Key challenges for the establishment of the monitoring, reporting and verification (MRV) system in China’s national carbon emissions trading market

Renhu Tang\textsuperscript{a,b}, Wei Guo\textsuperscript{a}, Machtelt Oudenes\textsuperscript{c}, Peng Li\textsuperscript{a}, Jun Wang\textsuperscript{d}, Jin Tang\textsuperscript{a}, Le Wang\textsuperscript{a} and HaiJun Wang\textsuperscript{b}

\textsuperscript{a}SinoCarbon Innovation & Investment Co. Ltd, Beijing, People’s Republic of China; \textsuperscript{b}State Key Laboratory of Multiphase Flow in Power Engineering, Xi’an Jiaotong University, Xi’an, People’s Republic of China; \textsuperscript{c}SQ Consult BV, Utrecht, Netherlands; \textsuperscript{d}Sichuan United Environment Exchange Co., Ltd, Chengdu, People’s Republic of China

ABSTRACT
An effective system for monitoring, reporting and verification (MRV) is the cornerstone of any carbon emissions trading market. This paper analyses existing MRV frameworks in China, including under the seven emission trading pilot schemes, to identify four key challenges for the establishment of an effective MRV system for China’s forthcoming national carbon emissions trading market: (1) ambiguity in the legal status of relevant policies and regulations, (2) unclear requirements for the content of monitoring plans, (3) lack of consistency and harmonization in accounting and reporting guidelines, and (4) lack of information technology (IT). The paper then considers the experiences and lessons of the European Union Emissions Trading Scheme (EU-ETS) and the MRV systems in the seven carbon emissions trading pilots, and puts forward suggestions for tackling the four key challenges.

Key policy insights
- It is crucial to create general framework legislation that is legally binding and of a sufficiently high legal status to facilitate legal enforcement of the MRV requirements and increase the compliance levels of MRV activities.
- Clear rules on the content of the monitoring plan and development of templates would harmonize approaches across regions and between reporting entities.
- It is important for implementing regulations to include specific requirements on monitoring and reporting in order to ensure compliance with the main monitoring and reporting principles.
- Use of IT should gradually evolve towards an integrated system that covers the whole compliance cycle, including monitoring plans, emission reports, verification and verification management, as well as multiple stakeholder access.

1. Introduction
Since 2013, Beijing, Shanghai, Tianjin, Chongqing, Guangdong, Hubei and Shenzhen have started pilot emission trading schemes (ETS), which have become a key topic of interest for many national and international researchers (Luo, Qin, & Wen, 2016; Zheng, Liu, & Wang, 2015). Whereas some researchers focus more on the prospects of the pilot schemes (Zhang, Karplus, Cassisa, & Zhang, 2014), the ETS schemes in general (Duan, Pang, & Zhang, 2014; Qi & Wang, 2013) and the experiences and lessons learnt in these seven Chinese ETS pilots (Jotzo & Löschel, 2014; Deng, Li, Pang, & Duan, 2018), others pay more attention to certain specific aspects of the ETS schemes, such as the allocation of emission allowances (Pang & Duan, 2016; Ye, Jiang, Miao, & Xie, 2017) or...
the cost of trading (Duan & Pang, 2013; Heindl, 2012) or alternatively a certain ETS pilot, such as Shanghai (Wu, Qian, & Li, 2014), Shenzhen (Jiang, Ye, & Ma, 2014; Jiang, Ye, Ma, & Miao, 2016), Hubei (Qi, Wang, & Zhang, 2014), or Guangdong and Shenzhen in a comparative study (Wang, Luo, Xie, Luo, & Zhao, 2016). In recent years, China’s forthcoming national carbon emissions trading system has become the centre of attention in the academic world, covering topics such as the overview and prospects of the national carbon emissions trading market (Jiang, Xie, Ye, Shen, & Chen, 2016), the transition from the ETS pilots to the national carbon emissions trading market (X. Zhang, 2015), the challenges and suggestions to overcome when launching the national carbon emissions trading market (Lo, 2016; Liu & Song, 2017; Qi & Cheng, 2018).

A crucial part of a well-functioning emissions trading system is the process of monitoring, reporting and verification (MRV) of emissions, which is key to gaining accurate information on emissions and ensuring the environmental integrity of the carbon emissions trading market (Dekkers & Oudenes, 2007; Fleurke & Verschuuren, 2015; Peeters, 2006). MRV has therefore been of particular interest to researchers in the Chinese ETS pilots, as well as when considering the national carbon emissions trading market. A common thread running through academic research over recent years shows that lessons on developing MRV systems and overcoming challenges can be learnt from existing ETS MRV systems, including in the EU, Japan and the US (Abrell, Ndoye, & Zachmann, 2011; Bai et al., 2016; Cao & Cui, 2012; Teng & Feng, 2012; Zhang, Liu, Cai, & Zhang, 2013). In addition, experience obtained when establishing and implementing MRV systems for the Chinese pilots provides valuable information for policy makers (Jeff, 2016; Peng & Yan, 2015; Wang, 2016; Wu et al., 2015; Zeng et al., 2016; Z. Zhang, 2015; Zheng et al., 2015; Zheng, Zhang, Liu, Yin, & Song, 2016; Zhou, Xie, Fang, & Li, 2017).

This paper highlights four key challenges for establishing and managing the MRV system in the national carbon emissions trading market. It outlines how experience and lessons learnt from MRV systems in the European Union Emission Trading Scheme (EU ETS) and China’s ETS pilots can be of added value when developing and fine-tuning the implementation of the MRV system in the national carbon emissions trading market. Taking these lessons into account the paper will provide suggestions for addressing the key challenges.

