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## **TECHNOLOGICAL GAPS AND SUPPORT FOR BAT/BET IMPLEMENTATION IN ECO-INDUSTRIAL PARKS**

Technological gaps in eco-industrial parks (EIPs) are a set of shortcomings, lags or missing technological elements (infrastructure, equipment, knowledge, digital solutions or processes) that prevent the effective functioning of the park in accordance with the principles of sustainable development, circular economy and best environmental technologies (BET)<sup>1</sup>.

Today, Ukraine has certain technological gaps in the development of EIP policy. They are manifested in a number of aspects that directly affect the effectiveness of the implementation of the principles of sustainable development, circular economy and environmental innovations. First of all, industrial parks (IPs) lack modern engineering systems, in particular treatment, energy, water supply and waste management systems. Often, intra-site engineering networks (water supply, sewage, wastewater and waste collection and treatment systems) are underdeveloped or outdated, which makes it difficult to ensure proper environmental standards. Connecting to external energy networks (electricity, heat, gas) can also be difficult or excessively expensive, especially in regions with underdeveloped infrastructure. An important problem is the insufficient digitalization of IP management processes. There is limited use of automated monitoring systems for environmental indicators (emissions, resource consumption, energy consumption, water consumption), as well as digital tools for environmental impact analysis. The low level of digital infrastructure complicates the collection, processing and assessment of data on the effectiveness of IP operations. A significant gap remains the lack of industrial symbiosis technologies for using waste from one enterprise as a raw material or energy resource for another. Because of this, the potential of the circular economy within IPs is only partially realized. The application of modern technologies for cleaning industrial and chemical waste, as well as processing and recycling technologies, is also limited. Another aspect is the limited use of renewable energy sources (RES) within IPs<sup>2</sup>.

In most cases, there are no large-scale solutions for the production of heat or electricity from renewable energy sources for industrial needs. There is also a lack of energy efficiency technologies necessary for the modernization of existing buildings, structures and production lines. An additional barrier is the financial inaccessibility of "green" technologies. The high capital cost of innovative equipment often exceeds the financial capabilities of small and medium-sized enterprises.

In Ukraine, grant and credit support mechanisms for the modernization of technological processes in accordance with EIP standards are not sufficiently developed<sup>3</sup>. No less important is the human and scientific gap. There is a shortage of specialists in the design, management and operation of EIP, as well as experts in the field of industrial symbiosis and the circular economy. The number of educational programs and trainings covering the technological and managerial specifics of EIP remains limited. In addition, although Ukraine already has a

national standard for EIP, not all industry technologies and sectors are covered by specific methodologies or requirements. There are no clear criteria for maximum emission levels for new industrial facilities, water and energy consumption standards, as well as requirements for waste management and recycling systems.

All this indicates the need for further development of technical, regulatory and personnel mechanisms to overcome existing technological gaps and form a full-fledged model of eco-industrial parks in Ukraine.

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