



(RESEARCH ARTICLE)



Carbon cost accounting in the cement industry

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Abstract

The existence of human beings is dependent on the environment in which they live, and one of the environmental threats today is air pollution due to the increase in greenhouse gases. Enterprises are considered the main actor of pollution due to the greenhouse gases they release into the atmosphere during their production. The aim of the study is to provide an application proposal for businesses to determine their carbon footprints and to take into account not only product and service costs but also environmental costs in their accounting processes. In particular, the study provides data to make carbon costs related to greenhouse gas emissions more visible and reported in the total production cost and also to reduce these costs. The research was conducted in the cement sector, where greenhouse gas emissions occur the most, and the results were presented.

Keywords: Greenhouse gases; Environmental accounting; Carbon footprint; Atmosphere; Pollution

1. Introduction

Human beings have used the environment for their own needs since the day they came into existence. However, this use has brought environmental problems due to rapid population growth and expanding industrial production in the last century. One of these environmental problems is the negative change in the atmosphere. Due to the fact that the energy used during the production of industrial products is largely met from fossil fuels, greenhouse gases released in excessive amounts are one of the leading factors that cause nature to fail to renew itself and the natural gas balance in the atmosphere to deteriorate. Environmental problems such as global warming, ozone depletion, drought, and climate change are largely the response of nature to human intervention in the natural ecological balance.

The inadequacy of national measures taken against the pollution of the atmosphere, which is the common value of all societies of the world, and the perceptible environmental problems arising from this pollution, have led to the necessity of taking several international measures. The United Nations Framework Convention on Climate Change, which was adopted in 1992 and given legal force by the Kyoto Protocol, which came into effect in 2005, marked a significant advancement in the conferences held under UN leadership to better understand and discuss the effects of greenhouse gases and the process of global warming. The Protocol establishes national targets and commitments for reducing greenhouse gas emissions.

Businesses, which are thought to be the primary source of greenhouse gas emissions, have been driven to take action in this regard by these international resolutions and national practices aimed at meeting their reduction objectives. Businesses now have to keep an eye on the carbon emissions they produce during manufacturing and compute and document their carbon footprints. Additionally, the idea of carbon accounting was born out of nations' attempts to align their legal frameworks and financial systems with these practices.

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The study provides a concept for an application that would make greenhouse gas emissions and the actions made to minimize them more apparent and reportable on business cost accounting systems.

In the study, using the case study method, the environmental costs of Pacelile Cement company operating in the cement production sector in March 2022 were recorded according to a sample chart of accounts prepared, making the environmental expenses obvious, and thus the costs caused by emissions were made visible and reported. In this context, a case study was conducted on the accounting system of the cement company and the cost and accounting system was reconstructed to identify emission costs. How to make the obtained data usable in management decisions has been revealed. In the study, the necessary literature review was conducted during the data collection phase.

2. Literature Review

Some of the academic studies in the literature on carbon cost accounting are Kumarasiri and Jubb (2016), in their study "Carbon emission risks and management accounting: Australian evidence", explain the impact of cost accounting and cost management accounting on business activities in the developing carbon market. Cadez and Guilding (2017), in their study "Examining distinct carbon cost structures and climate change abatement strategies in CO₂ polluting firms", aim to establish a basic understanding of carbon accounting practices, open up the carbon financial accounting debate to a wider international audience and build consensus. Broadstock et al. (2018), in their study titled "Voluntary disclosure, greenhouse gas emissions and business performance: Assessing the first decade of reporting", emphasized the importance and benefits of carbon management accounting practices based on the study results of companies practicing carbon management accounting. Ahmad et al. (2023), in their study titled "An Analysis of the relationships between Cost and sustainability indicators", introduces the carbon market transactions and gives information about the effects on the accounting system, and explains them with examples. Martineau and Lafontaine (2020), in their study "When carbon accounting systems make us forget nature: from commodification to reification", an application about carbon emission accounting is given and a suggestion is made on its applicability. Downar et al. (2021), "The impact of carbon disclosure mandates on emissions and financial operating performance", first tries to analyze the different carbon accounting arrangements that exist at the international level from a macroeconomic perspective. It then describes the basic practical carbon accounting principles and applications in different industries. Khatoon et al. (2023), in their study titled "Performance Management Accounting and Profitability: Evidence from Small and Medium Enterprises", focused on the recording of carbon trade transactions of enterprises within the framework of carbon accounting according to International Accounting Standards. Hazaea et al. (2023), in their research titled "Past, present, and future of carbon accounting: Insights from scholarly research", discussed the dimensions of carbon trade in the world and explained the different applications in carbon accounting with examples.

3. Conceptual Framework

Today, when the effects of significant changes in air pollution levels are felt more, it is necessary to determine the factors causing this pollution, monitor the amount of pollution, and take necessary steps to reduce it. For this reason, it is necessary to determine the footprints of all emissions that cause greenhouse gases in enterprises, which are the main actors of pollution, and to make adaptations to environmental accounting to reveal this situation in production cost accounting and reports.

