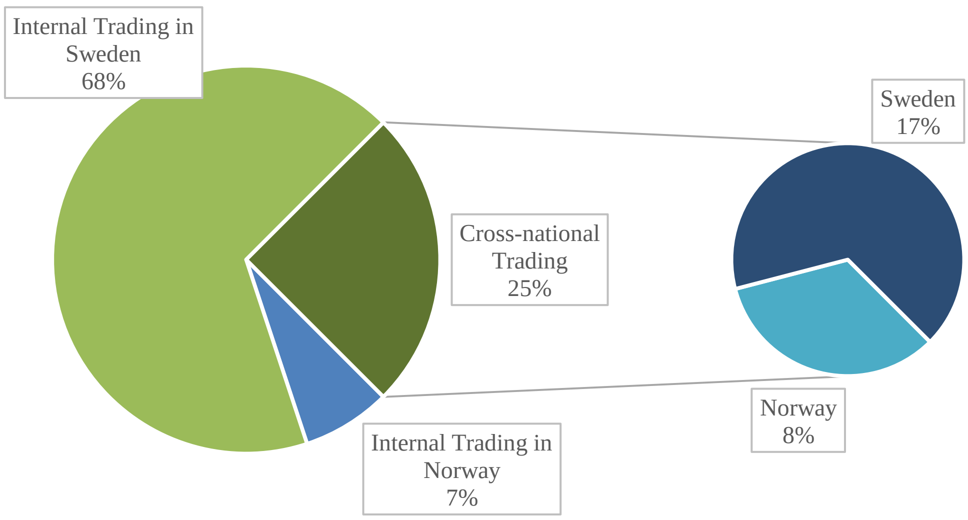
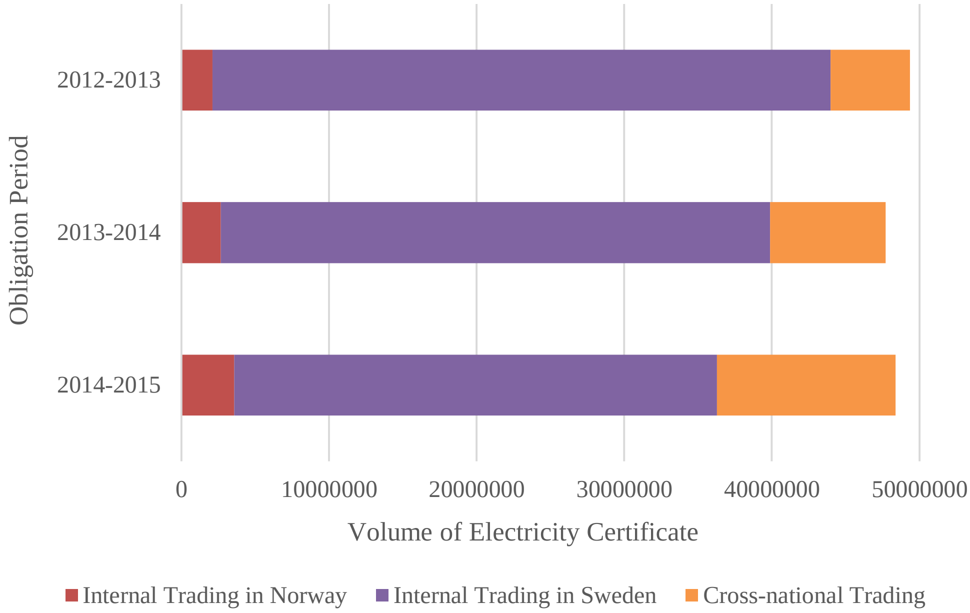


Figure 3. Trading volume of electricity certificates in the Swedish-Norwegian Electricity Certificate Market during the obligation period of 2012-2013, 2013-2014 and 2014-2015 (NECS, 2015; CESAR, 2015)



2.3.2 REGIONAL TRACKING SYSTEMS IN THE UNITED STATES

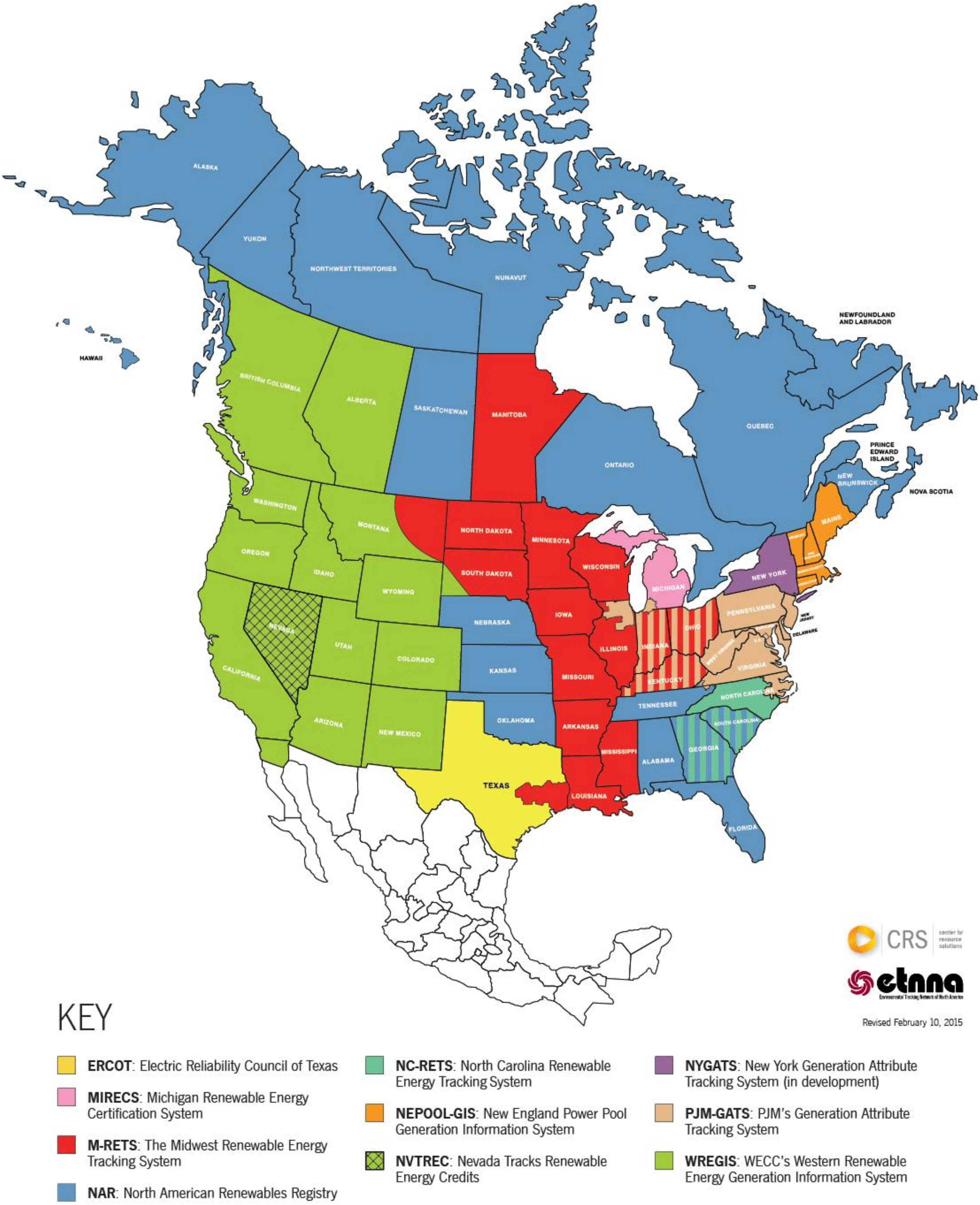
In the United States (US), RECS is implemented under “Renewable Portfolio Standard” (RPS). It should be noted that there is no RECS introduced in national level and most of the states implement their own RPS. In essence, the mechanism of RPS is mostly the same with RECS but most of the RPSs adopt a regional tracking system which is not a usual component existing in a typical RECS.