2. The basis and key challenges for the establishment of the MRV system in the Chinese national carbon emissions trading market

2.1. The basis for the establishment of the MRV system in the Chinese national carbon emissions trading market

In 2012, the National Development and Reform Commission of China (NDRC) drafted the Guidelines for the Accounting and Reporting of GHG Emissions for Key Enterprises (‘ARG’), and issued the guidelines in three batches (NDRC, 2013, 2014, 2015). The guidelines cover a total of 24 industry sectors and were used to collect data for the design and operation of the system.

In December 2014, the NDRC issued the Interim Measures on the Administration of Carbon Emissions Trading (‘Interim Measures’) (NDRC, 2014b), which provide the legal framework for the national carbon emissions trading market and include the basic requirements of the MRV system. These requirements were further elaborated in the Notice on the implementation of activities needed to set-up the National Carbon Emissions Trading Market and its Annexes (NDRC, 2016) (‘Document No. 57’). This document laid down more detailed requirements on the reporting and verification of historical carbon emissions data collected from the years 2013–2015, which

Table 1. Existing basic documents of the MRV system in the national carbon emissions trading market, their coverage and main problems.

| No. | Title of the document | M | R | V | Main Problems |
|-----|------------------------|---|---|---|---------------|
| 1   | Interim Measures       | √ | √ | √ | Lack of legal force, which causes difficulties in the implementation of the MRV system and problems in enforcing the requirements. The legal basis for imposing sanctions in the case of noncompliance is weak; |
| 2   | ARG                    | √ | √ | × | Lack of consistency in the calculation methods and selection of parameters in the accounting and reporting guidelines for different industries; |
| 3   | Document No. 57        | √ | √ | √ | Lack of clear requirements for a monitoring plan. The document is a work notice of the NDRC with limited legal force thereby causing differences in the implementation at local level. |

Note: ‘√’ means related and ‘×’ unrelated.
were used to calculate the allocation of emission allowances. These requirements, together with the *Interim Measures* and the ARG, currently form the legal MRV framework for the national carbon emissions trading market. Table 1 outlines which parts of the MRV system are covered by the legal documents and the main problems related to these legal documents.

As from January 2016 onwards, the provinces and municipalities in China started to report and verify carbon emission-related data covering the years 2013–2015. By the end of May 2017, all the provinces and municipalities had submitted their data. Although the legal status of Document 57 is ambiguous, it was still an improvement compared to the *Interim Measures* as it required companies to report supplementary historical data and provided more detailed requirements to collect those data. Before Document 57 was in place, a number of provinces (e.g. Inner Mongolia and Xinjiang) had to report and verify their historical data anew because the data originally collected were of poor quality and lacked the information contained in the supplementary data requests. This increased the administrative burden, not only for the companies but also for the provincial authorities. Lessons learnt from these years showed the importance of having harmonized and detailed rules on what data to report. It also became clear that good coordination between authorities when setting-up a national carbon emissions trading market is important. When multiple authorities are involved in a national emission trading scheme, harmonized procedures are key to ensuring that similar companies are treated in an equal manner and accurate data are obtained across provinces.

### 2.2. Key challenges for establishing an MRV system in the Chinese national carbon emissions trading market

Taking into account these experiences, four key challenges can be identified for establishing an MRV system in China. These four challenges were selected because they are very much related to the legal framework and the design of the MRV framework. Although the design of the national emission trading scheme and its MRV component has evolved considerably over the past years, further improvement on these four points could facilitate the effectiveness and robustness of the MRV scheme.

#### 2.2.1. Key challenge I: ambiguity in the legal status of relevant policies and regulations in MRV system

In accordance with the *Law of the People’s Republic of China* (NPC, 2015), the legal hierarchy of the laws and regulations is as follows: the highest status of law is an act issued by the National People’s Congress, followed by administrative regulations issued by the State Council, and local laws and regulations issued by the local people’s congresses. Of lower legal status are departmental regulations issued by subordinate ministries and commissions under the State Council and local regulations issued by local governments at all levels. The NDRC’s *Interim Measures* is a departmental regulation which has a relatively low legal status in the legislative hierarchy with limited legally-binding force. This has led to substantial differences in the implementation of the MRV of historical data in the various provinces and municipalities. A number of companies did not submit reports in time. Authorities had problems in enforcing the legislation on companies that were non-compliant. The standards that were used for collecting the data lacked harmonized procedures and the qualifications and competencies of the verification bodies were not sufficient. As the *Interim Measures* also provide the legal basis for the MRV of annual emissions, similar problems may occur. The quality of the MRV activities will largely be dependent on the willingness of the provinces, municipalities and participants to meet and implement the requirements. There is likely to be insufficient legal impetus and power to enforce the legislation, which could have an adverse effect on the overall quality of the MRV system.

