How applicable is the GPC Inventory to Chinese Cities? A Case study of Dalian, China

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This research aims to test the aplicability of the GPC Emission Inventory tool. As the tool was designed to calculate the GHG emission of Chinese cities, the authors decided to use Dalian as the object city. Dalian is a sub-provincial administrative city, a normal city which does not have the provincial administrative level like Beijingor Shanghai. The main data resources that are used in this tool are the city's statistical yearbook and the provincial statistical yearbook. Through the data collection and calculation procedure, the emission result is shown. However, this result is only part of the total emission as the waste treatment sector and forestry sector are not able to get access to the data. The result has been reviewed by the data availbility.With the analysis of data availibility, it is able to evaluate how applicable the GPC tool is. With this result, whether the GPC tool is really efficient or not can be concluded. Furthermore, during the data collection process, the authors have found several problems on data collecting and tool designing. Suggestions and possible ways to improve the practibility of the tool are also made.

Key Words :*Greenhouse Gas, Inventory, Emission, GPC, City-level*

1. Introduction

Global Warming is one of the most-concerned environmental problems all over the world since the last century. Nowadays, over half of the world population lives in the urban areas, and the projection shows that about 68.7% of the world population will be live in the urban areas by 2050 (World Urbanization Prospects and Revision, 2009). As over 75% of global energy consumption and 80% of green house gas emissions are produced in cities (Dodman, 2009), cities are more responsible for the global warming.So far, at least half of the total carbon emission of developing countries is emitted from China and one seventh of the total carbon emission amount of the whole world is produced from China (Qin, 2014). With the fast urbanization speed, it is predicted that until the middle of the 21st century, China's energy consumption will account for more than 60% of the total global energy consumption (Qin, 2014). Therefore understanding and mitigating GHG emissions in Chinese cities are of great importance.

An emission inventory is "a database of the amount of pollutants released into the atmosphere and it is developed for scientific applications as well as for policy processes and decision making"(Samer, 2013).The inventory of a city provides scientific evidances for setting mitigation goals and monitoring the progress. One of the city-level emission inventories that is earning more and more attention is the inventory that was designed by the World Resource Institute (WRI) together with the Local Governments for sustainablity (ICLEI) and the C40 cities, which was named as Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). This is a global-standard Greenhouse Gas Emission Inventory that aimed to reach the following goal during the calculation procedure, relevance, completeness, consistency, transparency and accuracy (GPC, 2014). In 2013, theWRI, Institute of urban and environmental studies of the Chinese Academy of Social Sciences, the World Wide Fund for Nature (WWF) and the Institute for Sustainable Communities (ISC) have designed a version especially for Chinese cities. The pilot version 1.0 of the GPC tool for the Chinese cities was published in 2013. So far the tool has been updated to the 2.2 version.

The authors have reviewed the current GHG inventory research and governmental actions in China, but we have not found a detailed report about any city (Yang, Li & Xu, 2016).

This research is to test if GPC is pratical to calculate the city-level emission meanwhile fullfill all the principles which were proposed by the tool designers.The authors take Dalian, a typical Chinese city as an example. This research can provide suggestions both to city's statistical department and the developer of the inventory tool, so that the calculation can be more convenient and accuracy of the calculation results can be increased.

2. Methodology

2.1 The GPC settings

The GPC emission inventory has divided the carbon sources into five sectors. The Energy Sector, the Industrial Production sector, the Agricultural Sector, the Forestry and Land Use Sector and the Waste Management Sector.

For the calculation of the energy sector, there are 2 levels' systems, the BASIC level and the BASIC+ level. The BASIC level requires data from emissions sources that are listed on the statistical yearbooks of the cities. It follows the classification method of the China's Statistical Yearbook of 2012. The calculation result of this level is enough to be reported in GPC Inventory Report and the Provincial GHG Inventory Report. The BASIC+ level requires a more comprehensive coverage of the emissions sources, especially focusing on the industry, construction and transportation sectors. It also contains Scope 3 emissions from Stationary Energy sources (only transmission and distribution losses) and from Transportation.The calculation result of the BASIC+ level is able to reveal which part of the sector produces the most GHG emissions, so that the result of the calculation is instructive. However, the access to the data for the BASIC+ level is even more difficult, because it requires more challenging data collection and calculation procedure. Thus, because of the limitation of the data access, this research only focuses on the BASIC level.

