



# Doosan Infracore Concept-X True Value

Value of the Concept-X  
at Future Construction Sites



True Value Case Study

KPMG Strategy Consulting Group,  
Sustainability

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# Doosan Infracore Concept-X



## How KPMG True Value helped build the case for autonomous site solution

### Doosan Infracore's "Concept-X" Creates a Limitless Future of Construction Sites

The global construction industry accounts for over 10% of global GDP. However, it is integral for construction industry to enhance productivity and safety while also reducing environmental impact for ensuring its sustainable growth.

To tackle various challenges at construction sites worldwide and to generate transformative value, Doosan Infracore has been developing "Concept-X," a project to create an all-purpose solution for the construction site of the future by combining state-of-the-art technologies since 2017.

Concept-X enables the improvement of productivity through operation of unmanned equipment and management of construction sites based on digital data of the construction sites. Moreover, it can generate such social and environmental values, greater than work efficiency, as improvements in worker safety, reductions of construction time, and realization of an eco-friendly construction site.

Doosan Infracore has, therefore, calculated economic, social and environmental value of Concept-X by using KPMG's "True Value" methodology and converted it to monetary value to analyze the solution's true value. Leveraging these efforts, we will strive to lead the innovation in the construction equipment industry and to grow into a company that generates sustainable value for all society.



**Sohn, Dong Youn**

Chief Executive Officer  
Doosan Infracore Co., Ltd.



# Concept-X Project

Doosan Infracore's Concept-X is an integrated control solution for the entire construction processes ranging from topographic survey of worksites through using of drone, automatic analysis of worksite data and establishment of optimal data-based construction plans, and autonomous operation of unmanned construction equipment and the control center. In preparation for its commercialization in 2025, Doosan Infracore has been introducing unmanned automation solutions in sequence. The first step to commercialization was the release of "XiteCloud"<sup>1)</sup> in May 2020 an earthwork management solution that optimizes work planning and supports the efficient management of construction sites by enabling establishment of land survey and other construction plans on an exclusive cloud platform. Based on its continued drive for innovation, Doosan Infracore is evolving from a construction equipment manufacturer into an integrated construction site solution provider.

## Unmanned Equipment

Unmanned automated equipment quickly and accurately carries out work based on data analyzed and transmitted by the X-center. Such unmanned equipment is designed to emulate skilled equipment operators at work and to achieve maximum productivity. The automation of Doosan Infracore's unmanned excavators and wheel loaders consists of three systems – perception, planning, and control. The unmanned equipment perceives its surrounding environment through various sensors, sets up a sequence of work plans, including lines of movement, and then executes the plans. It also performs work in a safe and accurate manner based on the control system that prevents collision or overturn.

