

The LIFE DIMITRA Project: Engineering and Deployment of a Demonstration Plant for Nutrient Recovery from Agricultural Digestate

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ABSTRACT

Anaerobic digestion (AD) plays a central role in the European energy transition, with biogas production expected to increase substantially under the REPowerEU strategy. Alongside renewable energy, AD generates large volumes of digestate, a nutrient-rich by-product containing nitrogen (N), phosphorus (P), and potassium (K). By 2050, digestate production in Europe is projected to reach 177 Mt (dry matter), potentially covering a significant share of EU fertilizer demand if properly valorized. However, current management practices, largely based on direct land spreading—pose environmental and regulatory challenges, especially in Nitrate Vulnerable Zones (NVZs), where strict nitrogen application limits constrain agricultural use. Nutrient leaching, greenhouse gas emissions, and logistical constraints linked to digestate instability further highlight the need for advanced upgrading solutions.

Within this framework, the DIMITRA project includes the design, construction, and installation of two demonstrative plants in Greece and Italy. DEMO 2, the Italian demonstration plant for agricultural digestate valorization, has been installed at “La Torre” agricultural cooperative (Isola della Scala, Verona, Italy), a livestock farm managing approximately 7,000 beef cattle and operating a biogas facility active since 2012. The farm processes around 35,000 m³/year of slurry, 18,000 t/year of manure, and 8,500 t/year of silage corn, producing biogas with 53–54% methane and generating approximately 8,600 MWh/year of electricity.

DEMO 2 is designed to recover and fractionate macronutrients from agricultural digestate through a sequence of pressure-driven membrane processes. The system consists of three main unit operations: (i) solid–liquid separation, generating a solid fraction rich in fibers and a liquid fraction containing dissolved organic and inorganic compounds; (ii) ultrafiltration (UF), producing a permeate enriched in ammonium and potassium salts and a concentrate containing microorganisms, phosphorus, and organic nitrogen; and (iii) reverse osmosis (RO), further separating the UF permeate into purified water and a concentrated stream rich in ammonium and potassium salts. This sequential configuration enables targeted nutrient recovery, generating concentrated mineral streams suitable as precursors for bio-based fertilizers. The entire DEMO 2 plant is integrated into a compact modular container (2.4 × 3.0 × 5.8 m), designed for operational flexibility. Individual treatment units can be activated or bypassed depending on the characteristics of the incoming digestate. Installed adjacent to the anaerobic digester, the system receives digestate via a dedicated pumping line from a storage tank. The modular design enhances transferability and replicability, allowing relocation to other AD facilities and adaptation to different agro-industrial waste streams.

By shifting from direct land application toward nutrient fractionation and concentration, DEMO 2 represents a scalable technological solution to improve digestate management, support circular bioeconomy strategies, and reduce environmental pressures associated with intensive livestock farming.