

Online Accounting Method for Carbon Emission of Coal Mines owned by the Coal Industry Group

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Abstract: An online carbon emission accounting method based on B/S structure for coal mines owned by the Coal Industry Group is proposed. Firstly, the carbon emission accounting method for coal mines owned by the Coal Industry Group is expounded, which is the basis of carbon emission accounting for coal mines. Secondly, an online accounting path of carbon emission for coal mines owned by the Coal Industry Group is proposed: The traditional top-down standalone accounting process of "carbon emission data acquisition, carbon emission calculation, carbon emission publication" is replaced by the bottom-up online accounting process of "carbon emission accounting tasks assignment, carbon emission data submission, carbon emission data audit, carbon emission calculation, carbon emission view", and the manual table lookup is replaced by system automatic table lookup to realize online calculation of carbon emissions. Then, taking Sql server as the database management system, ASP, C# as the development language, Dreamweaver, Visual Studio as the development platform, an online carbon emission accounting system based on B/S structure for coal mines owned by the Coal Industry Group is designed, which realizes online carbon emission accounting for coal mines owned by the Coal Industry Group. Finally, the application analysis results show that the method proposed in this paper can not only significantly improve the efficiency and accuracy of carbon emission accounting for coal mines owned by the Coal Industry Group, but also realize online sharing and comparison of accounting results, which is conducive for the Coal Industry Group to implement targeted monitoring and improvement of carbon emissions for coal mines owned by the Coal Industry Group.

Keywords: Online carbon emission accounting; B/S structure; Sharing and contrast.

1. Introduction

Global warming is a serious challenge for the current society, and the greenhouse effect caused by excessive greenhouse gas emissions is the main cause of warming [1-5]. CO₂ is one of the most important greenhouse gases, and reducing carbon emissions has become the focus of global environmental governance [5-10]. In 2020, China has clearly put forward the carbon peak by 2030 and carbon neutral by 2060 [11-13]. In 2021, global energy-related CO₂ emissions increased by 6% from the previous year to 36.3 billion tons, setting a new record high. Among them, China's CO₂ emissions exceed 11.9 billion tons, accounting for 33% of the global total, and reducing carbon emissions has become an urgent and difficult task in China's environmental management [14-16]. From the perspective of the industry, as the main energy source, the coal industry contributes more to China's carbon emissions, second only to the chemical industry [17-18]. In the context of "double carbon", the coal industry must take the lead [19]. It is known that the traditional practice of accounting for carbon emissions is to account for the whole enterprise [20]. However, the Coal Industry Group is a special type of enterprise, and the carbon emissions of its subordinate coal mines are the main part of the carbon emissions of the group, so if the accounting is done for the group as a whole, the accounting results will inevitably be too general [21], which is not conducive to identifying coal mines with large carbon emissions, monitoring and improving them effectively. For a Coal Industry Group, a more reasonable approach is to account for carbon emissions of its subordinate coal mines separately, and then aggregate the carbon emissions of each coal mine to obtain the total carbon emissions of the group. However, because the number of

subordinate coal mines in a Coal Industry Group is often large, if the traditional top-down standalone accounting method of "carbon emission data acquisition, carbon emission calculation, carbon emission publication", are adopted there must be disadvantages such as inefficient data collection [22-23], cumbersome and error-prone carbon emission calculation process [24], and lack of online sharing of carbon emission [25]. Based on this, an online carbon emission accounting method based on B/S structure for coal mines owned by the Coal Industry Group is proposed.

2. Carbon emission accounting method for coal mines

In order to facilitate the description of the carbon emission accounting method for coal mines owned by the Coal Industry Group, the variables are defined in Table 1.

Table 1. Variables definition

Variables	Meaning	Unit of measurement
E_{CO_2}	Annual CO ₂ emissions	tCO ₂ e
E_{burn}	Annual fossil fuel burn CO ₂ emissions	tCO ₂
AD_i	Annual consumption of the <i>i</i> th fossil fuel	t(solid, liquid) or million m ³ (gas)
EF_i	Emission factor of CO ₂ for the <i>i</i> th fossil fuel	tCO ₂ /t (solid, liquid) or tCO ₂ /m ³ (gas)
E_{pe}	Annual CO ₂ emissions from purchased electricity for the year	tCO ₂
AD_{pe}	Annual purchased electricity	MWh
EF_e	Average CO ₂ emission factor of purchased/output electricity	tCO ₂ /MWh