## X-center – a comprehensive construction site control system

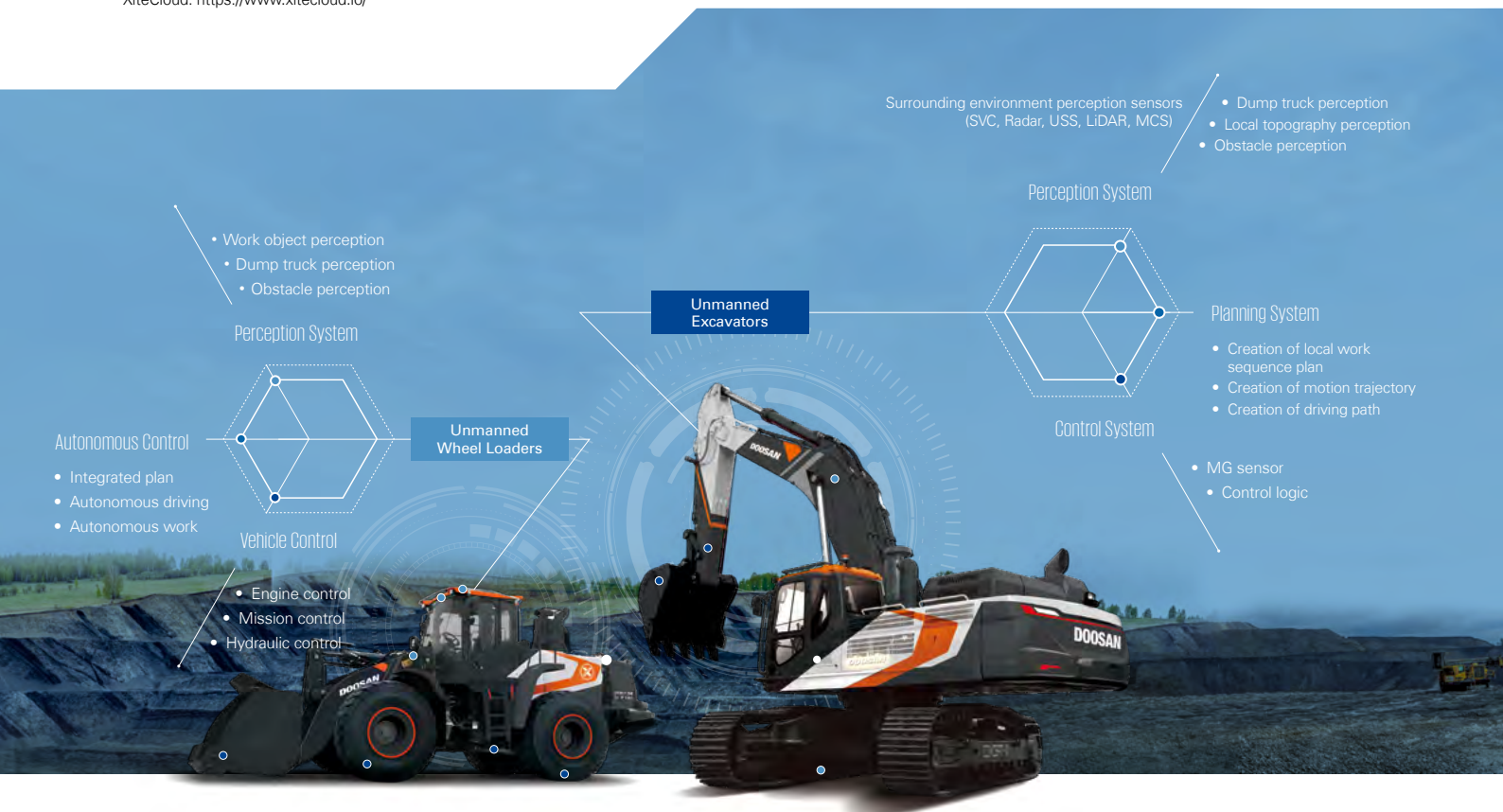
X-center, the center of Concept-X, is a system that monitors and controls the entirety of the construction site, including unmanned equipment to be used, in a comprehensive manner.

- Worksite topography is scanned and measured by a drone, and topographic data produced in a 3D format for establishment of work plans
- Unmanned equipment is operated and managed based on data analyzed by X-center
- Equipment data is remotely monitored and diagnosed, including earthwork status, motion paths and work plans, equipment locations and operation status, major parts status, and signs of abnormal operations through "Fleet Manager," thereby enabling efficient work management and support

## Prognostics and Health Management (PHM)

Prognostics and health management (PHM) enables equipment to self-diagnose its status and to identify potential breakdown sources, thereby ensuring a seamless operation in all environments. Unmanned equipment under PHM analyzes its daily operations and detect any signs of potential troubles among major parts on a real-time basis, thus enabling a comprehensive monitoring of the status of equipment health. The preemptive action to respond to risk factor can be taken as PHM keeps track of the history and forecasts the remaining lifespan of parts.

<sup>1)</sup> XiteCloud: <https://www.xitecloud.io/>



# The Approach

## Building societal cost and benefit into the original value

This analysis is to calculate the economic, social and environmental benefits of adopting Concept-X at future construction sites.

