Final impact assessment of a small-scale biomass gasifier fuel-cell CHP system for clean on-site power generation

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**FlexiFuel-SOFC system illustration**

- **SOFC = solid oxide fuel cell (SOFC)**
  (here: up to 6kW_{el})
Objectives

Market study
Potentials for fuel flexible residential heating systems in Europe

Techno-economic analysis
Systems definition and performance data

Part A
Environmental performance analysis

Part B
Environmental and socio-economic impact assessment

➢ Overall impact assessment building on analyses from the project partners
Application cases analysed in IA:

- **Application A** (around 70 kW\(_{th}\), operating 8,000 h/y): micro grids, hotels, small enterprises & hospitals

- **Application B** (around 20 kW\(_{th}\), operating 5,800 h/y): public buildings or residential buildings (multi-family houses) with a buffer storage system; electricity and heat production in winter and transitional period; heat supply without electricity production in summer
Technology options, FF-SOFC is compared to:

- Biomass boiler + grid electricity (BBwGrid)
- Wood chip fired small scale CHP (BCHP)
- Natural gas fired small scale CHP (NGCHP)
- PuroWIN (biomass gasifier) + PV (PWINwPV)

Example for this presentation:

- A1: olive stones
- A2: wood chips
- B1: olive stones
- B2: wood chips
Results

Application A2 (large system, wood chips)

* NO\textsubscript{x} emissions:

Strongly dependent on fuel nitrogen content!
TSP (total suspended particle) emissions

- Total TSP emissions and stock volume (Application A2, EU-28)

“negative” values:

→ result of avoided (more emission intensive) EU28 grid electricity generation
NO\textsubscript{x} emissions

- Strongly dependent on fuel nitrogen content!
- FF-SOFC: very low NO\textsubscript{x} emissions for biomass boilers

Total NO\textsubscript{x} emissions and stock volume (Application A2, EU-28)
CO emissions

FF-SOFC: lowest emissions
OGC (organic gaseous compounds) emissions

→ FF-SOFC: lowest emissions

Total OGC emissions and stock volume (Application A2, EU-28)
Avoided GHG emissions by FF-SOFC

- Fuel incl. LCA emissions (Ecodesign Impact Accounting, VHK 2018)
- GHG emissions avoided vs. EU28 grid electricity
Conclusions

- Environmental performance analysis (single product)

  - FlexiFuel-SOFC direct non-GHG emissions:
    - on par or better than best biomass technologies
    - Large improvements especially for CO and NO\textsubscript{x} emissions
    - on par or even better than natural gas CHP
      (except for strongly fuel dependent NO\textsubscript{x})
Conclusions

- Final Impact Assessment (EU28, incl. grid electricity effects)

  - FlexiFuel-SOFC overall non-GHG emissions:
    - lowest or close to the lowest total emissions for TSP, CO, OGC
      (avoided emissions due to avoided grid electricity generation)

  - Major GHG emission reduction potential vs. fossil fuel CHP

  - FlexiFuel-SOFC is also the system with highest fuel flexibility of all!
Thank you for your attention

Project webpage: http://flexifuelsofc.eu

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Work performed

- **Part A: Environmental performance analysis**
  - **Micro-scale, single product level**
    - direct comparison with other state-of-the-art systems
    - annual efficiencies, TSP, CO, OGC and NO$_x$ emissions
  
  Calibrate WIKUE stock model
  Analyse & compare different technology options
  Scenario analysis until 2050

- **Part B: Impact assessment (IA)**
  - **Macro-scale scenario analysis, EU-28** wide market introduction
  - Technical, environmental, and socio-economic aspects
Part B: Final impact assessment ➔ total market segment potential

Medium sales potential until 2050 (based on market study), EU28
Part B: Final impact assessment ➔ technical stock potential

Medium stocks scenario until 2050, EU28

- APPLICATION B2
- APPLICATION B1
- APPLICATION A2
- APPLICATION A1