E_{oe}	Annual output of electricity corresponding to CO2 emissions	tCO2
AD_{oe}	Annual electricity output	kWh
E_{ph}	Annual purchased heat corresponding to CO2 emissions	tCO2
AD_{ph}	Annual purchased heat	GJ
AD_{hw}	Annual heat of hot water	GJ
AD_{sas}	Annual heat of saturated steam	GJ
AD_{sus}	Annual heat of superheated steam	GJ
EF_h	Average CO2 emission factor of purchased/output heat	tCO2/GJ
E_{oh}	Annual heat output corresponding to CO2 emissions	tCO2
AD_{oh}	Annual heat output	GJ
Ma_{ω}	Quality of purchased/output hot water	t
T_{ω}	Temperature of purchased/output hot water	°C
Ma_{st}	Quality of purchased/output steam	t
En_{st}	Saturated/superheated steam enthalpy	kJ/kg
P	Saturated/superheated steam pressure	MPa
T	Saturated/superheated steam temperature	°C
E_{eCH4}	Annual escaped emissions of CH4	tCO2e
Q_{eCH4}	Annual escaped volume of CH4 from mining	m3
Q_{pCH4}	Annual escaped volume of CH4 from post-mine activities	m3
Q_{dCH4}	Annual destructed volume of CH4 by torch combustion or catalytic oxidation	m3
Q_{rCH4}	Annual recovered volume of CH4	m3
E_{eCO2}	Annual escaped emissions of CO2	tCO2e
Q_{mCO2}	Annual escaped volume of CO2 from mining	m3
Q_{rCO2}	Annual recovered volume of CO2	m3
E_{tCCO2}	Annual emissions of CO2 from torch combustion or catalytic oxidation	tCO2
t	Annual operating hours of the ventilation fan	h
Q_{if}	Air flow of the total air inlet roadway	m3/min
φ_{iCH4}	Volume concentration of CH4 in the total air inlet roadway	%
Q_{rf}	Air flow of the total air return roadway	m3/min
φ_{rCH4}	Volume concentration of CH4 in the total air return roadway	%
Q_e	Annual extracted volume of gas	m3
φ_{eCH4}	Volume concentration of CH4 of the extraction system	%
φ_{iCO2}	Volume concentration of CO2 in the total air inlet roadway	%
φ_{rCO2}	Volume concentration of CO2 in the total air return roadway	%
φ_{eCO2}	Volume concentration of CO2 of the extraction system	%

According to the accounting standard "GB_T 32151.11-2018 Accounting and Reporting Requirements for Greenhouse Gas Emissions Part 11 Coal Producers", carbon emissions from coal mines include burn emissions, electricity emissions, heat emissions, CH4 escaped emissions, and CO2

escaped emissions. The annual CO2 emissions are calculated by formula (1). The annual burn emissions are calculated by formula (2). Electricity emissions are divided into purchased electricity emissions and output electricity emissions. The annual purchased electricity emissions are calculated by formula (3). The annual output electricity emissions are calculated by formula (4). Heat emissions are divided into purchased heat emissions and output heat emissions. The annual purchased heat emissions are calculated by formula (5). The annual output heat emissions are calculated by formula (6). The ADph and ADoh are calculated according to the type of heat (hot water, saturated steam, superheated steam) by formula (7), (8), and (9), respectively. The CH4 escaped emissions are calculated by formula (10). The CO2 escaped emissions are calculated by formula (11). Among them, for QWCH4 and QWCO2, because in actual operation, the data of CH4 and CO2 relative embezzlement of each coal mine are not easy to obtain, and the results are not very accurate when calculated according to the 2018 standard, the calculation method for these two quantities is borrowed from the 2014 standard and calculated by formula (12) and (13) respectively.

$$E_{CO2} = E_{burn} + E_{pe} - E_{oe} + E_{ph} - E_{oh} + E_{em} + E_{Co2e} \quad (1)$$

$$E_{burn} = \Sigma(AD_i \times EF_i) \quad (2)$$

$$E_{pe} = AD_{pe} \times EF_e / 1000 \quad (3)$$

$$E_{oe} = AD_{oe} \times EF_e / 1000 \quad (4)$$

$$E_{ph} = AD_{ph} \times EF_h \quad (5)$$

$$E_{oh} = AD_{oh} \times EF_h \quad (6)$$

$$AD_{hw} = Ma_{\omega} \times (T_{\omega} - 20) \times 4.1868 \times 10^{-3} \quad (7)$$

$$AD_{sas} = Ma_{st} \times (En_{st} - 83.74) \times 10^{-3} \quad (8)$$

$$AD_{sus} = Ma_{st} \times (En_{st} - 83.74) \times 10^{-3} \quad (9)$$

$$E_{eCH4} = (Q_{eCH4} + Q_{pCH4} - Q_{dCH4} - Q_{rCH4}) \times 0.717 \times \frac{21}{1000} \quad (10)$$

$$E_{eCO2} = (Q_{wCO2} - Q_{rCO2}) \times 1.97 / 1000 + E_{tCCO2} \quad (11)$$

$$Q_{wCH4} = t \times 60 \times (Q_{if} \times \varphi_{iCH4} - Q_{rf} \times \varphi_{rCH4}) + Q_e \times \varphi_{eCH4} \quad (12)$$

$$Q_{wCO2} = t \times 60 \times (Q_{if} \times \varphi_{iCO2} - Q_{rf} \times \varphi_{rCO2}) + Q_e \times \varphi_{eCO2} \quad (13)$$

3. Online accounting path of carbon emission for coal mines

In order to realize the online accounting of carbon emission for coal mines owned by the Coal Industry Group, the accounting process of "carbon emission accounting tasks assignment, carbon emission data submission, carbon emission data audit, carbon emission calculation, carbon emission view" is proposed as shown in Figure 1.

The special flow is as follows.

