

HYDROGEN FUEL CELL WHEELED EXCAVATOR

Impact Valuation Report



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Interactive Guide

The Hydrogen Fuel Cell Wheeled Excavator Impact Valuation Report is available as an interactive PDF that includes features such as navigation to related pages and links to related webpages.

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CEO Message

Our sustainable growth is based on a strong belief in environmental sustainability.

We aim to secure technological leadership in hydrogen models and lead the market, not only by offering products that meet environmental regulations and laws for a comfortable environment for everyone in the future.


HD Hyundai Construction Equipment is a general construction machinery company that has been manufacturing various construction machinery such as excavators, wheel loaders, backhoe loaders, and skid loaders since 1985.

However, in the era of VUCA (Volatility, Uncertainty, Complexity, Ambiguity), if we become complacent and fail to respond to changes in the business environment, our competitiveness is bound to decline. We are facing new risks and opportunities due to changes in the business environment, such as climate change and increased social responsibility. In particular, countries around the world, including developed markets in North America and Europe, are tightening emission regulations and increasing demand for eco-friendly construction machinery.

Based on our belief in eco-friendliness, HD Hyundai Construction Equipment is accelerating the development of construction machinery with clean technologies such as electric and hydrogen models. Starting with the mass production of a 1.9-ton electric excavator in 2024, we are aiming for the mass production of a hydrogen excavator in 2026. In particular, we have developed and presented a beta version prototype close to commercialization at the BAUMA exhibition in Germany, the world's largest construction machinery exhibition, and CONEXPO in North America.

HD Hyundai Construction Equipment conducted an Impact Valuation of the hydrogen excavator to identify the potential value of the hydrogen excavator, which it expects to be a driving forces of growth for in the future. The analysis was conducted using EY's 'Long-term Value' methodology, which measures the tangible and intangible value delivered to stakeholders over the long term through the production and use of hydrogen excavator.

HD Hyundai Construction Equipment is at the forefront of innovation in the construction machinery industry and will continue to grow as a company that generates sustainable value for stakeholders, not just economic growth. We kindly request your interest and support for the innovation and fearless challenges led by HD Hyundai Construction Equipment.

CEO Choi Cheol-gon 

Vision for Hydrogen Economy

“In the coming 50 years, we will create new growth momentum different from what we have seen.” - HD Hyundai-

Finding new energy sources to mitigate the speed of climate change has become a common challenge for humanity. Among various new energy sources, hydrogen is gaining global attention as a future clean energy source. HD Hyundai, in March 2021, declared its commitment to leading the hydrogen market by leveraging the capabilities of its group affiliates across the entire hydrogen value chain, from production to transportation/storage and utilization, through the 'Hydrogen Dream 2030 Roadmap'. HD Hyundai Construction Machinery Sector, we will take on the role of utilizing the hydrogen value chain by developing and commercializing fuel cell-based construction machinery such as hydrogen excavators and hydrogen forklifts, as well as hydrogen combustion engines.



HD Hyundai Construction Machinery sector, Hydrogen Products

HD HYUNDAI XITESOLUTION

- Hydrogen forklift



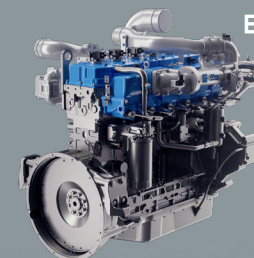
HD HYUNDAI CONSTRUCTION EQUIPMENT

- Hydrogen Excavator



HD HYUNDAI INFRACORE

- Hydrogen Engine



Impact Valuation Overview

Hydrogen Excavator

(14-ton hydrogen wheeled excavator)

A hydrogen excavator is an eco-friendly construction machine that uses the electrochemical reaction of hydrogen and oxygen in a hydrogen fuel cell to convert chemical energy into electrical energy as a power source. Since construction machinery requires a lot of power and long hours of operation on rough job sites, hydrogen fuel cells, with their high energy storage density and short charging time, are an excellent eco-friendly alternative technology. By utilizing hydrogen fuel cells to generate electricity, only pure water is emitted without any harmful gases like carbon dioxide. In addition, hydrogen excavators have the advantage of significantly reducing noise compared to internal combustion engine construction machinery.

