Circular Economy in Food Industry Waste Management (BIVALIA Workshop2 - 2026)

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Technological advances in methane emission monitoring

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Biomethane; Methane leak detection; Fugitive emissions; Continuous emissions monitoring; Life Cycle Assessment; Optical Gas Imaging

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Invited Speakers #2

Technological advances in methane emission monitoring

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Keywords: *Biomethane; Methane leak detection; Fugitive emissions; Continuous emissions monitoring; Life Cycle Assessment; Optical Gas Imaging*

Biomethane is a cornerstone of the circular economy through the energy recovery of agrifood waste. However, because methane has a Global Warming Potential (GWP) 80–86 times greater than CO_2 over a 20-year horizon, its classification as a "sustainable" fuel holds true only if biomethane remains entirely contained within the pipeline.

Recently, studies revealed that average methane loss across biomethane plants ranges between 4-6% of total production (with extreme outliers reaching up to 21%). Rigorous Life Cycle Assessment (LCA) demonstrates that even a 2-3% fugitive leak rate can erode more than 50% of the net greenhouse gas reduction benefits expected from replacing natural gas. Driven by the EU Methane Regulation (Directive 2024/1787), operators are now legally mandated to maintain transparent, quantifiable, and proactive emissions management.

Unmonitored leaks create a persistent blind spot, often representing an unmeasured loss of around €100,000 annually per facility. It is crucial to differentiate between methane slip (operational losses during upgrading, typically 0.5–2% of throughput) and fugitive emissions (leaks from valves, flanges, membrane seals, and digestate storage, which account for ~70% of a facility's total unmetered losses).

This technological review presents the spectrum of techniques for methane leak detection and quantification, spanning

1. close-proximity inspection,
2. fenceline monitoring,
3. aerial surveys, and
4. satellite tracking

alongside key technological advancements underpinning methane monitoring:

1. NDIR,
2. TDLAS, and
3. Optical Gas Imaging (OGI)

The combination of these technologies with machine learning models, digital twins, and computer vision is rapidly transforming environmental monitoring from a manual, labour-intensive task into an automated, unmanned operation. Implementing continuous and automated workflow monitoring routinely enables biomethane operators to pinpoint super-emitters and eliminate 45–60% of fugitive losses, yielding a typical payback period of under 12 months. Ultimately, this shift not only empowers operators to certify verified emission reductions for high-value carbon markets and regulatory compliance, but also delivers a direct boost to Return on Investment (ROI) by preventing the loss of valuable gas.

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