- (1) Each year, before accounting the Coal Group Administrator issues the carbon emission accounting tasks and notifies the Coal Mine Accountant of each coal mine to submit the carbon emission data of each coal mine.
- (2) Each Coal Mine Accountant submits the carbon emission data by categories through the online accounting system.
- (3) The Coal Group Administrator audits the carbon emission data submitted by each coal mine in turn, rejects the problematic carbon emission data and gives reasons for rejection.
- (4) Each Coal Mine Accountant verifies the rejected carbon emission data, corrects it if necessary and submits it again, and gives explanations when submitting.

- (5) The cycle continues until all the carbon emission data of each coal mine are audited and approved.
- (6) The Coal Group Administrator sets the status of the accounting task to "Close" and calculate the carbon emissions of each coal mine through the online accounting system and summarize them to get the total carbon emissions of Coal Industry Group.
- (7) After the calculation, the Coal Group Administrator can view and make horizontal /vertical comparison of the carbon emission of Coal Industry Group through the carbon emission board, and the Coal Mine Accountant can view and make vertical comparison of the carbon emission of this coal mine through the carbon emission board.

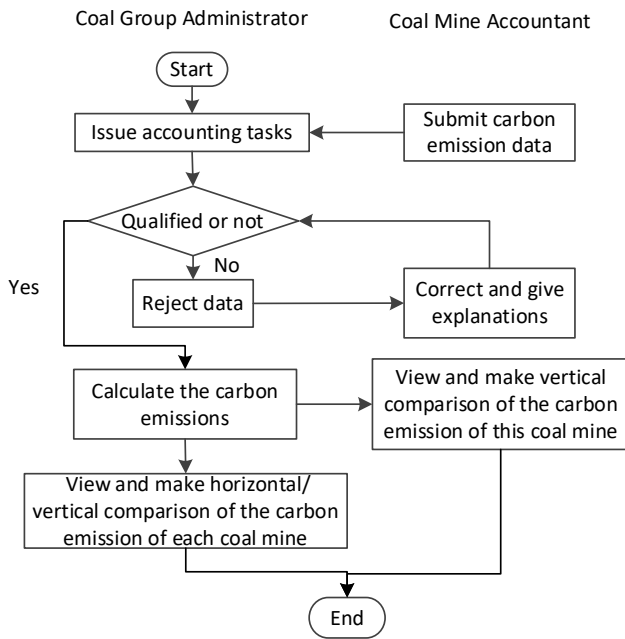


Figure 1. Online accounting process of carbon emissions for coal mines owned by the Coal Industry Group

In the accounting process shown in Figure 1, the carbon emission calculation process involves table lookup. If manual table lookup is adopted, it is impossible to realize automatic carbon emission calculation, so it must be converted into system automatic table lookup. The manual table lookups in the coal mine carbon emissions calculation process mainly include the acquisition of fossil fuel emission factors, electricity emission factors, saturated steam enthalpy, and superheated steam enthalpy. Among them, the method to accomplish system automatic table lookup of fossil fuel emission factors and electricity emission factors is relatively simple: it only needs to store the fossil fuel emission factors and electricity emission factors into the database, and then query the fossil fuel emission factors according to the name of the fossil fuel, and the electricity emission factors according to the year. The saturated steam enthalpy and superheated steam enthalpy are obtained by the "interpolation" method. For saturated steam, the saturated steam enthalpy is obtained by the following steps. For saturated steam, the saturated steam enthalpy is obtained by the following steps(referred to as the "two-parameter linear interpolation method" in this paper, Figure 2). Firstly, obtain En_a by linear interpolating according to temperature of the saturated steam(shown in formula 14). Secondly, obtain En_b by linear interpolating according to pressure of

the saturated steam(shown in formula 15). Thirdly, the arithmetic mean of En_a, En_b is taken as the enthalpy value. For superheated steam, obtain superheated steam enthalpy by "proportional double interpolation method" according to temperature and pressure, the formula shown in equation (16) ($T_0, T_1, P_0, P_1, En_{00}, En_{10}, En_{01}, En_{11}$ see Table 2). The method of automatic enthalpy calculation is as follows. Firstly, store saturated steam enthalpy and superheated steam enthalpy in a database (Sql Server database). Secondly, design two scalar functions (GetbhEn and GetgrEn) to obtain saturated steam enthalpy and superheated steam enthalpy.

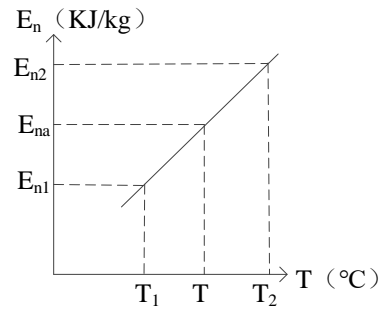


Figure 2. Two-parameter linear interpolation method

$$En_a = T_1 + \frac{En_2 - En_1}{T_2 - T_1} \times (T - T_1) \quad (14)$$

$$En_b = P_1 + \frac{En_2 - En_1}{P_2 - P_1} \times (P - P_1) \quad (15)$$

$$En = En_{00} + \frac{En_{10} - En_{00}}{T_1 - T_0} \times (T - T_0) + \frac{En_{01} - En_{00}}{P_1 - P_0} \times (P - P_0) \quad (16)$$

Table 2. Enthalpy table

		$T(^{\circ}C)$			
		...	T_0	T_1	...
$P(Mpa)$	
	P_0	...	En_{00}	En_{10}	...
	P_1	...	En_{01}	En_{11}	...

