THERMO-CHEMICAL CONVERSION OF BIOMASS - HEAT AND POWER

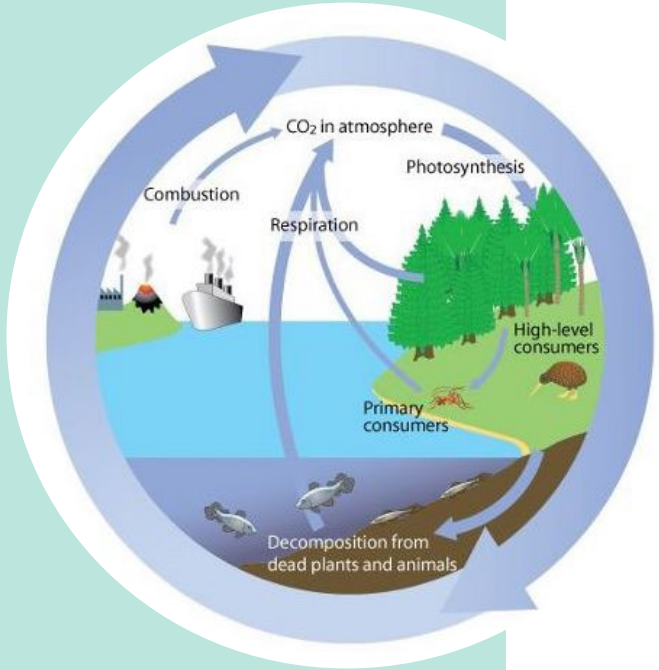
A CARBON NEGATIVE APPROACH

Prof Dasappa S

Chair, Interdisciplinary Centre for Energy Research
Professor, Centre for Sustainable Technologies
Indian Institute of Science
Email: dasappa@iisc.ac.in
Contact No: +91 80 23600536

PHOTOS OF VISIT

NATURAL CARBON SEQUESTRATION



- $C_{1.0}H_{1.4}O_{0.6}$ - 52% by mass is embedded in Carbon
- Natural sequestration - 1.9 kg CO_2e

Rotation (years)	1	10	20	40	50	60	80	90	100
GWP_{bio} factor	0	0.04	0.08	0.16	0.21	0.25	0.34	0.39	0.43

- If agro residue is targeted as biomass source, the GWP_{bio} will be 0

REF: WBCSD, 2013; IEA BIOENERGY 2020; GHG PROTOCOL; CHERUBINI, 2011 A

PHILOSOPHY OF THERMOCHEMICAL CONVERSION

- Combustion uses 6kg of air for 1 kg of biomass (Stochiometric value) to generate a mixture of gas containing CO2, H2O and N2.
- The gas mix has high thermal enthalpy but zero calorific value.
- On reducing stoichiometric air, process continues in an autothermal manner, but the thermal enthalpy of product gas starts reducing and calorific value starts increasing.
- Sub-stochiometric, autothermal, thermochemical conversion, is termed as gasification.

Combustion

Stochiometric air requirement – 6 kg/kg biomass

$C_{1.0}H_{1.4}O_{0.6} + 1.05\ (O_2 + 3.76\ N_2) \rightarrow CO_2 + 0.7\ H_2O + 3.95\ N_2$, zero calorific value

Air supply

Thermal enthalpy of product gas

DECREASE

INCREASE

Calorific value of product gas

Gasification

Sub-stoichiometric air control – 1.5 to 1.8 kg/kg biomass (maintaining autothermal condition)

