An Atmanirbhar and sustainable approach for Green hydrogen production using biomass

Biomass as a source of energy transition

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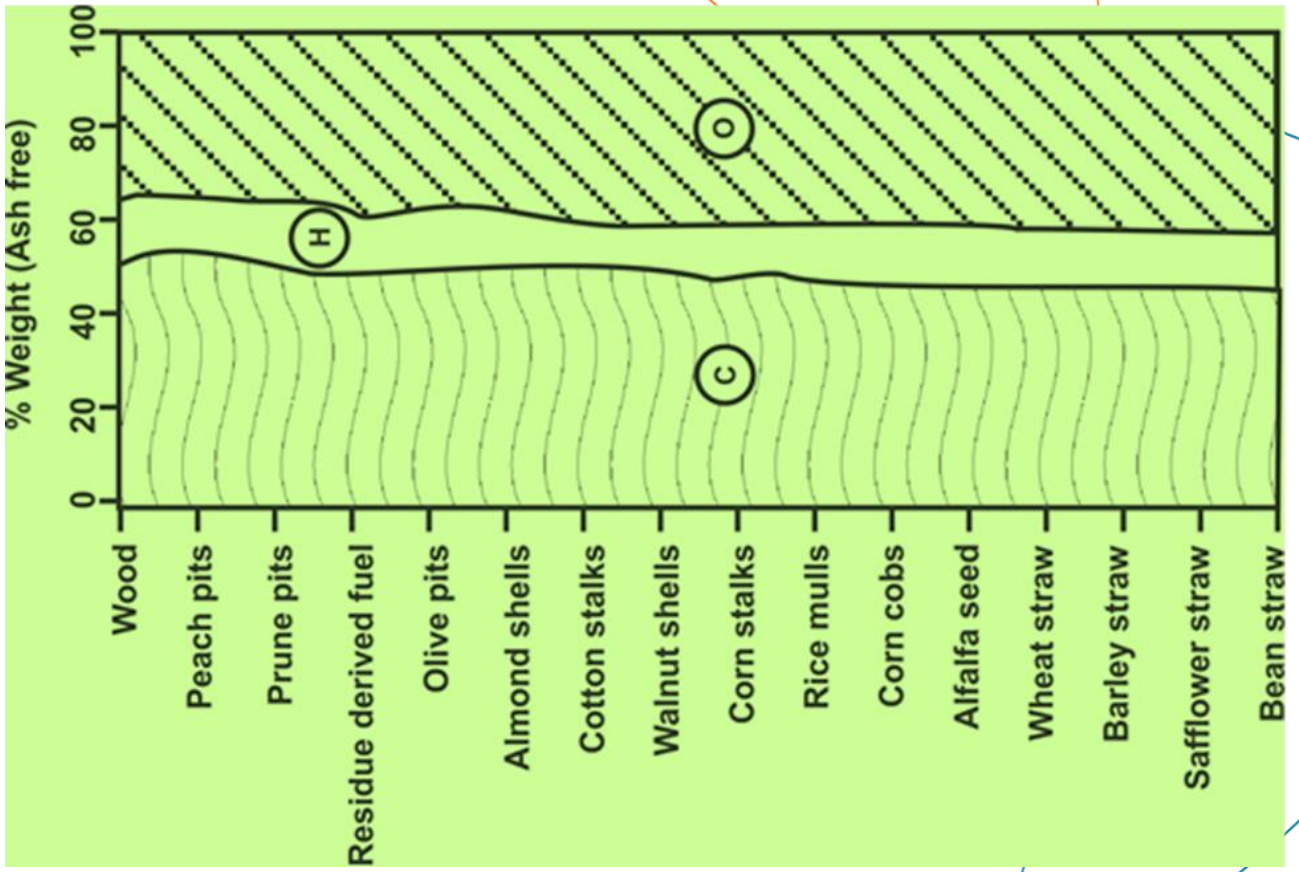
- Biomass and thermo-chemical process
- Details about bio-hydrogen process
- Why biomass and India's Potential of hydrogen from biomass
- Opportunities and Challenges
  - SWOT analysis
- Opportunity for sustainable hydrogen

Composition of biomass

Element	Mass fraction (%)
Carbon	52.02
Nitrogen	0.12
Sulphur	0.42
Hydrogen	6.55
Oxygen	41.43
Chemical Composition	$CH_{1.4}O_{0.6}$
Molecular weight	27.89 kg $kmol^{-1}$