4. Design of online carbon emission accounting system for coal mines

4.1. Functional Planning

As shown in Figure 1, the users in the online carbon emission accounting system of coal mines owned by the Coal Industry Group can be divided into two types of roles: one is the Coal Group Administrator, who is mainly responsible for basic data maintenance, carbon emission accounting tasks management (accounting tasks issuance, accounting tasks opening and closing, carbon emission data audit), carbon emission calculation, carbon emission view, etc.; the other is the Coal Mine Accountant, who is mainly responsible for the carbon emission data submission and the view the carbon emission of this coal mine. The function module of Coal Group Administrator is shown in Figure 3, which mainly includes five modules: system and security, basic data management, carbon emission accounting tasks management, carbon emission calculation, and carbon emission viewing. The function module of Coal Mine Accountant is shown in Figure 4, which mainly includes three modules of system and security, carbon emission accounting tasks management and carbon emission viewing.

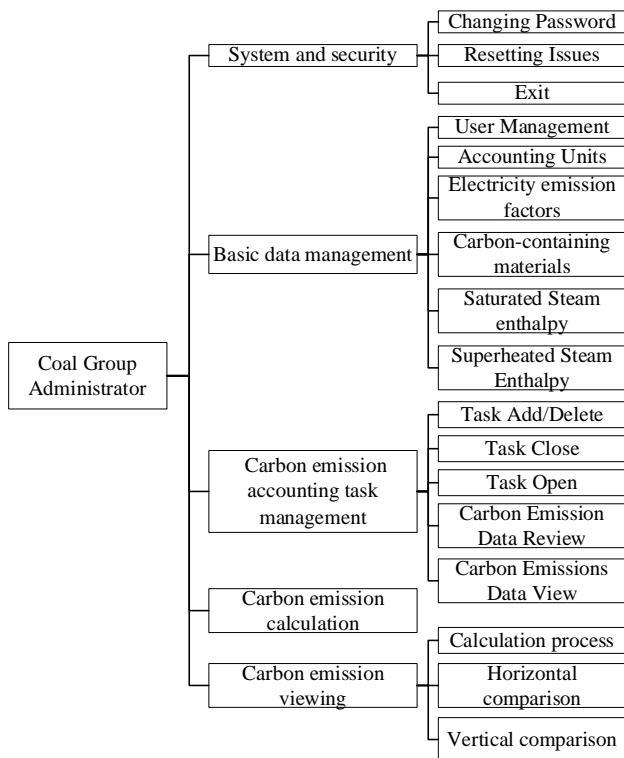


Figure 3. Coal Group Administrator Function Module

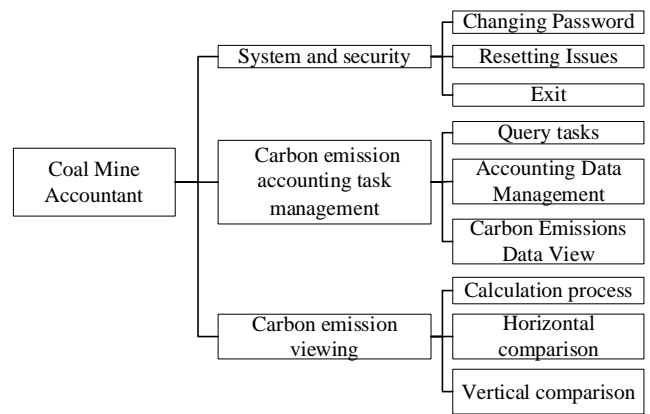


Figure 4. Coal Mine Accountant function module

4.2. Database design

Taking Sql server as the database management system, the database required for the system is designed according to the standardized design principles.

(1) Structure design of data table

The database mainly includes 13 data tables which are Unit, User, Accounting units, Carbon emission accounting tasks, Electricity emission factors, Carbon containing materials, Saturated steam enthalpy, Superheated steam enthalpy, Burn emissions, Emissions from electricity and heat, Escaped emissions of CH₄ during mining, Gas component during mining, and Total carbon emissions. The description of each data table is shown in Table 3, and the relationship between each data table is shown in Figure 5.

Table 3. Description of data tables

Serial number	Table name	Role	Remarks
1	Unit	Store coal mine information owned by the Coal Industry Group	
2	User	Stores the legal users of the system	
3	Accounting units	Stores accounting units for each coal mine	A mine can have one or more accounting units
4	Carbon emissions accounting tasks	Storing carbon accounting tasks	One accounting unit corresponds to one accounting tasks per year
5	Electricity emission factors	Store the electricity emission factors for each year in the area where the Coal Industry Group is located	
6	Carbon containing materials	Store data on carbon content, carbon oxidation rate, and carbon emission factor of fossil fuels or other carbon containing compounds	
7	Saturated steam enthalpy	Storage of saturated steam enthalpy table	Used for interpolation to obtain saturated steam enthalpy values
8	Superheated steam enthalpy	Storage of superheated steam enthalpy table	Used to interpolate to obtain superheated steam enthalpy values
9	Burn emissions	Store fossil fuel burn emissions data from coal mines	
10	Emissions from electricity and heat	Store coal mine electricity and heat emissions data	
11	Escaped emissions of CH ₄ during mining	Store CH ₄ escaped emissions and CO ₂ escaped emissions during mining	
12	Gas component during mining	Store the components of gas in the process during mining	
13	Total carbon emissions	Store the annual carbon emission fraction and total carbon emission of each coal mine	

The fields in Table 4 are calculated fields.

