

**Carbon Capture, Utilisation and Storage:
Opportunities, challenges and pathways to Net Zero**

Thematic workshop - 17th September 2026 - Faculty of Civil and Industrial Engineering,
Sapienza University of Rome

**Sorption-enhanced gasification of residual biomass for renewable
hydrogen: from atmospheric to pressurised operation and
integrated gas cleaning**

U. Pasqual Laverdura^{1*}, M. L. Grilli¹

1 - ENEA, Energy Technologies and Renewable Sources Department, Casaccia Research Centre, Via Anguillarese 301, 00123 Rome, Italy

* Corresponding author: umberto.pasqual@enea.it

The decarbonisation of emission intensive industries sectors calls for renewable hydrogen and for net carbon removal, residual and waste biomass, whose carbon is of biogenic origin, is attracting growing attention as the only feedstock that can simultaneously provide an energy carrier and a negative-emission pathway (BECCS). In this context, sorption-enhanced gasification (SEG) embeds CO₂ capture into the conversion step; a CaO-based sorbent sequesters CO₂ in situ, shifting the WGS equilibrium toward hydrogen, while the exothermic carbonation offsets the endothermic gasification, so that gasification, shift and capture occur within a single reactor operated at around 650 °C.

The integrated SEG process was validated on eight residual and waste feedstocks, both untreated and hydrothermally carbonised, carried out in two complementary configurations a rotary drum reactor (RDR) and a dual fluidised bed (DFB); even if characterized by different gas–solid contact patterns both configurations delivered a hydrogen-rich syngas (H₂ 70–87 vol.%, dry and N₂-free) with a low residual CO₂ content (3–10 vol.%). Tailored CaO sorbents on mayenite and calcium-zirconate supports outperformed natural dolomite over repeated carbonation–calcination cycles.

A five-stage hot gas cleaning (HGC) train (CO₂/H₂S polishing, alkali and particulate removal, ZnO desulfurisation, tar reforming; 400–650 °C) upgraded the raw gas to near-utilisation quality: tar was reduced from 12–40 to 1–6 g/Nm³ (>85% abatement) and H₂S + COS from 118–178 to below 8–28 ppm, while H₂ was preserved or even increased by the reformer. These data also fed a CPFD (computational particle-fluid dynamics) model of the fluidised bed for model validation at lab scale level and design and scale-up for the ZECOMIX infrastructure.

Within the current three-year plan (RdS_PTR25-27), the activity is being extended to pressurised operation: SEG under pressure, together with activities carried out by partners for HCl and H₂S removal by solid sorbents at ambient and elevated pressure, is developed to raise throughput, improve downstream integration and avoid syngas recompression, while pressure reshapes the calcium-loop and sorbent equilibria now under study.

Keywords: *sorption-enhanced gasification; residual biomass; hydrogen; pressurised gasification; hot gas cleaning*

Acknowledgments

Funded by “Development of ECCSEL-ERIC R.I. Italian facilities to improve user access, services and ENSure long-Term sustainability-ECCSELLENT” which allowed to enhance the ZECOMIX and SFERO infrastructures of the Italian ECCSEL ERIC node, ii) “Energy efficiency of Products and

Organized by

Nano Rome, 14-18 September
2026Innovation
Conference & Exhibition

**Carbon Capture, Utilisation and Storage:
Opportunities, challenges and pathways to Net Zero**

Thematic workshop - 17th September 2026 - Faculty of Civil and Industrial Engineering,
Sapienza University of Rome

Industrial Processes, Rds_PTR 2022-2024 and Rds_PTR 2025-207 (MASE)” and iii) GICO-
Gasification Integrated with CO₂ capture and conversion; HTC samples: INCAR-CSIC, Oviedo.

Organized by