A case study
from Danfoss

Decarbonizing construction machines

The challenge:

Source: IEA (2021). Greenhouse Gas Emissions from Energy

Construction

20%

of global energy-related carbon emissions come from the construction industry[2]

Over the next 40 years, the world is expected to build 230 billion square meters in new construction - adding the equivalent of Paris to the planet every single week.[1] **Construction machinery, such as excavators, is notorious for being inefficient, swallowing vast amounts of diesel, very little of which is converted to productive work.** Construction machines worldwide emit 400MT of CO2 per year[3] as much as the emissions from international aviation.[4] Decarbonizing heavy-duty construction machines will thus be critical if we are to curb GHG emissions.

1. UN Environment, GBA & IEA (2017). Global Status Report 2017, p. 2.
2. IEA (2021). Tracking Buildings 2021.
3. IDTechEx (2022). Electric Construction Machines Vital for Greener Construction
4. JRC (2022). CO2 emissions of all world countries.

The solution:
Reduce emissions from construction machinery

Today, the solutions are already there to drastically improve fuel efficiency in heavy construction machines, while more compact machines can be electrified. By combining electrification and energy efficient solutions in an excavator, just a quarter of the energy input is needed to shift the same amount of earth. Continued improvements in energy efficiency will pave the way for a full electrification of the construction industry.

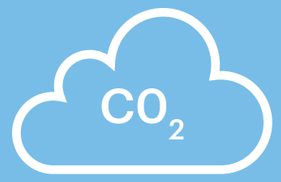
- An efficient and electrified excavator only needs 25% of the energy to do the same job as an inefficient, diesel-driven excavator.
- Electric construction machines enable low emission and less noisy construction sites.

Did you know?

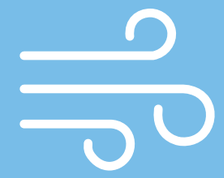
Today's excavator systems are only 30% efficient, meaning 70% of the energy supplied by the engine is wasted. This equates to an estimated fuel value of **$57 billion** a year wasted by excavators on a global level.

Source: Danfoss calculations

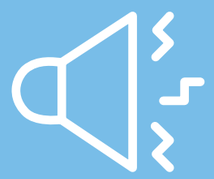
The societal **impact of construction** sites and machinery



Greenhouse Gas Emissions



Air Pollution



Noise Pollution

Running Costs

The building mass is growing

Energy efficiency paves the way for low-emission construction sites

As urbanization continues to grow at pace around the world, the construction of every new building requires materials, machinery and vehicles, all of which emit greenhouse gases.

The construction industry accounted for a total of 20% of global energy-related carbon emissions in 2020[5]. Decarbonizing heavy-duty vehicles such as excavators and wheel loaders used in the construction sector is therefore critical to achieving the objectives of the Paris Agreement. Moreover, many of these machines are to be found in urban areas, contributing to unhealthy noise and air pollution.

In the construction sector there is a huge, unharnessed energy efficiency potential that represents an opportunity for governments to improve the competitiveness of the construction sector while cutting carbon emissions. Construction machinery is often in the form of vehicles but, compared to regular family cars, they are much more complex and therefore harder to electrify.

Construction machinery is generally designed to complete a specific duty such as digging, lifting or grading, and typically uses a hydraulic system to transmit power. The construction site environment requires more than range from its vehicles – it requires power, reliability and durability. These requirements mean construction vehicles are often both heavy consumers of diesel and very inefficient in their energy use. This is a barrier for electrification since it means enormous battery capacity is required to power such massive machines.

Despite these challenges, a range of electric construction vehicles are already on the market. **For the mid- to large-scale construction machinery, solutions are already available now which improve energy efficiency substantially, reducing diesel consumption and paving the way for further electrification of the construction industry.**

5. IEA (2021). Tracking Buildings 2021.

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The low-emission construction site

Efficient and electric off-highway vehicles and machinery

There are many models of construction machines and vehicles with electrified motors available today which can reduce emissions, noise and air pollution on construction sites all over the world. As efficiency in bigger construction machines improves, more and more models of partially and fully electric vehicles are becoming available.

