Biomass energy - contribution by the Indian Institute of Science

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Content

- Background on gasification in India
- About IISc
- Activities at IISc on bioenergy
  - R and D
  - Commercialization
- Some inputs

Background on gasification in India

- There are several research groups in India from academic institutions involved in the biomass energy.
  - Indian Institute of Technology Bombay (IIT B), Sardar Patel Renewable Energy Research Institute (SPRERI), Indian Institute of Technology Khargpur, (IIT K), Indian Institute of Technology Guwahati (IIT G), Anna University, Indian Institute of Technology Delhi, (IIT D), Indian Institute of Science, Bangalore (IISc) are some of the premier institutions to name a few.
- These institutions have also focused on the usage of biomass, especially, in the thermo-chemical conversion process.

- Several manufacturers have carried out R&D in the area of combustion and gasification towards increasing the biomass energy in the country.
- Major initiative
  - In India, during the initial developmental efforts, Department of Non-conventional Energy Sources (now MNRE) took an important decision to field test the technology developed by various research and industrial groups. This was carried out during 1987 to 1994.
  - The major emphasis was on the water pumping application in the range of 5 to 50 hp. Even though there has been a mention of 35 MW equivalent of power generation with nearly 1700 systems in the field, it should be referred as demonstration package.

Current status

- There has been significant efforts from the MNRE towards supporting R and D in India and also in the promotion of the technology.
- Only few groups continued to work on gasification over the last 3 decades and contribute towards in sustaining the technological development

Research and development at the Indian Institute of Science

Conceived in 1896 by the inspired vision of the pioneering industrialist Jamsetji Tata

- Established in1909 as a Trust (Charitable Endowments Act 1890)
- Deemed University from 1957
- Funded by MHRD since 1993

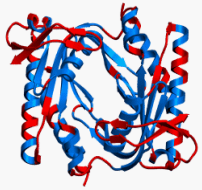
Vision

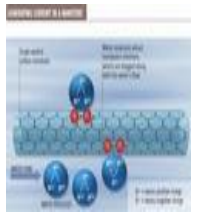
Founder's mandate: Institute designed to promote original investigations in all branches of learning and to utilise them for the benefit of India.

21st century: to be among the world's foremost academic institutions through the pursuit of excellence and the promotion of innovation.

Divisions

- Biological Sciences
- Electrical Sciences
- Mechanical Sciences
- Chemical Sciences
- Information Sciences
- Physical and Mathematical Sciences