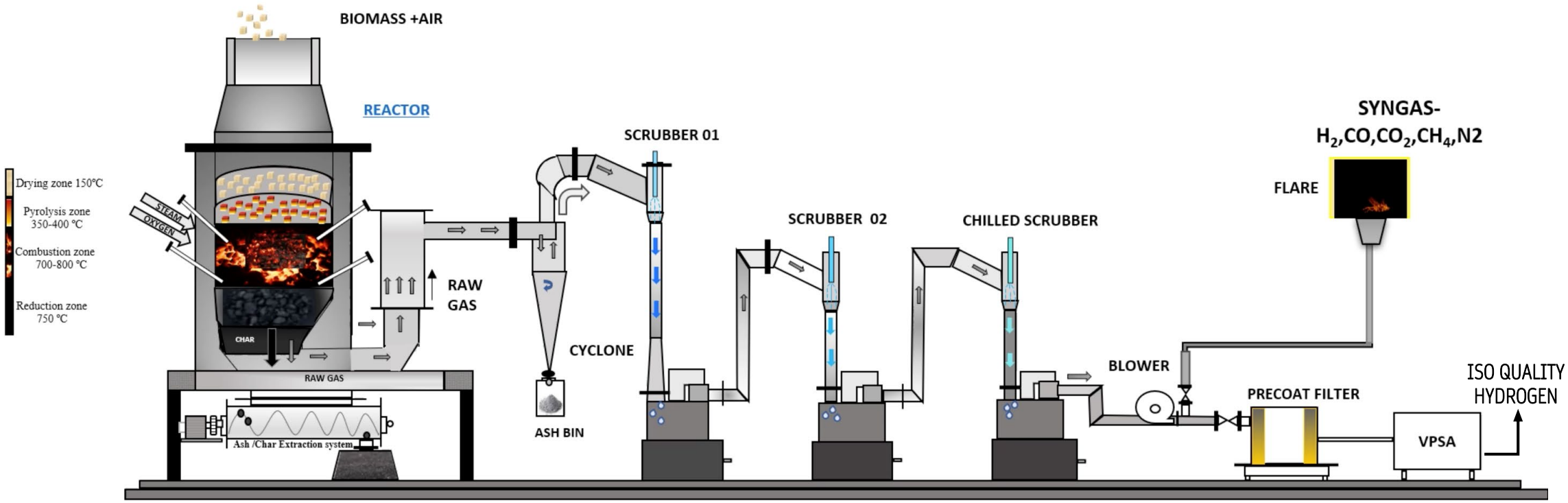
$CH_{1.4}O_{0.6} + 0.26\ (O_2 + 3.76\ N_2) \rightarrow 0.2\ H_2 + 0.2\ CO + 0.02\ CH_4 + 0.12\ CO_2 + 0.46\ N_2$,
5MJ/kg - calorific value

GASIFICATION THERMOCHEMISTRY

- Air gasification
  - $CH_{1.4}O_{0.6}$ + 0.26 (O_2+ 3.76 N_2)➞ 0.2 H_2 + 0.2 CO + 0.02 CH_4 + 0.12 CO_2+ 0.46 N_2
  - Producer gas - 20% H_2 + 20% CO + 2% CH_4 + 12% CO_2 + 46% N_2 :: ~ 05 MJ/kg
  - 40 – 50g of H_2/kg of biomass
  - 2.75 kg-producer gas/kg-biomass