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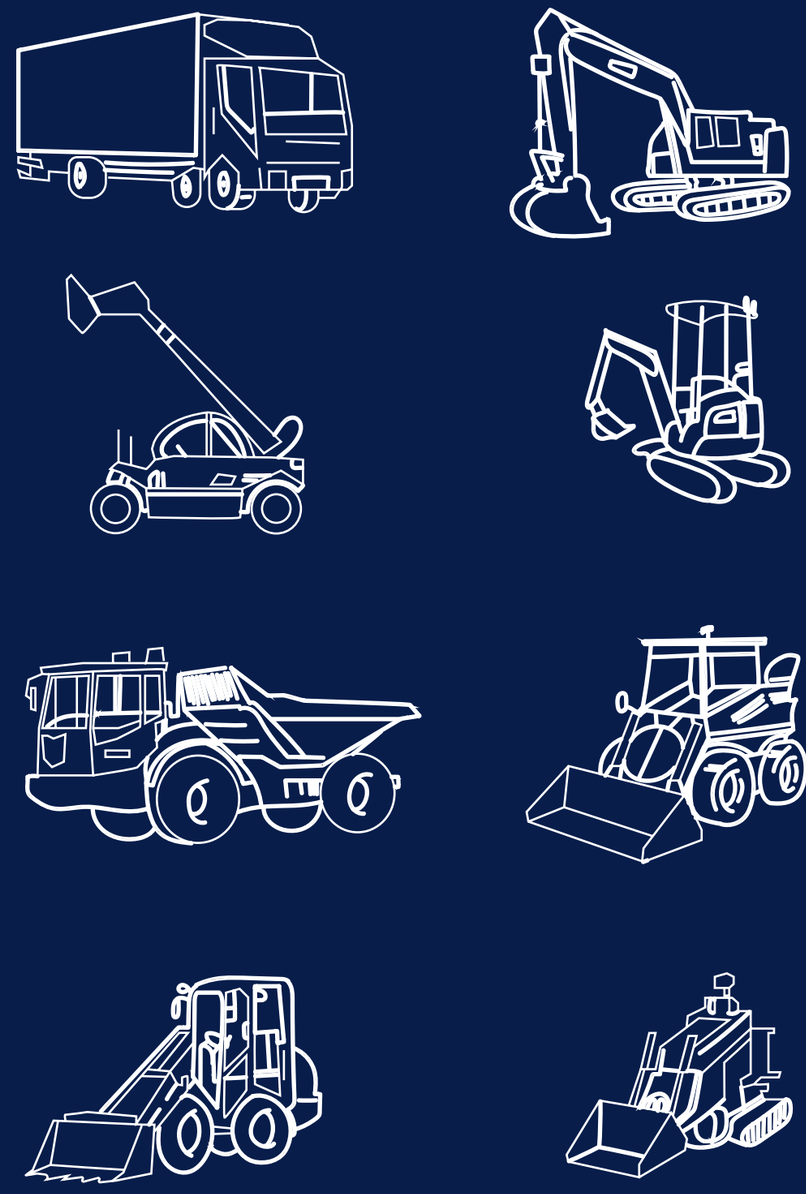

While the current stock of construction machinery is polluting, new and clean technologies are rapidly emerging. Big public buyers, such as cities, can play a key role in encouraging the development and deployment of these machines.[6]

6. Bellona (2019). Zero emission construction site, p. 7.

The potential in energy efficiency and electrification in construction machinery

The excavator as an example

Today's excavator systems are only 30% efficient, meaning 70% of the energy supplied by the engine is wasted before it is used to help the bucket move the earth.[7] The key to reducing emissions from excavators or other heavy vehicles is to improve the energy efficiency of the vehicle's system. This is the first and most important step, and it allows the full potential of electrification to emerge.