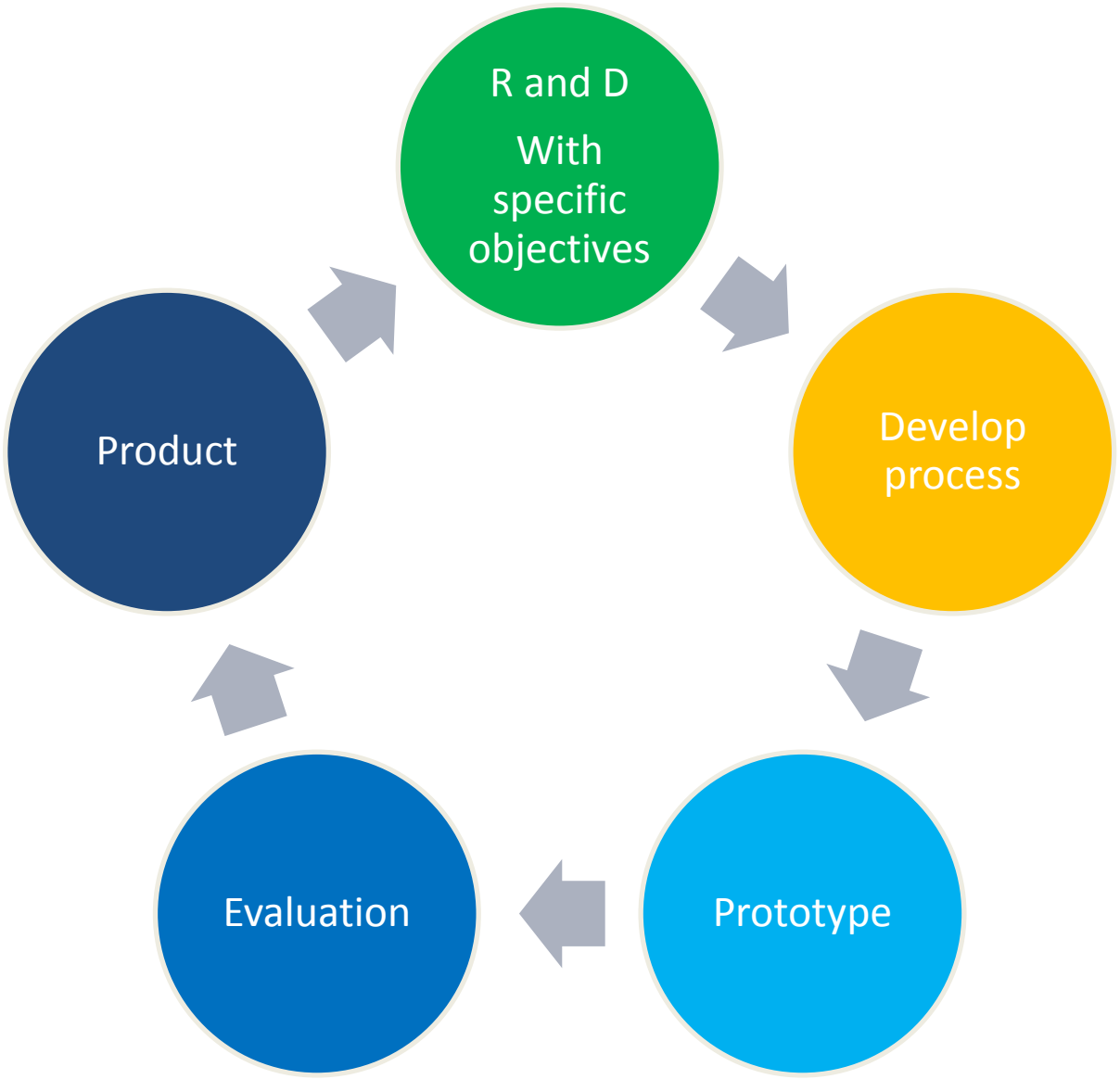


The lab

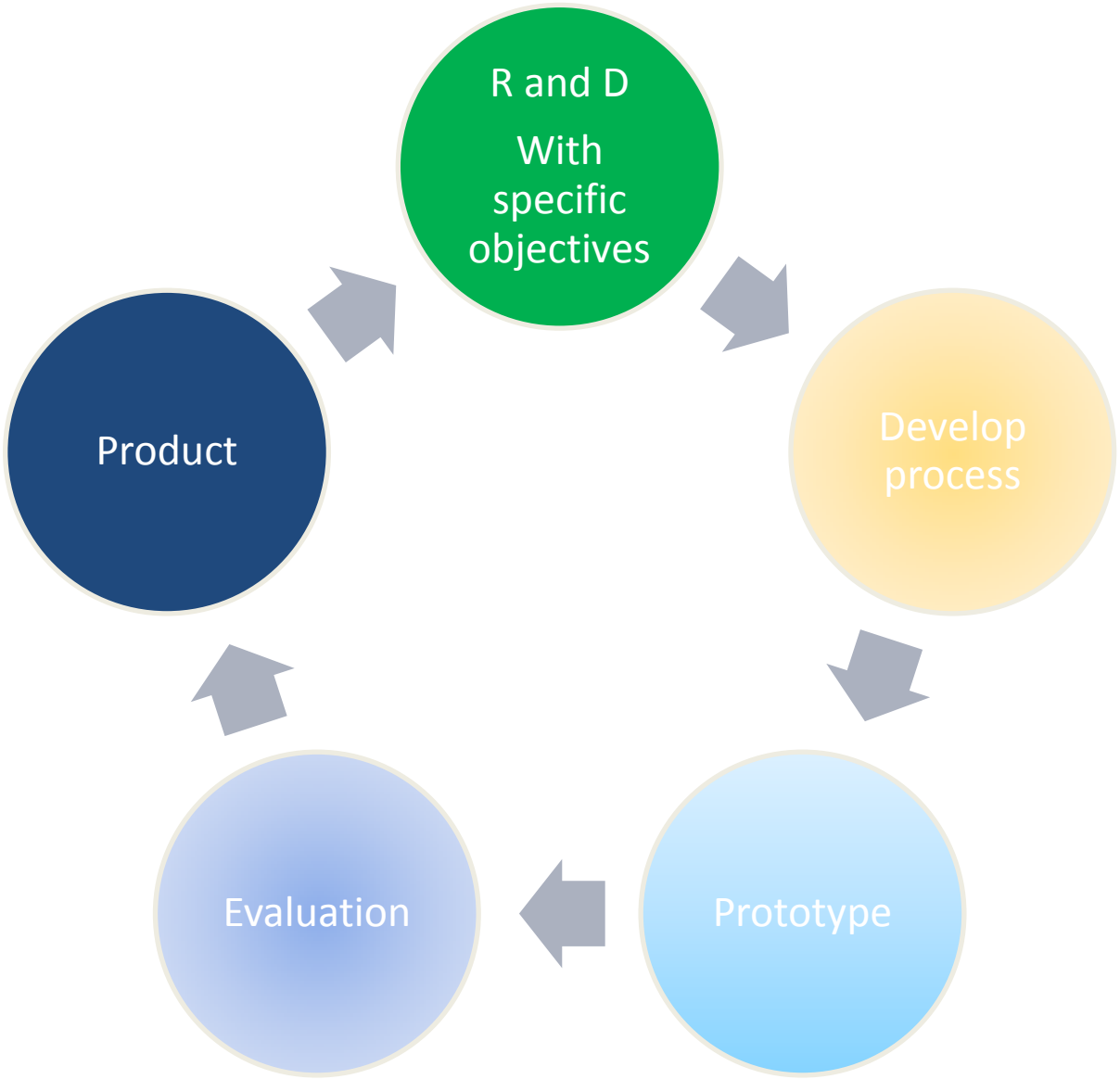
Thermo-chemical conversion

Well to wheel

Typical cycle for product development



Typical cycle for product development



Activities related to biomass

- **Research and development leading to technology packages**
  - Thermo-chemical conversion of biomass
    - Gasification
    - Hydrogen rich syngas generation
    - Domestic and commercial stoves
    - Activated/charcoal generation
  - Power generation
    - Dual fuel engines
    - Producer gas engines
  - End use devices for fuel utilization
    - Burners for producer gas
    - Hydrogen sulphide scrubbing for biogas
    - Precipitate silica from rice husk ash
- **Areas of on going research**
    - Mapping of bio-resources in India
    - MSW conversion
    - FT sythesis
    - SOFC

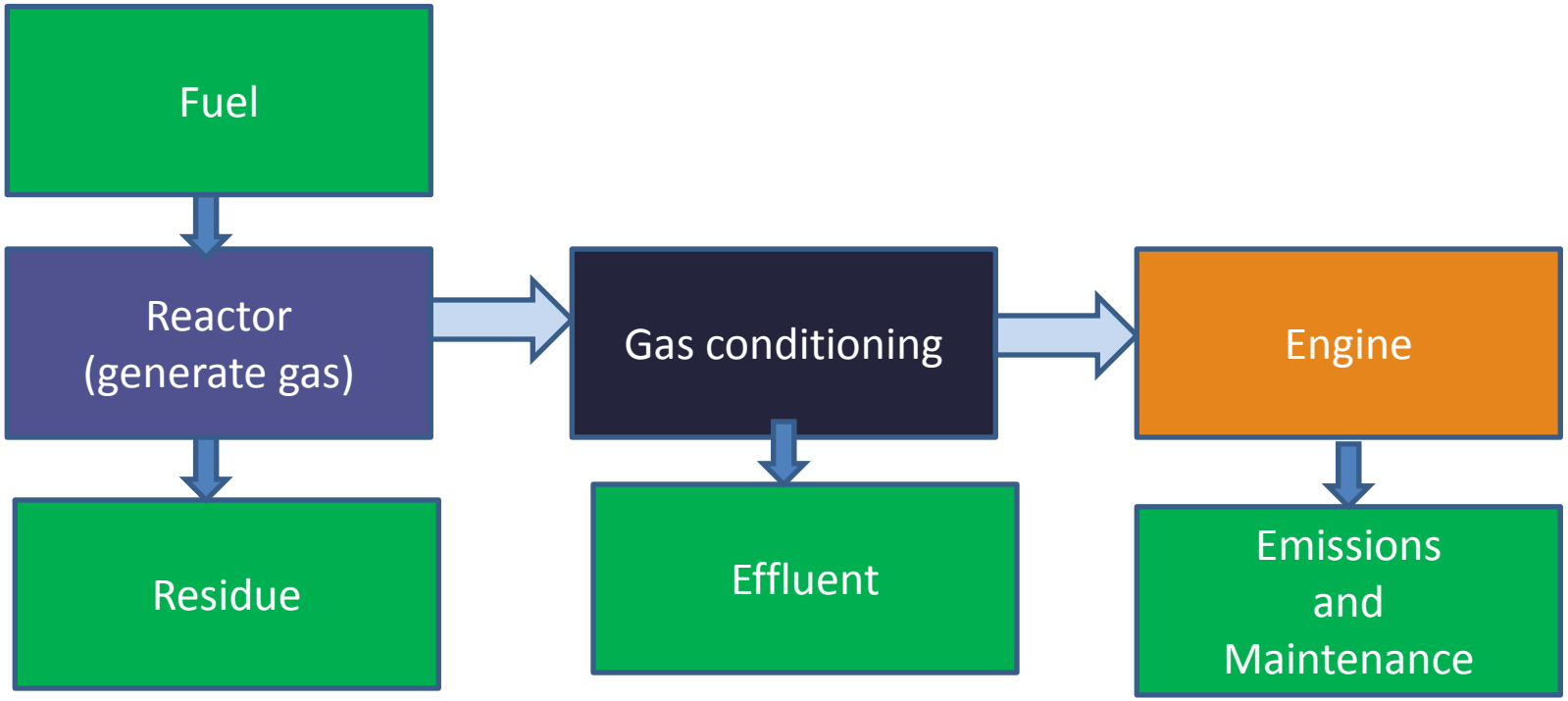
Biomass gasification

Process that converts solid fuel to gaseous fuel

- Used in an internal combustion engine for power generation to substitute fossil fuel
  - Diesel engine – for dual fuel application
  - Gas engine – for single fuel
- Used in heat application
  - Low temperature – drying, etc
  - High temperature – furnaces, kilns, etc
- Combination of the above - heat and power

Well to Wheel

Gasification process

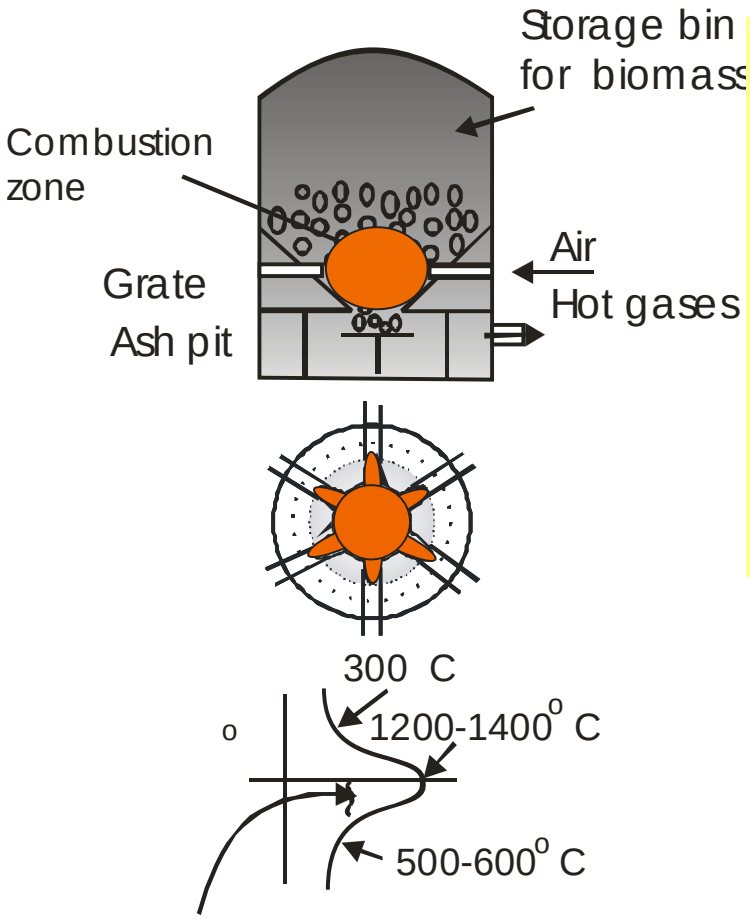


Thermo-chemical conversion
Major activities

The subject	The Issues	The Science
Biomass gasification	To ensure that tar and particulates are minimized, system elements are robust, multi-fuel capability to avoid ash fusion and yet have good quality gas	Controlling the aero-thermo-chemistry, new means of drop-tar-particulate condensation