SCHEMATIC DIAGRAM- IISC PATENTED GASIFICATION TECHNOLOGY

Open top downdraft fixed-bed gasification system



GASIFICATION TECHNOLOGY- FUEL AGNOSTIC

Corncob
200 kg/m^3

Wood chip
400 kg/m^3

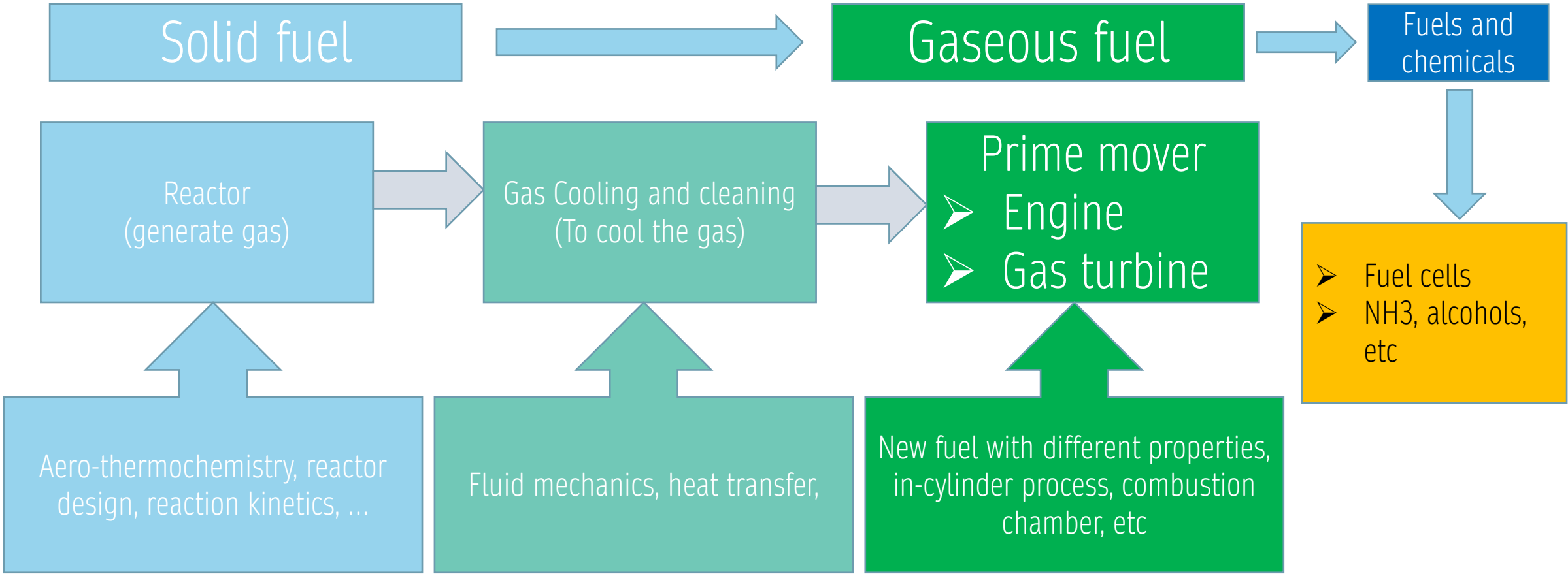
Mulberry pellet
570 kg/m^3

Coffee husk pellet
663 kg/m^3

Coconut shell
1000 kg/m^3

Bamboo
1156 kg/m^3

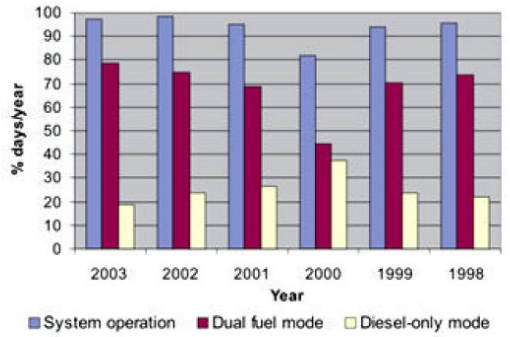
SCIENTIFIC ASPECTS OF THE TECHNOLOGY



- Interdisciplinary science overlapping the research component
- Product development - engineering the product which involves material, life, etc and finally economical

AN INTERESTING JOURNEY ……. FOR SUSTAINABLE ENERGY IN THE RURAL AREAS

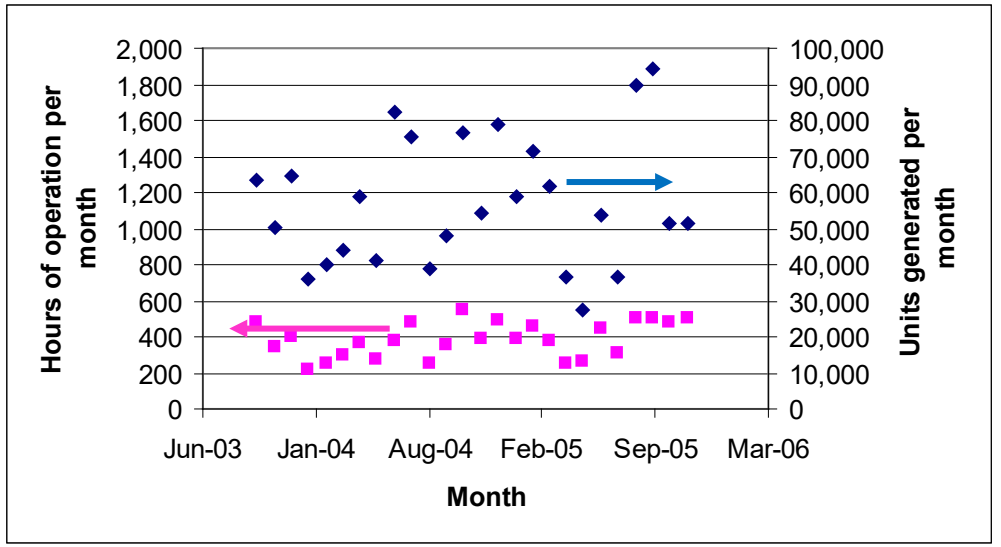
- With Pura being supported through biogas for meeting the critical energy needs of a rural house, (in Ungra). Took an initiative to identify an un-electrified village close to Ungra
  - Approach thermo-chemical process
  - The hamlet Hosahalli - not an easy terrain to reach
  - Un-electrified hamlet – semi-arid, 45 houses; 220 population;
  - Literacy level <5 %
  - One crop in a year – Rain ; remaining man hours spent as laborer
  - Village land of 2 hectares used to grow biomass
- Initially it was envisaged to provide electricity to all the houses (about 45 along with streetlight) using biomass gasification as the technology intervention.
- Issues addressed
  - Necessary permissions to supply electricity to
  - Convincing the villagers that the forest residue will be used for power generation
  - Technology being researched