250g of H2/kg of methane

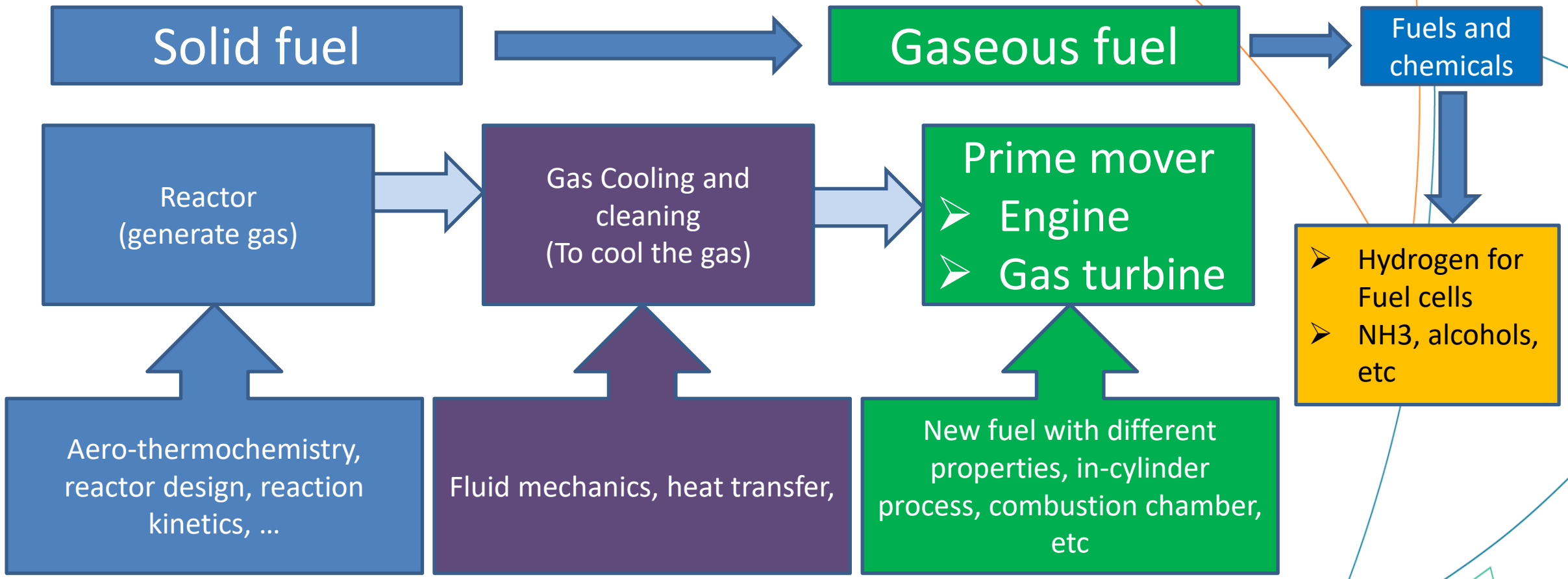
~65 g of H2/kg of Biomass

~110 g of H2/kg of water

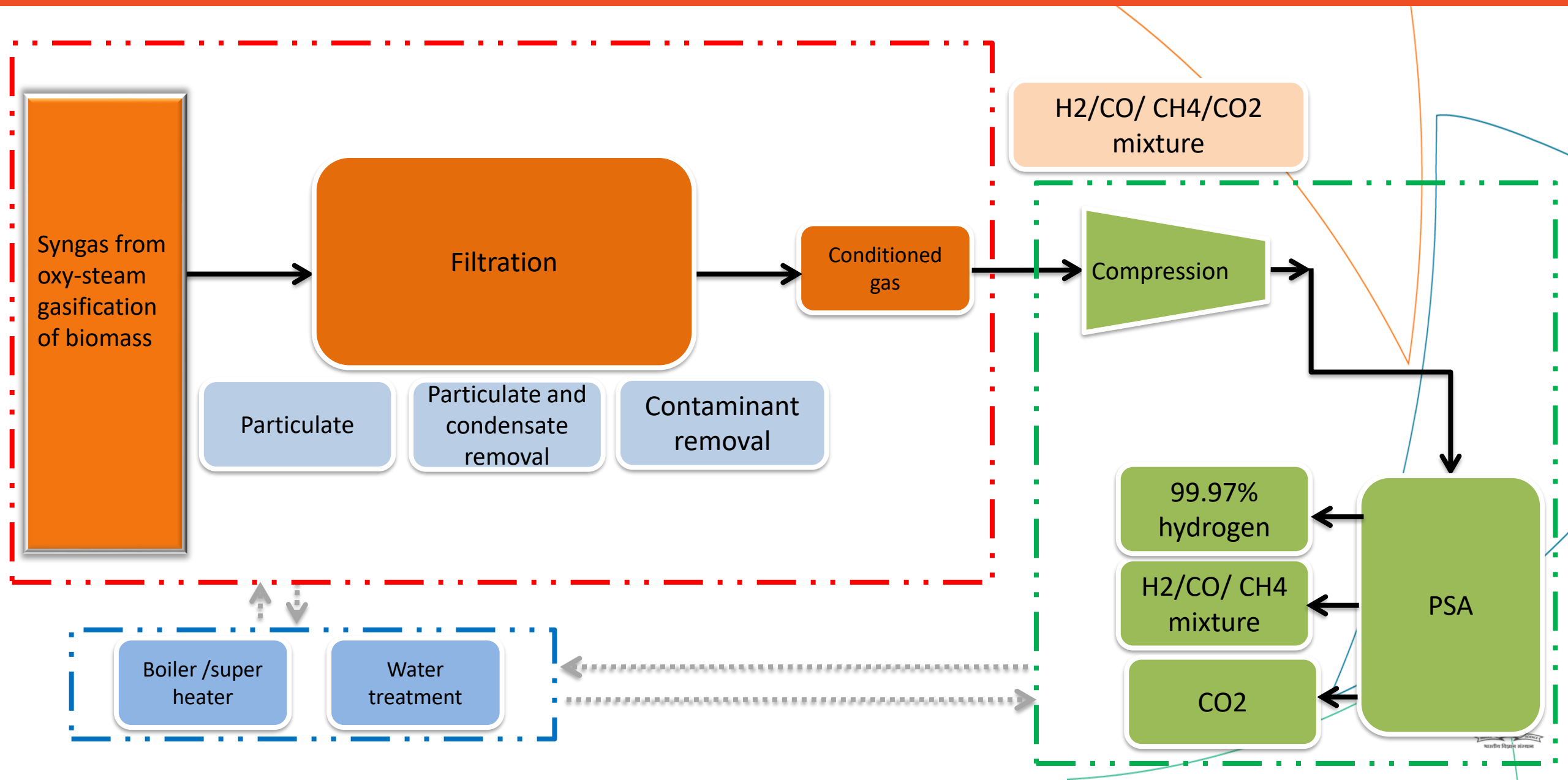
Gasification to hydrogen conversion

- Biomass to mixture of gas and separating hydrogen
- $C_{1.0}\ 0.7(H_2O) + 0.2\ O_2 + H_2O \rightarrow 1.7H_2 + CO_2$
  - Theoretical limit → 150 g of H_2/kg of biomass
- Air gasification
  - $C_{1.0}\ 0.7(H_2O) + 0_2 + 3.76\ N_2 \rightarrow 0.2\ H_2 + 0.2\ CO + 0.02\ CH_4 + 0.12CO_2 + 0.46N_2$