Reactor design –

WW II design - Closed top



Findings

- Designed for charcoal as the fuel
- Combustion zone confined to a small region
- Regions of low temperature
- Can handle only woody biomass
  - Size and density important
- Turn down ratio limited
- Problem of consistent gas quality

Some variations to this is available in the technology packages

The Approach

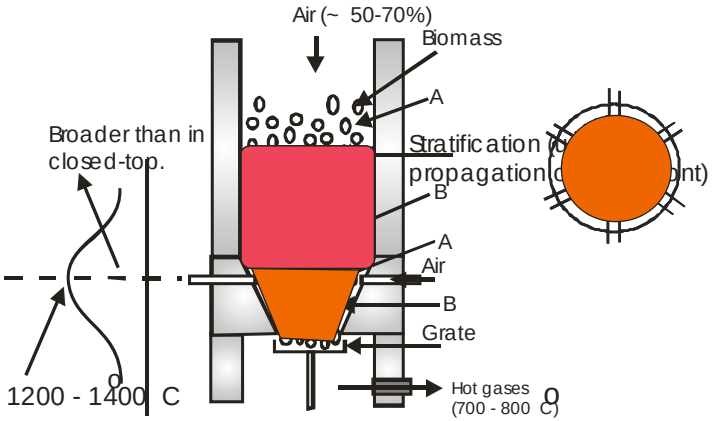
- Means
  - Extensive R and D towards understanding the process of gasification
- Achievement
  - An innovative Unique design of Open Top Reburn Gasification system
  - Increased residence time for gas in High temperature Zone
  - Overcoming the issues related to Closed top design
  - Only Multi-fuel gasification system in the world
    - Fuels woody in nature – direct after sizing
    - Residues ,loose material – after briquetting

Reactor design

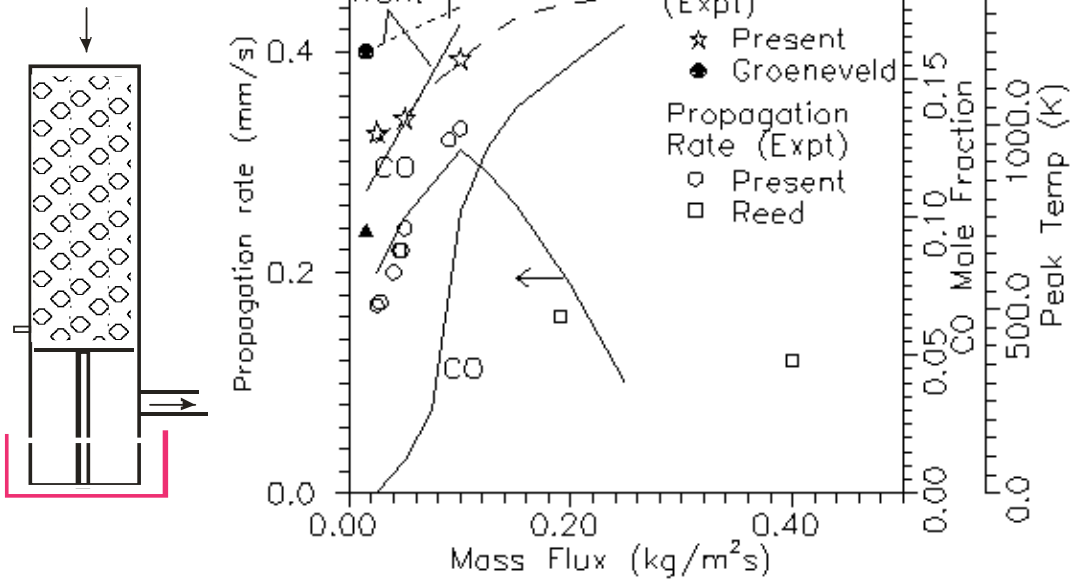
- IISc design – open top

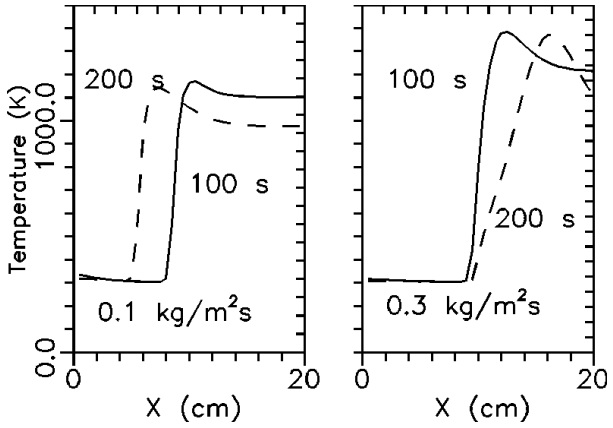
Novel reactor design

- Air is drawn from the top and from the air nozzles –
  - Uniform distribution
- Broader high temperature zone
- Enough residence time
- Consistent high quality gas over the turn down ratio
- Varying biomass quality – can accept all agro residues
- The ratio of air flow rate from the nozzle to the top depends on the fuel properties – size, density; the char consumption rate, etc



Basic Research – packed char bed





- With increase in mass flux the front velocity initially increases and then reduces
  - This fixes the turn down ratio of the gasification system
  - Superficial mass flux and ash properties are used as design parameters

Research highlights of thermo-chemical conversion

- Identifying and arriving at parameters for robust reactor design like
  - Superficial air mass flux for reactor sizing
  - Turndown ratio defined
  - Scaling up laws well established for a few kW to MW levels

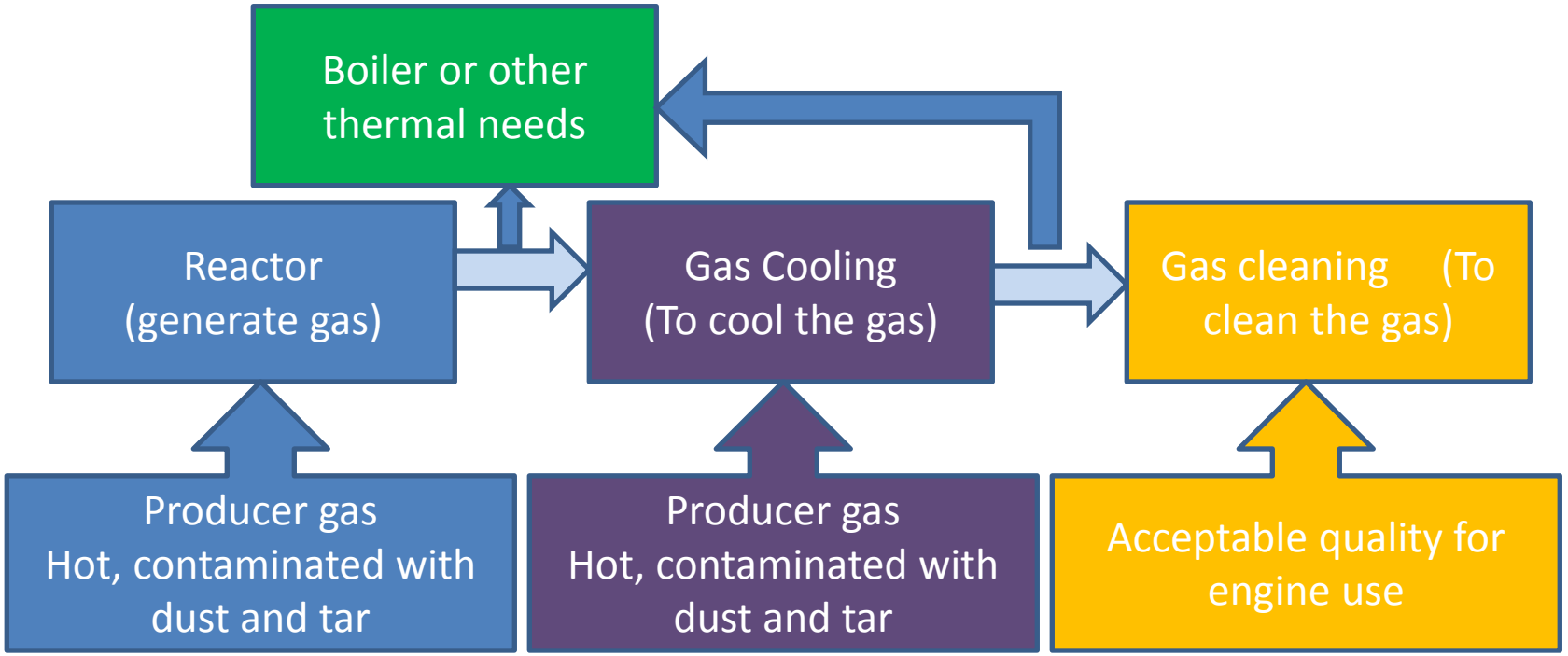
    (10 kg/hr to 2000 kg/hr)
    - All the dimensions of the reactor established with empirical relations
  - Multi-fuel capability proven
  - Consistency in gas quality (composition and contaminants)
- A unique reactor design to with multi-fuel capability




