Enhancing energy security and sustainability in cement plants through Turboden ORC technology

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The cement industry in the Gulf region is entering a new phase of transformation, driven not only by the global decarbonization agenda but also by regional priorities such as energy security, water scarcity, and industrial competitiveness.

Countries across the Gulf Cooperation Council are investing heavily in infrastructure and industrial development, resulting in sustained demand for cement. At the same time, producers are facing increasing pressure to optimize energy use, reduce operating costs, and align with emerging international regulations such as the Carbon Border Adjustment Mechanism (CBAM).

In this context, Waste Heat to Power (WHP), and in particular Organic Rankine Cycle (ORC) technology, represents one of the most direct and impactful approaches to enhancing the energy efficiency of the clinker production process

By capturing thermal energy from hot exhaust gases generated during clinker production, WHP systems can produce up to 30% of the electricity required by a cement plant. Without such systems, this valuable energy is not only wasted, but also additional resources such as water or electricity might be consumed to cool and process these streams. Implementing WHP not only reduces environmental impact but also improves operational efficiency and cost-effectiveness.

Over the past 15 years, the cement industry has increasingly embraced ORC technology as a dependable and competitive alternative to the conventional Steam Rankine Cycle (SRC) for heat recovery applications. This shift has been driven by continuous innovation in ORC systems, enhanced economic viability, and a growing global focus on sustainable industrial solutions.

Today, Turboden, a group company of Mitsubishi Heavy Industry and the foremost global supplier of ORC plants designed for medium-to-high-temperature applications in energy-intensive sectors, offers ORC solutions ranging from 500 kW to 40 MW of electrical output from a single turbine, marking a significant expansion into power ranges traditionally dominated by SRC technology. This evolution positions Turboden ORC not only as a complementary solution but as a leading option for large-scale cement plants seeking efficient, water-free, and low-maintenance heat recovery systems.

Between 2024 and 2026, Turboden successfully secured seven new projects exclusively within the cement industry, representing a combined installed capacity of over 40 MW of clean, water-free, electricity. This achievement highlights the growing appeal of waste heat recovery via ORC technology as a strategic solution for cement plants aiming to reduce their carbon footprint.

In addition, since the beginning of 2025, Turboden has commissioned five ORC plants in the cement sector, further reinforcing its leadership in industrial energy efficiency.

A standout example is the 13 MW ORC plant commissioned at Riyad Cement Company in the Kingdom of Saudi Arabia, the first of this kind in the Kingdom.

This project demonstrates Turboden's ability to compete in power ranges traditionally dominated by Steam Rankine Cycle (SRC) systems, especially in regions where water scarcity makes dry, closed-loop solutions like ORC particularly advantageous.

The plant recovers heat from both the preheater and clinker cooler gas streams of two clinker production lines (each rated at 5,000 tons/day) and is expected to generate more than 80 GWh/year of clean electricity. This will result in an annual reduction of over 37.000 tons of CO_2 emissions, contributing meaningfully to Saudi Arabia's broader decarbonization goals.

This particular ORC system marks a significant milestone as the first to recover heat from two separate kilns simultaneously. It showcases the exceptional flexibility of Turboden's ORC technology, which is designed to operate efficiently even when one of the kilns is offline for maintenance. This capability ensures continuous energy production and maximizes the utilization of available waste heat.

Moreover, the project demonstrates the strategic advantage of deploying a high-efficiency, large-scale ORC system, which benefits from a lower €/kW investment cost compared to smaller, low-temperature modular units. These smaller systems typically achieve less than half the efficiency and offer limited additional flexibility, making them less suitable and attractive for larger cement plants.

While a variety of strategies, including the use of lower-carbon fuels, improved material efficiency, and carbon capture technologies, are essential to reducing emissions in line with global climate targets, WHP stands out as one of the most immediate and cost-effective solutions to enhance both the sustainability and profitability of cement plants.

Cement plants typically have two sources of recoverable thermal power that can be utilized through an ORC unit: exhaust gas from the preheater towers and hot air from the clinker cooler. Turboden has installed numerous ORC units

in cement plants, recovering energy from either or both sources. The electric power output of these units ranges from 1 MWe to 13 MWe, depending on the exploitable thermal source conditions. However, Turboden can offer units with mechanical power ranging from 500 kWe up to 40 MWe from a single turbine and it has successfully implemented more than 460 ORCs worldwide in different sectors.

