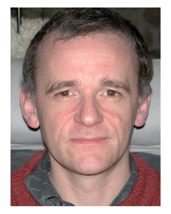
High yield methane generation from wet biomass and waste



Jeremy S. Luterbacher[1], Morgan Fröling[2], Frédéric Vogel[3], François Maréchal[1] and Jefferson W. Tester[4]

[1]Ecole Polytechnique Fédérale de Lausanne [2]Chalmers University [3]Paul Scherrer Institute [4]Massachusetts Institute of Technology

Introduction

Biomass feedstocks can efficiently be converted to Bio-Synthetic Natural Gas (bio-SNG) using *catalytic supercritical water gasification*. Major advantages:

- Fuel can be used in the existing infrastructure
- Use of waste biomass (wet, containing lignocellulosic material)
- Recovery of inorganic material: use as a mineral fertilizer
- No drying or distillation steps

Process modeling and energy integration is used to simulate optimized Swiss industrial scale scenarios for manure and wood chips; life cycle assessment is used to assess the associated environmental impacts

Methodology

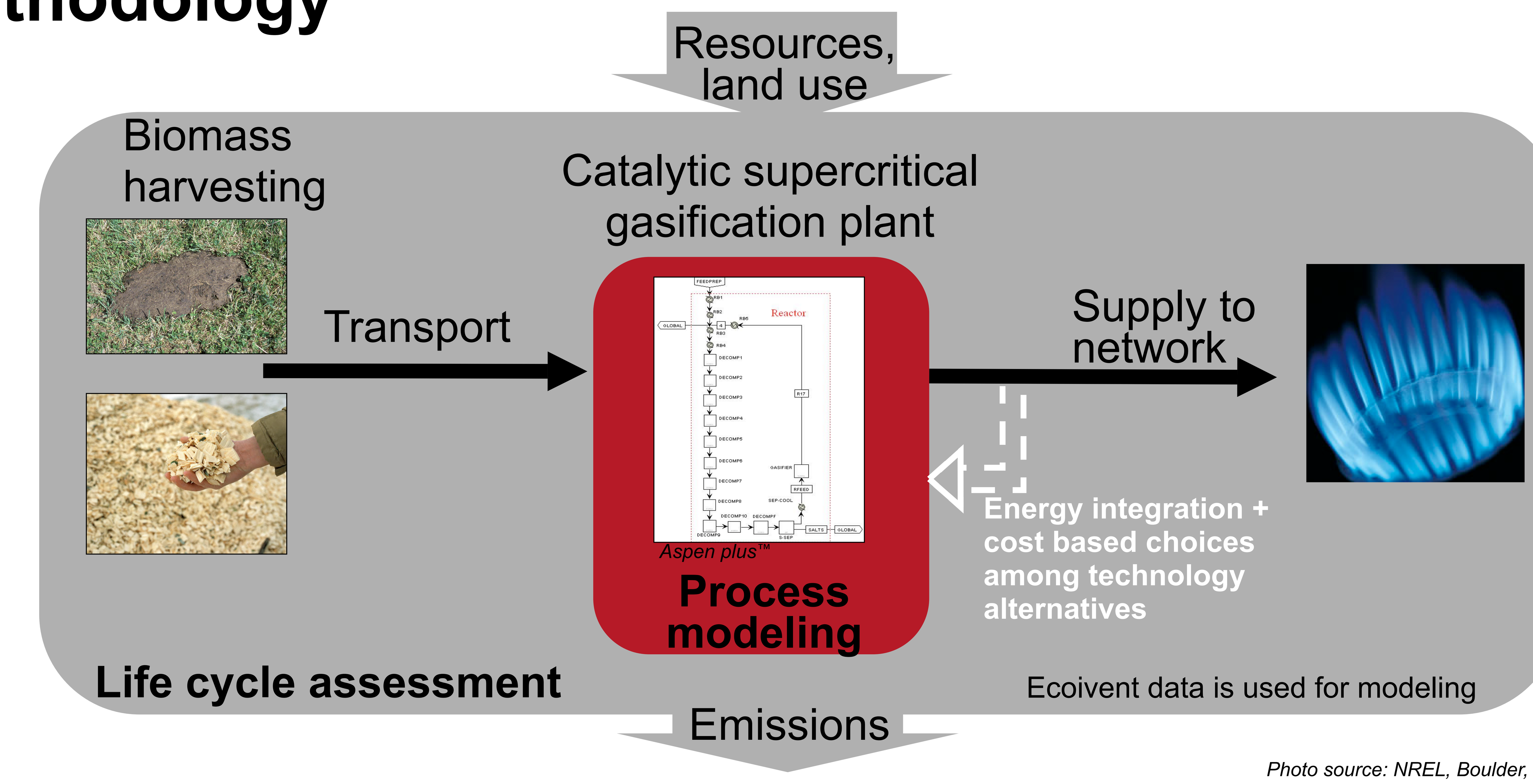
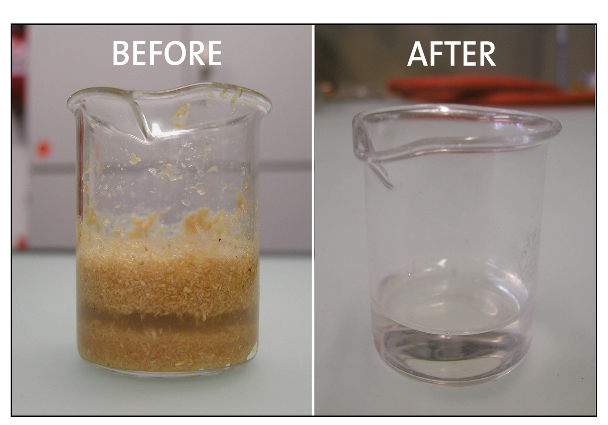