Concept-X is an integrated construction site control solution which includes the X-center technology that engages in a comprehensive control of unmanned construction equipment, such as unmanned excavators and unmanned wheel loaders, and of construction sites. To calculate the value of Concept-X, Doosan Infracore has analyzed various benefits of using the integrated control solution at a construction site compared to conventional construction sites. For more realistic analysis, the company first established guidelines on measuring benefits, including those on monetizing construction time reductions following an adoption of the control solution, based on an extensive collection of global materials on the benefits of using smart construction systems, including the smart construction technology roadmap established by the Ministry of Land, Infrastructure and Transport.

Next, the company created index that includes major economic, social, and environmental benefits of Concept-X. The benefits are derived from its unmanned equipment's performance at a construction site while comparing it to a conventional site with comparable scale and environment.

Economic benefits include productivity improvement indicators, such as design and land survey cost reductions, following the use of drone and 3D mapping as well as equipment and labor cost savings owing to the use of unmanned equipment. Social benefits are work injury cost reductions resulted from worker safety improvements. Environmental benefits are environmental cost savings associated with a reduction of fine dust, noise pollution and greenhouse gas (GHG) emissions, as well as the extent of damage to nearby forests.

Lastly, realistic calculation of the benefits of using Concept-X required a construction case with criteria identical to a simulated one to which Concept-X was to be applied.

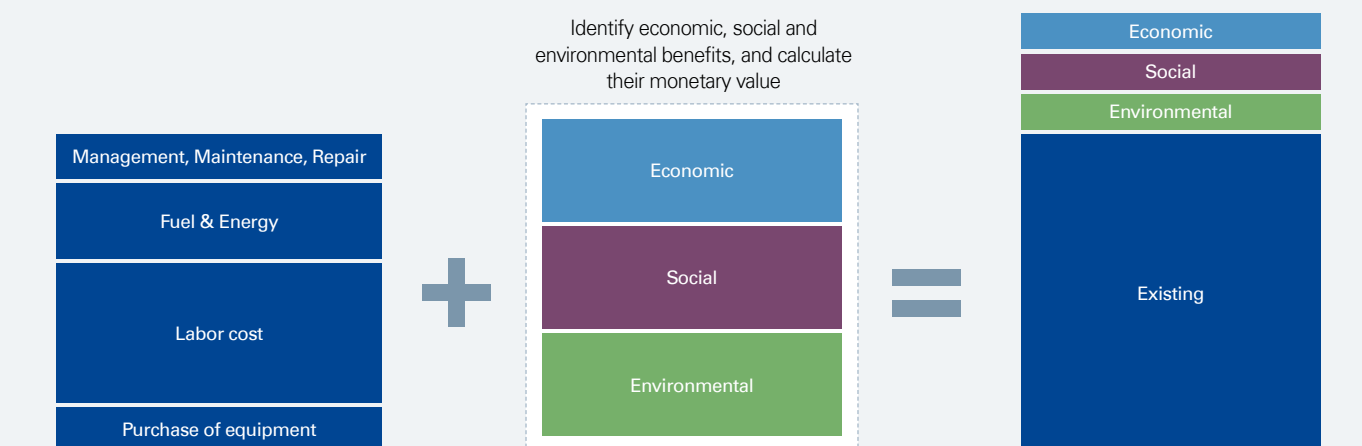
To this end, Doosan Infracore has examined many large-scale construction projects that had been recently carried out in Korea. The company selected few as ideal case studies of which the construction cost and environmental impact data could be verified independently. And at a virtual construction site with identical conditions for an identical period, Concept-X solution was simulated for calculation of its benefits.

The monetization of social and environmental value was done based on quantitative input data generated by the unmanned equipment at the virtual construction site, multiplied by the monetary value assigned to each data in the latest global research materials collected, in accordance with the KPMG's "True Value" methodology.

Of various economic, social and environmental benefits associated with Concept-X, indicators are chosen that are subject to value measurement in consideration of their business importance and impact on stakeholders.