A regional tracking system differs from RECS. It is an online accounting system for creating, managing, trading and retiring of REC under RPS. In other words, the regional tracking system cannot operate independently: it is a supporting system to RPS. With most states adopting their own RPS, the trading of REC between the states is possible as nine regional tracking systems are fully in operation, with a new tracking system for New York in development (U.S. Department of Energy, 2013; Environmental Tracking Network of North America, 2015). However, each of the tracking systems only track some states. For instance, the Electric Reliability Council of Texas (ERCOT) and New England Power Pool Generation Information System (NEPOOL-GIS) only provide tracking service for the users in Texas and states in New England respectively (U.S. Department of Energy, 2013). Map 1 shows the service regions of each of the tracking system. REC is partly transferable between different tracking systems, meaning that RECs in United States can be imported or exported from/to other states (North American Renewables Registry, 2015). In the following, the Western Renewable Energy Generation Information System (WREGIS) will be used as an example to illustrate the role of the tracking system in the California RPS.

Table 3. The inter-tracking system transfer capability of Renewable Energy Credits/Certificates in the US (North American Renewables Registry, 2015)

Transfer From	Transfer To
Western Renewable Energy Generation Information System (WREGIS)	• North American Renewable Registry (NAR) • North Carolina Renewable Energy Tracking System (NC-RETS)
Electric Reliability Council of Texas (ERCOT)	North Carolina Renewable Energy Tracking System (NC-RETS)
North Carolina Renewable Energy Tracking System (NC-RETS)	North American Renewable Registry (NAR)
Michigan Renewable Energy Certification System (MIRECS)	North American Renewable Registry (NAR)
North American Renewable Registry (NAR)	• North Carolina Renewable Energy Tracking System (NC-RETS) • Michigan Renewable Energy Certification System (MIRECS)
The Midwest Renewable Energy Tracking System (M-RETS)	• North American Renewable Registry (NAR) • North Carolina Renewable Energy Tracking System (NC-RETS) • Michigan Renewable Energy Certification System (MIRECS)
PJM’s Generation Attribute Tracking System (PJM-GATS)	• Michigan Renewable Energy Certification System (MIRECS) • North Carolina Renewable Energy Tracking System (NC-RETS)

Map 1. Service region of each regional tracking system for renewable energy credits/certificate in the United States (Environmental Tracking Network of North America, 2015)



The "California Renewables Portfolio Standard" was established in 2002 and it is "one of the most ambitious renewable energy standards" in the United States. Under the Standard, the obligated actors must procure eligible renewable electricity and associated Renewable Energy Credits for meeting their obligation. All Renewable Energy Credits are stored and tracked in the Western Renewable Energy Generation Information System (WREGIS) (California Public Utilities Commission, 2012). WREGIS was launched in 2007 in response to the needs of ensuring the credibility of renewable electricity generation and facilitating the growth of RE in the Western US (California Energy Commission, n.d.). It is an independent online accounting system for tracking RE generation by using verifiable data and monitoring the transaction of Renewable Energy Credits between 14 western states in the United States (WREGIS, 2015). The Renewable Energy Credits are created by the system which includes a unique serial number for each one megawatt hour of renewable electricity generated by accredited producers. The certificates could be used by energy market participants and policy makers to verify compliance with the RPS (WREGIS, 2015).

At the end of each compliance period, the California Energy Commission (CEC) will track and verify the total number of Renewable Energy Credits that each of the obligated actors possessed in the accounting system to ensure they meet compliance (California Public utilities Commission, 2012). The CEC will then submit its annual report to the California Public Utilities Commission (CPUC) and CPUC will determine whether an obligated actor complied with the obligation (California Public utilities Commission, 2012).

According to WREGIS (2015), the total number of Renewable Energy Credits from California rapidly increased by about 300% between 2008 and 2014 and it reached 47.8 million Renewable Energy Credits in 2014, which is equivalent to 47.89 TWh of renewable electricity. More importantly, the trading of Renewable Energy Credits from California was extremely active as the trading volume from California was raised by almost 5,400% within six years.

Moreover, as a regional tracking system, WREGIS enables electricity suppliers and other market participants from California to trade Renewable Energy Credits with the stakeholders in other states that are covered by WREGIS. According to the Union of Concerned Scientists (2014), a total of 15,559 MW facilities in California were eligible for generating renewable electricity under California RPS. In 2010, 43% of electricity generated from eligible RE resources in California was generated by the ten largest obligated actors within the state while the remaining 53% of eligible renewable electricity with associated Renewable Energy Credits was imported from out-of-state so as to fulfill the quota specified in the California Renewables Portfolio Standard (Union of Concerned Scientists, 2012). Most of the out-of-state renewable electricity and associated Renewable Energy Credits were imported from Washington, Oregon, Wyoming and Utah (Union of Concerned Scientists, 2012). California has the highest trading volume when compared to Nevada and Oregon (WREGIS, 2015). These results show the effectiveness and efficiency of the tracking system in forcing obligated actors to meet the quota and facilitating the active development of RE in California.

Map 2. The location of eligible renewable generation facilities under California RPS (Union of Concerned Scientists, 2014)

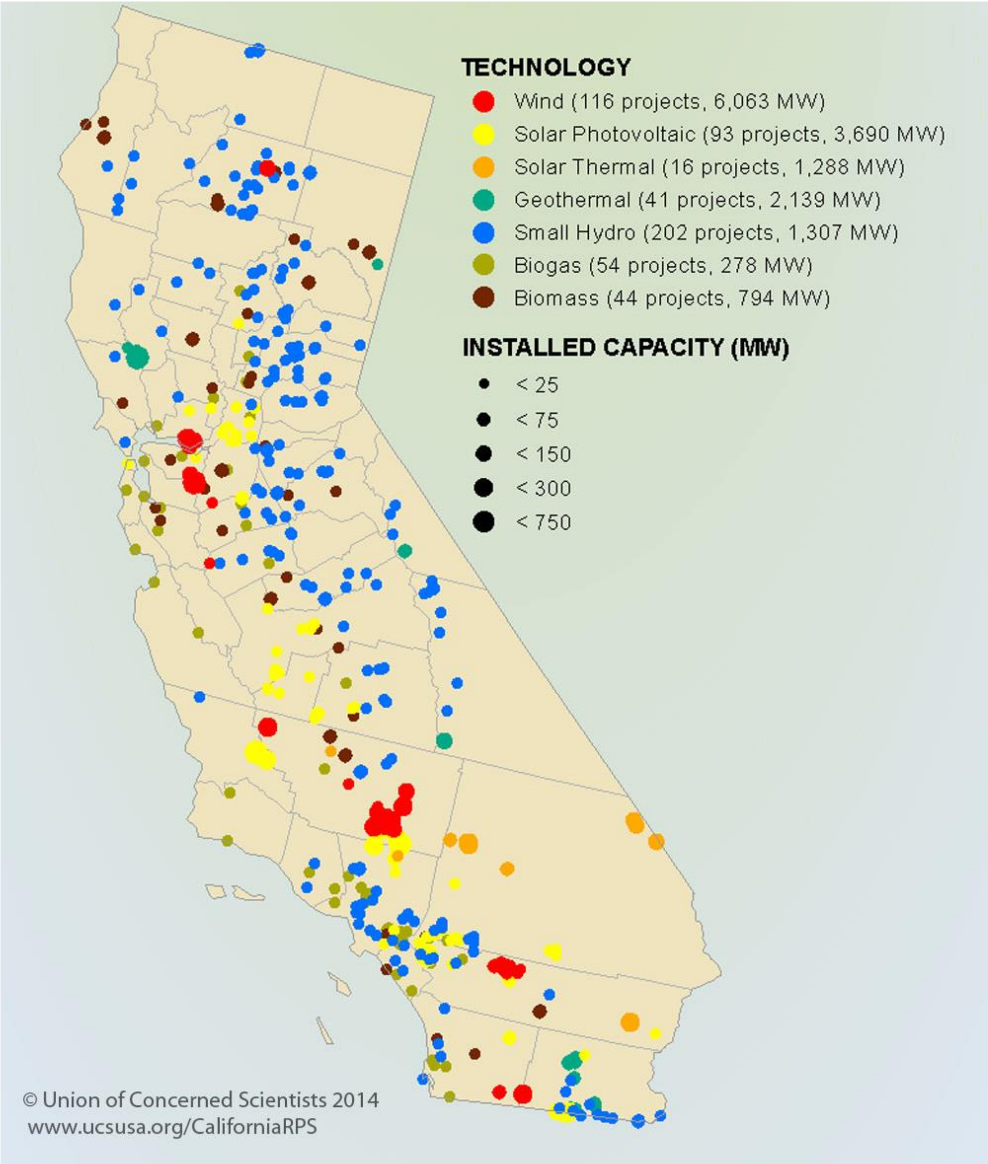


Figure 4. The percentage of eligible renewable electricity generated from in-state and out-of-state under California RPS in 2010 (Union of Concerned Scientists, 2012)