Customer	Country	Start-up	Kiln capacity (ton/day)	Heat source	Heat carrier	ORC gross electric power (kW)
CIMENTS DU MAROC (HeidelbergCement Group)	Morocco	2010	5.000	PH	thermal oil	2.000
HOLCIM ROMANIA (LafargeHolcim Group)	Romania	2012	4.000	PH + CC	thermal oil + superheated water	4.000
CRH SLOVAKIA	Slovakia	2014	3.600	PH + CC	thermal oil	5.000
CARPATCEMENT (HeidelbergCement Group)	Romania	2015	3.500	PH + CC	thermal oil	3.800
JURA-CEMENT-FABRIKEN (CRH Group)	Switzerland	2016	3.000	PH	superheated water	2.300
CEMENTI ROSSI	Italy	2018	3.500	PH + CC	none – direct exchange	2.000
ÇİMKO (Sanko Group)	Turkey	2019	9.500	CC	thermal oil	7.000
HOLCIM SUISSE ECLÉPENS (LafargeHolcim Group)	Switzerland	2020	2.300	PH + CC	thermal oil	1.300
SÖNMEZ ÇIMENTO	Turkey	2020	6.000	PH + CC	thermal oil	7.300
SECIL	Portugal	2024	3.800	PH + CC	thermal oil	7.200
CIMPOR (Souselas)	Portugal	2025	4.200	PH + CC	thermal oil	8.400
CIMPOR (Alhandra)	Portugal	Under construction	3.100	PH + CC	thermal oil	6.200
HOLCIM UAE (Holcim Group)	UAE	2026	7.500	PH + CC	thermal oil	10.000
MEDCEM	Turkey	2025	10.000	CC	thermal oil	11.000
CIMSA ESKISEHIR	Turkey	2025	4.500	PH + CC	thermal oil	5.900

Customer	Country	Start-up	Kiln capacity (ton/day)	Heat source	Heat carrier	ORC gross electric power (kW)
RIYADH CEMENT COMPANY	Kingdom of Saudi Arabia	2026	2 x 5.000	PH + CC	thermal oil	12.600
COLACEM SESTO CAMPANO	Italy	Under construction	3.000	PH + CC	thermal oil	2.000
HOLCIM OBOURG (GO4ZERO)	Belgium	Under construction	4.500	PH + CC Oxyfuel kiln	thermal oil	7.500
UNDISCLOSED	Turkey	Under construction	3.300	CC	thermal oil	3.500
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Figure 1: Turboden references in cement plants

The exhaust gas or hot air from the process enters a heat recovery exchanger, which transfers the thermal power in the gas stream to a thermal vector, typically thermal oil. The heat exchanger is designed to effectively handle the gas stream's specific conditions, managing pollutants and dust commonly present in the gas. The thermal vector then transfers the thermal power to the ORC working fluid, often cyclopentane for cement plant applications (being the working fluid that best fits with the thermal source characteristics in terms of temperature). The cyclopentane evaporates and enters the turbine, Turboden core product, generating mechanical power, which is converted into electric power by a connected generator. The expanded vapor then passes through an internal heat exchanger called regenerator, where it releases heat to its liquid phase coming from the opposite side. After the regenerator, the vapor enters the condenser, where it further cools down and returns to a liquid phase. This condensation, especially in Countries with scarcity of water, can occur by utilizing ambient air directly. In this way, no water is consumed for ORC plant operation. The ORC working fluid is then pumped back through the regenerator to the evaporator, completing its cycle.

Compared to traditional heat recovery systems like SRC, ORC technology offers clear advantages for cement producers. One of its most significant strengths is operational flexibility: ORC systems can efficiently manage thermal input variations from 20% to 110% of the design load, while maintaining efficiency levels close to nominal one.

Turboden ORC systems are fully automated, eliminating the need for constant on-site supervision and allowing cement plant teams to focus on their core operations.

The WHP plant is installed in bypass to the existing gas treatment line, ensuring that clinker production remains uninterrupted even during ORC maintenance or downtime.

Unlike solar PV or other renewable options, WHP offers superior economic efficiency thanks to its high utilization rate; it can operate continuously whenever the cement plant is running, delivering significantly more annual kWh while requiring minimal space.

Recent years have shown how energy price fluctuations can impact competitiveness, even in strong markets. WHP with ORC is now a mature, proven solution that locks in a stable electricity cost for the entire plant lifecycle, reducing exposure to sudden and unpredictable price spikes. Existing Turboden installations have already demonstrated this resilience in real-world conditions.

Turboden ORC in a cement plant, details of the ACC

Conclusion

In the Gulf region cement producers are facing a unique combination of challenges: ensuring energy security, optimizing operating costs, and aligning with an evolving global regulatory landscape, including mechanisms such as CBAM.

At the same time, constraints such as water scarcity and the need for process efficiency optimization are becoming increasingly critical in project design and plant operation.

Waste Heat Recovery through ORC technology directly addresses these regional priorities by enabling cement plants to increase energy self-sufficiency and reduce dependence on external power supply, operate with zero water consumption, improve process efficiency by turning waste energy into valuable electricity and reduce carbon intensity and enhance competitiveness in export markets

Backed by over four decades of experience, and with proven large-scale installations in the region, Turboden is ideally positioned to support this transition, offering flexible ORC solutions capable of delivering reliable power generation, enhanced efficiency, and full alignment with the specific requirements of the GCC market.

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