INDICATOR	
Economic	Design and land survey costs
	Worker productivity
Social	Safety accidents
Environmental	Greenhouse gas emission
	Fine dust
	Noise pollution
	Deforestation

### True Value Methodology



# The Challenge

## How do we apply financial values to environmental and socio-economic impacts?

Concept-X solutions, first demonstrated in November 2019, are in the process of being fine-tuned with the goal of a 2025 commercialization. Prior to commercialization, Doosan Infracore plans to introduce a series of new solutions in sequence. In cases where any of the fixed measurement of Concept-X solutions could not be achieved, the company has adopted alternative figures as defined in the following order: 1) latest measurements of value, 2) estimates of value upon commercialization of solutions, 3) effects of unmanned construction equipment solutions researched by outside parties, and in cases of multiple data, the most conservative figures are used.



### Examples of Basis of Monetization Used for Value Measurement

Impact	Cost (KRW)	Note
Costs of safety accidents	260,765,657 / 1 injured worker	<ul style="list-style-type: none"> <li>Occupational Safety &amp; Health Research Institute (2018)</li> <li>Applied the average frequency rate of accident at construction sites</li> </ul>
GHG – CO <sub>2</sub>	79.20 / KgCO <sub>2</sub> e	<ul style="list-style-type: none"> <li>Environmental Prices Handbook EU 28 Version (CE Delft)</li> <li>EPA, Technical update of the social cost of carbon for regulatory impact analysis (2016)</li> <li>EEA, Revealing the cost of air pollution from industrial facilities in Europe (2011)</li> <li>TruCost PLC, Natural capital at risk: the top 100 externalities of business (2013)</li> <li>Applied environmental impact evaluation data of construction project A in Korea (hypothetical construction environment) that was implemented since 2017 for amount of greenhouse gas emissions</li> </ul>
GHG – CH <sub>4</sub>	16.12 / KgCO <sub>2</sub> e	
GHG – NO <sub>2</sub>	8,366.64 / KgCO <sub>2</sub> e	
Fine dust – PM 10	31,401 / Kg	<ul style="list-style-type: none"> <li>Environmental Prices Handbook EU 28 Version (CE Delft)</li> <li>EU, Costs, benefits and economic impacts of the EU Clean Air Strategy (2017)</li> <li>For the amount of fine dust generation, used the environmental impact evaluation of construction project A in Korea (hypothetical construction environment) that was implemented since 2017</li> </ul>
Fine dust – PM 2.5	53,771 / Kg	
Noise pollution	130,607 / dB	<ul style="list-style-type: none"> <li>Referred to the characteristics of construction equipment noise determined by the National Institute of Environmental Research (2003)</li> <li>For the amount of noise generation and impact range, applied environmental impact evaluation data of construction project A in Korea (hypothetical construction environment) that was implemented since 2017</li> </ul>
Deforestation	79.20 / KgCO <sub>2</sub> e	<ul style="list-style-type: none"> <li>Environmental Prices Handbook EU 28 Version (CE Delft)</li> <li>EPA, Technical update of the social cost of carbon for regulatory impact analysis (2016)</li> <li>For the level of neighboring area forest damage and relevant GHG impact, applied environmental impact evaluation data of construction project A in Korea (hypothetical construction environment) that was implemented since 2017</li> </ul>

Note: The used proxy was applied by reflecting the inflation rate and exchange rate fluctuations from the base point to the calculation point

