

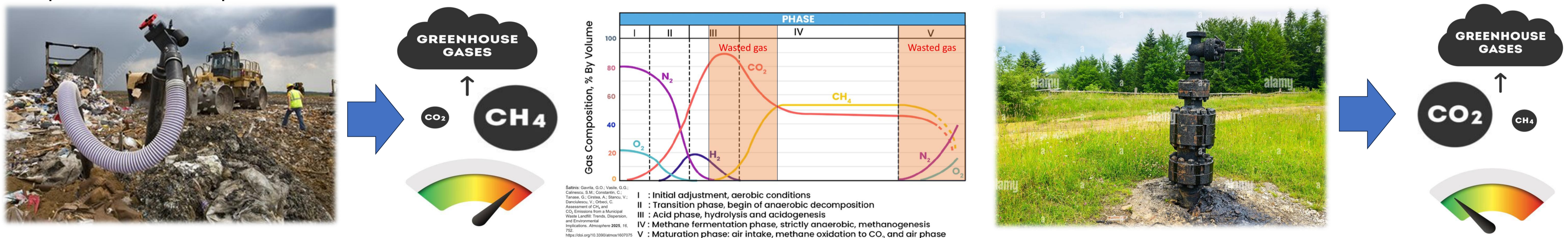
Low calorific gas combustion in the SI engine under oxygen enrichment

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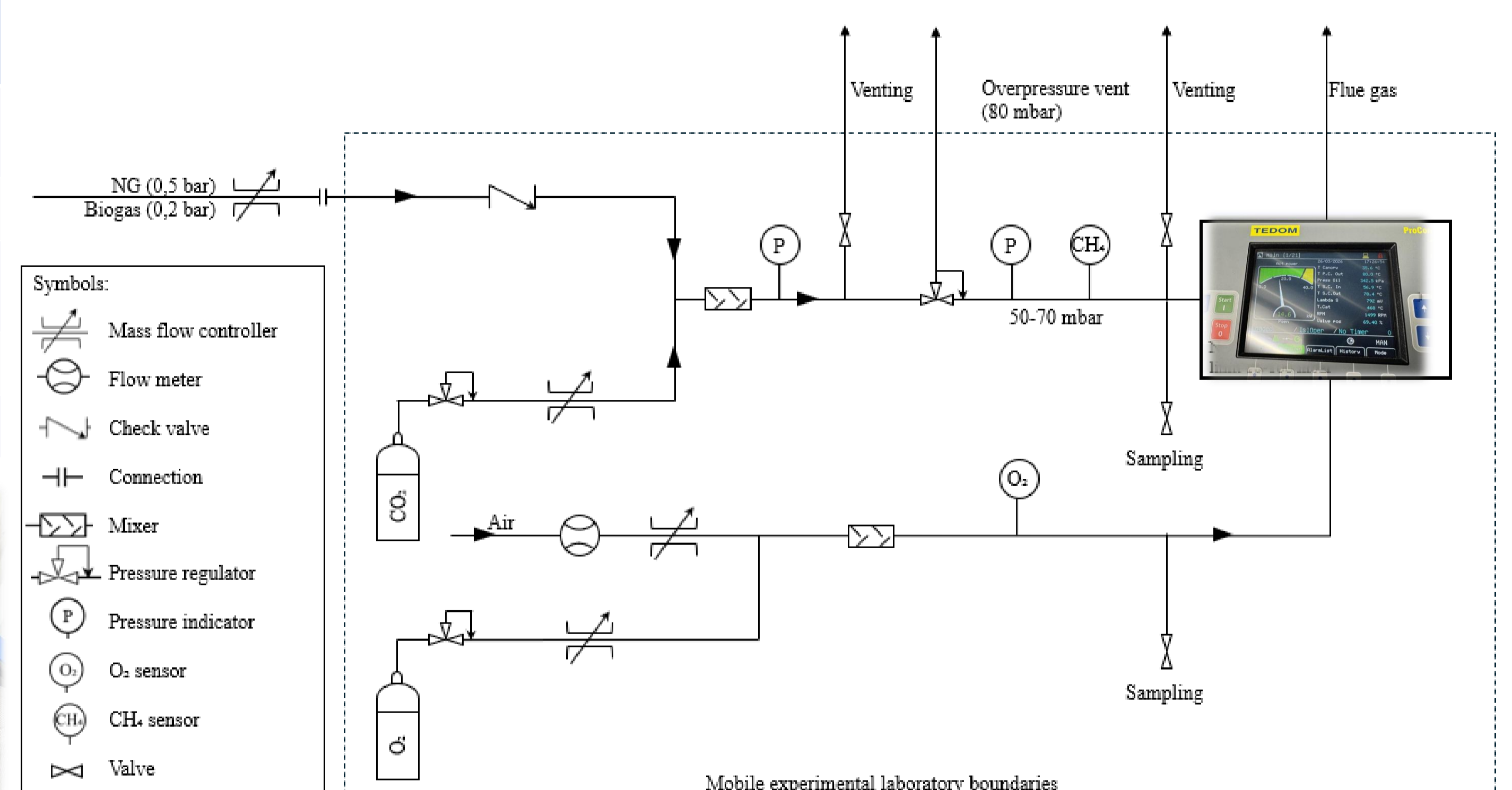
Keywords: Low calorific gas, engine, oxygen, CO₂, combustion, NO_x