For the rest of the sectors, activity level data are collected by details from the statistic books.

2.2Data availability and accuracy

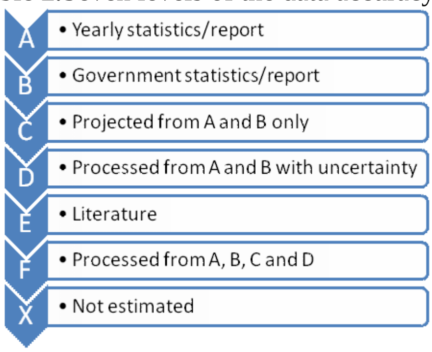
To show the result of data collection procedure clearly, the authors drew a chart for each subsector to show how much data are available for the calculation, how accurate the data is,and what the sources for the data are. Table 1 shows the technical terms that are used in the charts to identify the availability of the collected data.

Table 1. Technical terms to show the availability of the data required

Technical Terms	Definition of the term
Number	Activity data available
0	Statistics report a "0" or blank
NO	Not Occurring by judging from the references
NE	The activity is existing, but the activity amount can Not be Estimated because no data is available
NENO	Not Estimated because NO way to know if the activity exists in the city or not

In addition, the authors also divided the accuracy of the data into 7 levels, ranked from the most accurate (data from statistical yearbook) to the least accurate ones (data not estimated) shown as Table 2.

Table 2. Seven levels of the data accuracy



3. Data collection and calculation process divided by sectors

This section reports the data availability and accuracy sector by sector. Due to the space limit, we only provide some examples of our results.

3.1 Energy Sector

The combustion of energy is the major source of the urban Greenhouse Gas emissions. The GPC tool allows 2 kinds of data used to calculate the emission data of the energy sector. The first kind of data is the energy balance sheet, however, Dalian hasn't published its energy balance sheet. Thus, we can only calculate the GHG emissions from the energy sector with the 2nd kind of data, which is to collect the activity data of energy utilization from each sector. The required sectors include:

- ✧ The Agricultural, Forestry,
- ✧ Animal Husbandry and Fishery Activities;
- ✧ The Mining industries and Manufacturing industries;
- ✧ Generation and Supply industry for Electricity, Heating, Gas and Water;
- ✧ Construction Industry;
- ✧ Transport, Postal and Telecommunication

Services;
- ✧ Wholesale and Retail Trades; Hotel and Catering Services;
- ✧ Domestic Use;
- ✧ Other sectors

During collecting data for the energy sector, the collecting result of each sub-sector varies from each other. Some of the subsectors' charts can be filled with comparatively sufficient data, while others cannot. Among all the subsectors in the energy sector, the manufacturing industries have relatively sufficient data compared with subsectors like "Domestic Use subsector."Moreover, some of the subsectors, for example, there are no available data for "the Other Sectors" and it is also difficult to project from the provincial statistical yearbook due to the unclear proportion of how much it should be counted from the provincial data.Due to the length limitation, this paper provides some takes an example from each condition and present them with a subsector.

3.1.1Data collection from data sufficient subsector- The Manufacturing Subsector

The manufacturing Industry is one of the sectors that have the most full-scaled data that the authorss can get accessed from the city's statistical yearbook directly (Table 3).

3.1.2 Data collection from data insufficient subsector- The Wholesale and Retail Trades Subsector

This subsector still required projections from the provincial level data, as there are no data recorded on the city's statistical yearbook. The projection based on the number of employed persons in this industry (Table 4).

According to the chart 5-11 in the provincial statistical yearbook, the number of employed persons in this subsector of Dalian is 80,541 persons; while the total employed persons of Liaoning are 261,653.
80,541/261,653≈31%

So that Dalian had taken 31% of the total employed persons in the wholesale and retail trades subsector from Liaoning province. With this proportion, the projections can be made based on the chart 7-6 in the provincial statistical yearbook.