#### 2.2.2. Key challenge II: unclear requirements for the content of the monitoring plan

The *Interim Measures* stipulate that the covered enterprises shall develop a monitoring plan in accordance with the ARG and submit this to the authorities responsible for administering emission trading in the provinces, autonomous regions and municipalities. Enterprises are required to monitor their emissions in accordance with the plan, which must be approved by the relevant authorities. A drawback is that the legislation does not contain explicit requirements on the specific contents of the monitoring plan. This is not surprising, since Document 57 was issued in 2016 and originally intended for the data collection and reporting process of
historical emissions of the years 2013–2015. Detailed requirements on the contents of a monitoring plan to collect historical data would not be useful in that case. However, a monitoring plan is highly relevant for the monitoring of annual emissions in a carbon market system. A monitoring plan allows the responsible authorities to check compliance with the legislation and enables interested parties to understand how the company functions, what the monitoring boundaries in the enterprise are, and how the company should monitor their GHG emissions. It is tailored to the company specific situation and approved by the authorities. A monitoring plan also provides a framework for the verifier to check the accuracy of the data and assess whether the monitoring plan reflects the actual situation at the enterprise. Experience from historical data collection in 2016 has shown that the lack of more detailed requirements affects the quality of collected data. A monitoring plan that does not provide much detail on the monitoring boundaries and the applicable monitoring methodologies can cause problems in the monitoring itself, leading to ambiguity as to what monitoring methodology applies to a specific enterprise and data gaps that cannot be easily corrected. This reduces the credibility of data.

2.2.3. Key challenge III: lack of consistency and harmonization in the accounting and reporting guidelines

As mentioned before, the provisions in the ARG as well as the notification documents lack consistency and leave room for interpretation on some points. For example, there is an inconsistency in the requirements on data quality, inconsistencies in the applicable default values and a lack of harmonization in the verification requirements.

(1) Inconsistency in the requirements on data quality for different industries

For some industry sectors, less stringent requirements seem to apply to the data accuracy and quality in the monitoring methodology than for other industry sectors. This inconsistency cannot always be explained by the specific nature of the industry sector. For example, in the guidelines for the power generation industry, the net calorific value must be determined by using measured values, whereas the guidelines for the electrolytic aluminium industry requires the use of default values. The guidelines for steel, cement and flat glass industries, however, allow enterprises to measure or apply default values. Different data quality and accuracy requirements that cannot be justified because of technical infeasibility, unreasonable costs or the specific nature of the industry will reduce the comparability of the enterprises’ GHG emissions in different industry sectors.

(2) Lack of consistency in the default values applicable to different industries

Between industry sectors, there are inconsistencies in the default values that apply to the activity data of fuels or raw materials. An example of these inconsistencies is provided in Table 2.

As shown in Table 2 the default values for net calorific values of anthracite for different industries range from 20.304GJ/t to 26.7GJ/t, which makes the difference more than 30%. This means that, when applying the default value for the net calorific value, electrolytic aluminium enterprises will report emissions 30% lower than papermaking enterprises for burning the same tonne of anthracite. Although the differences in the quality of fuels partially account for the application of different default values in the guidelines, the vast range of deviations in the guidelines can cause inequalities. In a national ETS, this may lead to substantial varieties in the emissions of different industries and enterprises using the same fuel. This does not seem to be in line with the main monitoring principles of consistency and accuracy that should be part of any MRV system.

Table 2. The default values of the net calorific value of anthracite for different industries in the ARG (NDRC, 2013, 2014, 2015).

| No. | The default value of the net calorific value (GJ/t) | Industry                                                                                     |
|-----|--------------------------------------------------|---------------------------------------------------------------------------------------------|
| 1   | 20.304                                           | Magnesium smelting, electrolytic aluminium, steel, oil and gas production, petrochemical, coal production, independent coking, chemical industry |
| 2   | 23.210                                           | Civil aviation                                                                             |
| 3   | 23.2                                             | Ceramics, public buildings                                                                  |
| 4   | 26.7                                             | Papermaking, other nonferrous metals, food, electronic equipment, machinery equipment         |
| 5   | 24.515                                           | Mining, road traffic, fluorine chemical industry, and other industrial sectors                |
(3) The standards for selecting the verification bodies

At present, third-party verification bodies are selected by the provincial authorities to verify historical data in the national trading scheme. Although the annex to the Notice issued in January 2016, Annex IV: Reference Conditions for the Third-party Verification Bodies and Personnel for National ETS (NDRC, 2016), lays down requirements for the third-party verification bodies, the document is just a work notice with limited legal power. Because of this, the selection process and the quality of the verification bodies during the verification of historical data have varied among different provinces. For instance, the Notice requires that verification bodies cannot participate in any activities related to carbon asset management or carbon trading in order to avoid conflict of interests. However, some provinces have still chosen a number of enterprises that are engaged in carbon asset management and transactions to undertake third-party verifications (Hebei DRC, 2015; Tansuo, 2017; Zhejiang DRC, 2015). Qualification of verification bodies that is not rigorously managed and leaves room for interpretation in the competence and impartiality requirements will affect the verification bodies’ performance and the credibility of the data.

2.2.4. Key challenge IV: lack of information technology in the MRV system

The MRV system in the national emissions trading scheme is in its initial stages. When carbon emissions data over the years 2013–2015 were submitted by local enterprises to provincial authorities, this was either done in a word or excel format or electronically. Once the data were verified by the third-party verification body, the data were submitted to the national authorities using the same methods. Submission by paper has significant shortcomings:

(1) Compiling the emission report templates manually increases the risks of introducing errors in the data, and of data being manipulated and changed by unauthorized persons. Furthermore, it is more complicated to trace data back to the source.
(2) It is more difficult to extract data or conduct statistical analysis if the data are only documented on paper, in particular where large amounts of files and data are involved.
(3) As the data reports had to be transferred to different parties involving enterprises, provincial authorities, verification bodies and national authorities, submission by paper or even in a simple excel file complicated this process and increased the administrative burden. It adversely affected the efficiency of the administration often resulting in lots of repetitive work.