Photo source: NREL, Boulder, Colorado, USA

Results

Experimental

Wood before and after processing (complete gasification). Gas composition: 49 vol% CH_4, 43 vol% CO_2 and 8 vol% H_2[1].



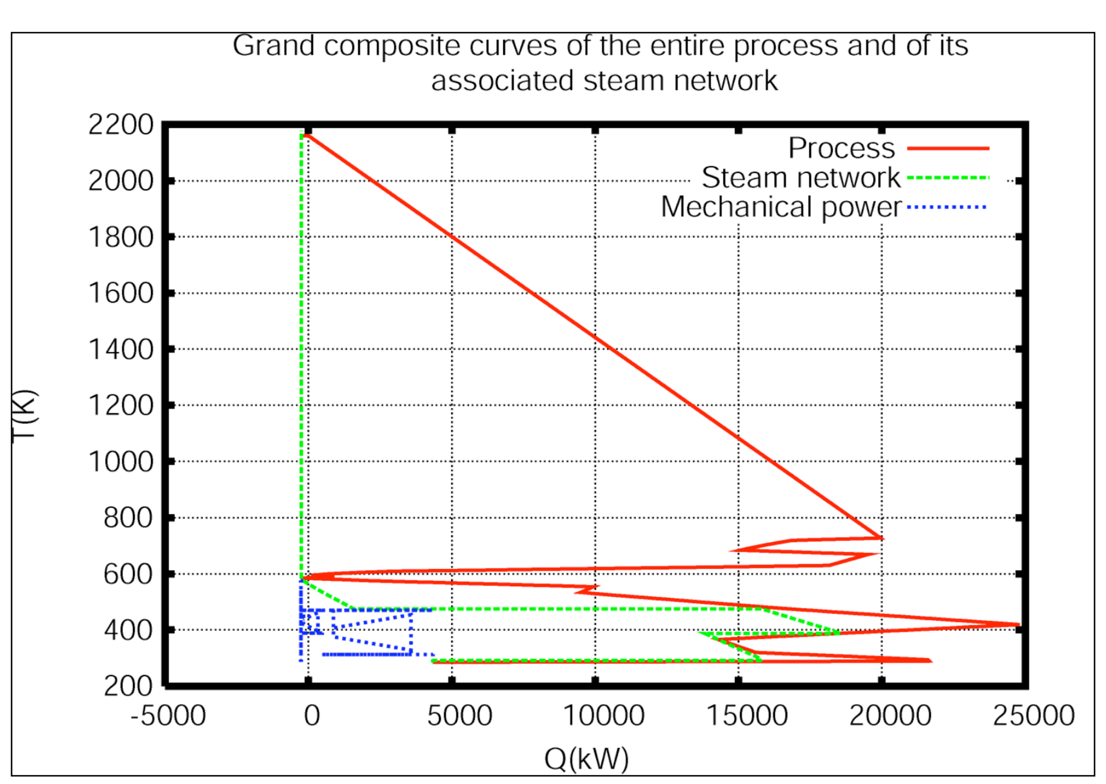
Balance type	Form	Useful Energy [MW]					
		Manure (Large-scale)		Manure (Small-scale)		Wood	
		Gas Turbine	Burner	Gas Turbine	Burner	Gas Turbine	Burner
Consumption	Biomass	251	251	8.37	8.37	50	50
Production	SNG	118	155	3.94	5.18	22.8	35.6
	Electricity	14.8	2.6	0.58	-0.020	4.8	1.7
	Total	133	158	4.52	5.16	27.6	37.3
Efficiency	**Chemical**	**0.47**	**0.62**	**0.47**	**0.62**	**0.46**	**0.71**
	Total	**0.53**	**0.63**	**0.54**	**0.62**	**0.55**	**0.75**

Process efficiency (LHV basis) for different production scenarios and for the different heat generation scenarios (turbine or burner)

Process modeling

Scenarios investigated: large-scale manure (rail transport, 16 Mtons of manure/year), small-scale manure (no long-range transport, 0.54 Mtons/year), wood (truck transport, 0.14 Mtons/year)