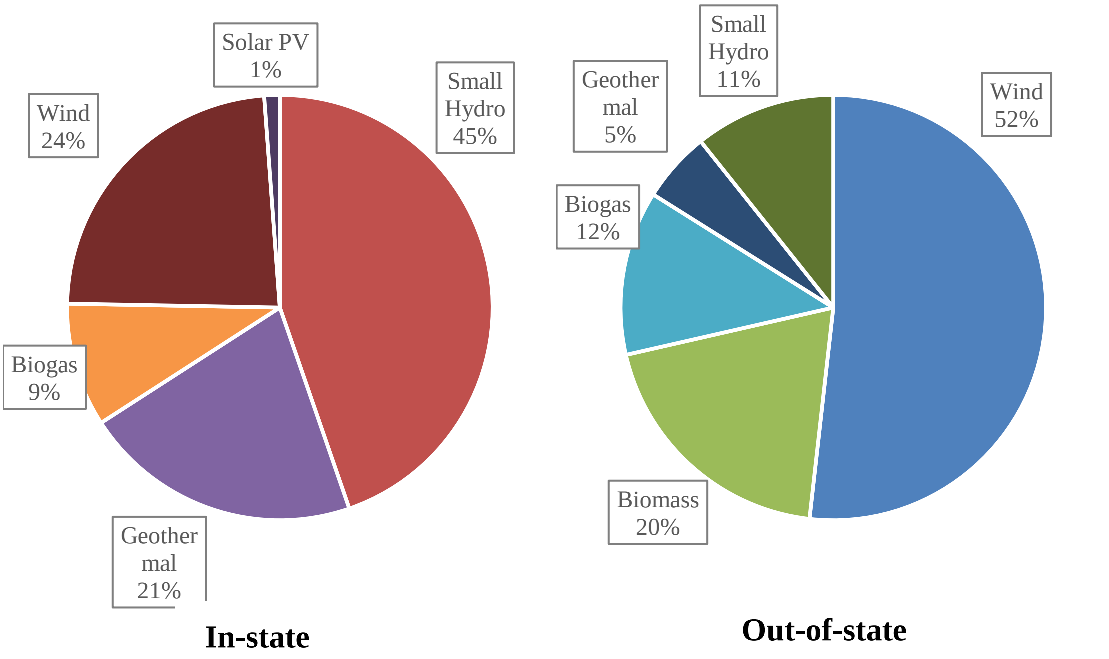


Figure 5. The total number and trading volume of renewable energy credits from California in the WREGIS between 2008 and 2014 (WREGIS, 2015)

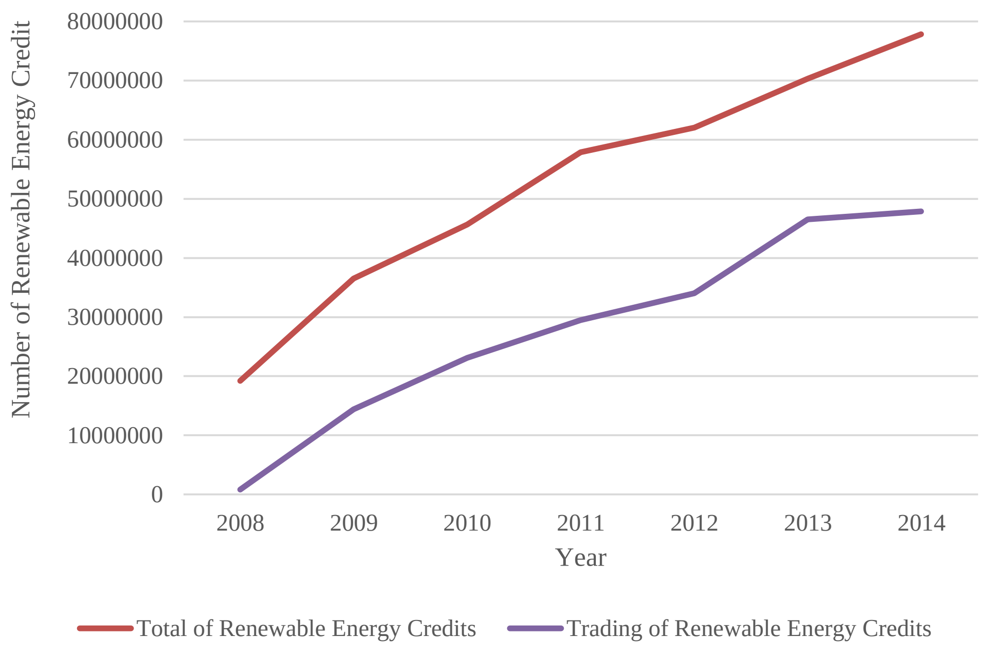
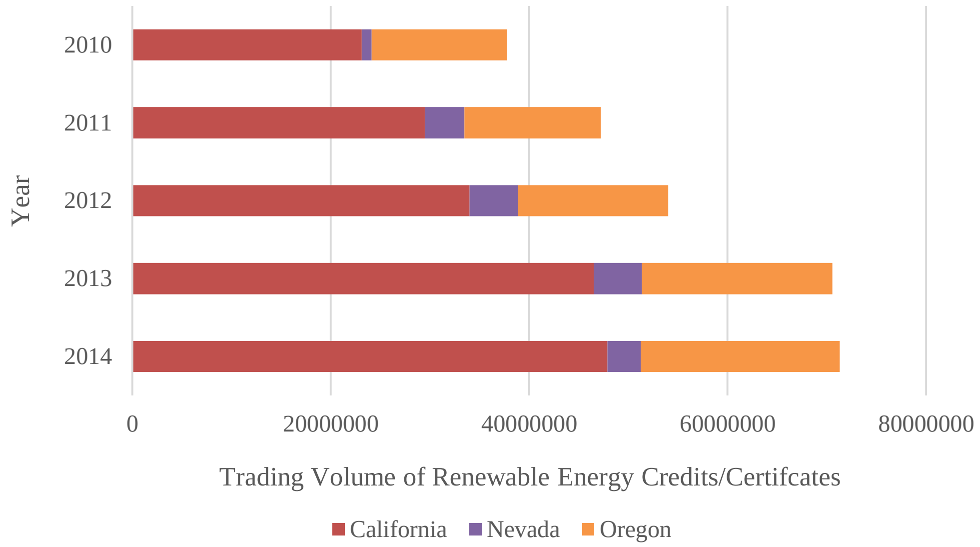


Figure 6. The trading volume of renewable energy credits/certificates between California, Nevada and Oregon in the WREGIS between 2010 and 2014 (WREGIS, 2015)



3. HONG KONG-GUANGDONG REGION RENEWABLE ENERGY CERTIFICATE SYSTEM: CONTEXT, POTENTIAL BENEFITS AND MAJOR BARRIERS

According to the energy context in HK-GD region and based on the primary data that was collected from the in-depth semi-structured interview, several potential benefits for developing a proposed HK-GD RECS and major barriers that hinder the proposed system will be identified in this section.

3.1. THE ENERGY CONTEXT IN HONG KONG AND GUANGDONG

Before studying the potential benefits and major barriers of the proposed HK-GD RECS, it is worthwhile to understand the basic energy context in the two territories since the power system is one of the important components in RECS.

3.1.1 HONG KONG AND GUANGDONG'S ELECTRICITY SECTOR

The electricity market in Hong Kong is monopolized by two investor-owned and vertically-integrated electricity companies, namely by China Light & Power Hong Kong Limited (CLP) and the Hongkong Electric Company Limited (HEC). CLP supplies electricity to Kowloon and the New Territories, including Lantau, Cheung Chau and several outlying islands while HEC supplies electricity to Hong Kong Island, Ap Lei Chau and Lamma Island (ISD, 2014). Each of the company is responsible for serving specific districts with no overlapping service areas.