Biomass gasification – Gas quality
The cooling and cleaning system

- The Challenge
  - Ensuring gas quality for engine use very critical
    - Low on Tar and Particulate - a dream come true for any Researcher
    - Dry gas
- Means
  - Innovative design of scrubber to cool the gas below ambient to dry and clean the gas to ppb levels
- Achievement
  - Contaminant in the gas less than 5 mg/m^3
    - A desire for any engine manufacture
  - Operation on engines with turbo chargers – over 100,000 hrs

Gasification process



Open top Dual air down draft – The IISc design

- R and D started early 1980's
- Approximately 500 man year's of effort
- Over 10,000 components

Biomass used in IISc systems





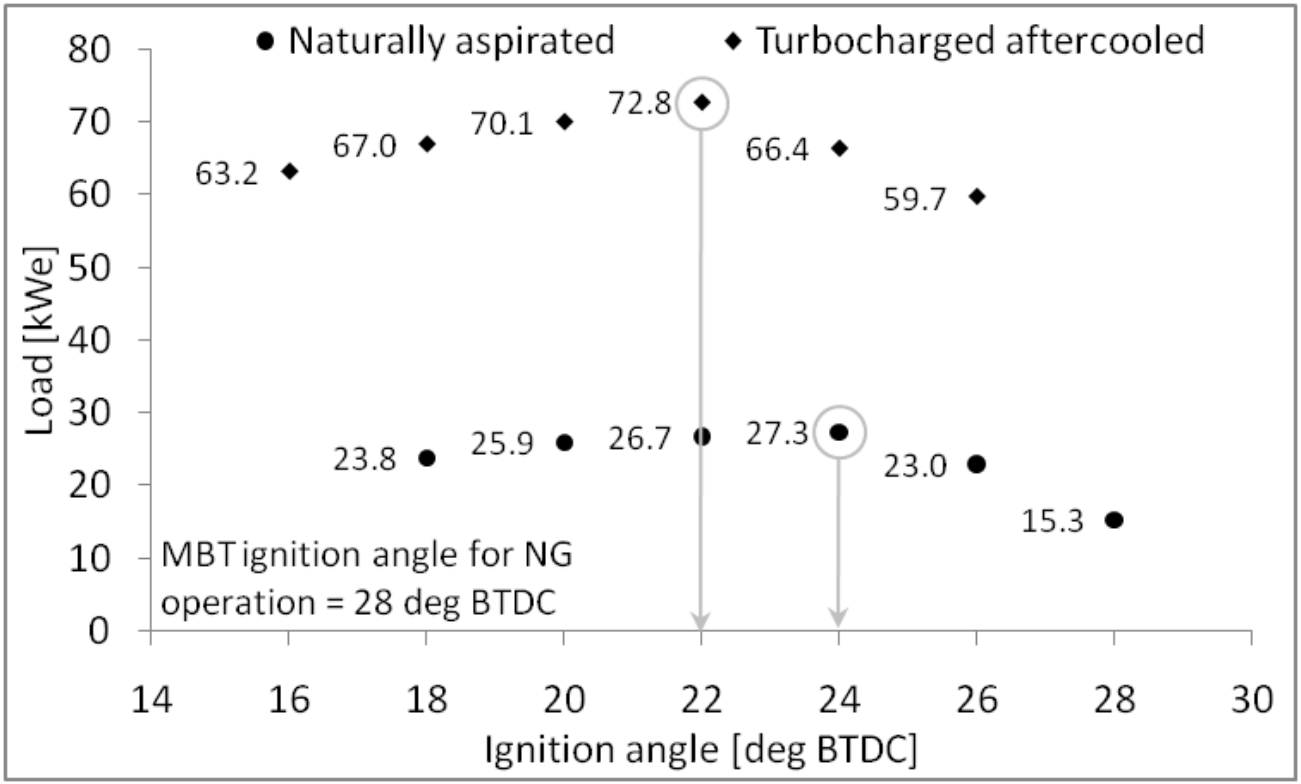


Producer gas engines

Producer gas engines Methodology

- Reasons for R and D o producer gas engines
  - No gas engines available in the market for producer gas operation
  - Carried initially fundamental work on gas engine by converting diesel operation to producer gas operation
  - Led to collaboration and transfer with engine manufacturers like Cummins, Waukesha, etc
  - Developed necessary tool for converting Natural gas engine to operate on producer gas
  - Over 15 MW power generation systems in the field

Spark sweep test for MBT determination



The spark sweep test towards identifying the MBT ignition timing and to capture the cylinder pressure trace for analysis of the descriptors indicates the ignition timing at 24 and 22 deg bTDC for naturally aspirated and turbocharged mode respectively.

The identified settings are 4 and 6 deg advanced as compared to the natural gas MBT ignition settings. The requirement of advance in the ignition setting is attributed to the higher flame speed for producer gas as compared to natural gas. With turbulence increasing the flame speed, the TA mode experience further retard of 2 deg as compared to NA mode.

The consolidated performance of the engine with the optimized turbocharger is presented below and compared with the performance of the engine under naturally aspirated and with the factory mounted turbocharger.

	Naturally Aspirated	Turbo Optimized
BMEP (bar)	3.70	9.87
SBC (kg/kWh)	1.35	1.0
Overall efficiency (%)	18	24
Specific Weight (kg/kWe)	38.4	14.4
Load per volume (kWe/ltr)	4.64	12.34

Engine modeling studies

The following classes of models are considered in the current study

Thermo-dynamic Models	**Fluid-dynamic Models**
Lumped system consideration with parameter variation as a function of time only. Formulation involves ODE's. In house code developed.	Spatial and temporal variation of properties are considered. Formulation involves PDE's. ANSYS-FLUENT is used for the simulations.
→ ***0D*** single zone HCCI model. → ***0D*** multi zone HCCI model [CHEMKIN-PRO] → ***0D*** Wiebe function based SI engine model. → ***0D*** Wiebe function based SI engine model with knock prediction feature. → ***Quasi D*** SI engine model. → ***Quasi D*** SI engine model with knock prediction feature.	→ ***2D*** model without gas exchange process. Used to validate laminar flame propagation correlations. → 3D model with full chemistry

Overall engine performance

- The turbo charged engines was closely monitored in the field,
  - During the initial phase joint inspection every 1000 hours
  - Checking of oil at regular intervals
- Over **200,000 hours** of operational experience in the field

- No major issue on the engine wear (based on studies by CIL)
- Engine capable of handling varying loads
  - 30 – 40 % block loading was possible

- SFC ~ 1 ± 0.1 kg/kWh
  - Efficiency (Wood to electricity) > 26 %
  - Efficiency (Gas to electricity) > 32 %

- Cummins India Limited has agreed to manufacture producer gas engines based on the input from IISc on the carburetion and ignition timing.

- Cummins has accepted Producer gas as a fuel and would provide performance guarantee along with the warranty for the equipment.