Efforts to address the climate change crisis are accelerating across industries, requiring construction equipment products to be advanced to reduce emissions and CO₂. In Europe, Stage V emission regulations are being implemented for non-road construction machinery, which imposes strict regulations on emissions. In addition, major countries are planning to ban the sale of new internal combustion engine vehicles by 2030, and the construction machinery industry is also expected to be subject to increased regulations. Since signing an MOU with Hyundai Motor Company and Hyundai Mobis in 2020 to jointly develop hydrogen fuel cell construction machinery, HD Hyundai Construction Equipment has been developing a 14-ton hydrogen wheeled excavator, and is aiming to introduce a beta version prototype close to commercialization at the 2022 BAUMA exhibition in Germany, the world's largest trade fair, and commercialize it in 2026.

Product for Impact Valuation

Hydrogen Fuel Cell Wheeled Excavator



Development Background



Key Features

- 01 Zero-emission technology that utilizes power from the chemical reaction of hydrogen and oxygen
- 02 No NO_x, SO_x, or PM emissions from equipment operation
- 03 By utilizing hydrogen fuel cells, there is no need for traditional engines, and the noise generated is minimal.

Impact Valuation Process for Hydrogen Excavator

01
Understanding
the product to be
measured



Interviews with hydrogen excavator development departments and personnel, review of internal data and relevant literature to understand the characteristics of the product to be measured and develop ideas for value measurement.

02
Recognize
product value



Identify the value a product creates, directly or indirectly, for stakeholders throughout its lifecycle. In this process, we establish the product or service that serves as the criterion for assessing the value of each product.

03
Setting a
reference price



Establishing the criteria and rationale for converting an accrual of product value into a monetized price. This process utilizes a variety of prior research and reasonable hypotheses to establish a fair price per unit of value.

04
Calculate the
Long-term Value
of a product



Multiply the accrual of product value by the reference price to get the value per category and stakeholder in the Long-term Value framework. The final Long-term Value of the product is then calculated by assuming the expected lifetime of the product.

Impact Valuation Result

HD Hyundai Construction Equipment conducted an impact valuation to identify the potential value of a hydrogen excavator. The value delivered to stakeholders by the hydrogen excavator was measured according to the EY Long-term Value Framework methodology, distinguishing it into 1) Customer value, 2) People value, 3) Societal value, and 4) Financial value. This assessment assumed that the hydrogen excavator would be utilized for 10 years¹⁾ after being sold. Customer value, People value, and societal value were measured in comparison to a reference point, which was a similar product, a diesel engine excavator. The LTV per hydrogen forklift was found to be approximately KRW 323 million. This can be estimated as the value provided to stakeholders by one hydrogen excavator sold and operated by HD Hyundai Construction Equipment over a period of 10 years.

1) Based on 1 year and 1,780 hours of operation

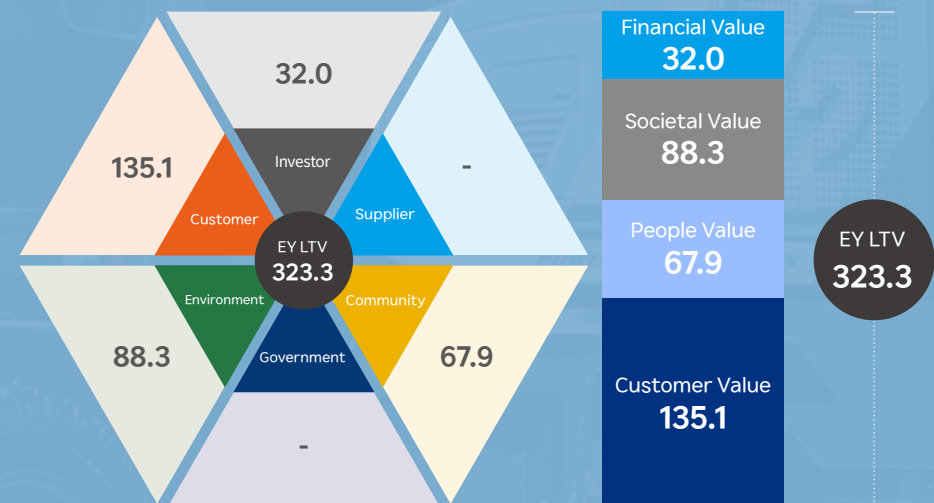
Valuation Result (Based on a 14-ton wheeled excavator)