In Guangdong, electricity generation and grid operation are segregated since the Chinese government introduced the electricity market reform in 2002. Electricity in Guangdong is generated by a number of electricity generation companies including Guangdong Yudean Group (GDYD), which is jointly owned by the People's Government of Guangdong Province and China Huaneng Group (GDYD, 2010). The electricity network in Guangdong is owned by the Guangdong Power Grid Corporation, which is a wholly-owned subsidiary of China Southern Power Grid (CSG). CSG provides electricity transmission and distribution in five of China's provinces, namely Guangdong, Guangxi, Yunnan, Guizhou and Hainan (CSG, 2012).

3.1.2 RENEWABLE ENERGY DEVELOPMENT: THE CURRENT STATUS AND MAJOR DEVELOPMENT IN HONG KONG AND GUANGDONG

The development of RE is decisive to the implementation of the HK-GD RECS. For this reason, it is vital to understand the RE development in Hong Kong and Guangdong. In the following, we will briefly describe the availability of RE resources and the government policies for supporting RE, as well as the latest RE development in these regions.

(a) Hong Kong

Hong Kong has potential RE in wind and solar power. With reference to the government study, wind and solar power could potentially contribute up to 38.5% and 17% respectively of the Hong Kong's total annual electricity demand in 1999 (EMSD, 2002). Nevertheless, there are several factors restricting Hong Kong to deploy RE in large-scale, such as the lack of flat land, restricted land uses and complicated approval procedures for planning and development (EMSD, 2002).

On the other hand, the Hong Kong government set the first RE target in 2005 with the goal of meeting 1-2% of Hong Kong's electricity supply by RE by 2012 (Sustainable Development Unit, 2004). Five years later, in 2010 the Hong Kong government proposed a new but modest RE target of having 3-4% of Hong Kong's electricity being generated from RE resources by 2020 (Environment Bureau, 2010). Both CLP and HEC developed their own pilot RE projects in Hong Kong. For instance, CLP set up the Hong Kong's first commercial-scale RE system in Town Island while the HEC installed the Hong Kong's first wind power station in Lamma Island (CLP, 2008; HEC, 2015). Both the power companies proposed to set up an offshore wind farm in Hong Kong but it will not be on going. (Environment Bureau, 2010).

(b) Guangdong

Guangdong has a wide range of potential RE resources, including wind, solar, biomass, hydro and geothermal. To facilitate the development of RE in Guangdong, the government has announced several major plans, including the "Guangdong Energy Development Twelfth Five Year Plan" (廣東省能源發展十二五規劃 *Guangdongsheng Nengyuan Fazhan Shierwu Guihua*) and "Exploitation and Development Plan of Emerging Energy Industries in Guangdong Province (2010-2020)" (廣東省新興能源及產業發展規劃 *Guangdongsheng Xinxing Nengyuan Ji Chanye Fazhan Guihua*) (Guangdong DRC, 2010). The Guangdong government has also set up ambitious targets on RE for 2015 and 2020. This policy support can accelerate RE development in Guangdong.

Table 4. A summary of potential and development plan of renewable resources in Guangdong (Greenpeace et al., n.d.)

Renewable Resources		Resources Potential	Installed Capacity (as of end of 2009)	Target for 2015	Target for 2020
Wind	Onshore	75 GW	1,140 MW*	2,000 MW	2,000 MW
	Near shore	20 GW	N/A	1,500 MW	8,000 MW
Solar (PV)		Annual radiation: 4,200-5,800 MJ/Sq meter	2 MW	120 MW	300 MW
Biomass		618 TWh	300 MW	120 MW+ 1 million tonne#	300 MW+ 2 million tonne#
Hydro		8.2 GW	Nil	Nil	Nil
Ocean + Geothermal		8 TWh##	Nil	30 MW	100 MW

* Include 500 MW completed and 640 MW under construction

+ In terms of electricity generation capacity; include waste to energy

In terms of liquid fuel

Geothermal energy only

(Sources: Guangdong DRC 2010; Statistics Bureau of Guangdong Province, 2010)

3.1.3 PRE-EXISTING HONG KONG-GUANGDONG REGIONAL ENERGY COOPERATION

Due to the geographical proximity of Hong Kong and Guangdong province, Hong Kong and Guangdong have cooperated more than three decades on various energy matters.

The origin of regional energy development between Hong Kong and Guangdong can date back to April 1979. It was the first time that the electricity grid in Hong Kong was interconnected with the Guangdong's power system (ISD, 2014).Through the interconnected electricity network, CLP started to export electricity to Guangdong province (ISD, 2014)

The next opportunity for regional cooperation came in the 1980s. The Guangdong government planned to build a nuclear power plant in Daya Bay. CLP invested in the Daya Bay Nuclear Power Plant with 25% equity (CLP, 2010). The nuclear plant started operation in 1994 and about 70% of the plant's output (approximately 1,380 megawatts) was exported to Hong Kong to meet its needs (CLP, 2010).

The opportunities for regional energy collaboration appeared frequently and the investment made by Hong Kong's electricity companies in power projects continued to emerge in Guangdong province. For instance, CLP invested in building the Guangdong Pumped Storage Power Station in 1994 with a total installed capacity of 2,400 megawatts. The generated power is exported to Hong Kong through the interconnected electricity network with Guangdong (CLP, 2010). CLP has also invested in a number of RE projects in Guangdong province, such as Huaiji Hydro Power Station (commissioned in 1997, 128 MW) and Nanao II and III Wind Farm (commissioned in 2007, 60 MW) (CLP, 2014).

2008 was a turning point in regional energy collaboration as the Chinese government and Guangdong province played a proactive role on the energy issue of Hong Kong. For instance, Hong Kong signed "Memorandum of Understanding on energy co-operation" with the Chinese government on August 2008. Such a memorandum reached a consensus on the continuous supply of nuclear electricity from Guangdong to Hong Kong (ISD, 2008). Also, the national government agreed to study the feasibility of supplying natural gas to Hong Kong via the Second West-East Natural Gas Pipeline (ISD, 2008). The signing of the "Framework Agreement on Hong Kong/Guangdong Cooperation" is firmly supported by the Guangdong's government because Guangdong province agreed to support Hong Kong's electricity needs by continuously exporting nuclear power until 2034 and it supported supplying natural gas to Hong Kong by building a LNG receiving terminal in Guangdong (ISD, 2008).

Moreover, the China's grid companies also started to participate in Hong Kong's electricity sector. In 2013, the CSG invested the Castle Peak Power Company Limited. It is the first time for a state-owned company to invest in Hong Kong's electricity industry (CLP, 2014). Afterwards, another state-owned enterprise, namely the State Grid Corporation, became one of the shareholders of the HEC (Reuters, 2014). Since then, the two Hong Kong electricity companies have been partially owned by Chinese state-owned enterprises.

In December 2008, the National Development and Reform Commission promulgated the "Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020)" (NDRC, 2009). In this plan, regional collaboration in the region of Pearl River Delta was elevated as a national strategy and Hong Kong even proposed to transform the Pearl River Delta region into a green and quality living area in response to the Outline. Three years later, Hong Kong, Guangdong and Macau collectively introduced "The Regional Cooperation Plan on Building a Quality Living Area" in June 2012 and the wider use of RE in the Pearl River Delta region was highlighted in the plan (Environment Bureau, 2012). Based on the Plan, it would provide a great opportunity for Hong Kong and Guangdong to further enhance regional energy policies, suggesting that RE could become the major direction for regional energy collaboration.

