Is Thermo-Chemical Conversion Process of Biomass - A Route for Fuel Cell Application?

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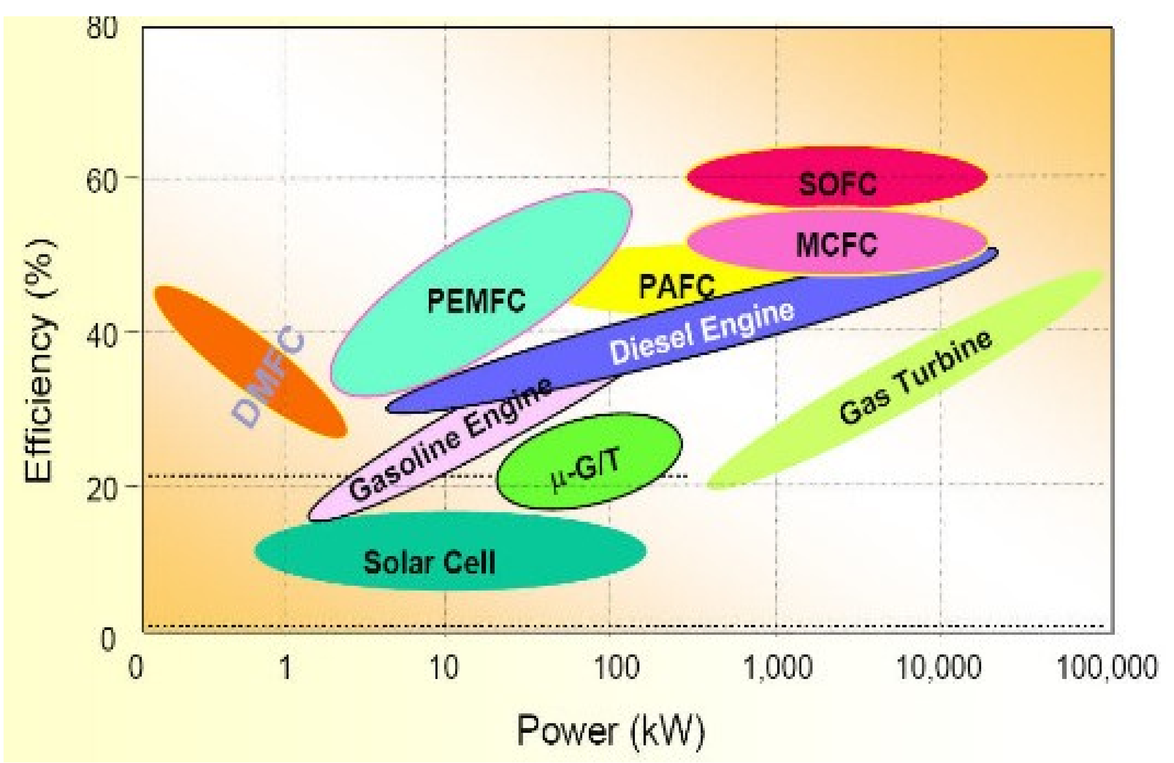
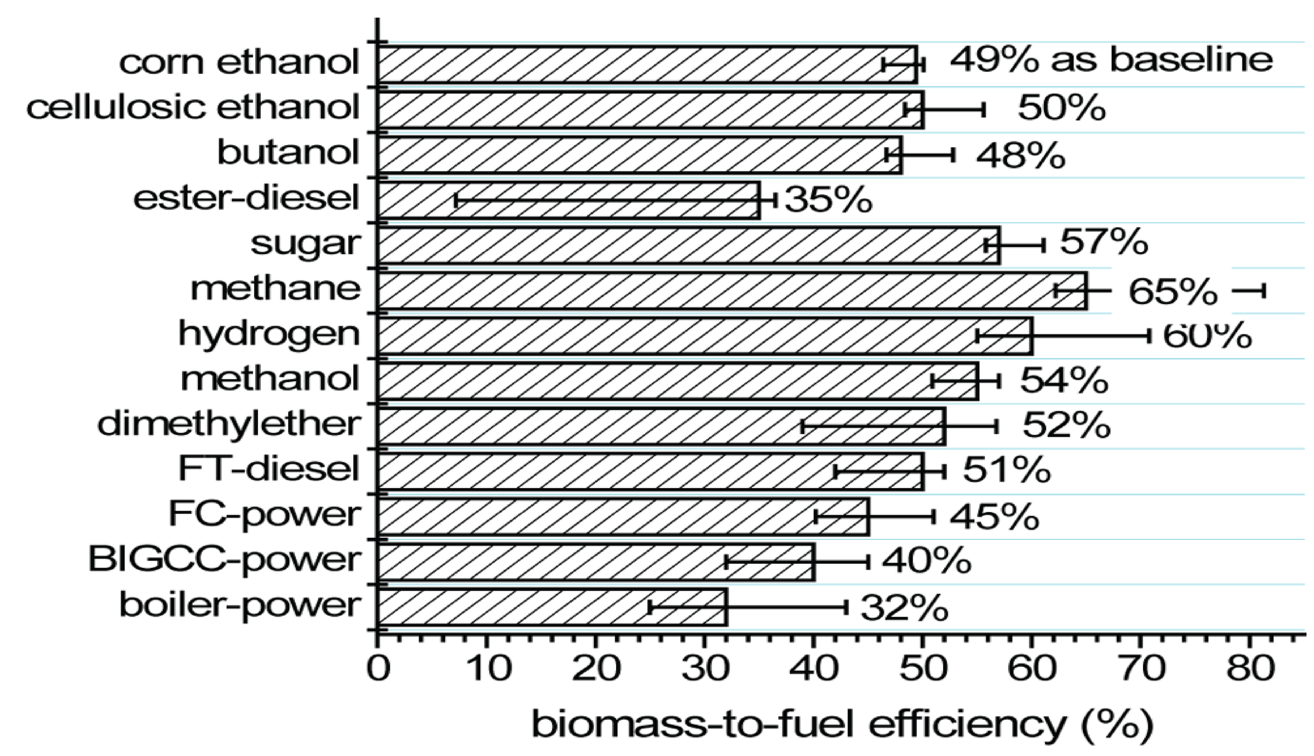
Increasing energy consumption and coupled with higher emissions from combustion devices operating with conventional fuels demands alternate energy sources, and Fuel Cell (FC) being an efficient, fuel flexible direct energy conversion technology has attracted the attention of researchers. With Primary usage of fossil fuel, use of renewable fuels is desirable, and producer gas/syngas generated from biomass has received widespread attention due to its carbon neutrality nature. Other than the environmental advantage with respect to emissions per kg of the fuel used, fossil fuel based hydrogen or other gaseous fuel resource does not support the green energy concept. Amongst the renewables, biomass a natural CHO complex is a desired route for attempting hydrogen or other gaseous fuel generation.