2.2.5. Other challenges

As in any emission trading scheme that is at its initial stages there are other challenges concerned when designing and implementing the scheme. This includes, for example, the difficulties in coordinating between the different authorities as well as the problems related to timely submission of required documents and the review of verified emission reports by authorities to monitor the quality of reporting and verification. However, these aspects are either being picked up while the scheme is continually improving in its design, or have less priority than the four key challenges mentioned in this paper because these take place later in the annual cycle of MRV.

3. Suggestions for tackling the four key challenges of the MRV system

This section aims to identify possible solutions for the four key challenges listed in the previous section taking into account lessons learnt in the EU ETS and the ETS pilots in China.

3.1. On key challenge I: ambiguity in the legal status of relevant policies and regulations in MRV system

3.1.1. Lessons from the EU ETS and Chinese ETS pilots

Experience in the EU ETS has shown the importance of having a clear legal framework that provides a strong basis for enforcing MRV requirements on different stakeholders. Directive 2003/87/EC (EC, 2003) forms the
legal basis for more detailed requirements in implementing legislation. It is legally binding for all EU countries and contains general framework requirements on allocation, auctioning, penalties, the main principles of MRV and the main roles and responsibilities of the different stakeholders. The legal framework in the EU ETS has evolved during the three trading periods (Verschuuren & Fleurke, 2014). At the start of the scheme, the implementing legislation consisted of Commission Decisions (EC, 2004, 2007) that needed to be implemented in national law. The detail of the requirements in the Commission Decisions grew over the years evolving from general requirements in the first decision to more stringent and detailed requirements on monitoring and quality assurance in the updated decision of 2007. Creating a more level playing field was a key objective in these years as installations were treated differently across the EU in the first years leading to inconsistencies and noncompliance. The introduction of two implementing regulations developed by the European Commission for the third trading period significantly improved the effectiveness and harmonization of the MRV system even further (EC, 2012a, 2012b). Both regulations are directly applicable to installations, verifiers, responsible authorities and accreditation bodies which clarify the roles and responsibilities of those parties. Detailed requirements are included on various MRV topics ranging from requirements on monitoring boundaries, monitoring plans, methodologies for quality assurance and control and improvement of the processes. Furthermore, the accreditation and verification regulations explicitly require verifiers to be accredited and supervised by national accreditation bodies: a major change compared to the first trading period when no such requirement existed (EC, 2012a). Together with the Directive, both regulations provide a strong legal framework. Competent authorities in the EU Member States can thus enforce the requirements directly on installations and impose sanctions if these requirements are not met. The same is true for accreditation bodies that can, for example, suspend verifiers or withdraw their accreditation certificate when they are not complying with the regulation and ISO standard 14065 (containing requirements for GHG validation and verification bodies) (ISO, 14065, 2013).

Of the seven Chinese carbon trading pilots, only Beijing and Shenzhen have legislation that is developed by the local people’s congress or have set up directives with legal effect. The other five pilot provinces and municipalities created local governmental orders or departmental regulations which do not have the same legally binding power as congress laws and directives. This makes it harder to enforce the legislation and impose sanctions (Peng & Yan, 2014). In recent years, studies have been carried out on the relationship between the legal effect of the relevant regulations in the Chinese carbon trading pilots and market performance. These studies show that the quality of MRV improved in the two pilots of Beijing and Shenzhen, which have developed regulations of a higher and more legally binding nature than the legal instruments in the other pilots (Mao et al., 2017). This in turn has enhanced the public’s confidence in the accuracy of the data, mitigating the risks to compliance. Legal instruments with a stronger legal power have a positive effect on the functioning of the carbon emissions trading market system. This improve the legality of decisions to enforce and impose sanctions in the case of infringements of the requirements. It also harmonizes and enhances the implementation of the MRV process, thus guaranteeing the effective operation of the carbon emissions trading system (Peng & Yan, 2014).

3.1.2. Suggested solutions
First of all, it is essential to develop law of a more legally binding nature to regulate MRV activities in the national carbon emissions trading market. The main legislation should be developed by the State Council which has a stronger legal basis and can therefore be more easily enforced. To ensure harmonization across the Chinese provinces it is suggested that the following key MRV issues should be covered:

(1) It is necessary to clarify and define the roles and responsibilities of the authorities responsible for the administration of MRV activities (at the national level, as well as the regional and local levels). In addition, the coordination and possible information exchange between those authorities should be regulated in the main framework legislation. Furthermore, the roles and responsibilities of enterprises should be clearly delineated in legislation.

(2) Requirements should be included for the national authorities to issue relevant management rules, regulations and binding guidelines that further elaborate on MRV activities. These rules and regulations would form part of a binding legislative framework on MRV.
3. Requirements should be incorporated for the national authorities to develop templates for the required documents such as monitoring plans, emission reports and verification reports.
4. The possibility for authorities to impose sanctions should be included if enterprises fail to meet the requirements.
5. The legislation should clarify that verifiers need to obtain an administrative license from the authorities in order to carry out verification. The main legislation should also define the responsibilities and obligations of the verification bodies, as well as the consequences should they fail to fulfil their obligations. More detailed and harmonized requirements on competence and impartiality of the verification bodies, applicable standards and verification in general should be included in implementing regulations.
6. It is necessary to clarify the basic principles and scope for the disclosure of the relevant data and information related to the MRV system, so as to provide a legal basis for the development of information disclosure rules where MRV-related data are involved.

