Life Cycle externalites assessment for biogas infrastructure options

P. Patrizio [a,b], S. Leduc [b], D. Chinese [a], F. Kraxner [b]
[a] DIEGM, University of Udine, Udine, Italy
[b] International Institute for Applied Systems Analisys (IIASA), Laxemburg, Austria

Further information: www.iiasa.ac.at/bewhere

Background

Northern Italy:
- 3rd largest biogas producer in the world and 2nd largest methane vehicles holder in Europe
- 95% of municipalities served with natural gas distribution pipelines
- 800 "virtual" 1 MW cogeneration plants in the territory

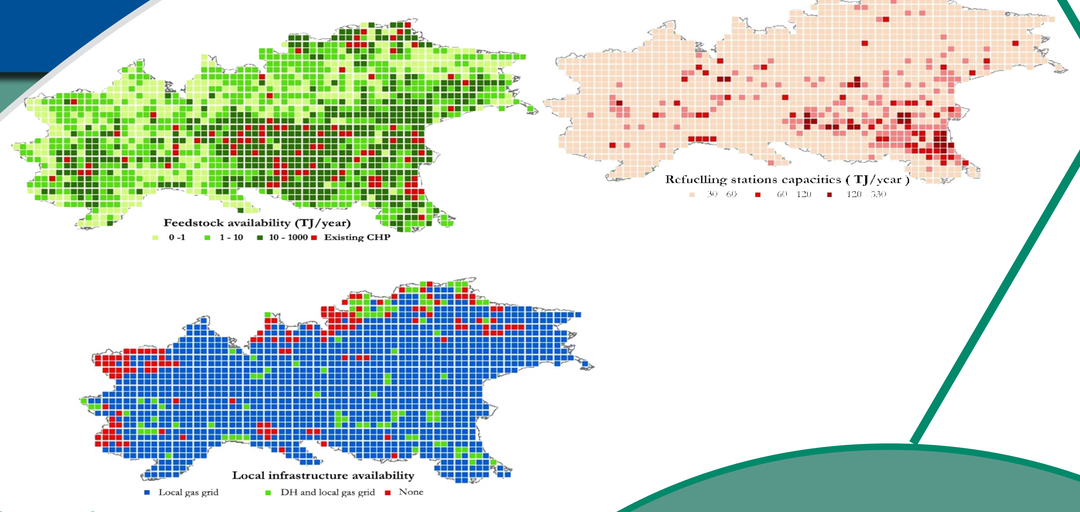
Objectives

- Identification of capacity and location of feasible biogas production plants and of their optimal technology mix
- Comparison of different methods of assessing the environmental impact of the biogas supply chain (**damage cost** approach and **avoidance cost** approach)

Methodology

- **Spatial explicit data gathering for more than 1,300 municipalities:**
  . Energy crops (sorghum and maize silage) and animal (cattle, swine and poultry) manure availability
  . Energy infrastructure
  . Energy demands
- **LCI methodology for emission assessment :**
  . Quantification of the airborne emissions released in the entire biogas supply chain
  . Pollutants considered: CO_2, CH_4, N_2O, NH_3, NMVOC, SO_2, NO_x , PM_{10}
- **IPA methodology for externalities assessment:**
  . Quantification of pollutants' damage cost factors
  . Different externalities database for stationary and transport processes

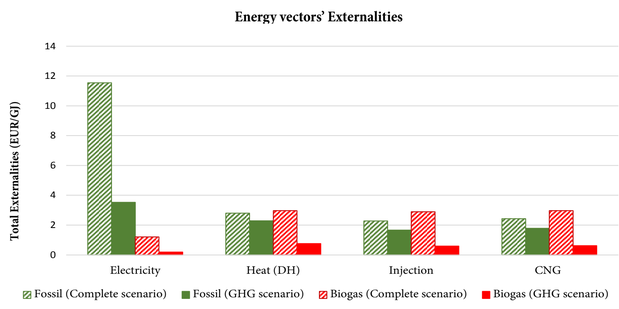
1. Spatial Explicit data gathering

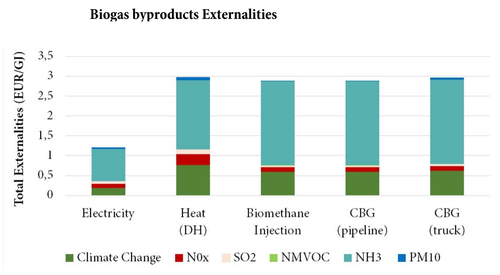


2. Life Cycle externalities assessment

Pollutants damage cost factors (EUR/kg)