  - Here about 40 – 45 g of hydrogen per kg of biomass
- Oxy-steam
  - $C_{1.0}\ 0.7(H_2O) + \mathbf{x}\ 0_2 + \mathbf{y}\ H_2O \rightarrow 0.25 - 0.50\ H_2 + 0.12 - 0.25\ CO + 0.04 - 0.05CH_4 + 0.15 - 0.25CO_2$
  - Up to 100 g of hydrogen per kg of biomass

Scientific aspects of the technology



Current scheme



5 kg/hr hydrogen generation facility at IISc

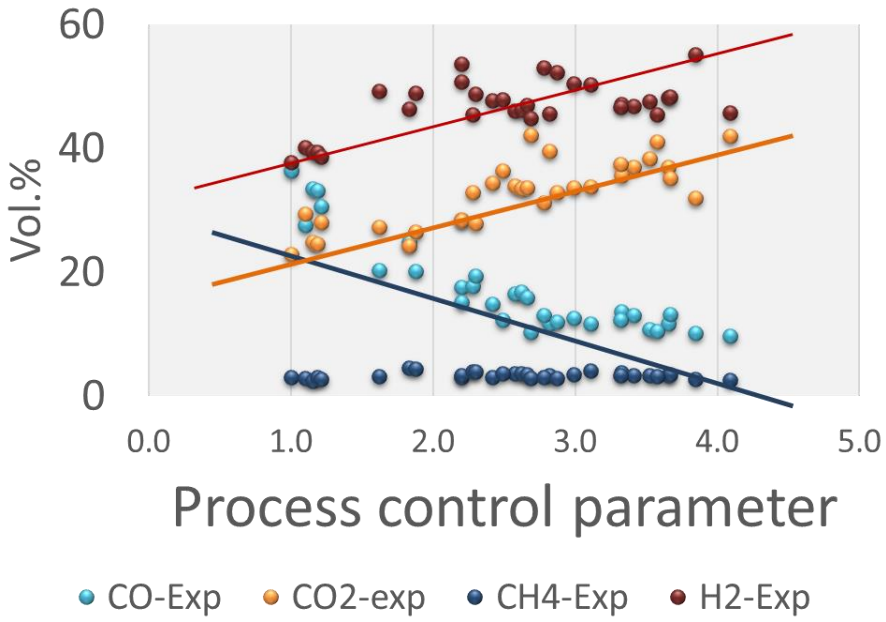
The 5 kgph hydrogen oxy-steam gasification system