(2) Scalar functions design

Two functions, GetbhEn and GetgrEn, are designed to automatically get value of the field "enthalpy" in the data

table " Emissions from electricity and heat " by interpolation. The specific design is omitted.

(3) Trigger design

In order to automatically update the field "Carbon content

of non-CO2 gas" in the data table " Escaped emissions of CH4 during mining" when the data table " Gas component during mining " is changed, an insert and a update trigger are designed for the data table " Gas component during mining "; In order to achieve automatic interpolation of the field "Enthalpy" by call the scalar functions GetbhEn and GetgrEn, an update trigger is designed for the data table " Emissions from electricity and heat "

(4) Stored procedure design

In order to realize the calculation of each part of carbon emission and the total carbon emission of each coal mine, an online stored procedure named "Carbon emission calculation" is designed. Double cursors are in the stored procedure. The outer cursor is used for dealing with each coal mine, and the inner cursor is used for dealing with each accounting unit of each coal mine.

Table 4. Fields of data tables

Serial number	Fields	Table
1	Burn emissions	Burn emissions
2	Emissions for purchased electricity	
3	Emissions for output electricity	
4	Emissions for purchased heat	Emissions from electricity and heat
5	Emissions for output heat	
6	CH4 destruction from torch combustion or catalytic oxidation	
7	CH4 emissions from exhaust system	
8	CO2 emissions from exhaust system	
9	CH4 emissions from extraction system	
10	CO2 emissions from extraction system	
11	CH4 destruction from gas recovery	Escaped emissions of CH4 during mining
12	CO2 destruction from gas recovery	
13	CH4 emissions from post-mine activity	
14	ECH4 escaped emissions	
15	ECO2 escaped emissions	
16		
17	Ers	
18	Egrd	
19	Escd	
20	Egrr	
21	Escr	
22	Ech4ty	Total carbon emissions
23	Eco2ty	
24	Eco2	

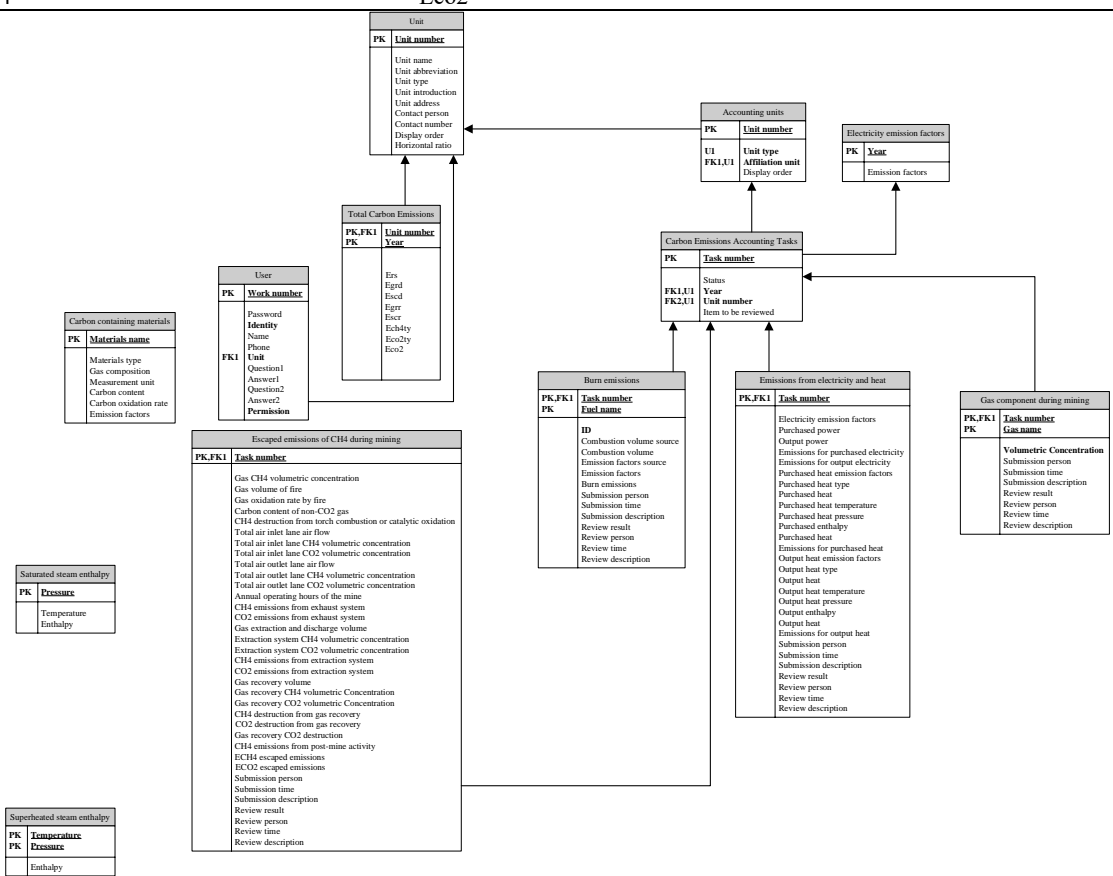


Figure 5. Inter-table relationship

4.3. Programming

Taking ASP and C# as development languages,

Dreamweaver 8.0 and Visual Studio 2019 as development platforms, an online carbon emission accounting system is designed. Among it, the carbon emission calculation is

realized by calling the stored procedure "carbon emission calculation".