Figure 7. A timeline about regional energy collaboration between Hong Kong and Guangdong (1979-2014) (CLP, 2010, 2014; Environment Bureau, 2012; ISD, 2008, 2014; NDRC, 2009; Reuters, 2014)

1979
Interconnection of electricity grids between Hong Kong and Guangdong

Early 1980s
CLP invested in Daya Bay Nuclear Power Plant *(The first investment in the Guangdong's electricity industry by Hong Kong's electricity company)*

1994
CLP invested in Guangdong Pumped Storage Power Station and the generated power is exported to Hong Kong

1994
Daya Bay Nuclear Power Plant started in operation and 70% of the electricity exported to Hong Kong *(The first time for Hong Kong to import electricity from Guangdong)*

1997
CLP invested in Huaiji Hydro Power Station *(The first renewable project in Guangdong invested by Hong Kong's capital)*

2007
CLP invested in Nanao II and III Wind Farm *(One of the earliest island-based wind power projects in Guangdong)*

2008
Hong Kong signed "Memorandum of Understanding on energy co-operation" with the Chinese government

2009
"Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020)" promulgated

2009
Extending the supply of nuclear electricity to Hong Kong by signing the "Framework Agreement on Hong Kong/Guangdong Cooperation" with Guangdong

2012
"The Regional Cooperation Plan on Building a Quality Living Area" announced

2013
The Southern China Power Grid invested in Castle Peak Power Company Limited

2013
Supplying natural gas to Hong Kong via the Second West-East Natural Gas Pipeline started

2014
The State Grid becomes one of the shareholders of the Hong Kong Electric

3.2. THE POTENTIAL BENEFITS OF A REGIONAL RENEWABLE ENERGY CERTIFICATE SYSTEM FOR THE HONG KONG-GUANGDONG REGION

According to the stakeholders’ perspectives from the interviews, ten potential benefits of the proposed HK-GD RECS are categorized in the environmental, economic, social and political aspects. The table below is a summary of stakeholders’ ideas on the potential benefits of the proposed HK-GD RECS.

Table 5. The stakeholders' perspectives of the potential benefits for regional energy collaboration between Hong Kong and Guangdong

Types of Stakeholder		**Electricity Company**	**Environmental Non-governmental Organizations**			**Academia**		**Representative of Consumers**	
Interviewee		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Environmental	Improving the air quality within the Pearl River Delta	✓				✓			✓
	Achieving the emission reduction target	✓				✓			✓
	Overcoming the wind power and hydropower curtailment			✓					
Economic	Increasing the capital and investment		✓		✓	✓			✓
	Stimulating renewable energy development		✓		✓	✓	✓		
	Lowering the price of RE					✓			✓
Social	Education and Promotion		✓						
	Social responsibility and external cost internalized		✓						
	Creating green jobs	✓							
Political	Integration			✓					

(Source: Author; based on face-to-face and telephone interviews)

3.2.1. ENVIRONMENTAL BENEFITS

Regional energy collaboration through RECS could improve the air quality in the Pearl River Delta region. RE has the advantage of low or no emission of greenhouse gases and air pollutants, and such a merit is beneficial to improving the air quality in the Greater Pearl River Delta region if more RE is employed in the region through RECS (Interviewee 1, 2015; Interviewee 4, 2015; Interviewee 8, 2015). A study suggested that if 5% of Hong Kong's electricity consumption came from renewable electricity, it could reduce carbon dioxide emission by 1.7 million tonnes and sulphur dioxide emissions by 3,000 tones (Greenpeace et al., n.d.). By doing so, not only can it reduce carbon emissions in Hong Kong and Guangdong (Interviewee 1, 2015; Interviewee 8, 2015), it can achieve the emission reduction targets formulated in the "PRD Regional Air Pollutant Emission Reduction Plan" and "A Clean Air Plan for Hong Kong" (ISD, 2012; Environment Bureau, 2013; Interviewee 5, 2015).

Moreover, if Guangdong is to export electricity to Hong Kong, its RE demand could be met by importing RE from surrounding provinces. This has been the case in Guangdong in recent years (China Electric Power Press, 2009, 2010; 2011). For instance, provinces with high output of renewable electricity, such as hydropower in Yunnan and Guizhou, can export electricity to Guangdong through the Southern Power Grid to meet the Guangdong's electricity demand (Interviewee 6, 2015). With importing renewable electricity from other provinces, the issue of "carbon shifting" could be avoided while also meeting the electricity demand of Guangdong. Therefore, stimulating the demand on RE through regional collaboration could potentially make more renewable electricity in other provinces "flow" into the market of Hong Kong and Guangdong, and in return achieve significant environmental improvement (Interviewee 6, 2015).

Furthermore, regional energy collaboration through RECS could overcome the problem of wind power and hydropower curtailment (棄風棄水 *Qifeng qishui*). Provided that Hong Kong is to purchase RE, such as wind power and hydropower, from Guangdong provinces and other peripheral regions, this could potentially increase the demand on wind power and hydropower in the regional market. For this reason, more RE could be connected to electricity grids and any surpluses of electricity could be transmitted to Hong Kong through the Southern Power Grid (Interviewee 3, 2015). Therefore, regional collaboration through RECS could contribute to reduce the waste of energy resources in Mainland China (Interviewee 3, 2015).

In addition, if Hong Kong is ordered to procure renewable electricity from Guangdong through RECS, Hong Kong can not only acquire clean energy from Mainland China (Interviewee 4, 2015), but it can also encourage the decentralization of RE in Guangdong and other peripheral regions, such as Yunnan, Sichuan and Hunan, due to the mechanism of RECS (Interviewee 2, 2015). For instance, since the government usually specifies small-scale hydro as eligible RE sources in RECS rather than large-scale hydro based on environmental considerations, the increasing demands on small-scale RE could promote decentralized development of RE in China (Interviewee 2, 2015). Such a demand could also be conducive to increase the number of small-scale renewable electricity producers in Hong Kong (Interviewee 2, 2015). Therefore, energy collaboration through RECS could potentially facilitate the development of RE in Hong Kong and Guangdong, as well as shifting the RE development pattern from centralized to decentralized systems in China.

3.2.2. ECONOMIC BENEFITS

Setting up a HK-GD RECS could increase the capital and investment on RE and thus it would stimulate the RE development in the Pearl River Delta region. One of the factors would be due to the increase in RE demand (Interviewee 5, 2015). Another factor is that the RECS would provide positive incentives for Hong Kong’s investors to develop more RE projects in Guangdong or in other Chinese provinces (Interviewee 2, 2015; Interviewee 4, 2015). Meanwhile, higher demand and more application of RE would mean that the price of RE could be further reduced due to the market mechanism (Interviewee 5, 2015; Interviewee 8, 2015). Therefore, RECS could be conducive to advance the RE development in Hong Kong and Guangdong by attracting more investments and cost reductions.

3.2.3. SOCIAL BENEFITS

Implementing RECS is a process of educating citizens about RE and raising public awareness on the environment (Interviewee 2, 2015). At present, most Hong Kong citizens do not have a comprehensive knowledge or understanding on the certification of RE and the importance of energy conservation (Interviewee 2, 2015). If the Hong Kong government introduces the RECS in stages, residents can gradually understand the significance of RECS because such an instrument would embody the principle of social responsibility and internalize external cost and environmental cost (Interviewee 2, 2015). Also, the public awareness on energy conservation can be raised as the higher cost of purchasing RE through RECS can urge people to save energy and conserve natural resources (Interviewee 2, 2015).

RECS could stimulate the RE development in Hong Kong and Guangdong, and in turn, promote greater job opportunities in the RE industry (Interviewee 1, 2015). RECS is a complex system and so, it requires many experts, engineers and professionals to ensure that the system and market would operate smoothly. Therefore, collaboration through HK-GD RECS could potentially create more green jobs in the region.

3.2.4. POLITICAL BENEFIT

Regional collaboration could facilitate the integration between Hong Kong and Mainland China (Interviewee 3, 2015). It is estimated that some pro-Beijing groups or organizations, such as the Chinese General Chamber of Commerce, would support regional energy collaboration in order to ingratiate themselves with the national government in Beijing (Interviewee 3, 2015).

3.3. THE MAJOR BARRIERS TO THE DEVELOPMENT OF A HONGKONG-GUANGDONG RENEWABLE ENERGY CERTIFICATE SYSTEM IN THE HONG KONG-GUANGDONG REGION

According to the stakeholders' perspectives from the interview, seven major barriers were identified. These barriers are categorized by environmental, social, political, technical and economic aspects. The table below is a summary of the stakeholders' ideas on the major barriers of the proposed HK-GD RECS.