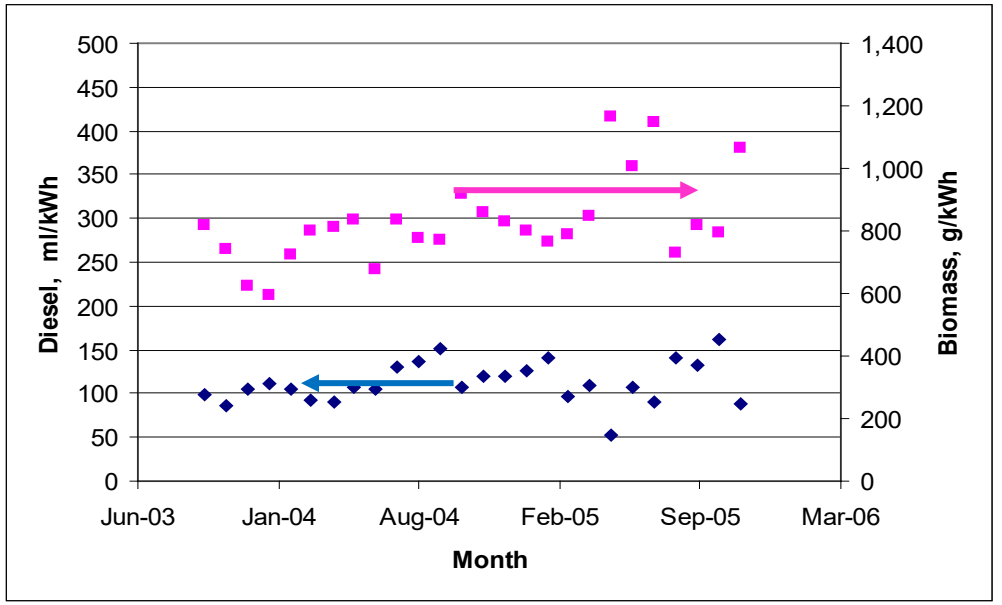


- Overall performance
  - The uptime for electric supply was greater 95%; corresponding uptime of grid electricity in neighboring villages ~60%;
  - The quality of electricity at Hosahalli 210V; with grid electricity experience voltage as low as 150 V
  - Service fee collection efficiency > 75 %
  - Was only Biomass energy village in the entire world