5. Application Analysis

Coal Industry Group P is located in Pingdingshan City, Henan Province. There are 14 coal mines owned by it. The method proposed in this paper is applied to calculate carbon emissions of the 14 coal mines for each year from 2015 to 2021 online. The carbon emission board of the 14 coal mines is shown in Figure 6.

If we want to see the specific details of each carbon emission, we can do as the following two steps: Step 1, click

on the blue number in the carbon emission board to see the accounting tasks. Take the carbon emission (596,755.9 tons) of mine 1 in 2021 as an example, the accounting tasks (There is only one accounting task 163 in this application case.) are listed in Figure 7. Step 2, click on the blue number in Figure 7 to see its calculation process. For example, the calculation process of the total carbon emission (596755.9) of accounting task 163 is shown in Figure 8. In addition, if we want to view the composition of the total carbon emission of each calculation task, we can click on the right link [link](#) in Figure 7. For example, the composition of the total carbon emission of accounting task 163 is shown in Figure 9.

Serial number	Year	Mine 1	Mine 2	Mine 3	Mine 4	Mine 5	Mine 6	Mine 7	Mine 8	Mine 9	Mine 10	Mine 11	Mine 12	Mine 13	Mine 14	Total	Horizontal ratio
1	2015	626953.4	329239.8	38594	439861.1	280036.2	251145.6	199927.8	635463.1	162326.2	620135.3	532419.4	284425.9	384755.2	137197.8	4922480.7	link
2	2016	608837.3	343727.8	37741.1	432027.8	301511.8	242679.5	202288.2	718718.4	162432.9	566137.1	527137.9	259162.5	399834.1	145833.2	4948069.5	link
3	2017	604908	332385.1	37715.3	382286	295912.3	240465.8	235741.1	691439.7	167335	642674.1	607931.1	260273.9	388208.6	144646	5031922	link
4	2018	630164.3	363735.6	31538.2	429354.6	304960.4	241909.4	266255	622796.6	191148.5	662534.5	595491.7	273771.1	347229.2	135284.6	5096173.8	link
5	2019	566514.9	367890.6	30455.4	385429.1	266832.2	238299.5	278023.7	733122.2	180279	673816.8	588932.2	230730.8	278100.4	161872.1	4980298.7	link
6	2020	583054.5	437032.4	32846.8	335555.6	326462.1	230318	331575.9	526560.2	174231	614182.9	610229.6	206095.9	316727.8	159776	4884648.7	link
7	2021	596755.9	452615.7	33281.2	545132.3	325009.7	228683.2	359943.3	722726.2	194816.7	585792.1	590392.4	203959	342693	161359.5	5343160.1	link
Total		4217188.3	2626627	242172	2949646.4	2100724.7	1673500.9	1873755	4650826.4	1232569.2	4365272.8	4052534.2	1718419.1	2457548.3	1045969	235206753.4	
Longitudinal ratio		link	link	link	link	link	link	link	link	link	link	link	link	link	link	link	link

Figure 6. Carbon emission board of coal mines owned by Coal Industry Group P

Serial number	Task number	Year	Unit Number	Unit Type	1. E _{burn} 【tCO2】	2. E _{pe} 【tCO2】	3. E _{oe} 【tCO2】	4. E _{ph} 【tCO2】	5. E _{oh} 【tCO2】	6. E _{ech4} 【tCO2】	7. E _{ecO2} 【tCO2】	Total: E _{CO2} 【tCO2】	Structure
1	163	2021	201-1	Well working	672.5	97381.1		13851.1		474230.1	10621	596755.9	link
合计												596755.9	

Figure 7. Carbon emission breakdown of Mine1 owned by Coal Industry Group P in 2021

