Hydraulic systems innovation for a greener demolition industry

In heavy-duty mechanical applications, hydraulic systems play a vital role by converting mechanical energy into hydraulic energy, creating high-power density and compactness. These systems are crucial in various sectors, including construction and demolition, where significant forces require high pressure. Piston pumps, one of the most important components of hydraulic systems, help machinery perform tasks requiring high force and precision. However, current hydraulic systems are plagued by inefficiencies, environmental concerns and safety issues, which is where the LIFE-PowerCylinder project comes into play.

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LIFE-PowerCylinder aims to enhance hydraulic systems used in demolition machinery, improve efficiency and lower emissions, and align with the European Union's Waste Framework Directive 75/442/EEC, a central piece of legislation governing waste management and recycling. By adopting innovative technologies in hydraulic systems, the project seeks to contribute to a more sustainable, efficient and environmentally responsible future for the construction and demolition industries.

Project background: challenges in hydraulic systems

Hydraulic systems are common in industries that demand high-force operations, particularly in construction, mining, agriculture and demolition. These systems, which include piston pumps and hydraulic cylinders, can generate large amounts of power in a compact form. Hydraulic pumps are especially important because they enable machinery to function under high pressures and flow rates, which is essential in heavy-duty machinery such as excavators, loaders, and cranes. In fact, the global market for piston pumps is projected to continue to grow due to rising demand across these sectors.

However, despite their widespread use, hydraulic systems have several significant challenges. The buildings and construction sector accounts for over a third of global energy consumption and nearly 39% of energy and process-related CO_2 emissions (International Energy Agency, 2019).

In addition, hydraulic machinery often operates in harsh environments and faces high stress over long operational hours. Thus, various failures often occur, leading to efficiency decline, pressure fluctuation, unexpected machine breakdowns, and, even worse, severe accidents. Hydraulic systems also use large amounts of harmful, not environment-friendly hydraulic fluids. Although sealing technologies have advanced considerably over the past 30 years, the development of hydraulic system operating pressures and response times repeatedly leads to leakage. According to hydraulic hose manufacturer Gates, it is estimated that 370 million litres of oil leak from hydraulic equipment every year. For comparison, one litre is capable of polluting one million litres of water. Current hydraulic cylinders are bulky and inefficient. Traditional systems also face the issue of energy waste, as full power is not always required for every operation. State-of-the-art solutions incorporate external pressure amplifiers, adding system complexity, boosting cost and increasing energy consumption.

Therefore, hydraulic systems require a high reliability and condition monitoring approach. In this scenario, hydraulic cylinders play a key role in satisfying the demand for technological upgrades and compliance with environmental standards to optimise machine and resource efficiency without sacrificing performance or profitability.

To address these challenges, the LIFE-PowerCylinder project has partnered with Mantovanibenne S.r.l. (manufacturer of demolition attachments) and Idraulica Sighinolfi Albano S.r.l. (manufacturer of hydraulic cylinders).

Sighinolfi Albano S.r.l. developed the first hydraulic PowerCylinder (PC), which integrates an internal pressure amplifier, the cartridge booster (CB), into the hydraulic cylinder. This novel cylinder offers several benefits:

- increasing efficiency, resulting in less fuel consumption of machines
- lowering CO_2 emissions, reducing weight due to smaller cylinder design
- geared towards raw material reduction (steel)
- less demand for harmful substances (hydraulic oil).

Avoiding high-pressure connections and external hoses mitigates the risk of external oil leakage and the danger of hose breaking/ exploding, reducing the probability of work accidents significantly.

With the integration of the PC into demolition attachments from the end-user Mantovanibenne (MBI), this project will show the potential of this new technology.

Objectives of the LIFE-PowerCylinder project

The LIFE-PowerCylinder project has clear and ambitious objectives designed to meet the EU's environmental goals while simultaneously addressing the inefficiencies of traditional hydraulic systems. The key objectives of the project include:

- **Optimising system design for efficiency**
  The project aims to design and manufacture advanced hydraulic cylinders with CB, improving efficiency by ensuring the force needed is only applied when required, much like an automatic gearshift. This leads to