HINDUSTAN PENCILS - A LEADING PENCIL MANUFACTURER OF THE COUNTRY

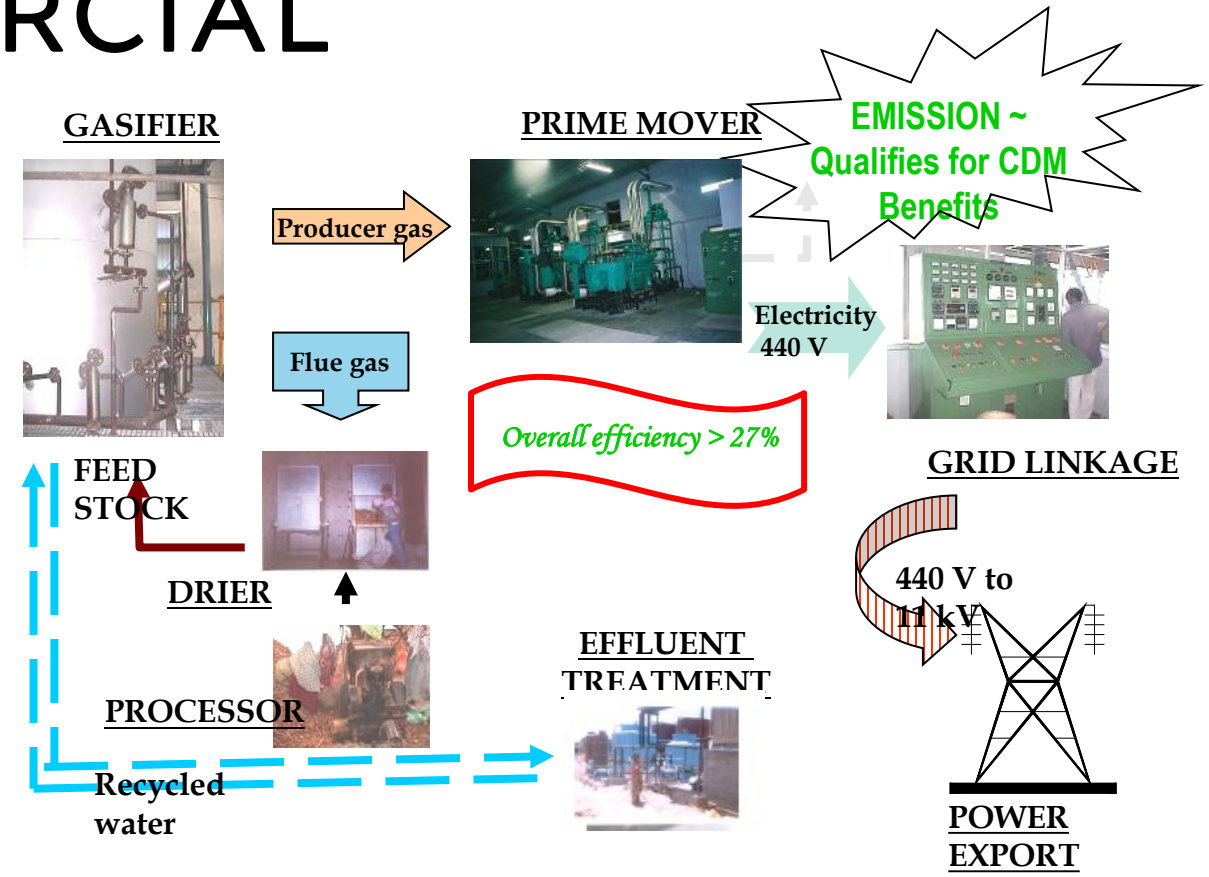
- Generates saw dust during the process
- Gasifier designed to operate on briquetted saw dust





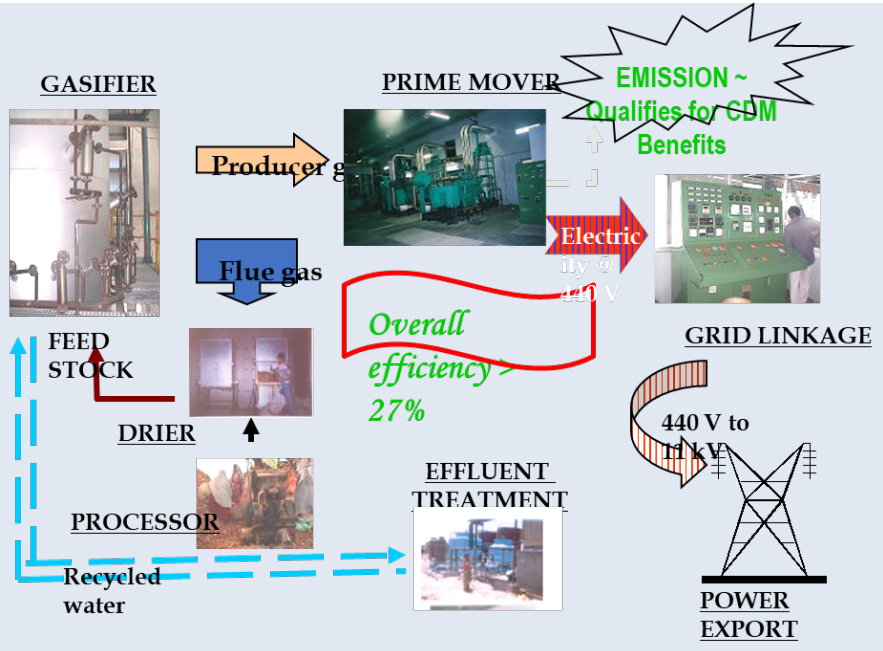
CASE STUDY OF COMPLETE SYSTEM – COMMERCIAL