3.1. Carbon Footprint

Carbon footprint is a measure of the total amount of Carbon Dioxide (CO₂) and other greenhouse gas emissions caused directly or indirectly by an activity or accumulated over the lifetime of a product, an individual, an organization, or even a city or state (Erfan et al. 2022).

Table 1 Classification of Carbon Footprint

Carbon Footprint									
Personal Carbon Footprint				Corporate Carbon Footprint					
Primary Carbon Footprint	Carbon	Secondary Carbon Footprint	Carbon	Direct Carbon Footprint	Carbon	Indirect Carbon Footprint	Carbon	Other Indirect Carbon Footprints	Carbon

Source: Mishra et al. 2022

3.1.1. Individual Carbon Footprint

- **Primary Carbon Footprint:** A measure of CO₂ emissions over which individuals have direct control (e.g. electricity consumption, vehicle fuel consumption, etc.).
- **Secondary Carbon Footprint:** It is a measure of indirect CO₂ emissions resulting from the goods and services consumed by individuals. This footprint occurs during the production process of goods and services.

3.1.2. Corporate Carbon Footprint

- **Direct Carbon Footprint:** It is the measure of emissions from fossil fuels used by organizations to carry out their production activities. For example, coal, natural gas, etc.
- **Indirect Carbon Footprint:** This is a measure of the emissions caused by the electrical energy consumed by the organization and the emissions caused by the steam, cooling or hot water purchased by the organization from another organization.
- **Other Indirect Carbon Footprint:** It is the measure of all emissions related to the products used by the organizations (for example, from raw materials to brochures for advertising purposes), subcontracted activities, fuels used by the rental vehicles of the organization, and land, sea and air transportation of the employees of the organization for business purposes.

3.2. Carbon Costs

Businesses are in constant interaction with the environment during their activities. This is because both the source of the raw material, which is the input of production and the basic input of the energy used in the production process are provided by the environment, that is, natural resources. The enterprise uses these natural resources as raw materials and presents them back to the environment by making some changes. The environment can be negatively affected both during the use of these resources, during production activities, and during the consumption of the products produced. Some of these natural resources used by enterprises (fossil resources) emit greenhouse gases during the production process and cause air pollution. Businesses that are responsible for this need to measure their emissions or calculate their pollution.

Due to the harm that corporate emissions do to the environment, numerous nations use policies like fines, levies, incentives, and market mechanisms to minimize emissions. These circumstances highlight the environmental costs associated with emissions for enterprises, which must be documented and reported. The term "carbon costs" refers to the emission of carbon dioxide and its effects, even though it is not the only greenhouse gas that corporations emit.

Although it is possible to classify environmental costs in different ways, these costs can be classified as follows (Ahmed et al. 2023).

- **Prevention (Mitigation) Costs:** Costs incurred by enterprises to reduce or prevent environmental pollution. Since emissions cause environmental pollution, they will be evaluated within this scope. For example, expenses such as filters, emission measurement devices, personnel, technical support, and training to reduce carbon emissions.
- **Utilization Costs:** These are the costs incurred by enterprises due to the use of natural resources while producing a product or service. For example, the carbon tax imposed on the carbon-containing fossil fuels used.
- **Damage Costs:** These types of costs are the costs that arise after the environmental pollution caused (penalty or compensation, etc.) and turn into direct expenses or losses. They are especially caused by the failure or neglect of environmental obligations within the legal period. For example, the amount of the fine imposed on the enterprise that does not use a filter even though it is required to use a chimney filter as per the legal obligation.

4. Carbon Cost Accounting

In their accounting processes, businesses should consider and record not only the costs that bring products or services to the point of sale but also the environmental costs that occur before or after the production of the product or the provision of the service (Kumarasiri and Jubb, 2016). Because increasing social environmental awareness is reflected in consumer expenditures, products and services that are less harmful to the environment may be preferred by consumers. At this point, businesses are trying to produce goods or services that are less harmful to the environment to compete with their competitors. In this process, they use cost accounting systems to monitor and control their environmental costs.

Most of the time, environmental expenses in India are not recorded in a separate account. In the process of cost accounting, the carbon costs that businesses bear as a result of the emissions they release into the atmosphere are primarily lost and accounted for as general production expenses. It is challenging to monitor the location and quantity of carbon expenses, as well as to record, audit, and regulate them because they are not displayed in distinct accounts. Because of this, it is important to open the proper expense locations and categories in separate accounts to reflect emission-related charges. This makes it possible to calculate the proportion of these emission-related charges to total costs as well as the source and amount of these costs. Additionally, it will support management planning aimed at containing and lowering carbon expenses.

Since the share of environmental costs in total costs is increasing today, these costs should be shown in separate accounts as a requirement of the concept of materiality, one of the basic concepts of accounting.

Enterprises can monitor their environmental expenditures or carbon costs related to emissions related to production in sub-accounts to be opened under 730 GENERAL PRODUCTION EXPENSES account if option 7/A is used, or in sub-accounts to be opened in accordance with the main accounts in account group 79 if option 7/B is used.