Technology transfer on Gasification

- Gasification technology
  - To industries in India and also globally
- Producer gas engine
  - Gas carburetion
  - Transferred to engine industries and working with many others
- Other technology transfer
  - Stoves
  - Hydrogen sulphide scrubbing
  - Silica

Nationwide State wise Web Biomass Atlas

- Biomass web atlas hosted during 2008 is maintained and is Operational since 2008 at- http://lab.cgpl.iisc.ernet.in/Atlas/

Atlas Enhancement

- Demography has been updated as per SoI
- The Agro-data for multiple years are being verified published by MoA
- The necessary software to distribute spatially the Rainfall has been developed by using 0.5deg grid data published by IMD (Indian Meteorological Dept.)
- In addition to Web Geographical assessment of Agro-biomass, Biomass from Forest and Waste lands with Visualization of Biomass Hot-spots, work on adding spatial mapping of biomass price is taken up
- The biomass pricing is under initial study

Biomass statistics

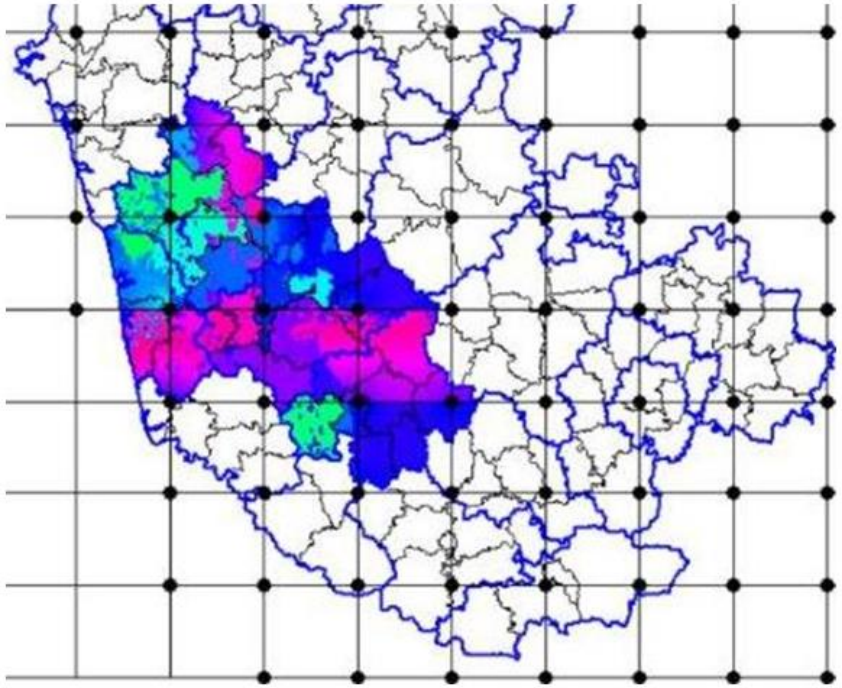
District: Bagalkot of Karnataka state								
Agro-biomass								
Crop Name	Residue Name	Biomass Generation (kT/Yr)	UR from Survey Report	Biomass Utilization for Cooking (kT/Yr)	Improved stoves biomass consumption rate (kg per kWhTh)	Traditional biomass consumption rate (kg per kWhTh)	Biomass used with improved stoves in kT	Saved biomass using Improved stoves (kT)
Arhar	Stalks	9.2	0.41	3.75	0.431	1.974	0.8	2.9
Arhar	Husk	1.1	Not reported					
Bajra	Stalks	48.3	0	0	0.431	1.974	0.0	0.0
Bajra	Cobs	8	Not reported					
Bajra	Husk	7.2						
Cotton	Stalks	33.6	0.89	29.96	0.422	1.933	6.5	23.4
Cotton	Bollshell	15.6	Not reported					
Cotton	Husk	15.6						
Groundnut	Stalks	54	0	0	0.422	1.933	0.0	0.0
Groundnut	Shell	8.1	Not reported					
Jowar	Cobs	121.2						
Jowar	Stalks	412	0	0	0.431	1.974	0.0	0.0
Jowar	Husk	48.5	Not reported					
Maize	Stalks	118.2	0	0	0.417	1.913	0.0	0.0
Maize	Cobs	20.8	0.50	10.40	0.417	1.913	2.3	8.1
Pulses	Stalks	14.3	0	0	0.417	1.913	0.0	0.0
Sunflower	Stalks	59.7	0.50	29.85	0.426	1.953	6.5	23.3
Wheat	Stalks	55.8	0	0	0.431	1.974	0.0	0.0
Wheat	Pod	11.2	Not reported					
	Total	1062.4		73.96			16.1	57.8

Biomass data and Rainfall mapping

District-wise Number of Households and Type of Fuel used for Cooking in Karnataka (As per 2011 Census)					
SL.No	Districts	Total / Rural/ Urban	Total No. of House-holds	Type of Fuel used for Cooking	
				Biomass Fuels	Non Biomass Fuels
1	Belgaum	Total	963825	669725	290592
		Rural	708069	599216	106335
		Urban	255756	70509	184257

Crop	Biomass Type	Price per ton	District
Paddy	Paddy Straw	25000	Bangalore
Rice	Rice Husk	2400	Bangalore
Groundnut	Groundnut Husk	3000	Tumkur