Introduction. Landfills are the third-largest source of anthropogenic methane emissions, a potent greenhouse gas contributing significantly to climate change. In response, the EU aims to phase out landfilling practices. Once organic waste is no longer deposited, methane generation declines, making Combined Heat and Power (CHP) production using conventional spark-ignited gas engines unfeasible due to insufficient gas quality and volume. Despite this, residual methane emissions to the atmosphere persist. To mitigate these emissions, landfills are typically sealed and equipped with "bio-windows"—engineered zones where methane-oxidizing microbes convert methane into carbon dioxide. However, these systems only partially reduce methane concentrations. Not all the gas generated within the landfill necessarily migrates through these bio-windows, meaning uncontrolled emissions can still escape into the atmosphere.

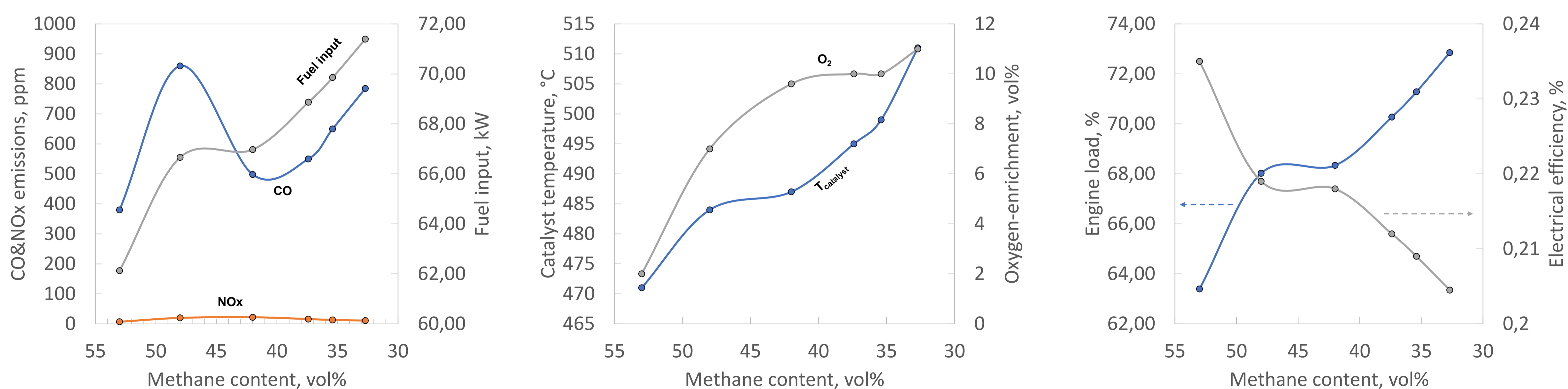


Methodology. To mitigate this risk and recover the energy content of residual methane, this study focuses on the utilization of low-calorific gases such as landfill gas with low methane concentrations in a naturally aspirated spark ignition engine, operated under varying levels of oxygen enrichment. The modified system was designed to combust low-methane gas mixtures (< 40 vol% CH₄ in CO₂) under stoichiometric conditions, with the oxygen concentration in the oxidiser varied between 22 and 40 vol%.

Parameter	Basic value	Experiment value	Parameter	Basic value	Experiment value
Electrical output, kW	30	14,6	Secondary circuit temperature inlet/outlet, °C	65/85	60/80
Heat output, kW	59	56,79	Min. methane content, vol%	50	32
Electrical efficiency, %	30,9	20,5	Oxidizer composition (O ₂ /N ₂), vol%	21/79	32/68
Fuel input, kW	97,1	71,4	Load, %	50	73
Ignition timing, °	21-26	21-16	Oxygen sensor, mV	760	760



Results. First run of the engine was done with natural gas, after the engine heated up, CO₂ fraction in the mixture was gradually increased to 45-47 vol%. Subsequently, the oxygen concentration in the oxidiser was increased in 2 vol% increments, allowing the CO₂ content in the fuel mixture to be raised up to 68 vol%. Adjustments to CO₂ and O₂ levels were guided by measured CO emissions and the temperature of the catalytic converter. Graphs below show the engine performance changing CH₄ content in CO₂.



Conclusions. Oxygen-enrichment application on the SI engine indicates positive results without harm to the engine (picture on the right) and ensures stable combustion of landfill gas with 32 vol% of CH₄ with considerably low emissions.



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