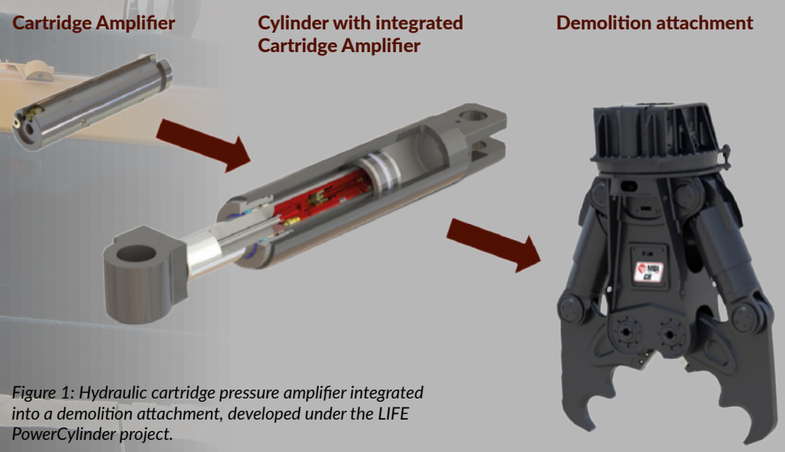
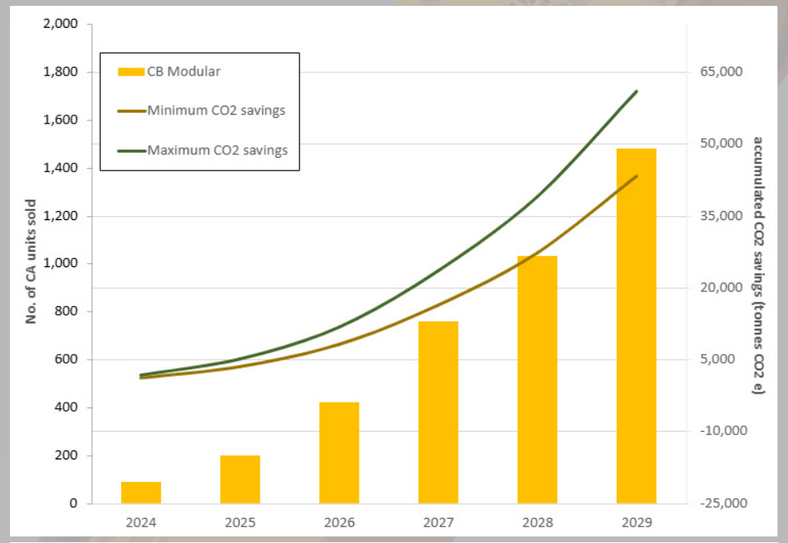


Figure 1: Hydraulic cartridge pressure amplifier integrated into a demolition attachment, developed under the LIFE PowerCylinder project.

faster and more effective machinery operation.

- **Integration into demolition machinery**
  The PC technology will be integrated into various demolition tool excavator attachments, such as crushers, rotating pulverisers and fixed pulverisers. By developing six prototypes in two sizes each, the project aims to demonstrate the adaptability of the technology and that the smaller tool is equal in performance to the larger one.
- **Real-world testing**
  The six prototypes will undergo extensive testing under controlled conditions at an artificial test site as well as on real demolition sites. The tests will be conducted over 300 hours to assess its performance, efficiency and environmental impact.
- **Environmental impact monitoring**
  Monitoring key environmental and health parameters such as fuel consumption, oil consumption, noise, dust and safety will be critical to understanding the impact of the PCs.
- **Replication and expansion**
  To promote wider adoption, the project will facilitate a replication strategy, ensuring knowledge and technology transfer to other sectors. Additionally, the technology will be adapted for smaller devices, significantly enhancing the environmental benefits.
- **Safety and health benefits**
  Increasing operational safety for workers is a priority, which will be addressed by reducing high-pressure parts and eliminating external amplification components.
- **Contribution to EU climate targets**
  The LIFE-PowerCylinder project is designed to help meet the EU's climate action targets and align with the European Green Deal and EU health, safety and environmental protection directives.

Future Perspectives of PowerCylinder Technology in Demolition Sector



Field test results (scenario 3):

- Assumed SmartCylinder® 10% faster than standard cylinder
- Assumed that some attachment with SmartCylinder® can work with smaller excavator
- Total CO_2 saving = 4.71 tons

Figure 2: Projected adoption of PowerCylinder technology in the demolition sector, showing anticipated sales of CA100, CA200, and CA300 units alongside accumulated CO_2 savings.