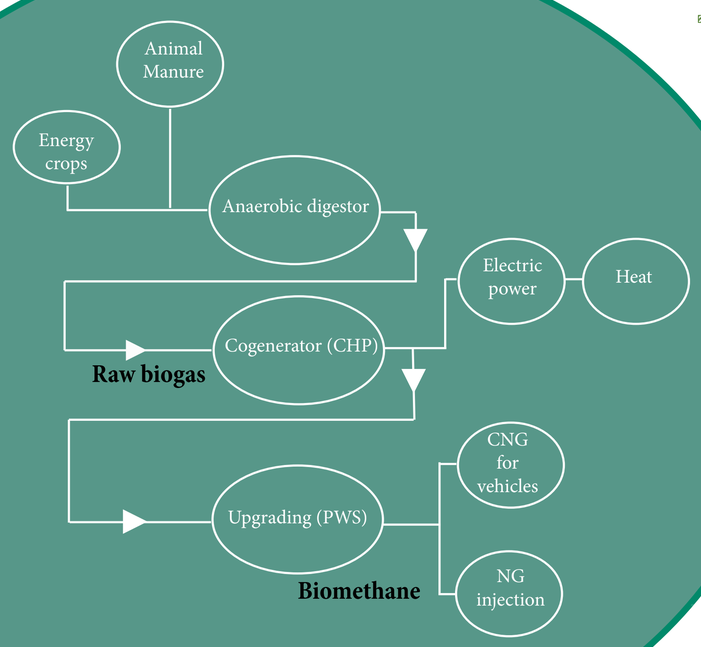
Energy vector	NO_X	SO_2	NMVOC	N_20	CO_2	CH_4	NH_3	PM_{10}
Conventional	7.06	6.75	1.06	7.24	0.026	0.575	12.71	15.2
Biogas	3.66	4.26	1.89	7.24	0.026	0.575	11.28	18.2





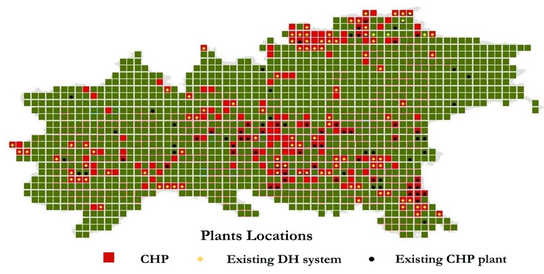
BeWhere objective function:

MIN Σ [(Annuzalized capital costs + Production costs + External costs)]

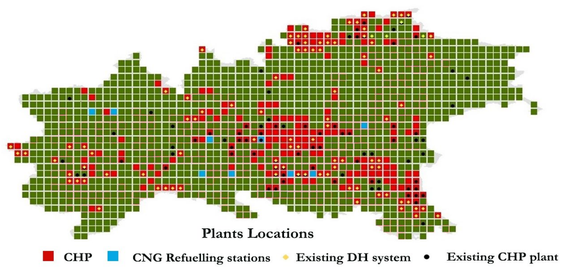


Production plant technology options

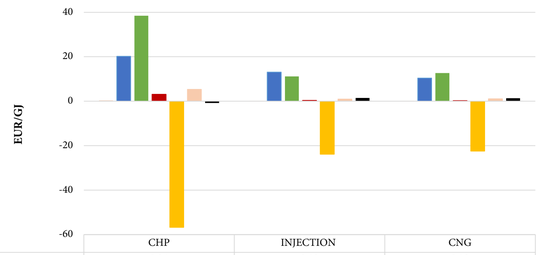
3. Model implementation (Damage cost approach)



4 Model implementation (Avoidance cost approach)



Biogas technologies Life Cycle Cost (EUR/GJ)



	CHP	INJECTION	CNG
Biomass procurment	0,24	0,13	0,13
Biomass transport	20,22	13,08	10,40
Production	38,45	11,18	12,69
Byproduct transport	3,12	0,37	0,23
Income	-56,70	-23,80	-22,40
Net cost	5,33	0,96	1,05
Net optimized cost	-0,80	1,50	1,36

Conclusions

- The contribution to climate change (avoidance cost approach) of biogas solutions is 20%-30% lower than the contribution of fossil alternatives
- Fossil energy vectors generate far lower ecosystems quality and human healt damages than the biogas byproducts
- Methane emissions during biogas production and upgrading do not show great influence on the results
- Ammonia emissions during farming activities (digestate spreading and chemical fertilizers usage) have the highest share of the final external cost

Model Results

Avoidance cost approach:

- 67 additional CHP plants located in proximity of existing DH systems (plant located at a maximum distance of 50 km from the DH grid)
- Positive net optimized cost for biogas upgrading solutions: high external costs arising from the biomethane life cycle

Damage cost approach:

- The number of CHP plants remains stable (existing DH systems totally served with cogenerative heat)
- 9 CNG facilities serving existing refuelling stations connected to low-pressure pipelines. The road transport option for biomethane delivery is never selected