Better system efficiency means smaller batteries are required to power electric construction machines. This in turn lowers the CapEx and OpEx of electrified construction vehicles and thereby accelerates the market adoption of low emissions construction machinery. Danfoss calculations show that an electrified excavator utilizing Danfoss Digital Displacement® technology will have a lower total cost of ownership (TCO) than a standard diesel engine within the near-term five-year horizon. In short, more efficient construction machines are good for people, the planet and profits.

The technologies already exist to improve energy efficiency and electrify excavators.

- **Compared to an inefficient, diesel-driven excavator, it is possible for an efficient and electrified excavator to do the same job with only 25% of the energy.**
- **Improved efficiency makes the electrification of construction machines easier, since smaller and cheaper batteries are needed.**
- **Improving energy efficiency and electrifying construction machines also provides great potential for reducing capital costs** and raw material requirements.

7. Danfoss calculations

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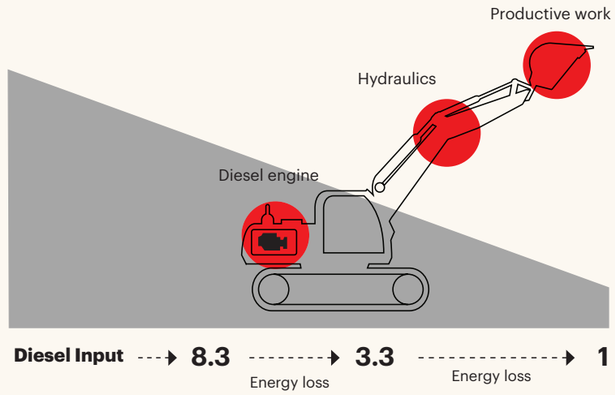
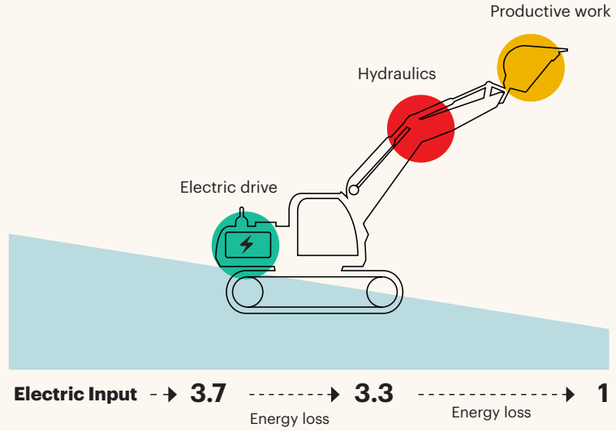
By combining electrification and energy efficient solutions only **25%** of energy input is needed to shift the same amount of earth.

This example highlights the potential in energy efficiency and electrification in a 16 ton conventional excavator

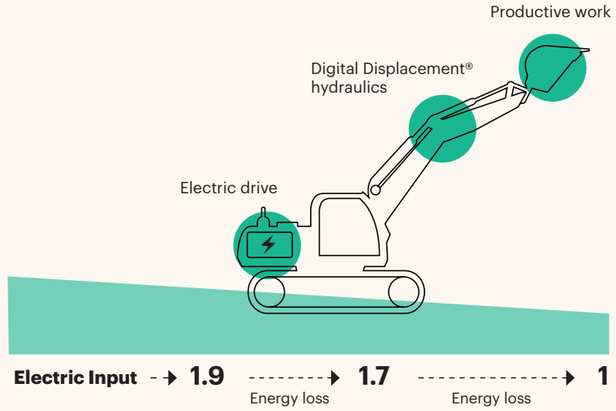
An inefficient ICE excavator requires an input of 8.3 units of energy to produce 1 unit of productive work



An electrified excavator with a conventional hydraulic system requires an input of 3.7 units of energy to produce 1 unit of productive work.