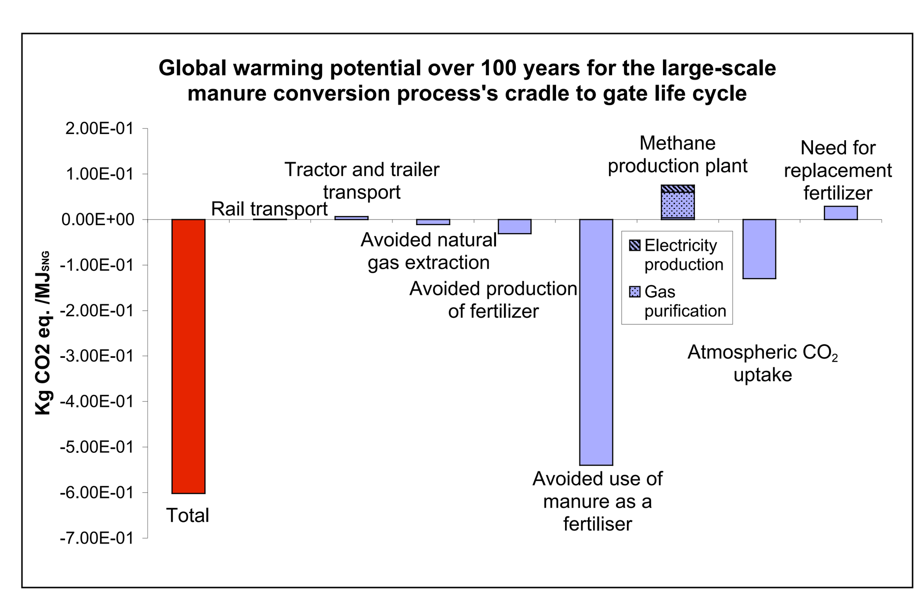
Energy integration using a burner for internal heat needs and a Rankine steam cycle for waste heat to electricity revalorization (13wt% of the crude product gas is burned)

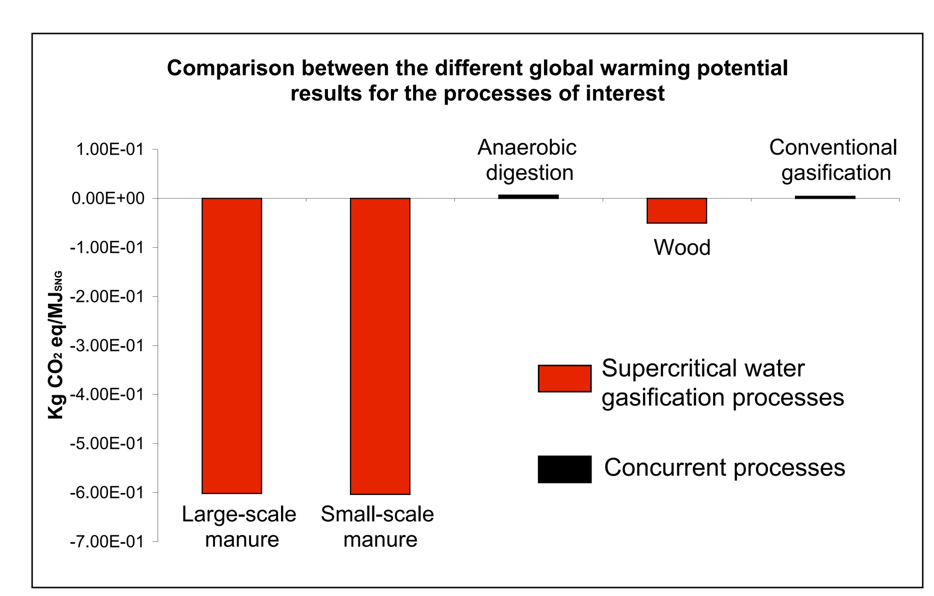


Life cycle assessment

Primary fossil energy source	Imbedded fossil energy [%]	
	Manure	Wood
Crude oil	6.5	5.0
Natural gas	1.8	1.6
Coal	2.6	2.1
Total	**10.8**	**8.7**

Imbedded fossil energy for the large-scale manure (practically identical to the small-scale) and the wood conversion processes





The global warming potential is calculated for the modeled scenarios and benchmarked toward concurrent processes (anaerobic digestion of manure and conventional wood gasification)

Conclusions

Process modeling - Meeting internal heat requirements is done most efficiently using a burner + Rankine steam cycle. Thermal efficiencies of **60%** are obtained for manure and of **75%** for wood

LCA - About **10%** Imbedded fossil energy for the supercritical water gasification processes; in comparison, the US corn grain to ethanol process has over 40% of imbedded fossil energy just in the form of natural gas[2].

Avoiding emissions from spread manure ⇒ very beneficial for manure. Carbon footprint is of **-0.6 Kg $CO_{2,eq.}$/$_{MJ\ BIO\text{-}SNG}$**.

Treating a waste and reducing the emissions associated to its use ⇒ a strong environmental performance for the manure conversion processes .

[1]M. Waldner and F. Vogel: Renewable Production of methane from woody Biomass by Catalytic Hydrothermal Gasification", Ind. Eng. Chem. Res.,44, 2005.

[2]J. Johnson: "Technology assessment of Biomass Energy: A multi-objective, life cycle approach under uncertainty" Doctoral Thesis, MIT 2006