We can track environmental costs in the accounting system by coding them as follows.

Table 2 Coding of Environmental Costs-1

000	00	00	00	0	000
Main Accounts	Expense Locations	00 - 99	Environmental	Expense	Types of
710 Direct Raw Material Expenses	10 - 19 Main Production Expense Locations	Cost Types	Cost Categories	Types	Auxiliary Expenses
720 Direct Labor Expenses	20 - 29 Auxiliary Production Costs		10 - 19 Mitigation Costs		
730 General Production Expenses	30 - 39 Auxiliary Service Expense Locations		20 - 29 Utilization Costs		
740 Service Production Expenses	40 - 49 Investment Expense Locations		30 - 39 Loss Costs		
750 Research Expenses	50 - 59 Production Facilities Management Expense Location.				
760 Marketing Expenses	60 - 69 Research and Development Expense Location				
770 General Expenses	70 - 79 Marketing, Sales and Distribution				
780 Finance Expenses	80 - 89 General Administration Expense Locations				

Source: Can, 1998:137; Fidan, 2009:119.

Emission-related environmental expenses can be recorded and monitored in auxiliary accounts to be opened under the relevant expense locations after their qualifications and expense locations are determined. These realized expenses can be categorized as shown in the table above and recorded according to the types of expenses under the relevant category.

If we detail the categories of environmental costs, we can create a sample chart of accounts as follows.

Table 3 Environmental Cost Categories

MITIGATION COSTS 10-Emission Reduction. 20-Less Solid Liquid Waste. 30-Noise Reduction. 40-.....	UTILIZATION COSTS 11-Using Emissions.* 21-Solid Liquid Waste Utilization. ** 31-Use of Noise.***	LOSS COSTS 12-Emission Loss. 22-Solid Liquid Waste Damage. 32- Noise Damage.
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*Cost of using natural resources that cause emissions; **Cost of using natural resources resulting in solid-liquid waste; *** Cost of causing noise

Table 4 Sample Cost Chart of Accounts

730 GENERAL PRODUCTION EXPENSES
• 10 X Main Production Expense
○ Non-Environmental Costs
○ Environmental Costs
10% Emission Reduction Cost
• Raw Material Expenses
○ Chimney Filter System Material Expenditures.
○ Emission Measurement Device Supplies Expenses.
• Worker Wages and Expenses
• Civil Servant Salaries and Expenses
• Benefits and Services Provided Externally
○ Biologist, Chemist Services
○ Chimney Filter System Maintenance Expenditure.
○ Emission Measurement Device Maintenance Expenses.
○ Personnel Training Expenses
○ Garden and Environmental Maintenance Expenses.
○ Environmental Management Service Procurement Expenses
• Miscellaneous Expenses
○ Environmental Certificate Expenses.
• Taxes, Duties and Charges
• Depreciation and Amortization
○ Chimney Filter System Depreciation
○ Emission Measurement Device Depreciation
• Solid Liquid Waste Reduction Cost
• Noise Abatement Cost
20% Emission Utilization Cost
• Raw Material Expenses
• Worker Wages and Expenses
• Civil Servant Salaries and Expenses
• Benefits and Services Provided Externally
○ Flue Gas and Pollutant Concentration Analysis Expenses
• Miscellaneous Expenses
• Taxes, Duties, and Fees
○ Carbon Tax
○ Fees
• Depreciation and Amortization

21 Cost of Solid Liquid Waste Handling
<ul style="list-style-type: none"> • Benefits and Services Provided Externally <ul style="list-style-type: none"> ○ Wastewater Collection and Treatment Expenditures ○ Solid Waste Collection Transportation and Disposal Expenses • Miscellaneous Expenses <ul style="list-style-type: none"> ○ 001 Environmental Certificate Expenses
30 Emission Damage Costs
<ul style="list-style-type: none"> • Raw Material Expenses • Worker Wages and Expenses • Civil Servant Salaries and Expenses • Benefits and Services Provided Externally • Miscellaneous Expenses <ul style="list-style-type: none"> ○ Penalties ○ Indemnities • Taxes, Duties, and Fees • Depreciation and Amortization

In the account plan organized as an example above, emission-related expenses are examined in 3 different categories in auxiliary accounts, and emission expenses that may differ according to the types of enterprises can be detailed in sub-accounts to be opened under these categories.