Table 6. The stakeholders' perspectives of the major barriers for regional energy collaboration between Hong Kong and Guangdong

Type of Stakeholder		**Electricity Company**	**Environmental Non-governmental Organizations**			**Academia**		**Representative of Consumers**	
	Interviewee	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Institutional	Absence of common policy and target				✓		✓		✓
	Disharmony of existing policy		✓	✓			✓	✓	✓
	The "Scheme of Control Agreement" as an obstacle		✓		✓			✓	
Social	Public opposition	✓		✓		✓			✓
Political	Low transparency and credibility	✓	✓	✓				✓	✓
Technical	Problem of interconnecting electricity grids	✓			✓	✓			
Economic	Increase in Electricity Tariff	✓			✓	✓	✓		
	Potential stock speculation		✓						

(Source: Author; based on face-to-face and telephone interviews)

3.3.1. INSTITUTIONAL BARRIERS

The absence of common policies and targets between Hong Kong and Guangdong would create a barrier of establishing a HK-GD RECS (Interviewee 8, 2015). Based on European experiences, although there are many similar RECSs within the European Union, the RECS in United Kingdom is different from other countries because of the different values of RECs and thus trading is impossible between these systems (Interviewee 8, 2015). Similarly, the institutional circumstances in Hong Kong and Guangdong are diverse since Guangdong formulated the RE policy and adopted the feed-in-tariff. On the other hand, Hong Kong does not possess any similar policies or economic incentives for RE (Interviewee 7, 2015). In addition, it is not easy to determine common renewable targets and quotas due to different contextual backgrounds (Interviewee 4, 2015); therefore, the lack of common RE policies and targets can be a barrier for regional collaboration between Hong Kong and Guangdong.

Lack of coordination of existing policies is another barrier for regional collaboration. It is essential for the Guangdong's government to coordinate its existing RE policies, including the Clean Development Mechanism (CDM) and carbon emission trading scheme, with RECS (Interviewee 2, 2015; Interviewee 3, 2015; Interviewee 8, 2015). These existing policies may have similar mechanisms or components with RECS, such as RE targets for different provinces or sectors (Interviewee 6, 2015), and it could probably lead to a clash as these policies may have overlapping areas. Therefore, the disharmony between existing policies and RECS could be an institutional barrier for regional collaboration.

Moreover, the Scheme of Control Agreement (SCA) does not encourage regional energy collaboration between Hong Kong and Guangdong. As SCA is a "local accounting document" instead of an energy white paper, it does not provide a strategic guideline for CLP or HEC to develop RE and energy collaboration (Interviewee 4, 2015). The 9.99% (total value of average net fixed assets) and 11% (total value of average renewables net fixed assets) permitted rate of return only provide incentives for CLP and HEC to generate electricity from their own sources within Hong Kong and it does not consider their RE investments outside the territory of Hong Kong (Greenpeace et al., n.d.). Hence, the SCA does not favor regional energy collaboration as the incentives stated in the SCA are limited to drive the two local electricity companies to explore RE collaboration projects with Guangdong (Greenpeace et al., n.d.).

Also, the high return rate stated in the SCA lead to great discontentment aroused from the general public and it would be hard to ask Hong Kong's citizen to support for RE. Currently, the SCA allowed CLP and HEC to obtain more revenue if they invested more in RE facilities within Hong Kong's territory. Although the original intention of setting up the permitted return is to encourage power companies to develop more RE in Hong Kong, such an agreement has become a means for power companies to maximize their profit. As a result, the general public may resist to accept RE as power companies can gain a permitted return by the increasing electricity tariff (Interviewee 2, 2015; Interviewee 4, 2015). Hence, the offshore wind farm proposed by CLP and HEC has still not yet been approved by the Hong Kong government since the government considered that the high construction cost of the wind farm would be benefit the electricity companies by gaining higher profits (Interviewee 2, 2015; Interviewee 7, 2015). For this reason, the Hong Kong government might face political pressure as the general public could be dissatisfied to the increment of electricity tariffs if these RE projects are to be approved (Interviewee 2, 2015; Interviewee 4, 2015). Therefore, such a permitted return stated in the SCA would be disadvantageous to the RE development.

3.3.2. SOCIAL BARRIER

Public opposition to import electricity from Mainland China is a major barrier to regional energy collaboration between Hong Kong and Guangdong. Generally, there are two possible causes for Hong Kong people's rejection to RECS, namely Hong Kong-Mainland contradictions and decreasing job opportunity.

The contradictions between people from Hong Kong and China have been gradually intensifying and such a tension has reached a climax in recent years. The conflicts have echoed the demand of independence and autonomy from some Hong Kong activists refuse to rely on China (Interviewee 3, 2015). The opposition to purchase Dongjiang water (東江水 *Dongjiang shui*) is one of the typical examples to reduce such dependency on Mainland China (Interviewee 5, 2015). Such unfavorable conditions for regional collaboration continue to exist as nearly 90% of public opinions disagreed with purchasing electricity from Guangdong province (now News, 2015). This is also one of the two options proposed by Hong Kong's government in the "Public Consultation on Future Fuel Mix for Electricity Generation" (Environment Bureau, 2014). To avoid depending on Mainland China caused by importing electricity from Guangdong province, there is a strong possibility that some legislative councilors would filibusters against the motion of importing electricity (Interviewee 1, 2015; Interviewee 5, 2015). Even worse, the latest news revealed that the Hong Kong government does not intend to purchase electricity from Mainland China in the short term (Ming Pao Daily News, 2015). Without the support from the government and general public, regional collaboration through HK-GD RECS would be a great challenge.

Moreover, the social opposition to regional energy collaboration is also about the concern of decreasing job opportunities in Hong Kong’s electricity sector (Interviewee 1, 2015; Interviewee 5, 2015). If Hong Kong imports electricity from Guangdong province, the local electricity companies would correspondingly decrease the local electricity generation and consequently lay off a certain number of employees so as to economise on manpower (Interviewee 1, 2015; Interviewee 5, 2015). Therefore, regional energy collaboration would possibly be subjected to public opposition due to the possibility of dismissal employees in the electricity sector.

3.3.3. POLITICAL BARRIER

Low transparency and credibility could be barriers on the implementation of HK-GD RECS. The transparency of RECS is a key to convince the two governments that the system is workable and controllable (Interviewee 1, 2015). However, although the exchange of information between Hong Kong and Guangdong is technically practicable, this could be challenged upon operation and whether China would be willing to exchange data with Hong Kong (Interviewee 2, 2015). Furthermore, the problem of transparency can involve the credibility of Chinese government. As aforementioned in the previous section, there is a tension between Hong Kong people and the Chinese government. Such mistrust could raise doubts about the credibility of RECs issued from Mainland China (Interviewee 3, 2015). The problem of “double counting” RECs could also appear in the Chinese market (Interviewee 2, 2015; Interviewee 3, 2015) and it could be difficult for the Hong Kong government to verify whether Guangdong’s electricity was generated from RE sources or not (Interviewee 1, 2015). A case was disclosed that some electricity generators in China would use coal for electricity generation during the intermittency of RE, but then the electricity would be treated as renewable electricity and sold at the price of the feed-in tariff (Interviewee 7, 2015). Therefore, low transparency and credibility would be detrimental to the regional energy collaboration between Hong Kong and Guangdong.

3.3.4. TECHNICAL BARRIER

The problem of interconnecting electricity grids could be a technical barrier to regional energy collaboration. If Hong Kong is to import renewable electricity from

Guangdong province, connecting the electricity grids of Hong Kong and Guangdong can become the prerequisite for transmitting renewable electricity between the two territories. However, such a prerequisite is currently unfeasible as Hong Kong's electricity companies do not intend to connect its electricity networks with the power grid in Guangdong province (Interviewee 1, 2015). Low reliability and stability of China's electricity grid are the primary considerations for the rejection of interconnection as it would potentially lower the stability of electricity supply in Hong Kong (Interviewee 1, 2015). Moreover, even though electricity companies agreed to interconnect with Guangdong's grid, it is still impossible to build cross-border underground cables or overhead lines since the former option is very costly while the latter is easily affected by lightning and tall trees (Interviewee 1, 2015). The power losses caused by long-distance transmission of electricity would be a potential problem as well (Interviewee 5, 2015). Hence, with the consideration of ensuring the stability of local electricity supply, the interconnection between Hong Kong and Guangdong's electricity grids for the purpose of regional energy collaboration would be technically difficult (Interviewee 4, 2015).