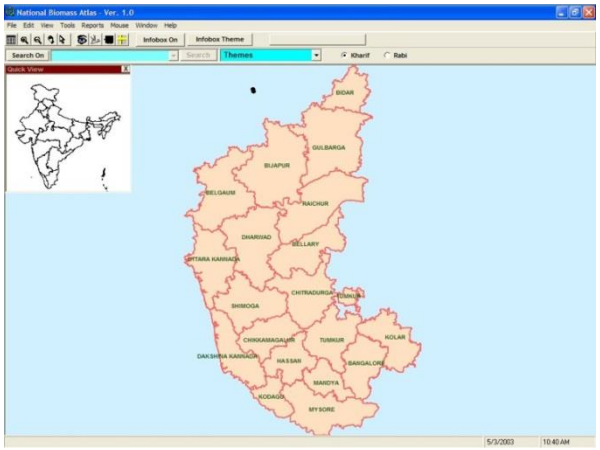
Biomass Price

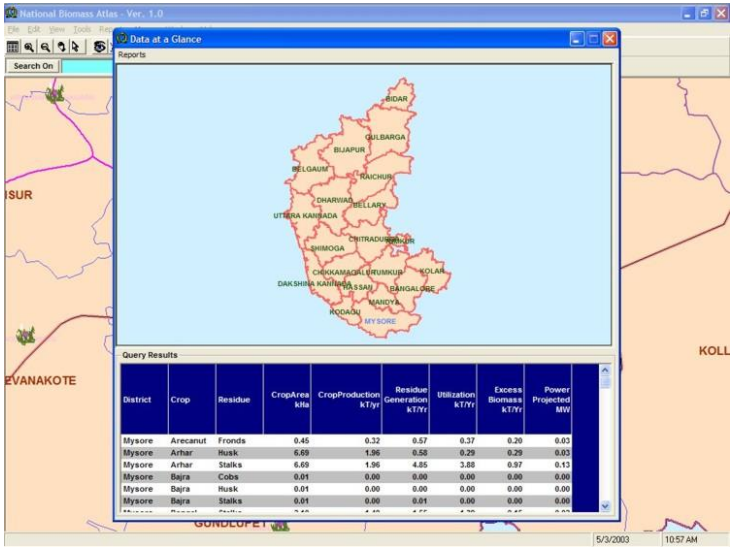


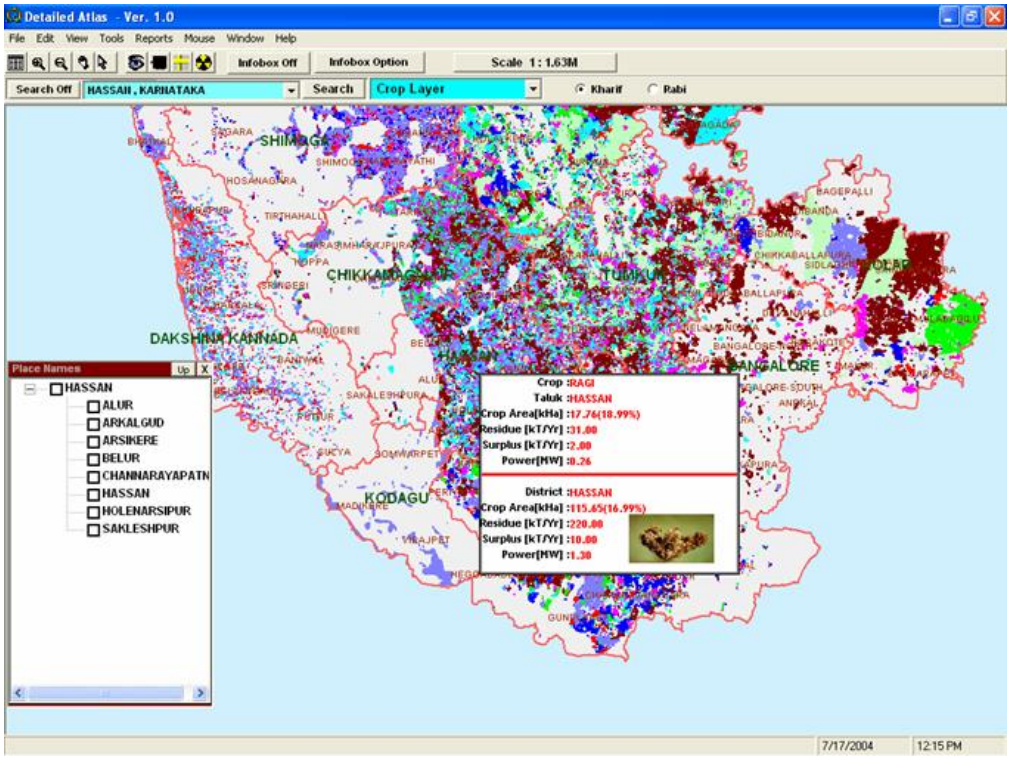
Rainfall Grid (0.5deg); Year 2005; Kharif; Karnataka

Isohyets used earlier only for one year

Biomass resource mapping







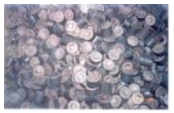
Brief history on the gasification technology at IISc

- Gasification research commenced in 1980's
  - Emphasis was on 5 hp diesel pump sets
- Over 450 Man-Years of R&D effort
- Evolved **State-of-the art** technology
- Undergone critical third party evaluation – by various groups
- Commercial applications ~ five years
- Licensed the technology in India and abroad

- **At IISc (Open top down draft technology - distinctly different from other designs)**
  - Multi-fuel capability
  - Power range 5 – 2000 kWe
  - Both power and high quality thermal applications
  - Over **450,000** hours of operational experience
  - Annual operational hours ~ 7000 hours
  - Gas cleaning system for **turbo-charged engines**
  - **Developed indigenous engines for producer gas operation**

Glimpses of the power projects ..

Beach Mineral Corporation – Tamil Nadu 1.5 MW



Hindustan pencils – Jammu

Cocodrilo - Cuba

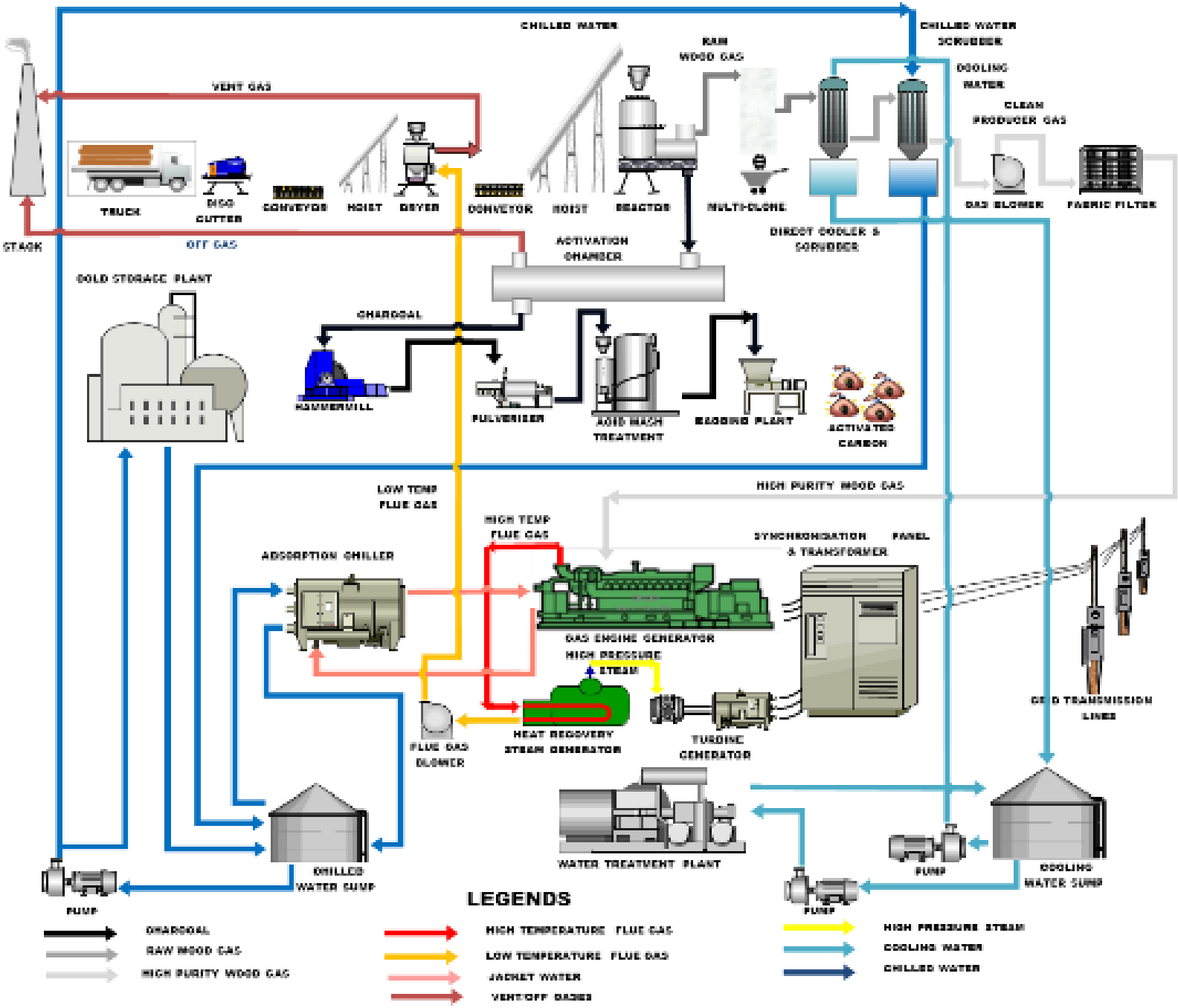
Gomathy mills – 1MW

A – Plus – Thailand 1.2 MW

Wood Power - Switzerland

Ndola, Zambia

POWER PLANT, ACTIVATED CARBON PLANT & COLD STORAGE



AGROGAS (ITALY) 70kWe

- Capacity: 70kWe
- The objective of the gasification project is power generation of 70kwe in Italy after identifying and establishing the gas compatibility for engine application and address the uses related to emission norms for Europe.
  - This package of the system is to suit European conditions after identifying the potential hazards and making a proper risk assessment.
- The technology aims at best practices of biomass gasification, Health, Safety, Environment (HSE) and risks.
- Initially tested in India and transferred to Italy under the collaborated project

1.2 MW project in Thailand

- The power plant in Thailand is based on IISc gasification system coupled to gas engines for power generation.
- IPP (Independent Power Producer) which is grid linked.
- Two Gasification system based on woody biomass of 1100 kg/hr capacity each.
- Two Gas gensets of Waukesha make, of 900 kWe capacity each (on Natural gas) to deliver about 1.5 MWe power with producer gas.
- The initial trails suggests that the engine rating is about 750 kWe as anticipated and long duration trials are being planned.