Table 5 Sample Balance Sheet Chart of Accounts

15 INVENTORIES
150 first articles and materials
150.10 First Materials and Supplies for Non-Environmental Activities
150.20 First Materials and Supplies for Environmental Activities
150.20.01 Emission Measurement Materials
150.20.02 Chimney Filter System Material Expenses
25 TANGIBLE FIXED ASSETS
250 LAND AND PLOTS
250.20 Lands
250.20.01 Carbon Capture Plant Land
251 UNDERGROUND AND ABOVE-GROUND INSTALLATIONS
252 BUILDINGS
253 PLANT MACHINERY and EQUIPMENT
253.10 Facilities
253.10.01 Carbon Capture Plant
253.20 Machines

253.30.Devices
253.30.01 Chimney Filter System
253.30.02 Emission Measurement Devices
254 VEHICLES
255 FIXTURES
256 OTHER TANGIBLE FIXED ASSETS
257 ACCUMULATED DEPRECIATION(-)
257.20 Depreciation of Machinery and Equipment
257.20.01 Chimney Filter System Depreciation
257.20.02 Depreciation of Emission Measurement Devices
258 CONSTRUCTION IN PROGRESS
258.10 Carbon Capture Plant
26 INTANGIBLE ASSETS
260 RIGHTS
260.10 Emission Right
261 GOODWILL
262 ESTABLISHMENT AND ORGANIZATION EXPENSES
263 RESEARCH EXPENSES
264 SPECIAL COSTS
267 OTHER INTANGIBLE ASSETS
268 ACCUMULATED DEPRECIATION(-)
268.10 Amortization of Rights
268.10.01 Amortization of Emission Rights

In accounting for carbon costs, different from the coding method in Table 3, the following path can be followed

Table 6 Coding of Environmental Costs-2

000	00	00	000
Main Accounts	Expense Locations	Environmental Cost Categories	Expense Types
710 Direct Raw Material Expenses	90 - 99 Other / Peripheral Expenses	10 - 19 Mitigation Costs	
720 Direct Labor Expenses		20 - 29 Utilization Costs	
730 General Production Expenses		30 - 39 Loss Costs	
740 Service Production Expenses			
750 Research Expenses			
760 Marketing Expenses			
770 General Expenses			
780 Finance Expenses			

In the above illustration, the costs incurred due to emissions are to be monitored only in the sub-accounts. In today's world where social awareness of environmental issues is increasing, the pressure on businesses to reduce environmental pollution is also increasing. Legal or voluntary practices in the face of this situation cause an increase in

environmental costs in enterprises. For this reason, it is necessary to make changes in the traditional chart of accounts that take into account environmental costs and make these costs more visible.

Table 7 Coding Environmental Costs-3

000	00	00	000
Main Accounts	Expense Locations	Environmental Cost Categories	Expense Types
715 Direct Raw Material Expenditures with Environmental Characteristics	10 - 19 Main Production Expense Locations	10 - 19 Mitigation Costs	
735 Environmental General Production Expenses	20 - 29 Auxiliary Production Costs	20 - 29 Utilization Costs	
755 Environmental Research Expenses	30 - 39 Auxiliary Service Expense Locations	30 - 39 Loss Costs	
765 Environmental Marketing Expenses	40 - 49 Investment Expense Locations		
775 Environment-Specific General Administrative Expenses	50 - 59 Production Facilities Management Expense Location.		
785 Environment-Specific Finance Expenses	60 - 69 Research and Development Expense Location		
	70 - 79 Marketing, Sales and Distribution		
	80 - 89 General Administration Expense Locations		

In today's developing conditions, it would be more appropriate to show environmental expenditures separately as a main account instead of showing them as an expense location under the main accounts (710.90 Environmental Expense Location), which has been the classical classification until today. As a result of this arrangement, environmental costs related to production should be shown in the "715 Environmental Direct Raw Material and Material Expenses" account, "735 Environmental General Production Expenses" account and period expenses should be shown in the "755 Environmental R&D Expenses" account, "765 Environmental Marketing Expenses" account, "775 Environmental General Administrative Expenses" account, "785 Environmental Financing Expenses" account. In this way, environmental costs can be directly monitored and directly reflected in the financial statements. In addition, as it is known, the opening of sub-accounts in enterprises can be freely determined by the employees of the enterprise. For example, one enterprise may specify the environmental sub-account with the sub-code 715.100, while another enterprise may specify it as 715.10 and another as 715.01. In this sense, using the appropriate blank accounts will be more useful in terms of ensuring the uniformity of national data.

5. Research Methodology

In 2022, total greenhouse gas emissions were estimated at 496.19 million tons of CO₂ equivalent according to the International Energy Agency (IEA), 2022. In this amount, energy-based emissions constitute the largest share with approximately 73%, while industrial processes take the second place with 13%. Waste and agricultural activities have a share of 3% and 11%, respectively (International Energy Agency, 2022). In addition, according to India's 2022 greenhouse gas emission inventory, 54.4% of 2022 CO₂ emissions in industrial processes originated from the cement sector (IEA, 2022).