Raw coal：59.5*31%＝ 18.445（10^4tn）
Gasoline：21.01*31%＝ 6.5131（10^4tn）
Kerosene：0.10*31%＝0.031（10^4tn）
Diesel Oil：5*31%＝ 1.55（10^4tn）
Fuel Oil： 0.50*31%＝0.155（10^4tn）
Natural Gas：1.07*31%＝ 0.3317（10^8cu.m）

3.2 The Industrial Production Sector

The industrial production sector collected the production amount of twelve types of industrial products, aims to calculate the emission of Greenhouse gas when producing them. However, the city-level statistical yearbook was not able to fill the requirement of these data. Moreover, though the provincial statistical yearbook also had the production data of some industrial products, but the ones that the GPC inventory tool requires are different from the ones on the provincial statistical yearbook.

From the city-level statistical yearbook, only 3 types of the industrial products' production data can be collected. However, for the aluminum production, the city-level statistical yearbook only recorded the annual output but didn't mention which technique was used to produce the aluminum. Therefore, the authors looked up to the emission factor in the inventory and found that the Side-mounted self-baking anode technique has a higher emission factor than the Point feeding prebaked cells technique. To make sure that the inventory has less error, the authors categorized the production data to the technique, which has a higher emission factor. Because of this uncertainty, the data accuracy of this product was classified to D level (processed from yearly statistical yearbook with uncertainty).

3.3 The Agricultural Sector

Greenhouse Gas emission from the Agricultural Sector counted basically from 3 perspectives. The CH4 emission data from the rice field, the N2O emission from the cropland and the CH4 and N2O emission from the livestock fermentation and livestock manure management(Table 5).

Data for the Agricultural Sector were all collected from the city-level statistical yearbook. Compare with the other sectors, the city-level statistical yearbook has a more holistic coverage of the data from the agricultural sector, which are required by the inventory tool. As Dalian's climate and geography may not meet the living condition of some plants and animals, such as the sugarcane and camel. In this research, example of the CH4 and N2O emission from the livestock fermentation and livestock manure management will be listed to present this sector.

Whereas, the statistical yearbooks, no matter the city-level, or the provincial level, neither of them had divided the way of breeding when recording the breeding stock number of the animals. There was only a total number of the breeding stock, as different ways of breeding has different emission factor, the authors categorized all the data to the blank which has the highest emission factor.

3.4 The Forestry Sector

The forestry sector is vital to every city because it is the largest absorber of the Carbon Dioxide. The forestry acts as the carbon sink in the city and it is helpful to slow down the global warming and climate change. How the city do with the forestry will also affect its emission amount. The tool required two sets of data for the forestry sector; one is the activity data of different types of trees, the other is the activity data of land use changing.

The authors firstly check the data from the city-level statistical yearbook, however, none of the required data can be found. Then from the provincial statistical yearbook, only the annual area variation of the economic forest can be collected. (Table 6)

3.5 Waste management sector

Waste management sector are divided into 5 parts. 1) CH4 emission from the waste landfill ativity data. 2) CO2 emission from the waste incineration activity data. 3) CH4 emission from the domeatic sewage treatment activity. 4) CH4 emission from the industrial sewage treatment activity. 5) N2O emission from the domestic sewage and industrial sewage activities.

However, the data that the inventory required are too detailed that the statistical yearbooks do not any records that can be used (Table 7). Take the first part as an example, the inventory divided the boundaries into 3 categories and each for 4 types of landfill sites management. By contrast, the city-level and the provincial statistical yearbooks only have the total amount of how much waste are treated annually, but not mentioned anything else. Therefore, though there was a data of the annual total amount, it is quite difficult to categorize it. The same situations happened in part four as well. As a result, no data can be filled into the blanks of this part. The authors chooses one of the subsector as the example from this sector.

4. Summary of the Results

After collecting and calculating all the sectors, the availibility of each level of data and the emission of that level are listed in Table 8 and Table 9.

From the two tables, it is easy to see that A level of data accuracy takes the most part of the calculated emission. As most of the emission are from the energy sector, energy sector is one of the sectors which has a relatively sufficient data. For the energy sector, out of 270 required data, 49 of A level data accuracy and 27 C level of data accuracy are found. Rest of the data are categorized as NENO and NE since there is no availible data that can be accessed to or even is not possible to sure whether the activity actually happened. Therefore, the percentage that NE and NENO takes is 75.32% of the required data in the energy sector. This indicates that there are still lots of uncertainties and lost parts in the energy sector even though its emission has taken the most part of the total emission.