(Unit: KRW in millions)

Categories	Value Recognition	Customer	Community	Government	Environment	Investor	Supplier	Total
Customer value	Fuel cost savings	128.8	-	-	-	-	-	128.8
	Construction company Scope3 emissions reduction	6.3	-	-	-	-	-	6.3
People value	Health benefits from Reduction in fine dust emissions	-	66.4	-	-	-	-	66.4
	Noise reduction	-	1.5	-	-	-	-	1.5
Societal value	GHG emission reduction	-	-	-	25.5	-	-	25.5
	Air pollutant emission reduction	-	-	-	62.7	-	-	62.7
Financial value	Increasing company profits	-	-	-	-	32.0	-	32.0
Total		135.1	67.9	-	88.3	32.0	-	323.3

(Unit: KRW in millions)

Each 14-ton hydrogen wheeled excavator delivers approximately **323 million KRW** in Long-term Value to stakeholders



This measurement was conducted based on data managed by the company, utilizing national statistics, research findings, and other relevant sources. The monetary values used in the measurement may be subject to change based on new research results, and the completeness of the measurement results cannot be verified, so it cannot be considered as part of financial disclosure.

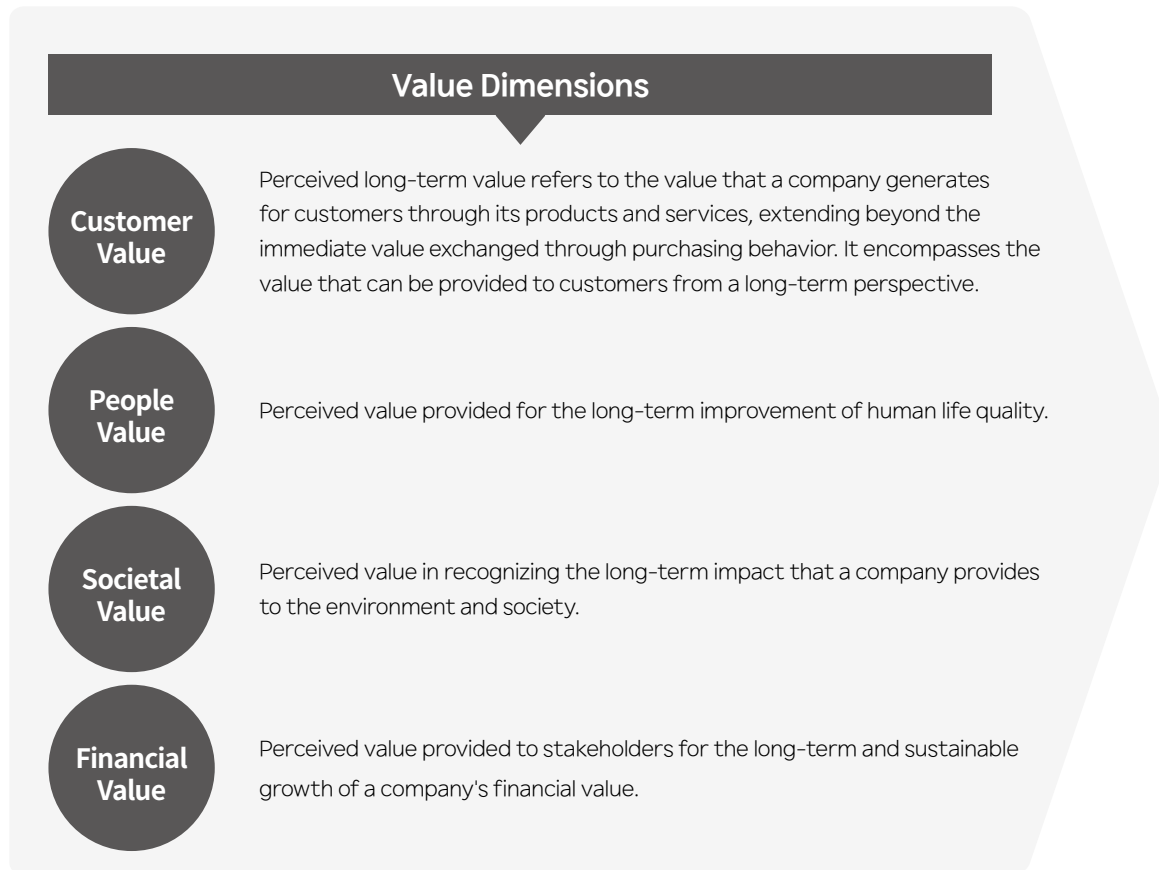
Impact Valuation Calculations and Rationale