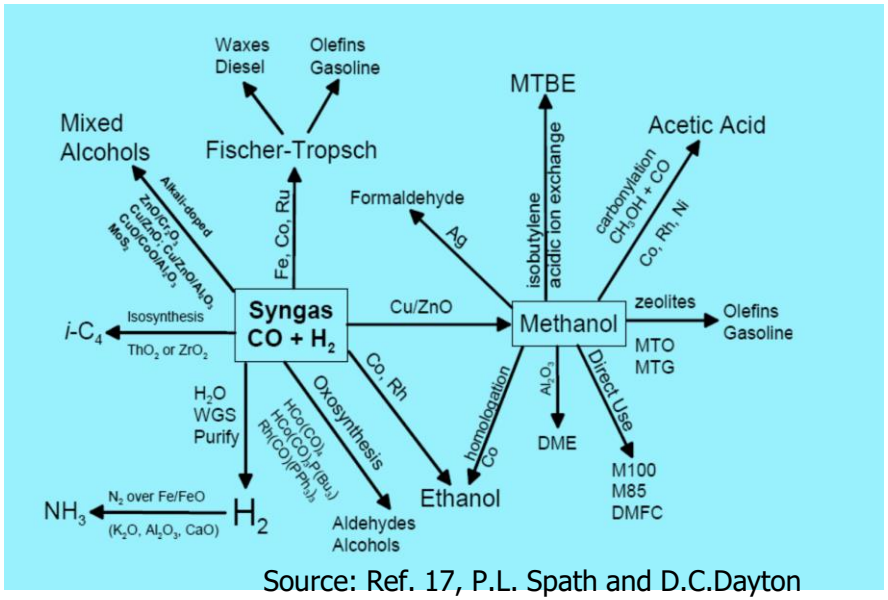
VPSA system for multi component mixture separation

Oxy-steam gasification results




CBR	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





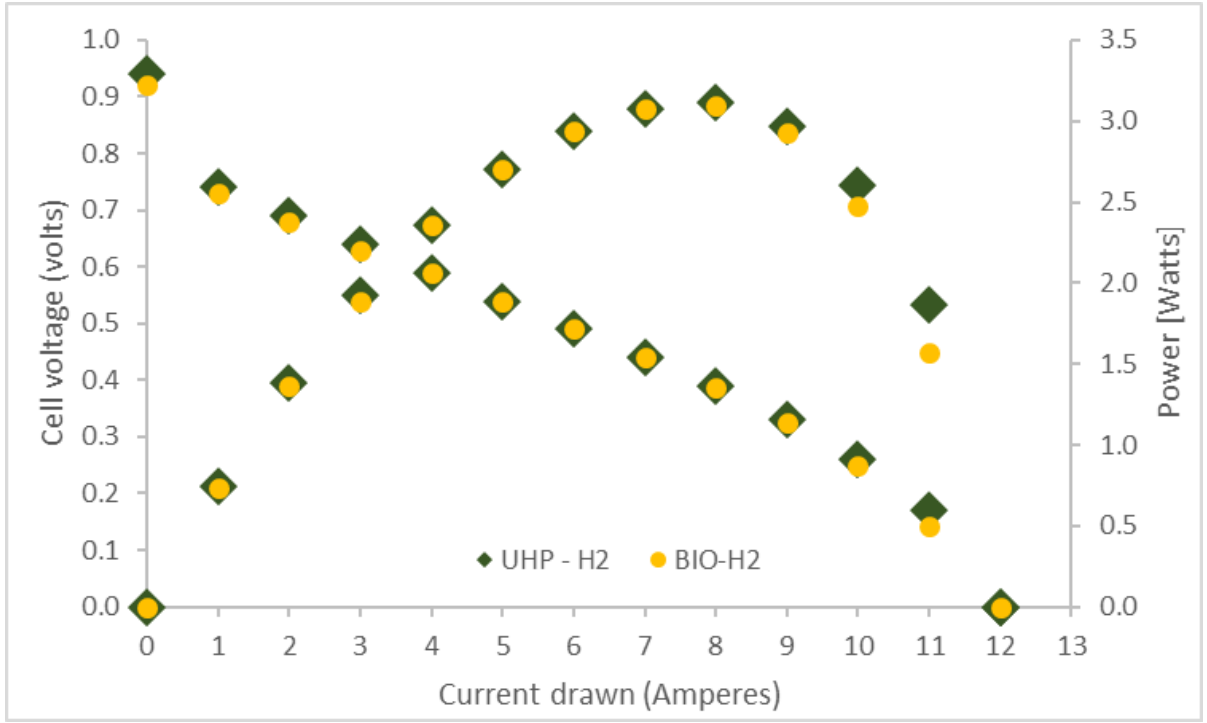
Source: Ref. 17, P.L. Spath and D.C.Dayton