Then for the industrial sector, only 2 out of 28 data are commited as level A data accuracy and one for level D data accuracy. 89.29% of data are unknown and this might cause big miss of emission.

Conditions are even worse for the forestry sector and the waste sector. Only one data from the forestry sector can be found and no data can be used to calculate the emission from the waste management sector.

By the comparison, conditions for the agricultural sector are much better. Only 29.03% of the required data cannot be filled into the tool, and this number are coming from the “NO”s of the data which actually means that no activities occurred for these categories.

In total, 75.6% of the data are marked as NO, NENO and NE. From the data availibility perspective, this is quite a big miss of data which effect the completeness of the emission result. Especially for the waste treatment sector, there are no data at all. Meanwhile,the A level of data accuracy only takes part of 16.75% of the total number of data. This is a very small proportion of the accurate data for the whole calculation procedure. This reveals the problem of not able to get access to the published and accurate data for most of the data that the tool requires. However, as the A level of data accuracy are mostly from the energy sector and the agricultural sector, the two sectors which have more sufficient data than the other sectors, the result of the calculated emission is closer to the real emission amount for these two sectors.

5. Findings and Conclusions

Throughout the whole data collection process and analysis part, the authors would like to emphasize the following findings, and make suggestions which might be helpful.

Table 3. Energy Consumption inthe Manufacturing Industry

Name of the Energy (Unit of measurement)	**Total Activity amount**					**Data Accuracy**	**Source**
		Raw Materials	**Energy converted not as fuel and power**	**Recycled amount**	**Transportation tools emission**		
Raw Coal,10^4tn	526.7009	NE	NE	NE	NE	A	Note
Cleaned Coal,10^4tn	7.62694	NE	NE	NE	NE	A	Note
Other Washed Coal10^4tn	15.60785	NE	NE	NE	NE	A	Note
Briquettes10^4tn	NENO	NE	NE	NE	NE	X	
Gangue10^4tce	0.7852	NE	NE	NE		A	Note
Coke10^4tn	1.28827	NE	NE	NE		A	Note
Coke Oven Gas10^8cu.m	0.007868	NE	NE	NE		A	Note
Blast Furnace Gas 10^8cu.m	0.000102	NE	NE	NE		A	Note
Converter Gas10^8cu.m	NENO	NE	NE	NE		X	
Other Gas10^8cu.m	NENO	NE	NE	NE		X	
Other Coking Products10^4tn	NENO	NE	NE	NE		X	
Crude Oil10^4tn	2449.7894	NE	NE	NE		A	Note
Gasoline10^4tn	3.747636	NE	NE	NE	NE	A	Note
Kerosene10^4tn	0.162213	NE	NE	NE	NE	A	Note
Diesel Oil10^4tn	15.656268	NE	NE	NE	NE	A	Note
Fuel Oil10^4tn	59.372844	NE	NE	NE	NE	A	Note
Naphtha10^4tn	159.9041	NE	NE	NE		A	Note
Lubricants10^4tn	0.145585	NE	NE	NE		A	Note
Paraffin Waxes10^4tn	NENO	NE	NE	NE		X	
White Spirit10^4tn	0.0284	NE	NE	NE		A	Note
Bitumen Asphalt10^4tn	0.48122	NE	NE	NE		A	Note
Petroleum Coke10^4tn	3.521387	NE	NE	NE		A	Note
LPG10^4tn	19.891514	NE	NE	NE	NE	A	Note
Refinery Gas10^4tn	64.3361	NE	NE	NE	NE	A	Note
Other Petroleum Products10^4tn	4.441436	NE	NE	NE		A	Note
Natural Gas10^4tn	0.508461	NE	NE	NE	NE	A	Note
LNG10^4tn	1.127041	NE	NE	NE	NE	A	Note
Heat10^{10}kJ	4229.34481	NE	NE	NE		A	Note
Electricity 10^8kW•h	144.1964	NE NE	NE NE	NE NE	NE	A	Note Collected from chart 11-7 in DSY
Other Energy10^4tce	0.0892	NE	NE	NE	NE	A	Note