Table 8 Total Greenhouse Gas Emissions by Sector

Year	Energy	Industrial	Agriculture	Waste	Total
(million tons CO₂ equivalent)					
2017	212.3	26.6	40.0	14.5	293.5
2018	240.3	34.6	40.8	16.9	332.7
2019	292.3	49.2	42.8	18.2	402.6
2020	320.1	56.8	50.6	18.1	445.6
2021	308.8	59.8	53.6	16.8	439.0
2022	361.0	62.4	56.5	16.2	496.1

Source: IEA, 2022

Table 9 Contribution of the Cement Sector to CO₂ Emissions

Years	2016	2017	2018	2019	2020	2021	2022
Percentage	71.9	76	81.9	81.4	59	56.6	54.4

Source: IEA, 2022

Technologically, when 1 ton of cement is produced, approximately 700-760 kg of CO₂ equivalent emissions are generated. According to the Ministry of Science, Industry and Technology cement sector report (2021-2022), a total of 70.57 million tons of cement was produced in 2022. As a result of this production, considering the above data, it is calculated that approximately 52.20 million tons of emissions were emitted as follows.

Table 10 Emission Amount of Cement Sector

Year	Annual cement production (million tons)*	1 ton of cement average emission amount	Approximate total annual emissions (million tons)
2018	35.95	0.75 ton	26.50
2019	42.79	0.75 ton	31.24
2020	62.81	0.75 ton	46.30
2021	60.42	0.75 ton	44.42
2022	70.57	0.75 ton	52.20

* Based on the data in Annual Report, 2022

On a global scale, 5% of all CO₂ emissions caused by humans are caused by cement production (Vadera et al. 2025). Our carbon cost accounting application research was conducted on the cement sector, which causes approximately 54.4% of CO₂ emissions resulting from industrial processes. During the research process, the enterprise's carbon-related cost data were extracted from the accounting process, divided into environmental cost categories and expense classes, and then presented in a comparable manner.

In our country, greenhouse gas emissions from cement factories are monitored and reported by accredited organizations in accordance with the regulation issued in 2016. Some of the expenses of the sector that may increase production costs due to emissions can be listed as follows;

- Greenhouse gas emission measurement and analysis expenses
- Depreciation expenses of greenhouse gas emission measurement device
- Training expenses
- Chemist and laboratory expenses
- Greenhouse gas emission management personnel costs
- Expenses for afforestation etc.
- Expenses related to greenhouse gas emission reduction investments
- Penalties, taxes

6. Production Process in the Research Sector

Two basic materials are used in cement production; clinker and gypsum. Apart from these, trass, marl, limestone, slag, fly ash, blast furnace slag, and similar materials called additives are added according to the type of cement produced. The cement formed when gypsum is added to the clinker at a certain rate and ground is called Portland cement, and the cement formed when the additive material is added and the ground is called blended cement. Admixed cements described in the standards are named according to the type and amount of admixture. The quality and homogeneity of the cement produced depends on the correct and constant combination of raw materials used in the production process (Alakkas et al., 2023).

Cement production generally consists of 4 stages. These stages can be called production phases.

- **Stage 1 Raw Material Preparation:** This is the stage of crushing and grinding the raw materials.
- **Stage 2 Raw Material Mixing in the Raw Material Mill:** It is the stage where raw materials (Limestone, Clay, Iron Ore, Slag, etc.) are mixed in certain proportions. The semi-finished product is called Farin.
- **Stage 3 Rotary Kiln Firing:** Farin is fired at a temperature of approximately 1400-1500 degrees. The semi-finished product is called Clinker.
- **Stage 4 Grinding in Cement Mill:** Clinker is ground in cement mills with gypsum and additives suitable for the type of cement to be produced. The resulting product is called cement.

In the cement production process, stages 1, 2, and 4 are the stages where electricity consumption takes place. The 3rd stage, where clinker production takes place, is the stage where fuels such as coal, fuel oil, and natural gas are used and where 70-80% of the total energy consumption takes place (Alakkas et al., 2023).

In cement production, the sector generally uses a wide range of primary fuels, mainly coal, but also pet coke, natural gas, and oil. Approximately 120 kg of coal is needed for the production of one ton of cement. In addition, depending on the technology used, approximately 90 to 120 kWh of electricity is required for the production of one ton of cement. In addition, approximately 60% of the production costs in the cement sector consist of fuel and electricity costs (Vadera et al. 2025).

Table 11 Cement Sector Cost Items

Cement Sector Cost Items	Average Cost %
Raw and Auxiliary Materials	9.6
Electricity	21.1
Fuel	38.0
Labor	9.4
Depreciation	7.0
Other Fixed Expenses (Material, DAH, etc.)	13.1
Other	1.8
Total	100.0

Source: Based on the data in Annual Report, 2022

The cement industry has four main emissions that have a cooling or heating effect on the earth and contribute to global warming and climatic change. These emissions are dust, sulfur, Nox, and carbon dioxide. Since the amount of carbon dioxide emission is higher than the first three substances in terms of the cement industry, the environmental impact it creates is greater. In this respect, the primary target for cement companies should be to reduce carbon dioxide emissions.

Carbon dioxide emissions in the cement industry occur in two ways: direct and indirect. Direct carbon dioxide emissions (excluding emissions during the process of extraction of raw material and bringing it to the production facility);

- During the use of fossil fuels in cement production
- It occurs during the transformation (calcination) of limestone (limestone) by chemical reaction (Liao et al. 2022).