Compounds (assay)	Maximum concentration	Bio hydrogen quality
Hydrogen (minimum) %	99.97	✓
Water (H2O)	5 ppm	✓
Total HC except methane	2 ppm	✓
Methane (CH4)	100 ppm	✓
Oxygen (O2)	5 ppm	✓
Helium (He)	300 ppm	✓
Nitrogen (N2)	300 ppm	✓
Argon (Ar)	300 ppm	✓
Carbon dioxide (CO2)	2 ppm	✓
Carbon monoxide (CO)	0.2 ppm	✓
Total sulphur compounds	0.004 ppm	✓
Formaldehyde (HCHO)	0.2 ppm	✓
Formic acid (HCOOH)	0.2 ppm	✓
Ammonia (NH3)	0.1 ppm	✓
Halogenated Compounds	0.05 ppm	✓
Particulate	1 mg/kg	✓

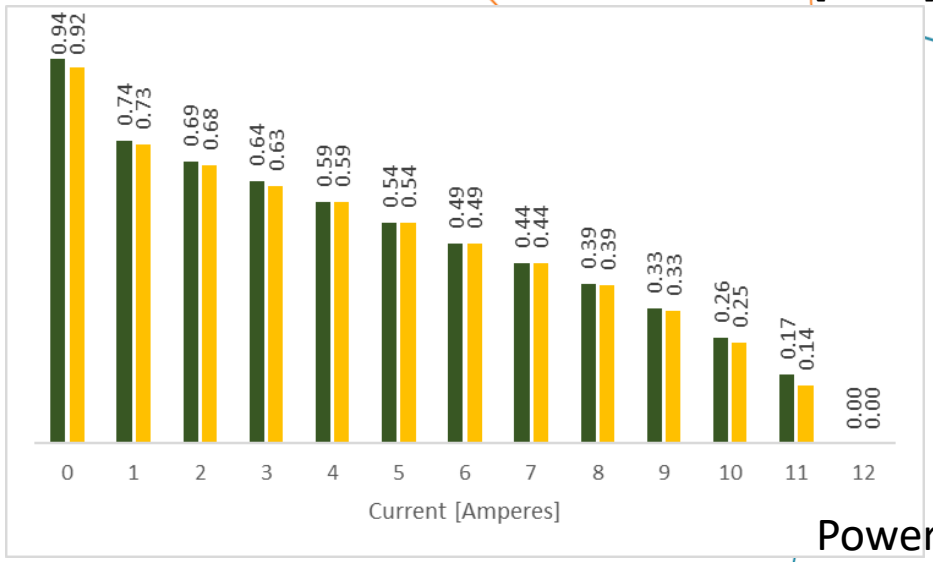
Discrete current step investigation – Establishing the polarization curve

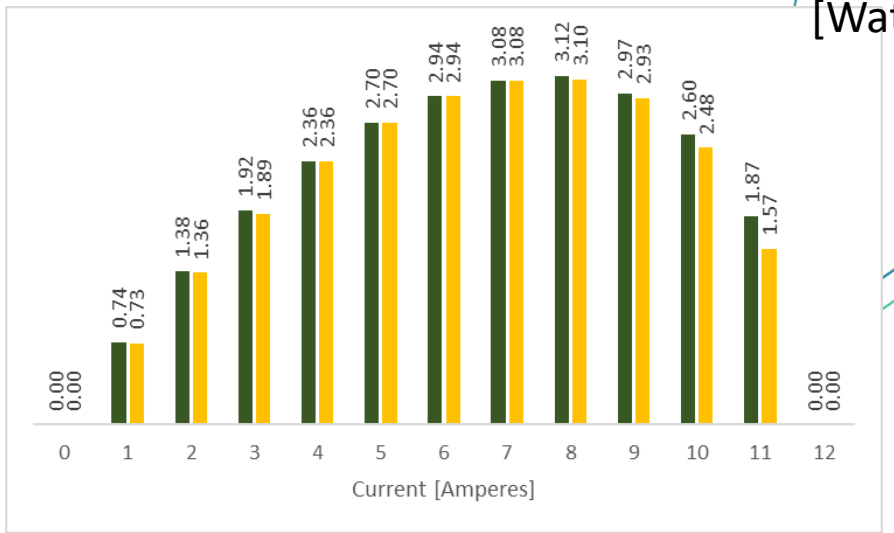
UHP Hydrogen

Parameter	Quantity
Hydrogen flow rate	150 mLPM
Oxygen flow rate	300 mLPM
Test point time	300 seconds each