Such a "technical reason "is also detrimental to develop Hong Kong's small-scale renewable electricity. At present, CLP and HEC do allow local small-scale renewable electricity producers to connect with CLP and HEC's electricity grids (CLP, 2012; HEC, 2009). However, small-scale renewable electricity producers would be charged an assessment fee based on the generation capacity of the RE system and there is no reward for small-scale renewable electricity producers if renewable electricity is generated and transmitted to CLP or HEC's electricity grids (CLP, 2012; HEC, 2009). The power company explained that ensuring strict technical specification of the RE system is necessary for maintaining the overall stability of their electricity grid and thus this is the reason for charging small-scale renewable electricity producers with assessment fees (Interviewee 1, 2015). Also, as small-scale renewable electricity producers would consume less energy from the electricity company if they generated electricity using their own RE system, comparatively electricity company has already purchased the renewable electricity generated from renewable electricity producers in the eyes of electricity company and thus there is no repayment for small-scale renewable electricity producers (Interviewee 1, 2015).

3.3.5. ECONOMIC BARRIER

There is opposition to regional energy collaboration as some stakeholders are concerned about the potential speculation in the REC market. At present, China has launched pilot carbon emission trading schemes in seven cities but this became a platform for Chinese citizens to make a profit by speculating carbon credits, like speculating in the stock market (Interviewee 2, 2015). Likewise, as REC is commodified in the market, speculation could potentially exist in the REC market and such an economic activity would not only violate the principles of establishing RECS, but it would damage the investors' confidence on regional energy collaboration and developing RE projects (Interviewee 2, 2015).

However, based on foreign experiences from the common market established by Sweden and Norway, the authority believed that market participants, especially speculator and traders, could play a role in stabilizing the prices of REC in the market (SEA & NVE, 2013). Such an argument is also supported by the steady average prices of RECs in the Swedish-Norwegian Electricity Certificate Market.

There is also an opposition to import RE from Mainland China as importing RE would lead to an increase in electricity tariff (Interviewee 1, 2015; Interviewee 4, 2015: Interviewee 5,1015). At present, the price of RE is generally higher than the cost of conventional fossil fuels and the Guangdong government would also need to subsidize RE, such as subsidizing solar photovoltaics by RMB ¥0.42 in Guangdong (Interviewee 6, 2015). Therefore, some stakeholders feel that society must pay a higher price for cleaner energy (Interviewee 4, 2015).

3.4. MAJOR CONSIDERATIONS FOR THE POSSIBLE MECHANISMS FOR A HONG KONG-GUANGDONG RENEWABLE ENERGY CERTIFICATE SYSTEM

After the discussion on the main divers, potential benefits and major barriers for Hong Kong and Guangdong to develop a regional RECS, several stakeholders have expressed their concerns on the process of system design and implementation.

(a) Goal setting

It is necessary to set a clear RE target for Hong Kong and Guangdong but it could be hard to specify the absolute value for boosting RE development. Most of the interviewed stakeholders could not decide on an absolute percentage for the RE target. Interviewee 2 (2015) from an environmental non-governmental organisation said that the potential capacity of RE in Hong Kong and Guangdong is the major consideration for setting a RE target.

(b) Institutional entities

Interviewee 4 (2015) thought that the Hong Kong government should not assign the task of tackling energy issues to the Environment Bureau as energy and RECS is highly complicated and the workload of the Bureau is already very high. Interviewee 4 (2015) thought that the Hong Kong government should consider establishing a dedicated department, like an Energy Bureau, for handling energy issues, setting up RECS, making long-term energy planning, as well as supervising energy industries.

Also, Interviewee 2 (2015) was concerned that that it could be hard for the Hong Kong government to supervise the operation of RECS in Mainland China if RECS is to be implemented in a regional scale. Interviewee 4 said that it is impossible to enforce Hong Kong law outside the administrative boundary of Hong Kong if any operations against the RECS regulations are revealed. Therefore, setting up a cross-border agency between Hong Kong and Guangdong could be considered for dealing with the issue of regional energy collaboration and RECS.

(c) Market rules

Market types, purchasing methods, obligated actor, quota, eligible resources, treatment of existing RE plants and penalty are the major components of market rules and the details of these components should be thoughtfully considered.

i. Types of market

It is difficult to decide whether to set up a voluntary market, compliance market or both types of markets. Interview 1 (2015) was concerned that the general public would not voluntarily purchase RE for no reason so he believed that only compliance market would be effective. However, Interviewee 5 (2015) expressed his concern on setting up a compliance market because he worried that forcing citizens to purchase RE would increase their financial burden via the electricity tariff.

Therefore, the government could launch a voluntary market and target at large enterprises, such as the Hong Kong and Shanghai Banking Corporation Limited (HSBC), as they express concern about climate change and corporate social responsibility (Interviewee 2, 2015). By purchasing RE, large enterprises could build up a positive corporate image and raise public awareness on RECS (Interviewee 2, 2015). Gradually, the market could be opened to smaller firms and citizens and finally be developed into a compliance market (Interviewee 2, 2015).

ii. Purchasing options

When comparing bundled and unbundled purchasing options, one should be aware that the electricity service includes electricity generation, transmission, distribution and retail. In Hong Kong, these services are provided by CLP and HEC. If one chooses the bundled option, it would require coordination between government and electricity companies and the electricity companies would need to import RE from other areas (Interviewee 2, 2015). Compared to the bundled option, the unbundled option has a higher flexibility as it would not be restricted by the power company and the electricity grid, and the government would only need to establish a market for market participants to trade RECs (Interviewee 2, 2015).

Interviewee 1 (2015) also noted that the power plants in Hong Kong have been equipped with desulfurisation installations, which are more advanced than those in Mainland China, and thus it should not reduce the local electricity generation. Instead, reducing Guangdong's electricity generation by fossil fuels would be more effective for improving the air quality in the Pearl River Delta region (Interviewee 1, 2015).

Interviewee 3 (2015) pointed out that buying a REC after the electricity is generated could not reduce the infrastructure cost while a Power Purchase Agreement could guarantee the purchase of a certain proportion of renewable electricity and such an option could provide a new source of capital for supporting new RE projects. If a wind farm is to be built in Hong Kong, large enterprises could bear the additional production costs by signing a long-term Power Purchase Agreement (Interviewee 3, 2015).

iii. Obligated actor

There are two types of actors that could be considered obligated actor in the HK-GD RECS, namely the electricity supplier and electricity intensive consumer.

Allocating obligation on the electricity supplier is the easiest method and the electricity supplier could transfer the extra cost to electricity consumers in respect to individual electricity consumption (Interviewee 1, 2015). However, it should be careful that the cost of purchasing RECs would be transferred to electricity consumer and this subsequently would increase the financial burden on electricity consumer (Interviewee 5, 2015). Moreover, it would provide only little incentive for consumer to save energy and it would not conform to the principle of "use more, pay more" (Interviewee 2, 2015).

Forcing electricity intensive companies to purchase RECs could be another option that is worth considering. Interviewee 2 (2015) commented that as the commercial electricity tariff is not calculated in a progressive way, these types of users could enjoy a lower rate of electricity tariff if more energy was consumed. To reflect the actual costs of electricity, the government could designate electricity intensive users as obligated actors and force these users to purchase RECs (Interviewee 2, 2015). In this way, electricity intensive consumers could bear their social and environmental responsibilities (Interviewee 2, 2015). However, such an option would require the government to provide incentives for electricity intensive consumers to purchase RECs, such as a reduction of profits tax (Interviewee 2, 2015).

iv. Quota

It would be difficult to allocate a quota to the electricity consumer as most of the information about electricity consumption is not disclosed by electricity companies (Interviewee 2, 2015). For this reason, Interviewee 2 (2015) advised the government to formulate a power consumption index and then allocate the corresponding quota to obligated actor based on the index. If the obligated actor exceed the index of power consumption, it would need to purchase a certain percentage of RE (Interviewee 2, 2015). By doing so, the interviewee believed that it would be the fairest way to allocate the quota to the obligated actor, but there is a concern that government would need to force the companies to disclose individual energy consumption by legislation.

v. Eligible resources

It is universally acknowledged that solar, wind, biomass, geothermal, tidal and wave are eligible RE resources; however, hydropower, waste and nuclear energy resources are controversial. Interviewee 5 (2015) supported that large-scale hydropower should be eligible in RECS because not all large dams damage ecology. Nevertheless, Interviewee 1 (2015), Interviewee 2 (2015), Interviewee 3 (2015) and Interviewee 6 (2015) opposed large-scale hydro as an eligible resource as large-scale hydropower would damage the ecology and river environments. Therefore, the policy-maker would need to define the scale of hydropower that is eligible for RECS, whether fewer than 1500kW or 30MW.