Expected results and impact

The LIFE-PowerCylinder project is expected to yield significant technical, economic and environmental results. These results will not only benefit the hydraulic systems in the demolition sector but also contribute to broader EU goals such as reducing CO_2 emissions, minimising waste and enhancing resource efficiency.

Technical and economic results

- **Faster and stronger hydraulic cylinders**
  The CBs will act like automatic gearshifts, providing up to 50% faster operation and generating 37% more force than conventional cylinders of the same weight. This leads to improved efficiency and reduced operational time.
- **Easier installation**
  Unlike external amplification systems, the PC can be integrated more easily into existing machinery without additional components or complications.
- **Job creation**
  The project is also expected to create around 30 new jobs, with four positions created before the end of the project and 26 more by 2029, further contributing to the local economy.

Environmental results

- **Energy efficiency**
  The new power cylinders will reduce overall energy consumption by 15–20%, as they only apply maximum force when needed. This reduction in energy use directly leads to lower fuel consumption and decreased CO_2 emissions.
- **Increased speed and reduced CO_2 emissions**
  The technology enables tools to complete the same tasks more quickly, allowing smaller excavators to perform the same jobs, leading to a reduction of 4.71 tons of CO_2 during the demonstration phase.
- **Reduced material use**
  The amplification ratio of the power cylinders (ranging from 2 to 2.8) allows for a reduction in rod diameter and weight. The downscaling of the hydraulic system will also result in lower weight, reducing material usage across the machinery.
- **Noise and dust reduction**
  By completing tasks more efficiently, the power cylinders will lead to a 10% reduction in noise pollution and a 7% reduction in dust generation, both of which improve worker safety and environmental quality.
- **Improved safety**
  The absence of high-pressure hoses and connections reduces the potential for mechanical failures, making the machinery safer and more reliable for workers.

Aligning with the EU's Waste Framework Directive

The LIFE-PowerCylinder project represents a major step forward in developing efficient, sustainable and safer hydraulic systems for the construction and demolition sectors. Integrating innovative technologies, such as the CBs, into hydraulic cylinders aligns with the European Union's Waste Framework Directive 75/442/EEC, emphasising resource efficiency, waste reduction and environmental protection.

This project also contributes to the broader goals of the European Green Deal, helping the EU achieve its climate action targets while promoting economic growth through technological innovation and job creation. The expected reduction in energy use, CO_2 emissions, and material waste demonstrates how cutting-edge hydraulic technology can support the EU's efforts to move towards a circular economy, where sustainability and resource conservation are at the forefront.

The LIFE-PowerCylinder project exemplifies how industrial innovation can lead to tangible environmental and economic benefits when combined with regulatory frameworks like the EU's Waste Framework Directive. As the project progresses, it is set to transform the hydraulic systems used in demolition machinery, offering a cleaner, more efficient and safer future for the industry.

References

International Energy Agency (2019) *Global Status Report for Buildings and Construction 2019*. Paris: IEA. Available at: https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019.

smart Cylinder SIGHINOLFI ADVANCE

PROJECT SUMMARY

LIFE-PowerCylinder is to demonstrate lower emissions and higher efficiency through innovative, downscaled hydraulic systems in demolition machinery. The project will develop and test six demolition attachments fitted with hydraulic cartridge pressure amplifiers. It aims to reduce energy consumption, cut CO_2 emissions, and improve performance, contributing to a more sustainable and efficient construction sector.

PROJECT PARTNERS

The LIFE PowerCylinder project brings together PistonPower s.r.o., Idraulica Sighinolfi Albano S.r.l. and Mantovanibenne S.r.l.. PistonPower s.r.o., a Slovakian company specialising in hydraulic systems, contributes its expertise in developing innovative solutions. Mantovanibenne S.r.l., an Italian firm renowned for manufacturing demolition attachments, provides advanced equipment design and production capabilities.

PROJECT LEAD PROFILE

Idraulica Sighinolfi Albano S.r.l., an Italian company with a rich history in producing high-quality hydraulic cylinders, leads the LIFE PowerCylinder project. Its extensive experience and commitment to innovation drive the project's goal of enhancing efficiency and reducing emissions in demolition machinery through the development of advanced hydraulic systems.

PROJECT CONTACTS

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