Indirect emissions, which are smaller than direct emissions, are electricity consumption, which is assumed to be derived from the consumption of fossil fuels. Approximately half of the carbon dioxide generated in the cement production process comes from calcination and the rest from the combustion of fossil fuels (Alakkas et al., 2023).

The amount of carbon dioxide produced in the cement production process depends mainly on the following factors (Liao et al. 2022);

Type of production process (efficiency of the process and sub-processes)

- Type of fuel used (coal, fuel oil, natural gas, petroleum coke, and other alternative fuels)

- Clinker/cement ratio (percentage of admixture)

The type of energy used, the technological infrastructure of the manufacturing facility, and the type of cement produced are some of the variables that might affect the amount of emissions in the cement production process. The variation in these components' choices has an impact on the sector's emissions as well.

7. Carbon Cost Accounting Implementation Proposal

The Pacelile Cement plant where the application is made is a cement production plant and the main production takes place in the following five stages.

- **Raw Material Preparation:** Limestone crushing and size reduction process is performed.
- **Mixing (Farin Mill):** Raw materials such as limestone, clay and iron ore, etc. are mixed in certain proportions according to the type of cement to be produced and Farin is formed. In the process of size reduction to the formation of farin, weight loss may occur due to drying to remove the moisture of the raw material.
- **Baking (Rotary Kiln):** This is the stage where the farin is cooked and clinker is formed. Weight loss of ~40% occurs in the calcination of farin to clinker (Approximately 1 ton of clinker is obtained from 1.65 tons of farin).
- **Grinding:** Clinker is ground by mixing with auxiliary materials according to the type of cement to be produced and cement is obtained.
- **Packaging:** It is the stage where the packaging of the produced cement is made.

In addition to these production locations, there are also the following auxiliary expense locations.

Table 12 Cement Sector Expense Locations

Main production expense locations	production site management expenses	auxiliary service expenses
- Raw Material	- Production Site Management	- Maintenance and Repair
- Mixing		- Laboratory
- Cooking		- Energy
- Grinding		

During the year, the company incurred environmental expenditures due to solid-liquid waste and emissions, and these expenses, which were monitored and identified, are as follows.

Table 13 Pacelile Cement Total Environmental Expenditures in 2022

2022 Total Environmental Expenditures (TL)						
Environmental expenses	Direct Materials	Raw Indirect Labor	Benefits and Services Provided Externally	Miscellaneous Expenses	Taxes, Duties and Fees	Depreciation and Amortization
Flue gas treatment system						
Analysis of flue gas and pollutant concentrations			105.346			
Purchase of a flue gas measurement device						
Wastewater analysis						
Purchase of wastewater measuring device						
Waste recovery and disposal facility						

Collection and treatment of wastewater by other enterprises, organized industrial zones and municipalities			37.684			
Expenditures for domestic and industrial waste						
Collection, transportation and disposal of waste by other enterprises, organized industrial zones, private companies, etc.			22.853			
Noise-canceling equipment						
Noise measurements						
Biodiversity and landscape conservation			343.071			
Environmental management systems (ISO 14001, EMAS, etc.)				6.951		
Compliance with environmental legislation and regulations						
Environmental Education and information programs			3.658			
Activities related to environmental permits such as discharge, emission permits, etc.						
Fuel analysis and environmental management services			35.713			
Payments to employees engaged in environmental activities		60.133				
Depreciation expense of property, plant and equipment used in environmental activities						30.300
Environmental cleaning tax					2.022	

7.1. March Environmental Expenses

The following services were procured in July 2021 for the analysis of flue gas and pollutant concentrations.

1 and 2 rotary kilns periodic waste incineration measurement:	30.090
Emission measurement, air quality measurement	51.849
Consultancy service fee	7.080
Other expenses	16.327

105.346 TL

- Expenses for the month of March: TL 8.778

730 General Production Expenses	8.778
730.13. Baking Main Production Expense	
730.13.02 Environmental Costs	
730.13.02.20 Emission Utilization Cost	
730.13.02.20.4 Outsourced F.H.	
730.13.02.20.4.001 Flue gas and pollutant analysis expenses.	
105.346/12=8.778 180 Expenses for Future Months	8.778

- In March, TL 2,1225 was paid to the municipality for the collection and treatment of wastewater

730 General Production Expenses	2.122
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.21 Cost of Solid Liquid Waste Utilization	
730.50.02.21.4 Outsourced F.H.	
730.50.02.21.4.001 Wastewater Collection and Treatment Expenses.	
	2.122

- For the collection, transportation and disposal of solid waste by a private company, service procurement expenses of 2.8076 TL were made and paid in advance in March

730 General Production Expenses	2807
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.21 Cost of Solid Liquid Waste Utilization	
730.50.02.21.4 Outsourced F.H.	
730.50.02.12.4.002 Solid Waste Collection, Transportation, Disposal G.	
	2.807

- In March, TL 26,1497 of service procurement expenses were incurred and paid in advance for the afforestation and maintenance of the garden and its surroundings

730 General Production Expenses	26.149
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.10 Emission Reduction Cost	
730.50.02.10.4 Outsourced F.H.	
730.50.02.10.4.005 Garden Environment Maintenance Expenses.	
	26.149

- The amount corresponding to March from the expense incurred and paid for ISO 14001 and EMAS environmental certificates is TL 580. The expense was distributed equally to environmental expense locations. The amount of expenses for March: $6.951/12= 579,25$ TL.