3.2. On key challenge II: unclear requirements for the content of the monitoring plan

3.2.1. Lessons from the EU ETS and Chinese ETS pilots

The concept of a monitoring plan has become more embedded in the EU ETS over the years. In the European Commission’s Decision for the Monitoring and Reporting of Greenhouse Gas emissions (EC, 2004), the term monitoring plan was not specifically mentioned, which led to differences between EU countries. Some countries required companies to have a detailed monitoring plan, whereas in other countries no specific requirements were included in national law, causing differences between installations as regards to how and in what detail the specific monitoring boundaries and methodology were defined for companies. When developing the update of the Commission Decision in 2007, it became clear that requiring the use of a monitoring plan and developing specific requirements on the content of the monitoring plan resulted in less difference between companies and increased transparency on the methodologies and concrete situations in the company. It also facilitated compliance checks by the competent authority as well as the verification of emission reports. Therefore, the updated Commission Decision of 2007 specifically defined the concept of the monitoring plan and included general requirements on its content. This included, for example, the monitoring boundaries, methodology and quality assurance and control measures implemented by the company to mitigate the risks of errors in the data. Although Commission Decision 2007 significantly strengthened the concept of the monitoring plan, differences between Member States and companies still existed, e.g. differences in whether templates were prescribed and used, and differences in the detail of monitoring plans. The Monitoring and Reporting Regulation (EC, 2012b) developed for the third trading period in 2012 increased the harmonization between Member States by including more detailed requirements on the content of the monitoring plan and how to address changes to it. Furthermore, the Commission developed a standardized and detailed template for monitoring plans and specified in Article 74 of the Monitoring and Reporting Regulation that if a Member State would develop its own national template or information technology (IT) system, this should contain at least the same information as provided in the Commission template. Lessons learnt through the various trading periods showed that for the concept of a monitoring plan to function properly, it is essential to set requirements on the content of the monitoring plan, and to regulate that the competent authority approves each monitoring plan and any significant changes, in particular those that affect the monitoring methodology. It is equally important to develop and require companies to use standardized templates as this provides a structured and harmonized approach in describing methodologies.

When considering the MRV practice of the seven Chinese ETS pilots, one can conclude that monitoring plans are treated differently. For the pilots that require enterprises to develop monitoring plans, Guangdong, Hubei and Shanghai have more detailed requirements, covering for example basic information of the enterprises, monitoring boundaries of the company, monitoring methods and data selection. Lessons learnt in the pilots show that the development and implementation of monitoring plans facilitates the monitoring and reporting of emissions and production data by enterprises, in accordance with the guidelines, and improves data quality, see Table 3.
### 3.2.2. Suggested solutions

As explained in previous sections, the monitoring plan is a useful instrument that serves as a management instrument for companies, allows competent authorities and verifiers to check compliance with the monitoring and reporting requirements, and enables parties to understand in a transparent manner how the company functions, which source streams are used and which monitoring methodology and specific methods on quality assurance and control are applied. Lessons learnt in the EU ETS and the pilots show that it is an essential element in ensuring the accuracy, consistency and completeness of monitoring and reporting. Introducing the concept of the monitoring plan in the national emission trading scheme of China would therefore be of added value and crucial for the ETS system to function effectively in the future. Based on the lessons learnt in the EU ETS and the pilots, it is suggested to lay down strict requirements for the implementation of the monitoring plan in legally binding law:

1. Enterprises falling under the scope of the emission trading scheme should develop their monitoring plan well before the monitoring starts, i.e. before the reporting period. Timely submission ensures careful preparation and consideration by all parties, thereby avoiding the situation where no monitoring plan is implemented and in place before the reporting period starts. This avoids confusion as to what company specific methodology the company will follow, mitigates the risk of introducing data gaps and prevents complications in the verification;

2. The legislation should include specific requirements on the content of the monitoring plan, specifically on the monitoring boundaries of the company (the source streams, emission sources, activities etc.), the monitoring methodology (e.g. default values, sampling standards etc.), methods used to determine the different parameters such as emission factors, description of the quality assurance and quality control system.

3. The monitoring plan, once approved, should not be changed arbitrarily, in order to ensure consistency and comparability of the monitoring methodology over time. However, in some cases, the actual situation within the company can change, e.g. addition of a fuel or change in the application of the monitoring methodology. In such cases, these changes should be properly explained, justified, documented and subjected to approval of the competent authority to ensure legal compliance and transparency for all parties concerned. As the detail of the monitoring plan evolved over the years in the EU ETS, it became clear that requiring the approval of the competent authority for every minimal change of the monitoring plan resulted in high administrative costs for companies and competent authorities. For that reason, only significant changes to the monitoring plan, in particular those affecting the monitoring methodology, need the competent authority’s approval in the EU ETS. It is suggested to assess which level of detail is required in the monitoring plan and what changes to the monitoring plan need the competent authority’s approval. When making these decisions, the right balance must be found between administrative burden and effectiveness on the one hand, and ensuring data quality on the other. In any case, all changes to the monitoring plan need to be recorded and notified to the competent authority;

4. A uniform national monitoring plan template should be developed to improve harmonization between enterprises and regions, and to ensure the monitoring plan will be of high quality across regions. A common template would ensure a level playing field for all operators, and would create efficiency gains for enterprises, authorities and verifiers who are active in several provinces.