Type of FCs and the operating temperatures [Stambouli, 2002, M Univ].

Fuel cell type	Electrolyte	Operating temperature
PEMFC	Solid organic polymer poly-per fluoro sulfonic acid	50-80 °C
Alkaline Fuel cell	Aqueous solution of potassium hydroxide soaked in a matrix	50-200 °C
PAFC	Liquid phosphoric acid soaked in a matrix	160-210 °C
MCFC	Liquid solution of lithium, sodium and/or potassium carbonates, soaked in a matrix	630-650 °C
SOFC	Solid Zirconia to which a small amount of yttria added	600-1000 °C



- Efforts towards fueling the FC over the last two decades, has been mostly hydrogen (H_2) or a mixture of gaseous fuel derived from fossil fuel.
- Improving efficiency and reducing CO_2 being prime motive apart from other benefits, **but still uses fossil fuels.**



Research at the Indian Institute of Science on Biomass gasification

Composition of Biomass: $CH_{1.4}O_{0.65}$

- Air gasification is a mature and widely used technology, but the theoretical limit for hydrogen production is ***about 60 g per kg of biomass; about 40 g realisable***
- Use of oxygen eliminates the inert element and using steam enhances hydrogen yield through char-steam (water gas) reaction.

Open top down draft configuration

- Syngas composition, hydrogen yield and performance parameters were monitored with varying steam to biomass ratio (SBR) and equivalence ratio.
- Experiments were conducted by varying SBR from 0.75 - 2.7 and ER ranging from 0.18 - 0.3.
- Long duration experiments carried out for analysis of system performance and stability of operation.
- 104 g per kg of biomass was obtained at SBR=2.7
- Gasification efficiency of over 85% was achieved at SBR=0.75
- Gas quality less than 5 ppm T and P
- H_2 to CO ratio controlled

SBR	0.75	1	1.4	1.5	1.8	2.4	2.7
ER	0.21	0.18	0.21	0.23	0.27	0.28	0.3
H_2 yield (g kg^{-1} of biomass)	66	68	71	73	94	99	104
H_2 yield (volume fraction, %) on dry basis	41.8	45.2	43.1	45.2	49.6	51.6	50.5
CO yield (volume fraction, %) on dry basis	27.6	24.9	26.5	24.9	17	12.4	13
H_2/CO	1.5	1.8	1.6	1.8	2.9	3.8	3.9
LHV (MJ Nm^{-3})	8.9	8.6	8.8	8.7	8	7.4	7.4
Hydrogen efficiency (%)	73.7	63.2	67.2	63.5	70.5	61	63.7
Gasification efficiency (%)	85.8	76.8	80.8	77	79.5	70.5	71.5

Strengths
Hydrogen or mixture of gases production through renewable route and probably **most sustainable** based on all the simulation studies

Weakness
No commercially available renewable energy especially biomass based in operation.

Opportunities
Limited / no work done for renewable energy source based H2 or gaseous fuel production and use in fuel cell applications - **Supports R & D** with the growing demand for distributed power generation

Threats
Fuel cell costs may undermine implementation

Conclusions

- Biomass based technological solution possible for both low and high temperature fuel cells
- Hydrogen from gasification after purification a possible route for PEM fuel application

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