# The Results

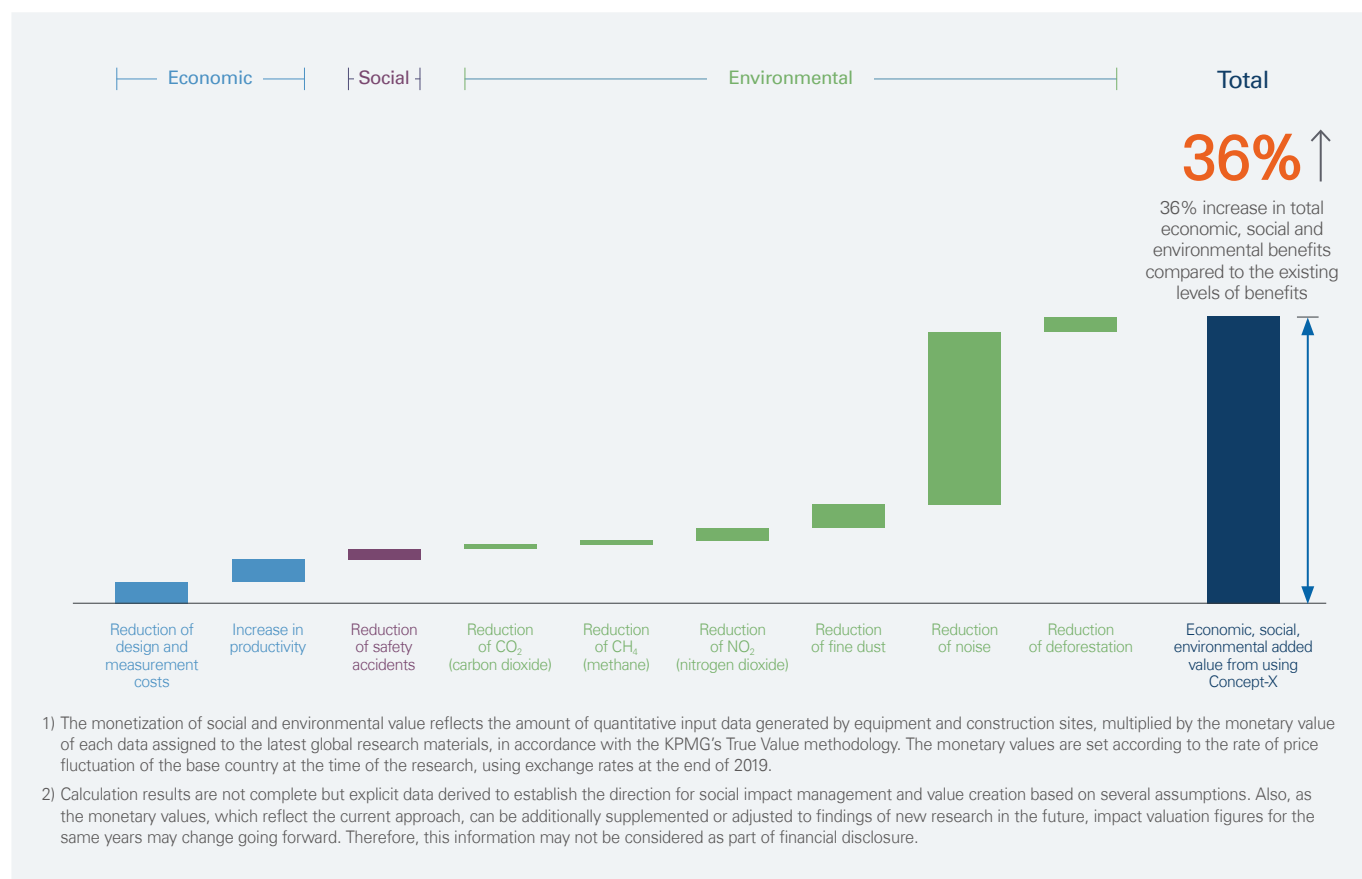
## What did we learn?

The calculation of the benefits of Concept-X projected at the virtual construction site shows the increase of around 36% in total economic, social and environmental benefits. They are represented by a varying degree of reduction of overall construction costs and time, including design and land survey, work injury losses, and environmental impact (greenhouse gas emissions, fine dust, noise, forest damage, etc.) during the construction.