Note: Collected from chart 11-4 in DSY

Table 4. Energy Consumption inthe Wholesale and Retail Trades Subsector

Name of the Energy (Unit of measurement)		Total Activity Amount	Transportation tools emission	Data Accuracy	Note
Raw Coal,	10^4tn	4.258	NE	C	Projected from charts 13-8 &7-6 in LSY
Cleaned Coal,	10^4tn	NENO	NENO	X	
Other Washed Coal	10^4tn	NENO	NENO	X	
Briquettes	10^4tn	NENO	NENO	X	
Gangue	10^4tce	NENO		X	
Coke	10^4tn	NENO		X	
Coke Oven Gas	10^8cu.m	NENO		X	
Blast Furnace Gas	10^8cu.m	NENO		X	
Converter Gas	10^8cu.m	NENO		X	
Other Gas	10^8cu.m	NENO		X	
Other Coking Products10^4tn		NENO		X	
Crude Oil	10^4tn	NENO		X	
Gasoline	10^4tn	12.13	NE	C	Projected from charts 13-8 &7-5 in LSY
Kerosene	10^4tn	NENO	NENO	X	
Diesel Oil	10^4tn	24.0842	NE	A	Collected from chart 4-13(2)in DSY
Fuel Oil	10^4tn	NENO	NENO	X	
Naphtha,	10^4tn	NENO		X	
Lubricants	10^4tn	NENO		X	
Paraffin Waxes	10^4tn	NENO		X	
White Spirit	10^4tn	NENO		X	
Bitumen Asphalt	10^4tn	NENO		X	
Petroleum Coke	10^4tn	NENO		X	
LPG	10^4tn	NENO	NENO	X	
Refinery Gas	10^4tn	NENO	NENO	X	
Other Petroleum Products10^4tn		NENO		X	
Natural Gas	10^4tn	NENO	NENO	X	
LNG,	10^4tn	NENO	NENO	X	
Heat,	10^{10}kJ	NENO		X	
Electricity10^8kW•h		4.258	NE	A	Collected from chart 11-7 in DSY
Other Energy	10^4tce	NENO	NENO	X	

Table 5. The CH_4 and N_2O emission from the livestock fermentation and livestock manure management.

Animal Species	Breeding Stock			Note	Data Accuracy	Attention
	Large-scale breeding	Breeding by famers	Free range husbandry			
Cow	NE	NE	20371	Collected from chart 4-8 in DSY	D	Data are defaulted to category with the highest emission factor
Non-cow	NE	NE	296761	Collected from chart 4-8 in DSY	D	
Buffalo	NO	NO	NO		X	
Sheep	20830	NE	NE	Collected from chart 4-8 in DSY	D	
Goat	626405	NE	NE	Collected from chart 4-8 in DSY	D	
Pig	2677945			Collected from chart 4-8 in DSY	A	
Poultry	73483400			Collected from chart 4-8 in DSY	A	
Horse	9640			Collected from chart 4-8 in DSY	A	
Donkey/Mule	30244			Collected from chart 4-8 in DSY	A	
Camel	NO				X	

Table 7. Activity level datafortheWaste Management Subsector

		data	Type of the landfill site	data	Recycled amount of Methand
Landfill Amount	Produced inside boundary and processed inside boundary(10^4tn)	NE	Managed **%**	NE	NE
			Non-managed—deep burial（>5m）**%**	NE	
			Non-managed —shallow burial（<5m）**%**	NE	
			Non-classified **%**	NE	
	Produced outside boundary and processed inside boundary(10^4tn)	NE	Managed **%**	NE	NE
			Non-managed—deep burial（>5m）**%**	NE	
			Non-managed —shallow burial（<5m）**%**	NE	
			Non-classified **%**	NE	
	Produced inside boundary and processed outside boundary(10^4tn)	NE	Managed **%**	NE	NE
			Non-managed—deep burial（>5m）**%**	NE	
			Non-managed —shallow burial（<5m）**%**	NE	
			Non-classified **%**	NE	
Component of the landfill garbage	Food waste(%)	NE			
	textile(%)	NE			
	Garbage from the park(%)	NE			
	paper(%)	NE			
	Wood and straw (%)	NE			