Grid linked project – Arasi Hi-tech biopower ltd

- First, single largest IPP based on fixed bed biomass gasification technology
- Biomass used – coconut shells, prosopsis Juliflora
- Plant conceived to operate in gas alone mode; in the initial phase dual-fuel engine installed later a bank of 5 nos of GTA 1710 G engines with higher compression ratio (1:10) were deployed
  - Peak power of 290 kW obtained against 355 kW on NG
- First time the gas engine connected to grid

Arashi Hi-tech Biopower Pvt Ltd

GASIFIER

Producer gas

PRIME MOVER

EMISSION ~ Qualifies for CDM Benefits

Electricity @ 440 V

GRID LINKAGE

Flue gas

Overall efficiency > 27%

FEED STOCK

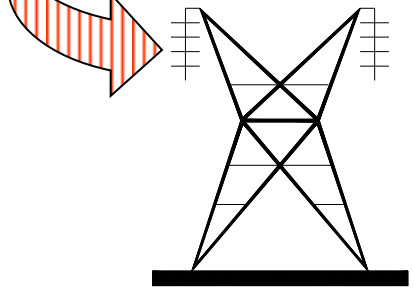
DRIER

PROCESSOR

EFFLUENT TREATMENT

Recycled water

440 V to 11 kV



POWER EXPORT

Wood power - Switzerland

- System installed in Switzerland
- A GE Jenbacher engine of PG rating of 350 kW was installed
  - System operation stablized and in fact was able to increase the power output to 425 kW
  - Since then the system has been operating well
  - Over 1.0 million units of electricity generated
- This has resulted in establishing technological superiority with GE Jenbacher

  This has resulted in planning large number of projects at MW level

- **Wood Power Ltd will no longer operate**
- Zurich, 13 October 2011

The Wood Power in Wila, the electricity produced using wood gasification ecological closes its operation. The power plants of the Canton of Zurich (CPB) as a co-owner have realized substantial parts of the objective of the pilot plant. You see good opportunities for the new generation of this technology and realize that an energy contracting at Empa and Eawag.

The Company Wood Power used an innovative approach to using wood gasification to produce CO2-neutral electricity. Simultaneously, the waste heat generated by the production process to be used commercially for high-quality wood chips for heating to dry. The family Bosshard from Wila has joined forces with the CPB, the Wood Power Ltd and the wood gasification plant operated since March 2007 as a pilot and demonstration plant.

Objectives achieved in the pilot project
After nearly five years of operation is now set. Relevant objectives have been achieved with the pilot plant and the technology could be crucial during the pilot phase of development. A commercial operation was not possible at this location, however. Instead, you would not only current but also the heat produced can be fully utilized. Demand for dried wood chips has not developed as expected and at the site Wila is no way to fully utilize the waste heat. This prompted Wood Power to cease their operation.

Heat and electricity for the Empa and Eawag
The CPB see good opportunities in the wood gasification and practice with the advanced technology project in the energy contracting at Empa and Eawag in Dübendorf. "The advantage of wood gasification technology is that it is achieved with relatively small units of 400 kilowatts an above-average investment efficiency," said Dominik Noger, sales manager of energy performance contracting. "With this system, the waste heat and heat in small networks fully utilized and thus the efficiency can be ensured." The CPB plans to take the wood gasification power plant with heat and power from Empa and Eawag end of 2012.

Unmanned 24-hour operation
By operating the plant in Wila has provided valuable insights. After various technical adjustments it now works flawlessly around the clock in 24-hour operation. All environmental requirements are met and the final operating permit has been issued - even for an unmanned operation. This is a great success that this technology has never reached anyone.

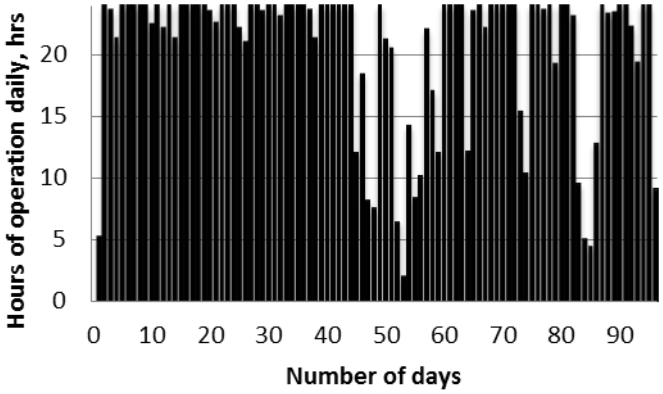
Technology continues to develop
The CPB committed to pilot and demonstration plants with the aim to explore and develop the new technology, with the risk that not every project will lead to success. Only in the course of a pilot project shows that the expectations are met. The CPB invest in such projects to generate new energy for new renewable energies, and thus ensure long-term security of supply.

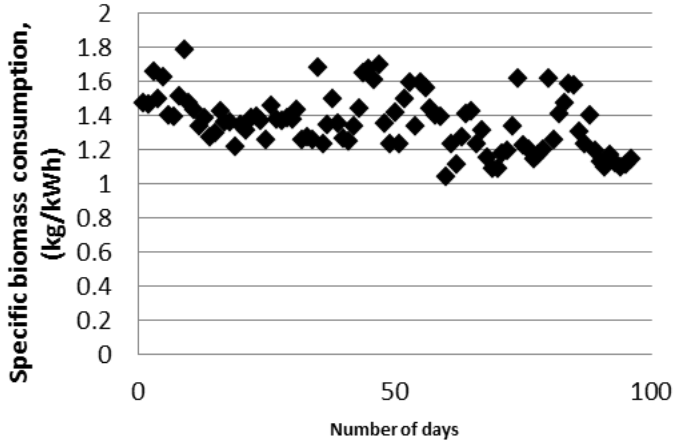
- **For more information:**
- Power stations in the canton Zurich
Priska Laïaïda
Dreikönigstrasse 18
PO Box 2254
8022 Zurich
Phone 058 359 52 99
Fax 058 359 53 99
E-mail: medienstelle@ekz.ch

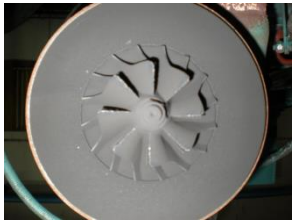
- http://www.ekz.ch/internet/ekz/de/medien/medienmitteilung/archiv/2011/oktober/mm-woodpower.html

Grid connected biomass gasification power plant in Karnataka

Gasification power plant connected to the grid in Karnataka as a part of Biomass Energy for Rural India a program under GoK/UNDP/MNRE







S Dasappa, D.N. Subbukrishna, K.C. Suresh, P.J. Paul and G. S. Prabhu, Operational experience on a grid connected 100 kWe biomass gasification power plant in Karnataka, Energy for Sustainable Development, 15, 2011, 231–239, Elsevier.

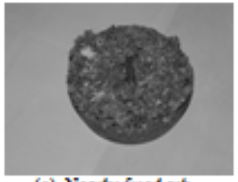
Case study for multi-fuel capability – digester waste gasification

(a). Soft ash

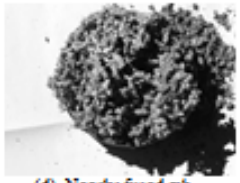
(b). Soft ash

(e). Highly fused ash

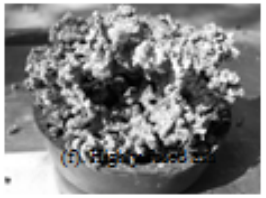
Air mass flux rate (kg $m^{-2}s^{-1}$)	Observation
0.09	Soft ash
0.14	Soft ash
0.16	Soft ash
0.17	Soft ash
0.20	Fused ash
0.23	Fused ash
0.28	Highly fused ash
0.32	Highly fused ash



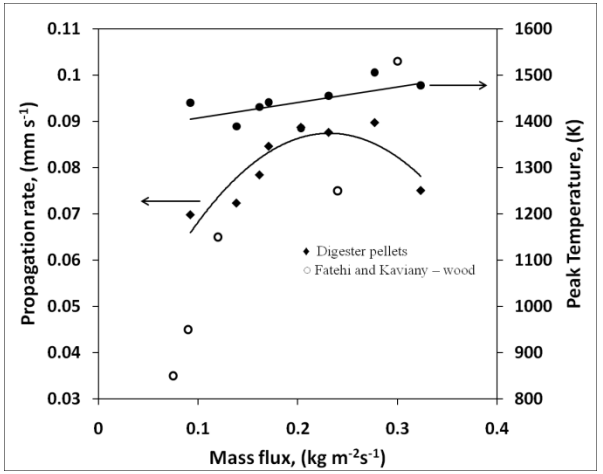
(c). Nearly fused ash



(d). Nearly fused ash



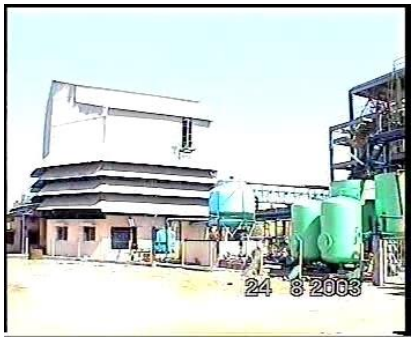
Bio digested waste briquettes	
Dimension of briquettes as received	Diameter = 65 mm, Height= 55 mm
Density, kg m^{-3}	910 ±20
Bulk density, kg m^{-3}	480 ±20
Moisture content, % (dry basis)	10
Ash Content, %	9 - 11



P.M. Gnanendra, D.K. Ramesha, **S. Dasappa**, Preliminary investigation on the use of biogas sludge for gasification, *International Journal of Sustainable Energy,* 2011.