- First, single largest IPP based on fixed bed biomass gasification technology
  - Biomass used – coconut shells, prosopsis Juliflora
  - 5 nos of GTA 1710 G engines
  - Peak power of 290 kW obtained against 355 kW on NG
  - First time the gas engine connected to grid - Over 40000 hrs
  - Audit report after 5000 and 10000 hrs



Cummins provided guarantee on their engines

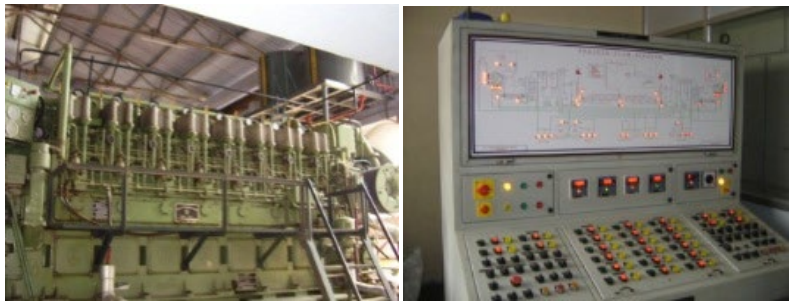
GLIMPSES OF THE POWER PROJECTS ..



Aarya Hi-Tech– Tamil Nadu 1.0 MW

Beach Mineral Corporation – Tamil Nadu 1.5 MW

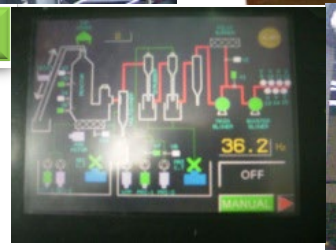
Hindustan pencils – Jammu

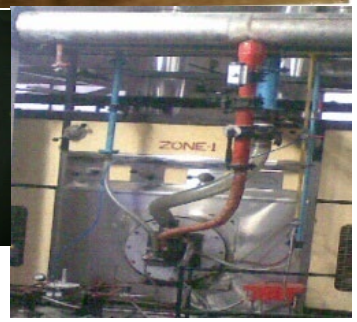


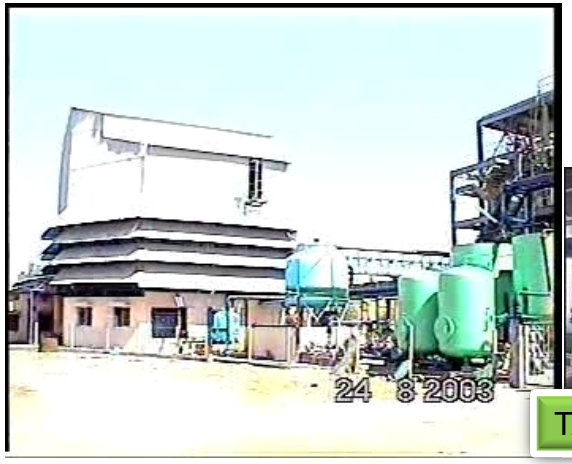
Gomathy mills – 1MW

GLIMPSES OF SOME THERMAL SYSTEMS

ITC - Vellakovil



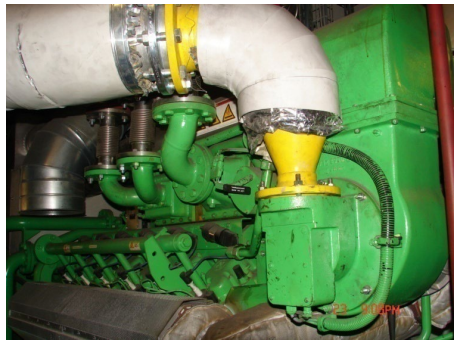




TANFAC - Cuddalore

Amrita - Cochin

GASIFICATION SYSTEM IN OVERSEAS – FEW EXAMPLES



400 kWe Grid connected – Wila Switzerland

1000 kWe Grid connected – Thailand

250 kWe, Hiroshima, Japan

1000 kWe, San Francisco, USA

50 kWe Cocodrilo - Cuba

TECHNOLOGY AND SOCIETAL IMPACT

- Novel and unique gasification technology with multi-fuel capability
  - State of the art technology
  - Engine manufacturers across the globe
  - Technology transfer across the globe
- Indigenous producer gas engines established
- Provide technology leadership across the globe
- Replacing 50 Tons of oil daily
  - Annually : Over 0.16 million tons ~ 5000 m INR
  - Over 160 Tons of CO_2 mitigated

THANK YOU