### Indicators

Classification	Indicator	Key content	Value measurement direction and calculation method
Economic	Reduction of design and land survey costs	Reduction of work time and input costs resulting from improved design and land survey accuracy and efficiency	Amount of reduction of design and land survey costs
	Increase in worker productivity	Optimization of personnel expenditures as a result of optimal personnel allocation to construction sites	Allocation of work supervisors and construction equipment operators whose number was optimized through unmanned-automation X Adjusted personnel expenditures
Social	Reduction of safety accidents	Reduction of social costs due to construction site accidents	Social impact of reduced accident frequency rate compared to previous construction sites as a result of a reduction of the construction period and allocated personnel
Environmental	Reduction of greenhouse gas emissions	Reduction of social costs due to carbon dioxide and air pollutant discharge	Amount of reduction in total construction site GHG emissions as a result of reduced construction period X Environmental costs of GHG emissions
	Reduction of fine dust	Reduction of social costs due to fine dust emissions caused by construction	Amount of reduction in total construction site fine dust generation as a result of reduced construction period X Environmental costs per fine dust type
	Reduction of noise pollution	Reduction of social costs caused by noise in the vicinity of construction sites	Amount of reduction in construction site noise generation as a result of reduced construction period X Environmental costs of noise damage per unit area of construction site vicinity
	Reduction of deforestation	Reduction of social costs related to causing deforestation near construction sites	Reduced amount of deforestation as a result of reduced construction period X Environmental costs, including GHG impact caused by forest damage

### Total Economic, Social and Environmental Benefits Compared to the Existing Levels of Benefits



## Results

(Unit: KRW million)




Impact	Economic, social and environmental costs of previous construction (A)	Economic, social and environmental costs when Concept-X is applied (B)	Economic, social and environmental benefits of using Concept-X (A-B)
Reduction of design and land survey costs	56,382	10,825	+ 45,557
Increase in worker productivity	33,272	2,697	+ 30,575
Reduction of safety accidents	824	275	+ 549
Reduction of greenhouse gas emissions	1,374	922	+ 452
Reduction of fine dust	35,329	13,915	+ 21,414
Reduction of noise pollution	1,566,014	1,050,795	+ 515,219
Reduction of deforestation	11,533	7,739	+ 3,794
Total	1,704,728	1,087,168	+ 617,560

Note: As for a hypothetical construction environment in which it could evaluate the potential benefits of Concept-X, Doosan Infracore chose a specific construction project, among recent large-scale construction projects in Korea, of which costs and environmental impact data were possible to calculate. The company then calculated the value that the adoption of the Concept-X would generate in such environment in comparison with the existing construction site.

Note: All figures were rounded off, and therefore small differences may occur in sums.

36% increase in total economic, social and environmental benefits compared to the existing levels of benefits

## Value of Concept-X at Future Construction Sites

 <p>Economic</p>	<p>Concept-X's drone-based 3D mapping technology reduces land survey time and costs up to around 80% of existing ones, as it increases the consistency of survey. Moreover, unmanned automated construction sites require two-thirds fewer onsite personnel, such as work supervisors and construction equipment operators. Total construction time also decreases by 32.9%, contributing to a sizeable reduction in construction costs.</p>
 <p>Social</p>	<p>Concept-X forecasts and detects equipment breakdowns beforehand based on PHM. In addition, unmanned equipment performs equally well in a challenging terrain, contributing to improve the safety of workers. When measuring the effect of safety enhancements, Doosan Infracore has used estimates on a reduction of indirect work injury costs resulting from the presence of fewer personnel at construction sites and a reduced construction time, compared to the social costs of worker injuries that had occurred at the sampled construction site.</p>
 <p>Environmental</p>	<p>The leading environmental benefit of Concept-X is a reduction of fuel consumption and GHG emissions resulting from the economic benefit of improved fuel efficiencies as well as noise pollution in areas surrounding construction sites owing to a shorter construction time. In addition, the estimated number of construction hours saved will have a positive impact on reducing air pollutants, fine dust, deforestation, and other environmental pollutants in areas near construction sites.</p>



# What Next

## How will Doosan Infracore use the analysis?

Doosan Infracore is strengthening the communication with customers regarding its product competitive strengths from the perspectives of total cost of ownership (TCO) and productivity. Going forward, the company plans to further improve its analysis of economic, social and environmental benefits of Concept-X, as illustrated in this report, calculate the true TCO of products that includes their social and environmental impacts in addition to the economic TCO of products, and then disclose relevant outcomes to stakeholders.