#### Table 3. Requirements of the ETS pilots on monitoring plans (Beijing DRC, 2015; Guangdong DRC, 2014; Hubei PPG, 2014; Shanghai, 2013).

| Name of the pilot | MP required | Deadline for submitting the MP | MP Register Required | MP Approval Required | MP Changing Approval Required |
|-------------------|-------------|-------------------------------|----------------------|----------------------|-----------------------------|
| Guangdong         | √           | By 15 March                   | ×                    | √                    | √                           |
| Hubei             | √           | By 30 September               | ×                    | ×                    | ×                           |
| Shanghai          | √           | By 31 December                | ×                    | ×                    | ×                           |
| Beijing           | √           | ×                              | ×                    | ×                    | ×                           |
| Tianjin           | ×           | ×                              | ×                    | ×                    | ×                           |
| Chongqing         | ×           | ×                              | ×                    | ×                    | ×                           |
| Shenzhen          | ×           | ×                              | ×                    | ×                    | ×                           |

Note: ‘√’ means satisfied and ‘×’ means not satisfied. MP: Monitoring Plan.
3.3. On key challenge III: lack of consistency and harmonization in the accounting and reporting guidelines

3.3.1. Lessons from the EU ETS and Chinese ETS pilots

The EU ETS monitoring and reporting requirements are built on the principles that underpin any MRV system. Of crucial importance is the completeness of monitoring and reporting. Every source stream and emission source covered in the scope of the EU ETS and falling under the installation must be included in the determination of emissions. Hence, there are strict requirements in the current legislation on what falls under the scope of the EU ETS and how to define the monitoring boundaries. The EU ETS distinguishes between a calculation-based methodology, a mass balance methodology and a measurement-based methodology. A mass balance methodology is applied in specific situations, mostly when it is difficult to relate the emissions directly to individual input materials (EC, 2012d). In a measurement methodology, the enterprise measures GHG emissions through instruments in the stack of the installation, also called a continuous emission measurement system. In some cases, a combination of methodologies is applied. Most installations in the EU use the standard calculation-based methodology.

The consistency of the monitoring methodology is ensured by defining strict requirements on how to determine the various parameters in the methodologies. Depending on the size and nature of the source stream and size of the installation, several options are available in the calculation-based methodology, in which the activity data are multiplied by the emission factor and oxidation or conversion factor. Activity data are determined by continually metering at the process of emissions, batch metering taking into account stock changes or the use of invoices for small installations (if chosen). For the other parameters, such as the emission factor and net calorific value, either default values (e.g. Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines factors, United Nations Framework Convention on Climate Change (UNFCCC) national inventory factors, factors set by the competent authority or in legislation) apply or companies are required to determine the parameters through sampling and analysis carried out by laboratories.

A most important feature of the EU ETS, as with UNFCCC reporting, is the use of tiers to assess and report the maximum allowable uncertainty level that is required for the monitoring of each individual parameter: fuel use, net calorific value, emission factor, and biomass fraction, oxidation factor or other parameters. A tier approach is applied in both the calculation-based and the measurement-based methods. In general, tiers with lower numbers represent less stringent requirements and are less accurate than higher tiers. Tiers of the same number (e.g. tier 2a and 2b) are considered to represent equivalent levels of uncertainty, but using a different determination (EC, 2012d).

The size of the installation and the size of the source stream determine what tier is applicable for determining a specific parameter for a source stream. The largest installations are required to apply the highest tier with the lowest uncertainty value for activity data, approximately 2.5% maximum uncertainty value. Furthermore, those installations are required to carry out sampling and analysis to determine the specific parameter. Stringent requirements apply on how to carry out sampling and analysis: e.g. a requirement to have a sampling plan approved by the competent authority, or a requirement to apply specific sampling standards. Deviation from applicable tiers is only possible in very specific cases if the company can demonstrate technical infeasibility or unreasonable costs for achieving the applicable tier.

The tier approach, the detailed requirements on monitoring, sampling and analysis, as well as the quality assurance and quality control measures that need to be implemented to mitigate risks of errors in the data have improved the accuracy, consistency and transparency of monitoring and reporting. These approaches and requirements apply regardless of the specific industry sector, ensuring that similar industries are treated in an equal and consistent manner. In addition, sector specific requirements for the activities covered by the EU ETS are laid down in legislation, further detailing calculation formulae, particular default factors and analysis frequencies for the different sectors covered by EU ETS.

The seven Chinese ETS pilots have taken the initiative in developing relevant technical standards or guidelines when establishing their MRV systems. Most of the provinces and municipalities have developed general guidelines on the monitoring and reporting of the data, which are supplemented by monitoring and reporting guidelines for different industries. The general guidelines prescribe the use of uniform default values for
parameters, such as the net calorific value of the fossil fuels and the carbon content per unit. By using uniform values, there is less inconsistency in the application of default values and thereby fewer differences between industries that cannot be explained by industry specifics. Table 4 provides the status quo of the guidelines in the pilots. Of relevance here are the verification guidelines and types of administrative measures that can be imposed on verification bodies. Pilots that had formulated more detailed requirements in these guidelines and set-up administrative measures for different types of infringements of verifiers encountered less problems in the verification.

### 3.3.2. Suggested solutions

Taking into account the experience of the EU ETS and Chinese carbon trading pilots, the following suggestions can be made to improve consistency and accuracy in the future national emissions trading market in China:

1. Legally binding national regulations or guidelines should include strict requirements on the definition of monitoring boundaries (e.g. emission sources and source streams, type of emissions included) and sector specific monitoring methodologies. A robust MRV system would also benefit from more specific rules on sampling, the parties that are doing sampling and analysis, and applicable standards and procedures that should be followed when sampling and analysing. Furthermore, specific requirements on quality assurance and quality control are important as these mitigate the risks of introducing errors in the data and non-compliance with the monitoring plan and requirements. Verification will be more effective in this case, and can be less detailed if the risks of making errors are low (EC, 2012c). Requirements could cover, for example, calibration of measurement equipment, quality control on IT data management systems, procedures to record all data and activities on monitoring and reporting, procedures for reviewing and correcting errors in the data, and procedures for filling data gaps.