Table 6.Activity level data forthe Forestry Subsector

	Stock Volume (m^3)	Annual area variation (ha.)	Total area (ha.)	Note	Data Accuracy
Arboreal forest	NE		NE		X
Woodland，Scattered tree, trees planted by the side of house, roads, rivers and fields	NE				X
Bamboo forest		NE			X
Economic forest		800		Collected from chart 13-25 in LSY	A
Shrubbery		NE			X

Table 8.Data availibility and emission proportion of each level of data accuracy of each sector

Sector	Subsector	Number of Data	Total GHG	A level of DA	GHG	C level of DA	GHG	D level of DA	GHG	NO	NE	NENO	Percentage of NO、NE and NENO
Energy	All Subsectors	270	17246.12	49	15804.1	27	1442					194	75.32%
	Biomass	4									4		
	FE of NG	12									12		
	FE of Oil	16								8	8		
	Information	6									6		
Industry		28	769.04	2	761.37			1	7.67	9	9	7	89.29%
Agriculture	Rice cultivation	3		1	error occurred					2			29.03%
	Crop	18	38.48	13	38.48					5			
	Enteric and waste management	10	155.66	4	cannot be separated			4	cannot be separated	2			
Forestry and Land	Forestry	6	-5.2	1	-5.2						5		88.89%
	Land use	3										3	
Waste	Waste Landfill	14										14	100%
	Waste Incineration	6										6	
	Household Wastewater	9										9	
	Industry	13										13	
Total number		418	18204.1	70	16598.8	27	1442	5	7.67	26	44	246	75.60%

Table 9.Data availibility and emission proportion of each level of data accuracy compare with the total

Level of DA	A	C	D	NO	NE	NENO
Total number of each level	70	27	5	26	44	256
Percentage it takes of the total number of Data	16.75%	6.46%	1.20%	6.22%	10.53%	61.24 %
Total emission of each level	>16598.79	1441.98	>7.67	——	——	——
Emission percent-age	>91.18%	7.92%	>0.04%	——	——	——

5.1From the viewpoint of data collection

(1) The lack of published data

Unlike Beijing or Shanghai which are municipalities directly under the Central Government, Dalian is just a normal Chinese city. In China, the municipalities are managed as provonces. Therefore, they have more sufficient yearbooks which cover more data that can be used by the GPC tool. However, Dalian does not have those data reported dependently, but reported together with Liaoning province. Since the inventory tool aimed to cover all carbon sources and carbon sinks of the city, it is important to get access to the required data from published resources.Dalian, as a sub-provincial administrative city, should have a more open-accessed statistical database to show the transparency of the city management.

(2) The projected data might not be accurate

As some of the data are only recorded on the provincial statistical yearbook as a whole with the intire province, it is not easy to make accurate projections from the total number. For example, in the energy sector, the city-level statistical yearbook does not have records for several subsectors, therefore, to get a relatively accurate data, projections are made according to the employed persons, or products output, etc. However, this still might not be accurate to calculate the emission.

(3) The indistinct definition of the data

During the data collection process, indistinct definition of the data had caused problems. Take an example of the consumption of raw coal in the construction industry;Chinese names for raw coal are recorded differently on the tool and the statistical yearbooks.Theauthors took some time to find out if the 2 names identify to the same object. Moreover, when collecting data for “the other sectors” under the energy sector, “the other subsectors” in the provincial yearbook was not defined as which subsectors in details, it is hard to figure out if the data on the provincial statistical yearbook can be used in the GPC tool. This kind of uncertainty increases the inaccuracy for the final calculation result. To avoid problems like these, more standardized terminology should be regulated to verify the same object. On the other hand, the provincial statistical yearbook should identify its data more clearly.

5.2 From the viewpoint of Inventory tool design

(1) The data that the tool requires are too detailed that the available ones cannot be classified.