These efforts will enable stakeholders, including customers and society, to have a better understanding of the economic, social and environmental costs and benefits of Doosan Infracore's products throughout their lifecycle. In addition, based on the improved analysis, the company will develop products that generate not only outstanding performance and economic value, but also greater social value, compared to peer products, and make increased efforts to lead a technological innovation socially and environmentally beneficial.

### How Concept-X will Contribute to the UN SDGs

The United Nations Sustainable Development Goals (UN SDGs) are a set of sustainable development goals the UN adopted in September 2015, specifying the common goals that the international community must achieve by 2030 as a way to effectively address modern society's economic, social and environmental crises, and thus realize a sustainable society. Doosan Infracore seeks to innovate the industry, enhance customer value, and contribute to ease climate change by connecting its innovation activities with the sustainable development goals of the UN SDGs.



#### Industry, Innovation and Infrastructure

Innovate the construction industry ecosystem and contribute to social infrastructure expansion based on unmanned construction site solutions



#### Responsible Consumption and Production

Enhance user safety and strengthen product responsibility based on PHM and others



#### Climate Action

Facilitate GHG reduction at construction sites by shortening total construction periods and expanding electro-hydraulic application

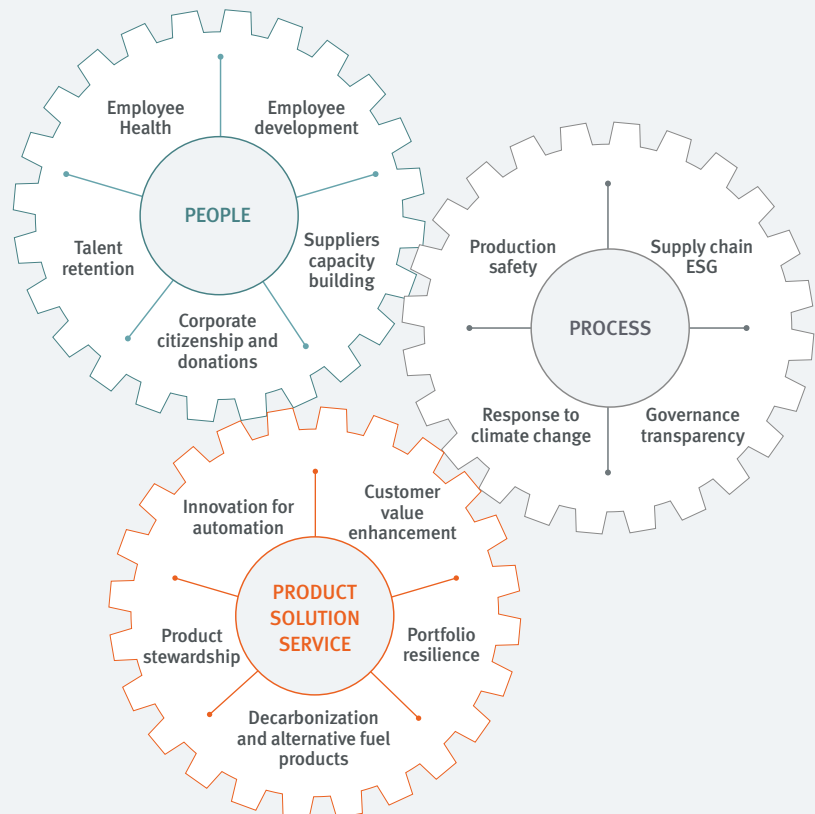
## Doosan Infracore Sustainable Value Framework

In conducting business, Doosan Infracore pursues sustainable growth that generates not only financial but also social and environmental values.

In 2019, the company launched "Sustainable Value Framework" that contains mid- to long-term ESG goals and growth direction for the purpose of integrating the management of financial and non-financial performances.

Accordingly, the company will share data on business growth and stakeholder performance on value creation through disclosure of three areas – People, Product/Solution/Service, Process – and 14 indices by 2025.

Details on the Doosan Infracore Sustainable Value Framework are available on pages 18 and 19 of Doosan Infracore's 2019 Integrated Report.





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