<p>1. E_{burn}</p> $E_{burn} = \Sigma(AD_i \times EF_i)$ $= 167.79 \times 3.159 + 47.73 \times 2.958$ $= 672.5 \text{ (tCO}_2\text{)}$
<p>2. E_{pe}</p> $E_{pe} = AD_{pe} \times EF_{pe} / 1000$ $= 166777100 \times 0.5839 / 1000$ $= 97381.1 \text{ (tCO}_2\text{)}$
<p>3. E_{oe}</p>
<p>4. E_{ph}</p> $E_{ph} = AD_{ph} \times EF_{ph}$ $= (Mast \times (Emst - 83.74) / 1000) \times EF_{heat}$ $= (47273 \times (2747.3937988281 - 83.74) / 1000) \times 0.11$ $= 125918.906 \times 0.11$ $= 13851.1 \text{ (tCO}_2\text{)}$
<p>5. E_{oh}</p>
<p>6. E_{ech4}</p> $Q_{wCH4} = t \times 60 \times (Q_{if} \times \varphi_{ICH4} - Q_{rf} \times \varphi_{rCH4}) + Q_e \times \varphi_{eCH4}$ $= 8760 \times 60 \times (33676 \times 0.0012 - 33289 \times 0) + 11869100 \times 0.08$ $= 21240126.72 + 949528$ $= 22189654.72 \text{ (m}^3\text{CH}_4\text{)}$ $Q_{pCH4} = 3102000 \times 3 + 0 \times 0.94 = 9306000 \text{ (m}^3\text{CH}_4\text{)}$ $Q_{dCH4} = 0 \times 0.08 \times 0 = 0 \text{ (m}^3\text{CH}_4\text{)}$ $Q_{rCH4} = 0 \times 0 = 0 \text{ (m}^3\text{CH}_4\text{)}$ $E_{ech4} = (Q_{wCH4} + Q_{pCH4} - Q_{dCH4} - Q_{rCH4}) \times 0.717 \times 21 / 1000$ $= (22189654.72 + 9306000 - 0 - 0) \times 0.717 \times 21 / 10000$ $= 474230.1 \text{ (tCO}_2\text{)}$
<p>7. E_{ecO2}</p> $Q_{wCO2} = t \times 60 \times (Q_{if} \times \varphi_{ICO2} - Q_{rf} \times \varphi_{rCO2}) + Q_e \times \varphi_{eCO2}$ $= 8750 \times 60 \times (33676 \times 0.0007 - 33289 \times 0.0004) + 11869100 \times 0$ $= 5391394.56 + 0$ $= 5391394.56 \text{ (m}^3\text{CH}_4\text{)}$ $Q_{pCO2} = 0 \times 0 = 0 \text{ (m}^3\text{CH}_4\text{)}$ $E_{ecO2} = 0 \times 0.000043 \times 0 \times 44 / 1 = 0 \text{ (tCO}_2\text{)}$ $E_{ecO2} = (Q_{wCO2} - Q_{pCO2}) \times 1.97 / 1000 + E_{ecO2}$ $= (5391394.56 - 0) \times 1.97 \times 10 + 0$ $= 10621 \text{ (tCO}_2\text{)}$
<p>Total: E_{CO2}</p> $E_{CO2} = E_{burn} + E_{pe} - E_{oe} + E_{ph} - E_{oh} + E_{ech4} + E_{ecO2}$ $= [672.5] + [97381.1] - [0] + [13851.1] - [0] + [474230.1] + [10621]$ $= 596755.8 \text{ (tCO}_2\text{)}$

Figure 8. Calculation process of Eco2

If we want to make horizontal comparison of the carbon emission of each mine, we can click on the right link [link](#) in Figure 6. For example, the horizontal comparison of the carbon emission of each coal mine is shown in Figure 10. If

we want to make vertical comparison of the carbon emission of a coal mine or Coal Industry Group P in different years, we can click on the bottom link [link](#) in Figure 6.

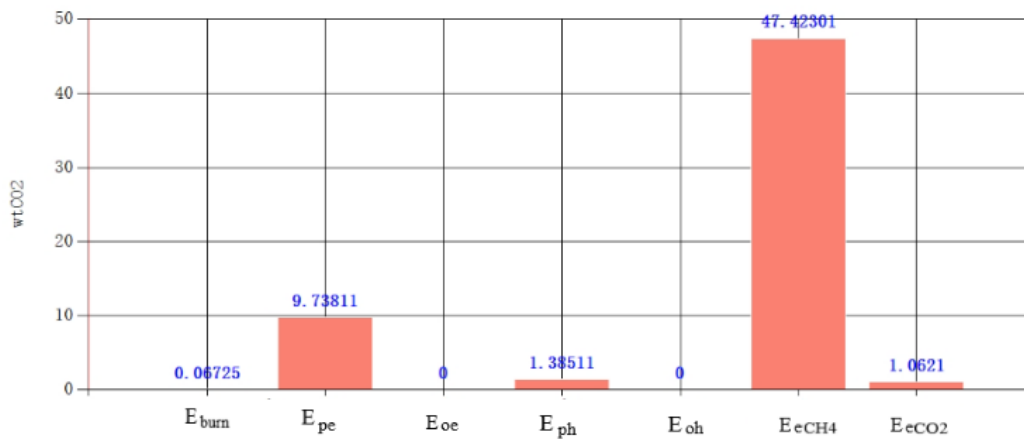


Figure 9. Carbon emissions composition of accounting task 163

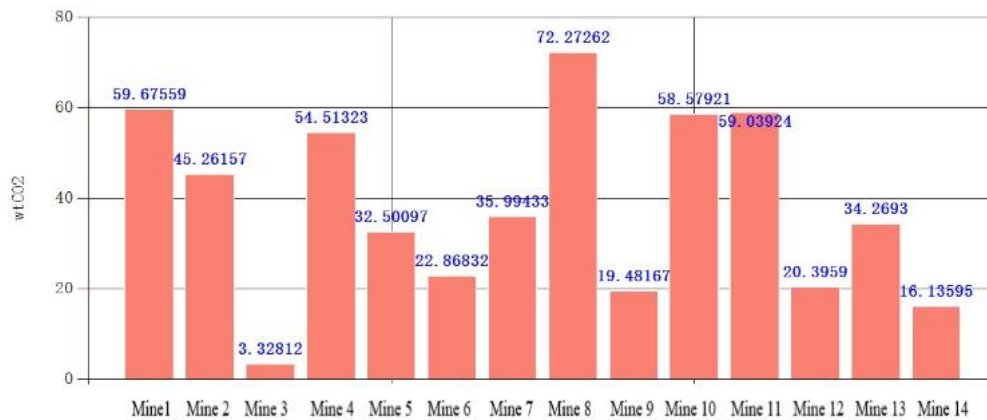


Figure 10. Horizontal comparison of carbon emissions of coal mines owned by Coal Industry Group P in 2021

For example, the vertical comparison of the carbon emission of Coal Industry Group P is shown in Figure 11, and the vertical comparison of the carbon emission of Mine1 is shown in Figure 12.