2. Standardization of default values of the parameters should be considered because this avoids differences in the values that cannot be explained.

3. Uniform templates should be developed for required documents such as the monitoring plan, the emissions report and the verification report. This would standardize how the documents are completed and harmonize approaches across provinces and regions.

4. The gradual introduction of the ‘tier’ concept should be considered in the future. The fact that the monitoring methodology is tailored to the size of emissions across industries promotes equal treatment of enterprises, while at the same time taking into account an element of cost efficiency as well as consistency and accuracy.

5. Harmonized national requirements on verification and verification bodies should be included in legally binding legislation to ensure that verification is of high quality and the verification bodies and their personnel remain competent and impartial. International standards such as ISO standard 14065 (ISO, 2013) can help in this process though it must be noted that these standards are programme neutral and specific requirements are needed in legislation (Dekkers & Oudenes, 2007). This concerns, for example, requirements on competence, impartiality, verification reporting and consequences of verification. Together with a robust verification management system where responsible authorities are involved in assessing and supervising the competence, impartiality and performance of verification bodies and their personnel, these are

| Name of the pilot | Number of sector specific guidelines | Verification guidelines Developed | Administrative measures to be imposed on verification bodies |
|------------------|--------------------------------------|----------------------------------|----------------------------------------------------------|
| Shenzhen         | 3                                    | √                                | √                                                         |
| Shanghai         | 9                                    | √                                | √                                                         |
| Beijing          | 7                                    | √                                | ×                                                         |
| Guangzhou        | 10                                   | ×                                | ×                                                         |
| Tianjin          | 5                                    | ×                                | ×                                                         |
| Hubei            | 11                                   | √                                | ×                                                         |
| Chongqing        | 1                                    | √                                | ×                                                         |

Note: ‘√’ means satisfied and ‘×’ means not satisfied.
important elements in ensuring high quality verification. This allows the authorities responsible for supervising verification bodies to enforce the requirements on verification bodies and impose sanctions if necessary.

3.4. On key challenge IV: lack of information technology in the MRV system

3.4.1. Lessons from the EU ETS and Chinese ETS pilots

After the first phase of the EU ETS, the importance of using IT for the functioning of the MRV system was recognized and several EU countries started to develop electronic systems to reduce the administrative burden and to improve the quality of data. Approximately 16 EU countries use some type of electronic system, varying from basic electronic reporting systems that only allow for electronic submission of the emission report to a simple automated work flow system covering more steps in the compliance cycle or very sophisticated IT systems (EEA, 2017). About five countries apply a full-blown sophisticated eXtensible Markup Language (XML) based IT system and e-portals that include all processes and required MRV documents. It allows for multiple stakeholder access and facilitating single data entries, automated checks and storage of information in one database (Larkin, Sachweh, Hazrat, Eaton, & Rankin, 2015).

Automatization of the MRV system cannot be achieved overnight. After more than ten years of emission trading, only about half of the EU countries are using electronic IT systems to manage their MRV administration. The main reasons for the delay in implementing IT systems are the high costs involved for setting up IT systems, and the fact that competent authorities were sometimes reluctant to receive and submit official information electronically instead of on paper. Furthermore, internal national specific procedures sometimes did not accommodate IT systems and there was a lack of a harmonized standard for electronic exchange of MRV data. For the third trading period, a uniform XML standard has been developed and more activities were organized by the Commission to promote the use of IT systems, increasing EU countries’ interest in the benefits of using IT systems. The Monitoring and Reporting Regulation defines general requirements on the use of automated systems ensuring integrity, confidentiality and authenticity of the data.

Most of the seven Chinese pilots have considered using IT in the operation of their MRV system. After 4 years of efforts, the status quo of the information system of the seven pilots is shown in Table 5.

Table 5 shows that the seven Chinese ETS pilots have all established an electronic MRV-related information system. However, the type and functions of these information systems vary widely. Two of the pilots have only developed the reporting module (Chongqing, Tianjin), whereas two other pilots, Guangdong and Beijing, have set-up IT systems that cover the whole MRV compliance chain requiring monitoring plans, emission reports and verification reports to be submitted using those electronic systems. This has significantly improved the efficiency of MRV data transmission and administration. It has reduced the administrative burden in the preparation and management of MRV activities and facilitated the documentation of paper records. The IT systems allow for automatic completeness checks on reports and documents submitted, effective communication and distribution of the reports to experts for review, and automated extraction of key data needed for the allocation of allowances and statistical analysis. Although some of these modules have been incorporated in the IT

Table 5. Coverage of the information system in the seven Chinese ETS pilots.

| Name of the pilots | Monitoring | Reporting | Verification |
|-------------------|------------|-----------|--------------|
| Shenzhen          | ×          | ✓         | ✓            |
| Shanghai          | ✓          | ✓         | ×            |
| Beijing           | ✓          | ✓         | ✓            |
| Guangzhou         | ✓          | ✓         | ✓            |
| Tianjin           | ×          | ✓         | ×            |
| Hubei             | ×          | ×         | ×            |
| Chongqing         | ×          | ✓         | ×            |

Notes: In the beginning of the operation of the Hubei Pilot ETS, an information system with monitoring and reporting modules was introduced. However, it has gone out of service for technical reasons.
Source: Interviews with verifiers participating in the ETS pilots.
system, their automatization level is relatively simple. The verification module in the information system, for example, was developed and applied in three pilots in Shenzhen, Guangdong and Beijing. However, its function is simple; verifiers can only use it to download the emission report and upload the verification report of the enterprises within the system.