730 General Production Expenses	580
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.20 Emission Utilization Cost	
730.50.02.20.5 Miscellaneous Expenses	
730.50.02.20.5.001 Environmental Certificate Expenses. 290	

730.50.02.21 Solid Liquid Waste Utilization Costs	
730.50.02.21.5 Miscellaneous Expenses	
730.50.02.21.5.001 Environmental Certificate Expenses. 290	
180 Expenses for Future Months	580
<u>6.591/12=580</u>	

- An expense of 8268 TL was incurred in March for environmental training. The expenditure was distributed equally to the environmental expenditure locations

730 General Production Expenses	826
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.10 Emission Reduction Cost	
730.50.02.10.4 Outsourced F.H.	
730.50.02.10.4.004 Personnel Training Expenses 413	
730.50.02.11 Solid-Liquid Waste Reduction Goods.	
730.50.02.11.4 Outsourced F.H.	
730.50.02.11.4.004 Personnel Training Expenses. 413	
	826

- In March, 4049 TL service procurement expenses were incurred for coal analysis

730 General Production Expenses 404	404
730.13. Baking Main Production Expense	
730.13.02 Environmental Costs	
730.13.02.20 Emission Utilization Cost	
730.13.02.20.4 Outsourced F.H.	
730.13.02.20.4.001 Flue Gas and Pollutant Concentration Analysis	
	404

- In March, 1.18010 TL was spent on environmental management service procurement. The expenditure was distributed equally to environmental expense locations

730 General Production Expenses 1.180	1.180
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.10 Emission Reduction Cost	
730.50.02.10.4 Outsourced F.H.	
730.50.10.4.006 Environmental Management. Service Procurement Expenses 590	
730.50.02.11 Solid-Liquid Waste Reduction Goods.	

730.50.02.11.4 Outsourced F.H.	
730.50.10.4.006 Environmental Management Service Procurement Expenses. 590	
	1.180

- The following wage payments were made to employees working in environmental activities for March.
Gross Wage: 4.272 TL

Social Security Payment: 739 TL

The distribution of environmental expenses according to the hours worked is as follows.

Emission Activities: TL 1253 (1 person)

Solid Liquid Waste Activities: TL 3758 (2 persons)

730 General Production Expenses	5.011
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.20 Emission Utilization Cost	
730.50.02.20.2 Labor Wages and Expenses.	
730.50.02.21 Solid Liquid Waste Utilization Cost.	
730.50.02.21.2 Labor Wages and Expenses 3758	
000 Related Accounts	5.011

- March depreciation expense of the filter device used to reduce dust emission during the raw material preparation phase is TL 2.525

730 General Production Expenses	2.525
730.13. Baking Main Production Expense	
730.13.02 Environmental Costs	
730.13.02.10 Emission Reduction Cost	
730.13.02.10.7 Depreciation and Depletion Py.	
730.13.02.10.7.001 Depreciation of Chimney Filter System	
257 Accumulated Amortization	2.525
30.300/12= 2.525	

- The amount of environmental tax paid during the year corresponding to March is 168,5 TL. The expense was distributed equally to environmental expense locations

730 General Production Expenses	168,5
730.50. Production Site Management Expense	
730.50.02 Environmental Costs	
730.50.02.20 Emission Utilization Cost	

730.50.02.20.6 Taxes, Duties and Fees 84,25	
730.50.02.21 Solid-Liquid Waste Utilization Costs.	
730.50.02.20.6 Taxes, Duties and Fees 84,25	
180 Expenses for Future Months	168,5
2.022/12=168,5	

7.1.1. Unit Product Carbon Footprint Calculation

The total amount of production in the enterprise in March and the total amount of carbon dioxide emissions released during the production process are approximately as follows. (The amounts remaining in the stages are not taken into account).

- Total production amount: 127,600 tons
- Estimated total amount of CO₂ emissions caused: 112,288 tons

Direct emission (Fuel + Calcination)* : 95.7 tons

Indirectly caused emission (Electricity etc.)**: 17.864 tons

Note: Estimated average values have been used as information on the resulting CO₂ emission values was not available.