From Figure 10, it can be seen that the carbon emission of the Mine 8 in 2021 is higher. By tracing the calculation process, it can be found that the main reason for the higher carbon emission of the Mine 8 is that their electricity and escaped emissions are larger.

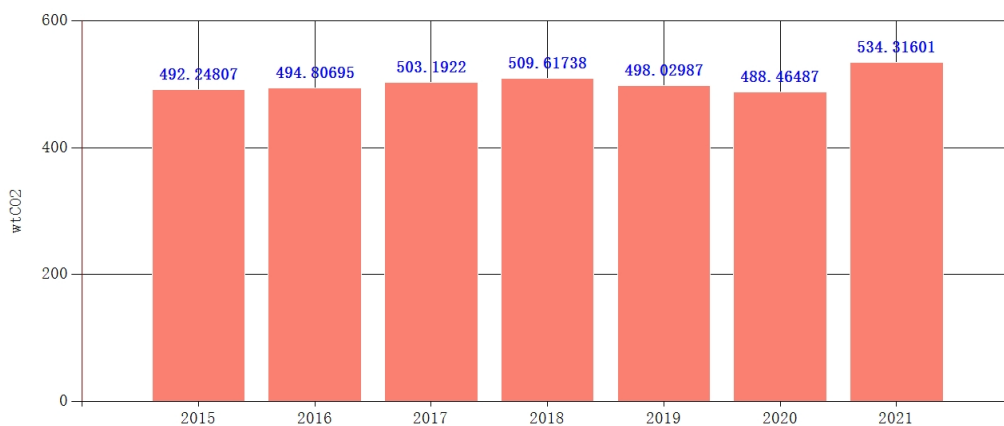


Figure 11. Vertical comparison of carbon emissions from 2015-2021 for Coal Industry Group P

From Figure 11, it can be seen that the total carbon emissions of Coal Industry Group P are generally stable from 2015 to 2020, but the increase is larger in 2021. By tracing the calculation process, it can be found that the reason for the larger increase in 2021 is the larger increase in electricity, heat and escaped emissions of coal mines owned by Coal Industry Group P in that year.

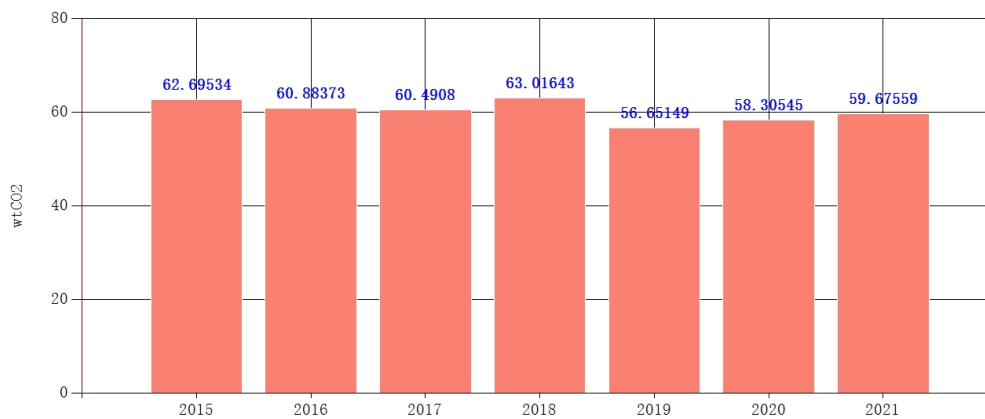


Figure 12. Vertical comparison of carbon emissions of Mine 1 from 2015-2021

From Figure 12, it can be seen that the carbon emissions of Mine 1 from 2015-2021 are relatively stable.

6. Conclusion

In view of the disadvantages of the traditional top-down stand-alone accounting method for carbon emission accounting of coal mines owned by the Coal Industry Group, such as inefficient data collection, cumbersome and error-prone carbon emission calculation process, and lack of online sharing of carbon emission, an online carbon emission accounting method based on B/S structure for coal mines owned by the Coal Industry Group is proposed. Through the accounting process of carbon emission accounting tasks assignment, carbon emission data submission, carbon emission data audit, carbon emission calculation, carbon emission view, the top-down standalone accounting method is transformed into a bottom-up online accounting method. By converting manual table lookup into system automatic table lookup, the carbon emission calculation is automated, which improves the efficiency of carbon emission accounting and ensures the accuracy of carbon emission accounting results. By storing the accounting results remotely, the carbon emission accounting results are shared, which is convenient for the Coal Group administrators to make horizontal and vertical comparison of carbon emission of each coal mine, and is conducive to the effective monitoring and improvement of carbon emissions for coal mines owned by the Coal Industry Group.

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