Value Recognition	Measurement Methods	Monetization base price	Monetization reference price sources
Fuel cost savings	Ratio of FC product fuel efficiency (12.9 km/kg) to diesel engine fuel efficiency (3 km/L) based on heavy-duty trucks	<ul style="list-style-type: none"> · Diesel price: KRW 1,783/L · Hydrogen price: KRW 4,000/kg 	<ul style="list-style-type: none"> · Diesel prices: December 2022 average · Hydrogen price: 2030 projected price from the Ministry of Trade, Industry and Energy's Hydrogen Economy Revitalization Roadmap
Construction company Scope3 emissions reduction	Comparable (diesel) CO ₂ eq emissions x carbon credit trading price	· Carbon credit trading price: KRW 16,000/ton	· KAU22, as of Dec/29/22
Health benefits from Reduction in fine dust emissions	Comparable (diesel) PM2.5 emissions x Health benefits of reducing PM2.5 emissions	· Health benefits of reducing PM2.5 emissions: KRW 0.214 billion/ton	· A Study of the Effects of Particulate Matter (PM2.5) Emissions on Respiratory Disease, Last updated, Youngsoo Lee, 2015
Noise reduction	Comparable (diesel) noise x Noise Environmental Price	· 80 DB or more Environmental Price : 111euro	
GHG emission reduction	Comparable (diesel) CO ₂ eq emissions x Social Cost of Carbon	· Social Cost of Carbon : 51USD/ton	· Social Cost of Carbon, EPA, USA
Air pollutant emission reduction	Comparable (diesel) air pollutant emissions x Eco-cost per air pollutant	<ul style="list-style-type: none"> · CO Eco-cost : 0.24396Euro/kg · NOx Eco-cost : 6.3638Euro/kg · PM10 Eco-cost : 7.98Euro/kg · PM2.5 Eco-cost : 35Euro/kg · VOC Eco-cost : 0.0102168Euro/kg 	· Eco-costs emissions 2022 V1.1, TU Delft (2022)
Increasing company profits	Estimated product price (3x comparable products) x Sales operating margin	· Operating margin on sales: 7.4%	· Standards for Special Purpose Machines, Industrial Research Institute (2021)

Long-term Value Method

The value of a company, product, or service is not just the value described in its financial statements. Value comes in many different forms and perspectives, and both tangible and intangible values need to be measured and managed in line with a company's strategic priorities. EY Long-term Value recognizes the limitations of current market approaches to value measurement and aims to explain the long-term value of companies, products and services through the measurement of intangible and non-financial values. The EY Long-term Value methodology can be applied to the measurement of value creation across a company's operations and to the measurement of specific products and services. The Long-term Value measurements in this report are for a specific product (hydrogen excavator), and the results are illustrative of the product being measured and do not affect the calculation of corporate value or the value of other products and services.





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