3.4.2. Suggested solutions
The use of IT in MRV for emission trading has significant benefits in reducing the administrative burden for all parties concerned, improving the efficiency of MRV administration and increasing the accuracy of carbon emissions data of the enterprises. The MRV system of the national carbon emissions trading market will affect a large number of enterprises from different sectors, complicating the submission, statistical analysis and assessment of documentation if this is being done manually. Based on lessons learnt in the EU ETS and the pilots, the following suggestions can be made for the automatization of the MRV system:

(1) In the short term, it is suggested to develop standard file specifications (EXCEL and XML) for the main reporting forms and exchange of data in the MRV system. This would speed up the construction of the national GHG emissions reporting system, improve the data submission system using optimal information technology, and make sure that the enterprises submit their information in such a way that the data can be analysed later. The IT system should be designed with the ability to expand the functionalities and interfaces from a simple reporting system to one that includes a monitoring plan module and verification module.

(2) In the longer run, the suggestion is to establish an MRV gateway website for the publication of all the information about MRV-related data submission, information disclosure, rules release, Q&A platform, capacity building, etc. This will allow parties to exchange information and communicate on MRV related topics. All relevant data will also be maintained in one place.

(3) In the long term, the suggestion is to establish an integrated MRV IT system and develop a web-based automated MRV process covering all elements of the compliance cycle: monitoring plan, registration, updates of monitoring plan, approval by the competent authority, reporting, verification as well as the administration of the verification bodies. In addition, the system should include a large data analysis module for analysing the MRV information collected from different sources.

4. Conclusions
When developing a national emission trading scheme, a robust MRV system is essential for the functioning of that scheme. A key feature of a robust MRV system is that it should be built on general monitoring and reporting principles such as completeness, accuracy, consistency and transparency. Although the implementation of the national emission trading scheme in China is improving, four key challenges for implementing an MRV system can be identified. These challenges were also encountered in one of the longer-running emission trading schemes, the EU ETS, which is now in its third trading period, as well as the trading schemes in the different Chinese pilots. Based on lessons learnt in these systems, the paper outlined suggestions for addressing these key challenges. Most of these suggestions would also be relevant for the design of other emission trading schemes. The conclusions of this paper are as follows:

Firstly, it is crucial to create general framework legislation that is legally binding and of a sufficiently high legal status to facilitate legal enforcement of the MRV requirements and increase the compliance levels of MRV activities. This is true for any MRV system of an emission trading scheme. The main requirements on roles and responsibilities for the stakeholders involved, timelines, scope of the ETS scheme, legal basis for MRV requirements as well as sanctions should be laid down in the legal framework legislation. More detailed requirements and standards on MRV should be included in implementing regulations that are legally binding. Templates and guidance should facilitate the interpretation and implementation of the legislation, and thereby form a complete MRV regulatory policy system.

Secondly, a monitoring plan is a key feature of an MRV system: it serves as a management tool for companies, facilitates compliance checks by the competent authority and allows for more effective verification. Lessons
learnt in the EU ETS show that defining the content of a monitoring plan in legislation helps to mitigate differences between companies and improve the quality of the monitoring plans. These plans should be subject to the approval of the competent authority and should not be changed arbitrarily without justification. Significant changes to the plan should get approval by the competent authority. When developing the rules for any MRV system, careful consideration should be given to achieving a delicate balance between cost efficiency and ensuring consistency, transparency and integrity of monitoring and reporting. Clear rules on the content of the monitoring plan and development of templates would harmonize approaches across regions and between enterprises and facilities.

Thirdly, it is important to include specific requirements on monitoring and reporting in implementing regulations to ensure compliance with the main monitoring and reporting principles. Such requirements concern for example: clear definitions, monitoring boundaries to ensure completeness of emission source streams and emission sources, general monitoring rules that are applicable to all sectors (e.g. requirements on measurement instruments, sampling and analysis), application of standards relevant for monitoring and robust quality assurance and quality control measures. A gradual development to a tier approach as applied in the EU ETS could improve consistency and accuracy of monitoring while taking into account cost effectiveness.

Fourthly, in any emerging MRV system of an emission trading scheme it is essential to ensure that there are sufficient competent and impartial verification bodies and that they are properly authorized or accredited to carry out verification. Programme specific requirements in legally binding regulations would support this verification management process. This will allow the authorities responsible for supervising verification bodies to enforce the requirements and impose sanctions if necessary.

Fifthly, IT systems are important tools to not only increase the efficiency of the MRV system, but also enhance the data quality and integrity of the system. Standard file specifications such as standard EXCEL and XML formats can have a positive effect on the design and implementation of such IT systems, expediting their development and enabling information exchange across regions. A gradual evolution of IT systems would be a more realistic approach ultimately expanding to an integrated system that covers the whole compliance cycle including monitoring plans, emission reports, verification and verification management as well as multiple stakeholder access.

It should be pointed out that the above suggestions should not necessarily all be implemented before launching an emerging emission trading scheme and in this case specifically the national carbon market in China. The establishment and improvement of the MRV system is a long process which will evolve gradually over time. Although in future more stringent requirements may be necessary to ensure a proper functioning emission trading scheme, implementing the above suggestions gradually within two to three years would have significant benefits.

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