Interviewee 4 (2015) thought that waste should be included under eligible resources as we cannot stop producing waste and thus there is continuous supply of waste for producing energy. However, Interviewee 3 (2015) disagreed with the idea of treating waste as an eligible resource because waste cannot be recycled after incineration. In addition, Interviewee 2 (2015) said that waste already consumes resources in essence and thus waste should not be an eligible resource. Furthermore, Interviewee 1 (2015) thought that waste is not a clean energy and it cannot contribute to improve the air quality as producing electricity with waste will emit carbon dioxide during the incineration process.

However, Interviewee 4 (2015) argued that nuclear should be considered as an eligible resource because nuclear energy would only require a small amount of uranium to generate a large amount of electricity. Nonetheless, Interviewee 3 (2015) disagreed, stating that nuclear power is a RE resource since uranium would be exhausted and used nuclear fuel rod cannot be recycled.

Table 7. A summary of stakeholders' ideas on eligible resources for regional RECS between Hong Kong and Guangdong

Types of Stakeholder		**Electricity Company**	**Environmental NGOs**			**Academia**		**Representative of Consumer**	
Interviewee		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Solar		✓	✓		✓	✓	✓		
Wind		✓	✓		✓	✓	✓		
Hydro	Small -scale	✓				✓	✓		
	Large -scale		×	×		✓	×		
Biomass		✓				✓	✓		
Geothermal		✓	✓				✓		
Tidal		✓				✓	✓		
Wave		✓	✓				✓		
Waste		×	×	×	✓				
Nuclear				×	×	✓			

* The symbol of "✓" represents that the interviewee agreed the resource can be regarded as an eligible resource while "×" represents that the resource should be excluded in RECS. A blank space means that the resource was not mentioned by the interviewee. No opinion was collected from Interviewee 7 and Interviewee 8.

(Source: Author; based on face-to-face and telephone interviews)

vi. Treatment of existing RE plants

One should bear in mind that the purpose of establishing RECS is to stimulate the RE development so only new RE projects or new installed capacity of RE are eligible to be rewarded REC (Interviewee 1, 2015; Interviewee 3, 2015). All existing power plants are not eligible to gain REC because existing plants do not contribute to new installed capacity of RE (Interviewee 1, 2015; Interviewee 3, 2015).

vii. Penalty

Generally, the interviewed stakeholders thought that obligated actors who fail to meet their obligations should pay a fine that higher than the price of a REC (Interviewee 2, 2015; Interviewee 3, 2015). It is because a low penalty level cannot create a deterrent effect and obligated actor would rather pay fines than purchase RECs (Interviewee 2, 2015). Moreover, if enterprises fail to fulfill their obligations, the government could disclose the name of these enterprises. This would have a greater deterrent effect since enterprises are greatly concerned about their corporate image (Interviewee 2, 2015). Furthermore, reducing the permitted rate of return is another option if the quota is designated to the power companies (Interviewee 2, 2015; Interviewee 3, 2015).

viii. Certificate value

Generally, one REC is equal to one megawatt hour of renewable electricity generated from eligible RE resources. However, the size of REC in the United Kingdom is determined by the types of RE resources. Also, the value of imported REC could be reduced to a lower rank. Therefore, the Hong Kong and Guangdong government should consider whether the value of REC are to be determined by respective RE resources or not, such as a lower rank for large-scale hydropower. Furthermore, policy-makers in Hong Kong should consider whether the REC imported from Guangdong should have a lower value or not. Moreover, the validity of RECs are usually permanent but some RECs would expire within 1-5 years. Also, some RECs can only be "banked" for 1-2 years. Thus, the policy-makers should carefully consider the REC's validity.

(d) Implementation plan

Interviewee 3 (2015) stated that the social acceptability and the degree of the interconnection of electricity grids between Hong Kong and Guangdong are the prerequisites of implementing the proposed HK-GD RECS but none of which exist in Hong Kong. Aiming at these barriers, Interviewee 3 (2015) said that the first task for the Hong Kong government is to revise the SCA by reducing the permitted rate of return of the two Hong Kong power companies or even excluding the fixed assets of electricity generation from the permitted return. Moreover, Interviewee 3 (2015) recommended the Hong Kong government should establish an Energy Bureau to tackle the energy issue and formulate the "Competition Law" and "Electricity Act" for dealing with the barrier of electricity grids caused by the vertically-integrated structure of the Hong Kong power companies. Then, it could introduce the proposed RECS in Hong Kong and Guangdong independently. As the RECS is highly complicated, it could be potentially uncontrollable if the system is to be implemented at the regional scale in the early stage (Interviewee 3, 2015). When the operation of the proposed RECS becomes efficient in Hong Kong and Guangdong, it could at last, set up a cross-border agency and a regional RECS (Interviewee 3, 2015).

4. CONCLUSIONS

This paper generally introduced the components and mechanism of RECS by drawing upon overseas experiences and examined regional RECSs using two case studies. In the context of Hong Kong and Guangdong, we investigated the potential benefits, major barriers and main considerations of implementing a regional RECS between the two territories. However, further studies are needed to examine the details and feasibility of implementing a HK-GD RECS.

Table 8. List of Interviews

Code	Interview Background	Types of Interview	Date of Interview	Duration of Interview	Recording	Transcript
Interviewee 1	A professional from a local utility company	FI	13 Mar, 2015	1 Hour 30 Minutes	✗	Appendix II
Interviewee 2	A campaigner from Greenpeace	FI	23 Feb, 2015	1 Hour	✓	Appendix III
Interviewee 3	A manager from World Wide Fund (WWF), A former senior campaigner in Greenpeace	FI	6 Mar, 2015	1 Hour 30 Minutes	✓	Appendix IV
Interviewee 4	An officer from World Green Organization (WGO)	FI	5 Mar, 2015	30 Minutes	✓	Appendix V
Interviewee 5	A professor from the Department of Geography, Hong Kong Baptist University (HKBU)	FI	2 Mar, 2015	1 Hour	✗	Appendix VI
Interviewee 6	A researcher from the Energy Strategic Research Center of Institute of Energy Studies of Guangzhou, Chinese Academy of Sciences	TI	10 Mar, 2015	30 Minutes	✓	Appendix VII
Interviewee 7	An officer from the Planning and Training Division in Consumer Council	FI	10 Mar, 2015	1 Hour	✓	Appendix VIII
Interviewee 8	An officer of Chief Planning and Trade Practices in Consumer Council	FI	10 Mar, 2015	1 Hour	✓	Appendix VIII

* As some interviewees agreed to be interviewed anonymously, this research indicated all interviews by code. The code comprises a word "Interviewee" and followed by one digit of the interviewee number. The interview formats included face-to-face interview (FI) and telephone interview (TI). Parts of interviews were recorded.

Appendix I. General Questions for Interview

Part 1

1. How do you define “Renewable Energy”?
2. What do you think about the development of renewable energy in Hong Kong?
3. Do you know what ‘Renewable Energy Certificate System’ is?

Part 2

4. How to design a proposed Hong Kong-Guangdong Renewable Energy Certificate System?
   - Which types of the market is more suitable for Hong Kong? Compliance market or voluntary market?
   - Who will be the obligated actors that must buy a certain amount of Renewable Energy Certificate? Electricity producer, electricity suppliers or consumers?
   - Which will be the institutional entities for executing, issuing and monitoring the proposed system?
   - How to set the renewable energy target and quota?
   - What will be the eligible resources? Does it include large-scale hydro and wind power?
   - Does it allow banking or borrowing?
   - Does it need a grading system when Hong Kong importing Renewable Energy Certificates from Guangdong? (e.g. imported certificates will only have one-fifth the value of domestic ones in Denmark)
   - Does it need to set a minimum price or maximum price?

Part 3

5. From the perspective of technical, financial, political and environmental feasibility, to what extent Hong Kong can collaborate with Guangdong through developing a Hong Kong-Guangdong Renewable Energy Certificate System?
6. What are the main drivers, facilitating factors and potential benefits for developing a Hong Kong-Guangdong Renewable Energy Certificate System?
7. What will be the major barriers for implementing a Hong Kong-Guangdong Renewable Energy Certificate System?
8. What will be the possible options for overcoming the major barriers?

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