Glimpses of some thermal systems

ITC - Vellakovil



TANFAC - Cuddalore

Amrita - Cochin

ITC – a case study

- ITC Vellakovil, Tamil Nadu, operates 24 hrs daily and 6 days a week.
  - The daily biscuit production is around 70 tons
  - Oil Consumption is around 110 to 120 litres /hr.
  - FO consumption varies with the quality of biscuit.
  - Oil consumption is about 40 litres per ton of biscuit production

Critical requirements

- Temperature profile in various zones
- Z1:190, Z2:220, Z3:250, Z4:310, Z5:265. Z6:260, Z7:240
- To maintain ± 5C always
- Availability 24 hours and minimum 6 days a week
- Ensure fuel flexibility
- The Gasification system of 500 kg/hr using coconut shells as the fuel
- Gas line about 50 m from the gasifier location
- 3 burners with dilution facility to maintain different temperatures in the different zones.

Biscuit Baking Ovens at ITC – Producer Gas Burners

2.3 MW power project in Tirupur

Project : 2.3 MW project in the heart of Tirupur for power generation and air conditioning of a shopping mall.

There has been some financial issues on the borrowing of capital from the banks and the project is delayed.




Cummins Co-generation group – 1.2 MW as an IPP in Tamil Nadu

- Gasifier was commissioned and the was operated for evaluation gas quality
- Biomass consumption was about 800 kg/hr.
- Engine checks being carried by Cummins

Anisole and Thimble after 3 hours of Gas passage

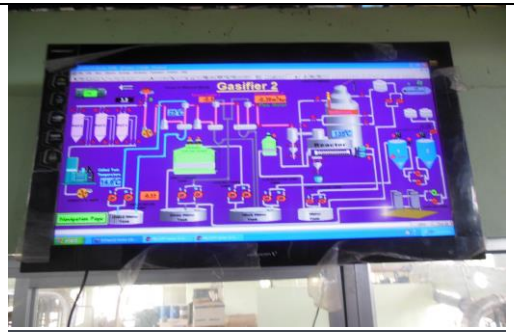
Gas after Pre-Coat filter

Gas before Pre-coat filter

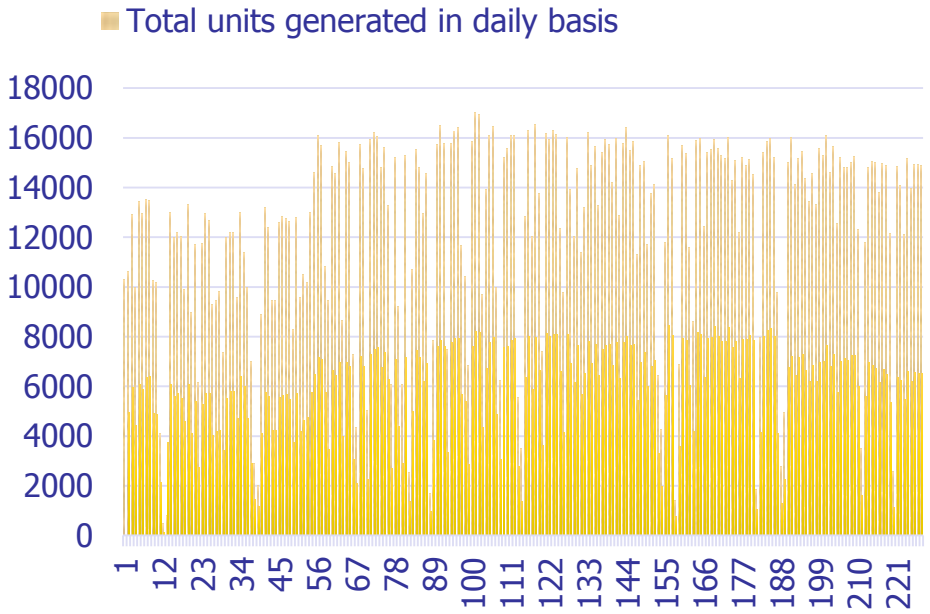
Time	CO%	CO2%	CH4%	H2%
1600	19.59	10.2	2.18	19.8
1620	19.59	10.2	2.18	19.8
1635	19.4	10.59	2.16	19.88
1650	19.17	10.76	2.16	19.2
1705	18.9	10.95	2.14	19.18
1720	18.89	11.01	2.13	19.22
1730	19.11	10.66	2.02	19.51
1740	19.21	10.75	2	19.56
1750	19.25	10.77	1.99	19.02
1800	19.34	10.76	2.04	19.64
1810	19.17	10.88	2.13	19.67
1820	19.18	10.92	2.08	19.67
1830	19.18	10.72	2.09	19.64

1.5 MW in Gadag, grid connected

- One gasifier of 1200kg/hr operated for more than 102 hours. The gas quality checked for its composition and found Ok. Also checked the gas quality with anisole and thimble test, found OK.
- The system was grid parallel to check on all the electrical connection and electricity was pumped to the grid apart from auxiliary load.
- All the four gen sets has been commissioned and load trail taken up to 100 kW based on the load availability.
- All breaker operations for Grid incomer checked in Synchronized condition



Sahyadri Starch Industries – one of the H_2S removal plants



Field performance

	Simbavali H_2S Scrubbing system	Sahyadri H_2S Scrubbing system	Loknete H_2S Scrubbing system
Designed Plant biogas flow rate capacity	550 m3/hr	550 m3/hr	725 m3/hr
Designed H_2S %	3 %	2.5 %	3 %
Observed H_2S %	4 %	1 %	4 %
Plant operated in hours	3320 hrs. (Till 9th August 2013)	6907 hrs. (Till 5th Sept 2013)	1000 hrs
Cumulative gas Scrubbed, m^3	965,550	1,914,081	3,690,90
Cumulative energy generated	2,124,100 kWh (Till August 9,2013)	4,210,980 kWh (Till Sept 5,2013)	812,000
Average H_2S in outlet	100 – 150 ppm	20 – 30 ppm	150 ppm

Precipitated silica

- Our Licensee M/s Usher Agro Limited is setting up a 5 ton per day silica plant at their rice milling plant site near in UP.
  - Detailed engineering, equipment ordering has been completed for a 5 ton per day plant to be set up by M/S Usher Eco Power.
  - Installation of reaction vessels, gasifier to meet the thermal energy needs have been in progress. It is expected that the plant would be operational by end of 2013.

SWOT analysis – biomass power

For India and several developing nations

Strengths	**Weakness**
Decentralised; Strengthens self-reliance , Environmentally sound; Locally available fuel, ability to meet the fossil fuel applications/replacement	Replicability not yet proven at distributed power generation scale; Present costs may **(claimed)** be too high; Potential not adequate to replace fossil fuelled energy conversion; Fuel dispersed; Standardization of technology package with services, etc; Low visibility
Opportunities	**Threats**
Costs are declining; Gestation period nearly zero; Power generation costs lower than fossil fuel system; Fossil fuel substitution very high; Potential very high	Power sector reforms may under emphasize biomass based systems; Inefficient and environmentally hazardous technology implementation,

Some inputs

- What are major drivers in biomass utilization and valorization in the international context?
  - Focus on country's priority sector .
  - Oil imports are growing
  - Waste is an issue
- What underlying policies and roadmaps can lead to more sustainable use of biomass?
  - Level playing field for Biomass based energy solutions
  - Policy and other related aspects
  - In corporate both fundamental R and D and also implementation programs
- What is the industry's role, and what can public-private partnerships bring to the table?
  - Sector wise roadmap for industry to participate and explore
  - Needs short terms support along with necessary policy changes
- What are major topics for collaboration, in particular with India-one of the largest growing economies in the world?
  - Ensure the program is part of the National programs
  - Energy is very important
  - Best practices for sustainable growth

The work carried out on the biomass gasification technology has received significant funding from the MNRE.

……Thank you

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