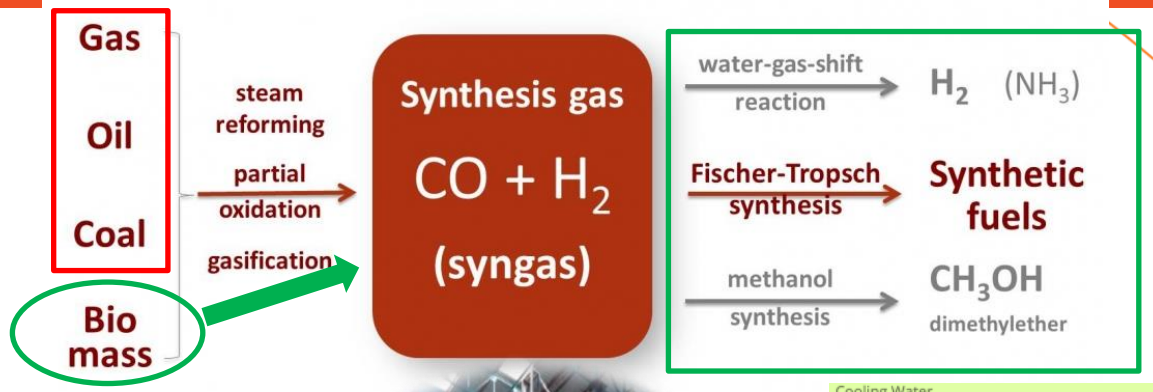


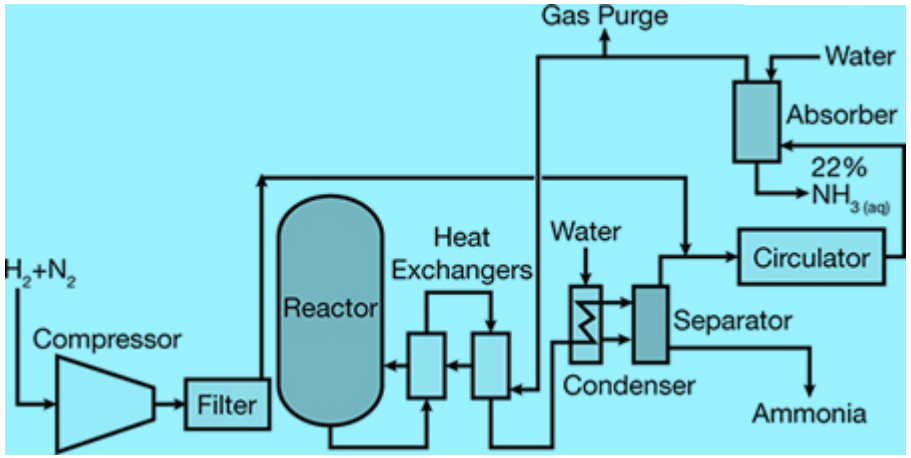
BIO Hydrogen

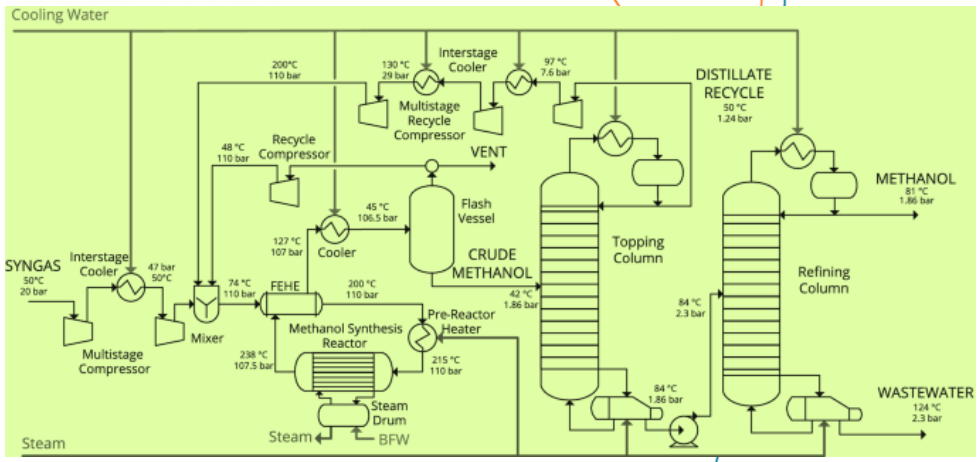




Biomass to hydrogen and chemicals







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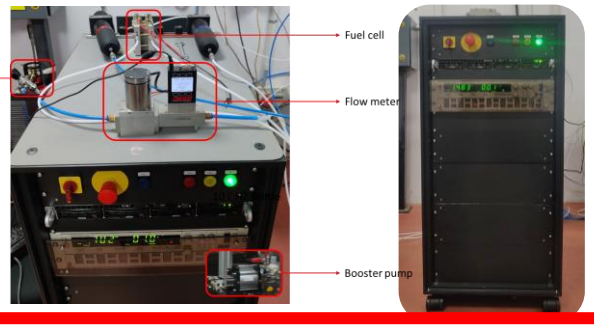
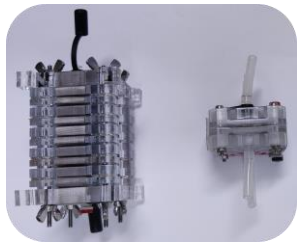




Biomass as a potential source - India

State	Area (kHa)	Crop production (kTon/year)	Biomass generation (kTon/year)	Surplus biomass (kTons/year)	Power Potential (MWe)
Total (including other states)	107760.7	347893.5	511040.9	145105.7	18729.9
Forest and waste lands	60000		155473.9	104048.1	14561.5

- 250 million tons of surplus biomass (~70 million tons of oil equivalent) from agro residues and forest and wasteland
- At 10 % utilization ~ 1.25 million tons of Green hydrogen
- Mitigates emissions

Observations from the SIGHT document

- Approved Initiatives for biomass
  - Protected 40,000 Metric Ton / Annum ~ 5 Ton per Hour is dedicated for Biomass based Hydrogen generation technology
    - Can participate in the agnostic pool also
  - Production linked incentive for 3 years
- Request
  - Create a Framework for CAPEX Incentive scheme for biomass
  - Agro residue utilisation based enhanced PLI support
    - Support emission reduction

Why Biomass?

- India being an agro-based economy - need to handle the residues.
- **Impact**
  - Technical
    - Biomass is a CO2 neutral technology – can be carbon negative
    - Continuous operation ~7500 to 8000 hrs/year
    - Supports distributed generation
    - Indigenous technologies are available – supports GoI initiatives
    - Provides Energy security to the country
    - Supports country's climate change commitments