An electrified and energy efficient excavator requires an input of 1.9 units of energy to produce 1 unit of productive work.



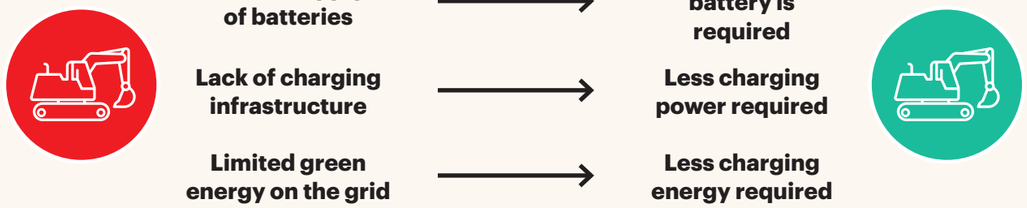
Source: Danfoss calculations

Solutions for reducing carbon emissions in construction machinery

Clean and cost-effective solutions

Improving energy efficiency reduces carbon emissions in the short and medium term and accelerates electrification for the long term. Energy efficiency solutions available today immediately reduce emissions in diesel and hybrid machines and improve the business case for electric drivetrains. Better system efficiency means smaller batteries – lowering the costs of going electric.

Energy efficiency paves the way for electrification



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Construction machines worldwide emit 400MT of CO_2 per year, as much as the emissions from international aviation. 50% of that comes from excavators

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How to improve energy efficiency in construction machines

1 Reduce hydraulic idle losses

Reducing energy consumption when the vehicle is not operating is an easy and cost-effective way to save energy. These idle losses can be reduced through solutions such as variable displacement pumps.

2 Reduce hydraulic losses

Hydraulics systems are essential to many off-highway vehicles but are often extremely inefficient. Energy losses can be reduced markedly through solutions such as digital hydraulics or independent metering valves. In an excavator, the Digital Displacement® pump makes it possible to operate multiple actuators simultaneously by setting independent pressures and flows for each of them, allowing for a significant energy reduction.

3 Improve energy recovery systems

Energy recovery systems can reuse energy used during operations e.g., when braking or lowering a boom.

How to electrify construction machines

1 Install an electric motor

Replacing the internal combustion engine with an electric motor in an off-highway vehicle can improve the maximum overall efficiency from 25% to 56% [8]. "This effectively eliminates local air pollution and significantly reduces noise pollution.

2 Fully electric systems

In fully electric off-highway vehicles, all loads are electrically driven. This allows for very energy efficient operations while emissions, as well as noise and air pollution, are effectively eliminated.

8. Beltrami, Daniele, Paolo Iora, Laura Tribioli, and Stefano Uberti (2021). Electrification of Compact Off-Highway Vehicles, p. 16.

Emissions from construction machinery can be reduced with immediate effect

As the world's population nears 10 billion in 2050, new roads, bridges, buildings and public spaces are needed. By some estimates, the global construction sector accounts for just over 20% of global carbon emissions.[9] Of these emissions, around 5.5% is directly attributed to the fossil fuels used in machines and equipment on construction sites.[10]

Until recently, low emission construction sites may have seemed unattainable, but market innovations are gathering speed and changing the construction industry. Many cities around the world are now using their procurement power to reduce emissions and pollution from the construction sector. Technical innovation and government regulation can make the decarbonization of construction sites and machines the next big driver in the green transition.

9. IEA (2021). Tracking Buildings 2021.
10. Huang et. Al (2017) Carbon emission of global construction sector.

Chief Editor: Judith Neijzen
Editors: Kasper Elbjørn, Niall Caldwell, Leif Bruhn, Craig Grant, Nina Harjula, Rikke Skou Melsen, Sara Vad Sorensen, Emil Romer Hansen, Adrien Chereau
Art Direction: Xandra Maria van Leeuwen, Dorte Riisager Ballermann
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