* Approximately 0.75 tons of CO₂ is directly released in the production of 1 ton of cement

$$127.600 \text{ ton} \times 0.74 \text{ ton} = 95.7 \text{ ton CO}_2$$

**Approximately 0.14 tons of CO₂ is directly released in the production of 1 ton of cement

$$127.600 \text{ ton} \times 0,14 \text{ ton} = 17.864 \text{ ton CO}_2$$

- Approximate amount of carbon emissions per 1 ton of cement:
 $112.288 / 127.600 = 0,88 \text{ tons CO}_2 \text{ emission / ton cement}$

7.1.2. Unit Product Emission Cost Account: (TL)

Environmental Costs: 50.550,5

Mitigation Costs: 30.680

Utilization Costs: 19.870,5

Loss Costs: -

Emission Related Costs: 40.486,25

Emission Reduction Cost: 29.677

Emission Utilization Cost: 10.809,25

Emission Damage Cost: -

Unit Emission Cost:	<u>Total Emission Cost</u>	=	<u>40.486,25 TL</u> ≈ 0,32 TL/ton
	Total Production Amount (Ton)		127.600 ton

As a result of the production realized during the month, the total production cost per ton was realized as TL 72.46. The share of emission costs in total production costs;

$$\begin{aligned} \text{Ratio of Emission cost to Total cost} &= \frac{\text{Emission cost per ton}}{\text{Total production cost per ton}} \\ &= \frac{0,32 \text{ TL}}{72,46 \text{ TL}} = 0,00442 \approx 4,5 \text{ per thousand} \end{aligned}$$

According to the results of the above calculations, one ton of cement produced in March caused approximately 0.88 tons of carbon dioxide emissions and the expenditures made due to emissions caused an increase of approximately 0.32 TL in the cost of one ton of cement. This increase was realized at a rate of approximately 4.5 per thousand of the total cost. It should be noted that the amount of unit product emissions may vary depending on the type of product, the type of fuel used, the production process, the technological level of the production tools used, etc.

Table 14 Pacelile Cement Environmental Costs in March 2022

Environmental Costs (TL)									
	Mitigation Costs			Utilization Costs			Loss Costs		
	Emission Reduction Cost	Cost of Solid-Liquid Waste Reduction	Noise Abatement Cost	Emission Utilization Cost	Cost of Solid-Liquid Waste Utilization	Noise Handling	Emission Damage Cost	Solid-Liquid Waste	Noise Damage Cost
1-IMM									
2-Worker				1.253	3.758				
3-Civil Servant									
4-DSFH	27.152	1.003		9.182	4.929				
5-Miscellaneous				290	290				
6-Tax				84,25	84,25				
7-Amortization	2.525								
Unit Total	29.677	1.003	-	10.809,25	9.061,25	-	-	-	-
Group Total		30.680			19.870,5		-		
General Total	50.550,5								

8. Conclusion

Greenhouse gases that occur in the production processes of goods and services of enterprises and are released to nature cause environmental pollution. In the long run, this pollution affects both people who live an environmentally dependent life and businesses. These effects can be in the form of increased social pressure due to environmental pollution, consumer disfavor of products and services with high carbon footprints and decrease in sales, obligation to invest in clean technologies, and increase in costs due to practices such as environmental taxes.

Today, many countries have imposed reduction obligations on businesses to reduce greenhouse gas emissions. For this reason, in order to be advantageous against their competitors and to base their future planning on more realistic foundations, businesses should calculate all their costs, including the costs arising from greenhouse gas emissions, completely and accurately and take the necessary measures for cost control.

In order to ensure cost control, the information transferred to accounting must be recorded, reported, and interpreted completely and clearly. In this respect, the cost accounting system should be renewed to cover all cost elements and the uniform chart of accounts should be restructured at the level of main or auxiliary accounts in such a way that the costs incurred due to emissions are not allowed to be lost in other cost items. It should be known that the more clearly the environmental cost item can be revealed, the more effective it can become in management decisions.

It will not be difficult to predict that with the scientific studies to be put forward in the future and the effects of climate change becoming more noticeable, social environmental awareness will increase, legal regulations may be introduced to present the carbon footprint on products and services to consumer information, and environmental changes will occur in consumer behavior. For this reason, the decisions to be made by business managers by taking into account environmental factors in production and sales planning may have a direct impact on consumer preferences and sales figures of the products and services produced. In this case, the company will either invest in clean technologies and take other necessary measures to minimize its carbon footprint or it will have difficulty finding a place in the competitive market.

One of the primary sources of carbon emissions, the cement industry, was used in this study to document the entire environmental costs incurred by Pacelile Cement Company. A sample chart of accounts was also suggested. Managers are now able to make more informed decisions as a result of the increased visibility of environmental costs in reporting in relation to cost kinds, locations, and environmental cost categories. Furthermore disclosed were the emission cost of the unit product and the emission cost ratio in relation to the total cost, as well as the carbon footprint of the unit product created—that is, the approximate quantity of carbon emissions discharged into the atmosphere per unit product produced.

Consequently, it can be observed that enterprises will persist in experiencing direct or indirect impacts and incur some expenses related to environmental preservation and the mitigation of carbon emissions. For enterprises, the most crucial thing is to reduce the pace of impact. Businesses must be able to precisely detect carbon costs, disclose them, make them available for management decisions, and control these costs by making the appropriate decisions in order to achieve this. This is only possible with an effective accounting and costing system that accounts for environmental costs.

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