    - Possibility to show globally biomass to hydrogen – a reality
  - Social
    - Supports farmers
    - Ensure employment
    - Business opportunities
    - Supports distributed generation

Opportunities and Challenges for bio-hydrogen

- **Opportunities**
  - Technology has been developed and tested at reasonable scale
    - 10 kg/hr plant will be operational in IOCL R and D campus for fuel cell bus
    - Range of applications – Refinery, Ammonia, Methanol. SAF, etc
  - Limited co-ordinated efforts towards Biomass energy for large scale impact
  - Biomass to value added fuels can partially replace CH_4 based fuel derivatives
  - Supports usage of MSW
- **Challenges**
  - Fuel Supply chain
    - MSP for residues
    - Fuel preparation and supply chain mechanism
      - Incentivizing based on Production Linked Incentive for biomass to hydrogen
    - GST related issues

SWOT analysis from biomass to hydrogen

Strengths

Decentralized; Strengthens self-reliance , Environmentally sound; Value addition to the agro-residues

Locally available fuel, ability to meet the fossil fuel applications/replacement

- Indigenous technology
  - Directly from biomass to hydrogen
- Employment potential

Weakness

- No level playing field
- Fuel dispersed;
- Not many players in the sector
- Low visibility
- Completely indigenous technology

Opportunities

- ATMA Nirbar
- Potential very high
- Distributed concept
- Gestation period nearly zero;
- Hydrogen generation costs are comparable to that of fossil fuel system;
- Supports GoI's initiative on Green NH3 and Urea
- Being biogenic the process allows for –ve carbon footprint

Threats

- Reforms under-emphasize biomass-based systems;
- No access towards level playing field,