Some of the sectors require the data that are too detailed. Take the waste management sector as an example, the GPC tool asked for the data that specified to the boundaries and the depth of burial. However, only the total number of waste disposal is published; no further details can be found. Thus, it is impossibe to fill in the blanks that the tool required because of the total number cannot be classified and fullfill the blanks. As a result, the waste management sector does not have any data; no emission can be calculated from the waste treatment sector.Waste treatment sector is one of the main carbon sources in the urban system, without the calculation, the total number of a city’s emissionlacks a big part. Though the result will be more accutate if data are required more detailed, it is difficult for most of the Chinese cities to fill in the data which are so specifically. To solve problems like this, it might be better if the tool just require one total number or less number so that it is not that difficult to collect the data.

(2) The way of collecting biomass fuel data is irrational.

In the GPC inventory tool, the activity data of the biomass fuel is collected independently within the energy sector. Four main types of the biomass fuel are required to fill in with a total consumption number. However, in the city-level statistical yearbook, the biomass fuel is not recorded independently but counted into the energy consumption devided by industries under the energy sector. Therefore, the activity data for biomass fuel cannot be filled in to the inventory tool directly. The tool was developed to cover all the emission sources, which includes the burning of biomass fuel. To count the biomass fuel consumption in the manufacturing subsector under the energy sector, the authors had to convert the energy of biomass fuel to the coal equivalent.

So far, as the detailed consumption record of biomass fuel is not available in the city-level statistical yearbook, it is better to just collect the data subsector by subsector.

3) The switch of unit measurements is inappropriate.

As the tool is designed for the city-level inventory, the units of the data that the tool requires are too high. For example, the tool requires the activity level data of raw coal in 104ton. However, on the city-level statistical yearbook, the activity level data are recorded in ton. Thus, to fill in the inventory tool, the users have to switch the unit firstly. This is an extra movement that can be avoided from the design of the tool. As the tool mainly focus on the city-level data, the tool should use the units that are same with the statistical yearbooks so that the users will not have to do more calculations.

5.3 Overview of the tool

The GPC inventory tool for Chinese cities developed by WRI together with the Institute of urban and environmentl studies of the Chinese Academy of Social Sciences, the WWF and the ISC, is an inventory that covers a complete carbon sources in the city. It has reached the principal of completeness. However, the tool was not fully filled because of the lack of data. Dalian, as a normal Chinese city, does not have much published data that can be used for the emission calculation. Also, many of the data were counted with uncertainty. For the tool developers, it is better to know that a normal Chinese city does not hav much data published compared with cities like Beijing or Shanghai. Therefore, when collecting the data, the tool should not require data that are classified in too much detail. Though accuracy is also one of the principals of the inventory, it does not work if there are data but cannot fill into the tool. Therefore, even though the result might be not that accurate, it is better than no emission result can be counted.

In a word, as the current situation of data availibility, cities like Dalian and less developed than Dalian would not be able to calculate the total emission through this tool. Cities that are more developed and have higher administrative level may have more completed published data that can fill the requirement of the GPC tool.

5.4 Summary and Conclusion of the whole research

This research is to test if the GPC Inventory tool is applicable to the city-level inventory counting. The authors has used Dalian as the object city and most of the data are found from the city-level statistical yearbook and provincial statistical yearbook.

The final calculation result is analyzed by the data availibility and emission proportation. From the result, 75.6% of the data that the tool required for the calculation are not able to be filled into the tool, which leaves an unknown emission. Moreover, data which are A level of data accuracy only takes 16.75% of the required data.

During the data collection period, several problems are found which are related with the data and the design of inventory tool. Problems from the data's perspective are 1) the lack of published data, 2) the indistincedefination of the data and 3) The projections of the data may not be accurate. While problems from the tool design's perspective are 1) the data that the tool requires are too detailed that the available ones cannot be classified, 2)the way of collecting biomass fuel data is irrational and 3) the switch of unit measurements is inappropriate.

Overall, so far, the application of GPC inventory tool on the normal city's emission calculation still needs more time. As the limitations on the data published and data that can be accessed from reliable sources, the calculation for the city's emission is incomplete. To have a more accurate and complete emission result, the developers of the tool should make some changes on the data required by the tool, while the cities also need to improve their data quality.

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