A Comparison of the Environmental Consequences of Power from Biomass, Coal, and Natural Gas

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Outline of Presentation

Purpose of LCAs conducted

System descriptions
- Biomass IGCC
- Average coal
- Coal/biomass cofiring
- Natural gas combined cycle

Comparative Results
- Energy
- Greenhouse gases
- Other air emissions
- Resource consumption

Life Cycle Assessment: Definition

LCA, in the context of novel systems, is:

- a systematic analytical method
- used to quantify the environmental benefits and drawbacks of a process
- performed on all processes, cradle-to-grave, resource extraction to final disposal
- ideal for comparing new technologies to the status quo
- helps to pinpoint areas that deserve special attention
- reveals unexpected environmental impacts so that research can be focused on mitigating them

  (no show-stopping surprises)

Purpose of Studies

Biomass LCA was conducted to answer common questions:

- What are the net CO_2 emissions?
- What is the net energy production?
- Which substances are emitted at the highest rate?
- What parts of the system are responsible for the greatest impacts?
- What should biomass R&D focus on?

Coal and natural gas LCAs the foundation for quantifying the benefits of biomass power.

Direct-fired biomass system describes current biomass power industry.

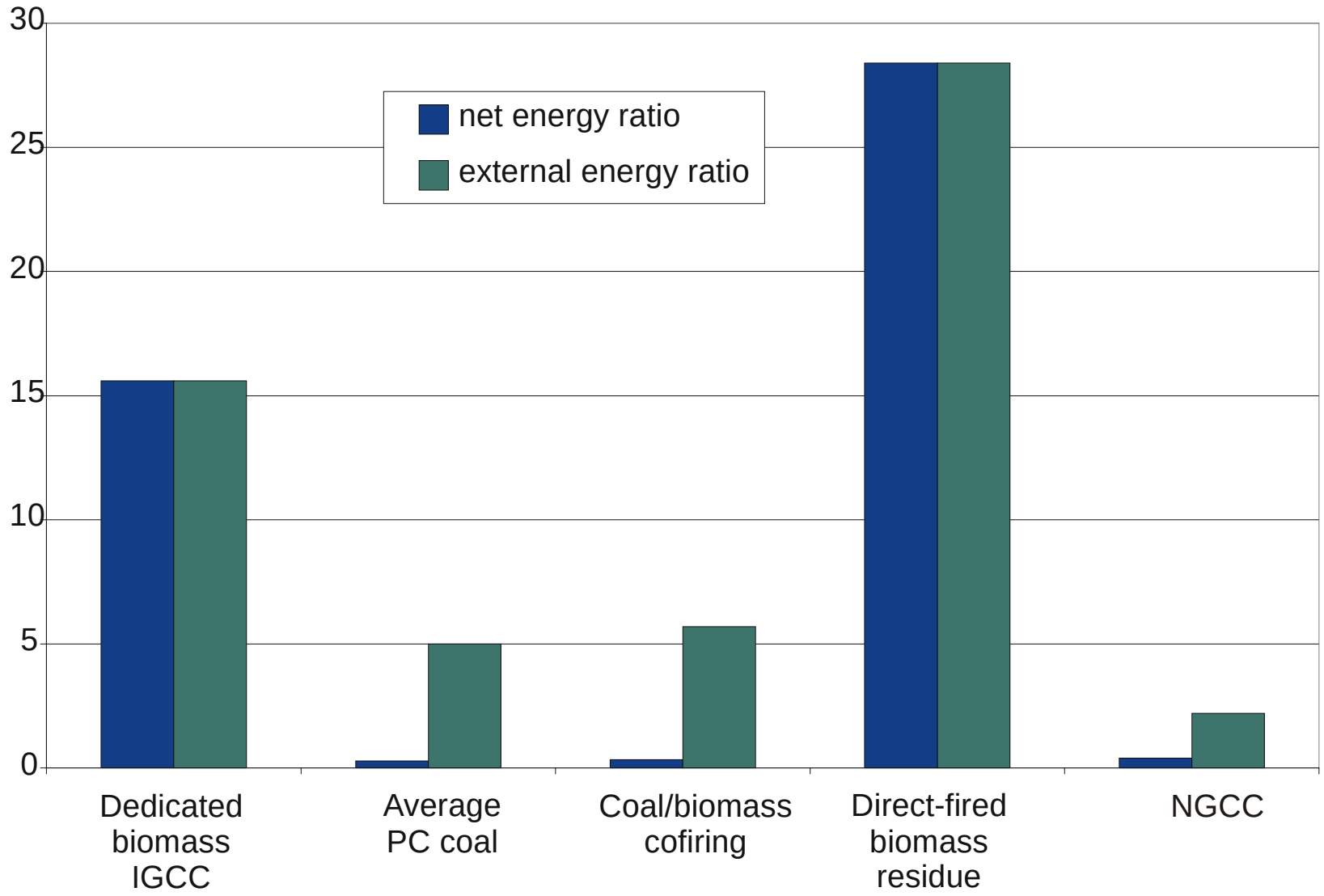
Cofiring LCA examined near-term option for biomass utilization.

Each assessment conducted separately - common systems not excluded.

Systems Examined

Biomass IGCC	Indirectly-heated gasification Dedicated hybrid poplar feedstock Zero carbon sequestration in base case
Average coal	Pulverized coal / steam cycle Illinois #6 coal - moderate sulfur, bituminous Surface mining
Biomass / coal cofiring	15% cofiring by heat input Biomass residue (urban, mostly) into PC boiler 0.9 percentage point efficiency derating Credit taken for avoided operations including decomposition (i.e., no biomass growth)
Direct-fired biomass	Biomass residue Avoided emissions credit as with cofiring
Natural gas	Combined cycle Upstream natural gas losses = 1.4% of gross

Life Cycle Energy Balance



Energy Balance Oddities

Key question: why are the energy results so poor for the fossil systems?

Answer: Upstream Energy Consumption is High

	Non-feedstock energy (kJ/kWh)	% of non-feedstock energy related to:		
		Flue-gas cleanup	Transportation	Natural gas production or coal mining
Biomass IGCC	231	0%	16%	N/A
Direct biomass	125	0%	49%	N/A
Coal	702	35%	32%	25%
Natural gas	1,718	0.5%	N/A	98.3%

Carbon Cycle (GHG Emissions)

Example flows:

- Biomass energy crop - photosynthesis, carbon sequestration in soil
- Biomass residue - avoided decomposition emissions
- Coal - coal mine methane, coal mine waste
- Natural gas- fugitive emissions, leaks
- General - incomplete combustion, upstream fossil fuel consumption

Key question: On a life cycle basis, what are the net greenhouse gas emissions of these systems?