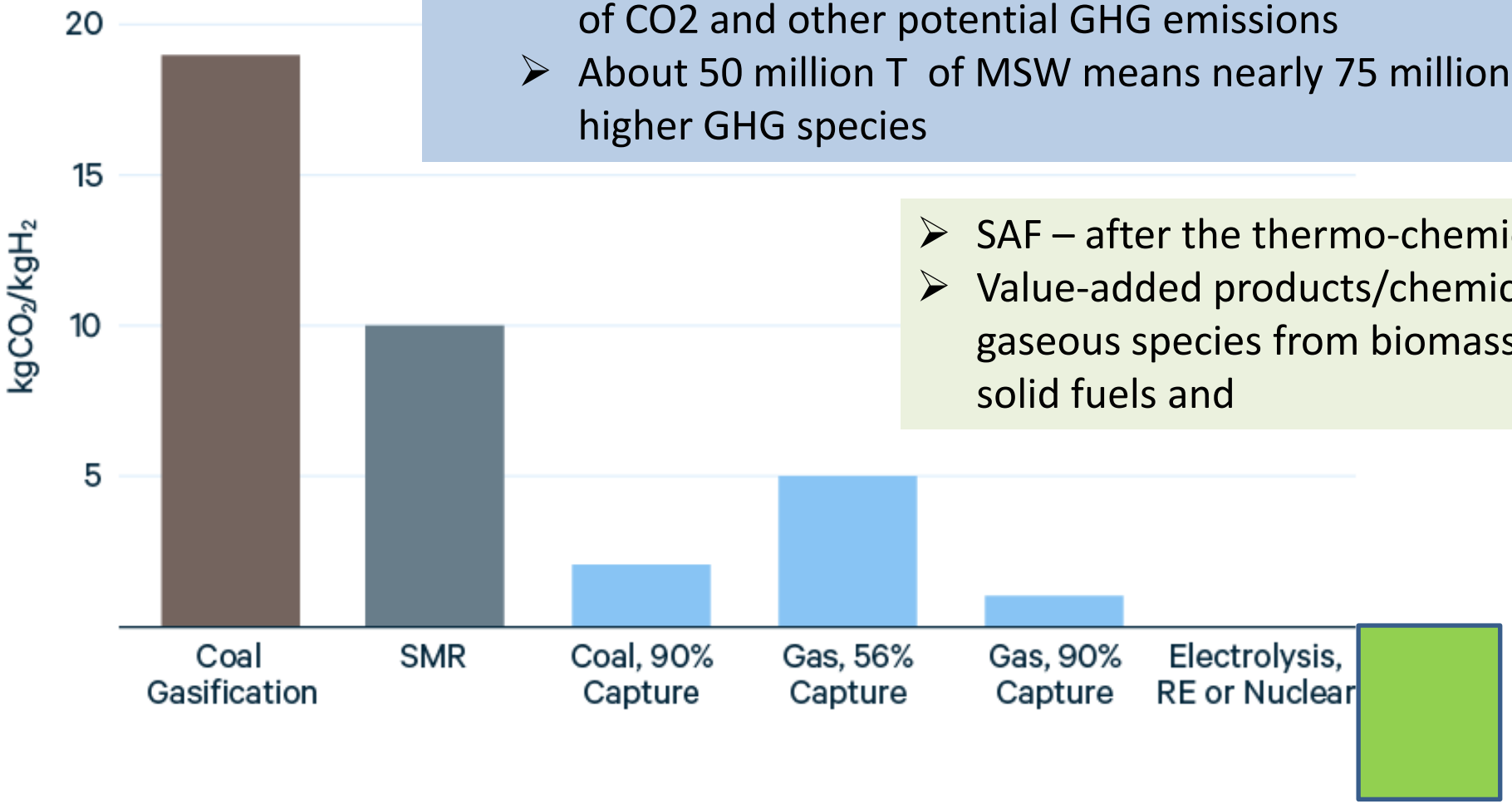
Need for Centre of Excellence - Biomass to hydrogen

- Biomass is a complex fuel and is available in various forms
  - Processes and technologies for converting biomass to energy (commercial)
- Biomass sector has no co-ordinated efforts
  - A very important resource as India is agro-based economy
- For the mission mode approach, Biomass to Green hydrogen is a line item that requires several players to join hands to meet the overall objectives
  - Limited opportunities for importing technology for our country with the range of fuels, especially MSW (an important portfolio with limited focus at present)
    - Atmanirbhar
- Backend support to the Mission program at MNRE on Biomass

Opportunity for sustainable hydrogen

A resource that is available

- Surplus of 250 Million T means the possibility to mitigate nearly 400 million T of CO2 and other potential GHG emissions
- About 50 million T of MSW means nearly 75 million T of CO2 and potentially higher GHG species



- SAF – after the thermo-chemical conversion of biomass
- Value-added products/chemicals from pure/mixture of gaseous species from biomass, H2, CO, CO2, for a range of solid fuels and

..... Thank you

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