R & D on RE for sustainable development – an ISPRE action

- On ISPRE
- Perceived demands on RE
- Clean heat for cooking
- Electricity for homes and industry
- Liquid biofuels for transport
- New options
- Way forward

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ISPRE ICSU REN21 Renewable Energy Policy Network for the 21st Century CAETS

The Mission of ISPRE

- Identifying gaps in existing efforts and recommending future R&D priorities and strategies

- Providing strategic guidance for renewable energy R&D efforts worldwide

- Improving the effectiveness and coherence of national, regional and global R&D efforts

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What ISPRE will not do

- Energy policy development
- Policy-prescriptive or policy-driven work
- Organization or carrying out of education and training

Technological R&D Focal Points of ISPRE,

Examples:

- Biomass energy and bio-fuels
- Photovoltaics
- Solar thermal power plants
- Wind energy systems
- Small hydro energy systems
- Solar heating, cooling
- and dehumidification……

Interdisciplinary R&D Focal Points of ISPRE

Source: UFOP e.V.

- Energy policy and economics research
- Environmental impacts and “sustainable potentials”
- Resource assessment and mapping, energy meteorology
- Public acceptance of energy technologies and policies
- Energy systems (energy storage, grid integration, …)

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Sponsors and Partners of ISPRE

- International Council for Science (ICSU)

- REN21 - Renewable Energy Policy Network for the 21st Century

- International Council of Academies of Engineering and Technological Sciences, CAETS

A memorandum/letter of understanding was signed with the sponsors; members of ISPRE were appointed by the partners

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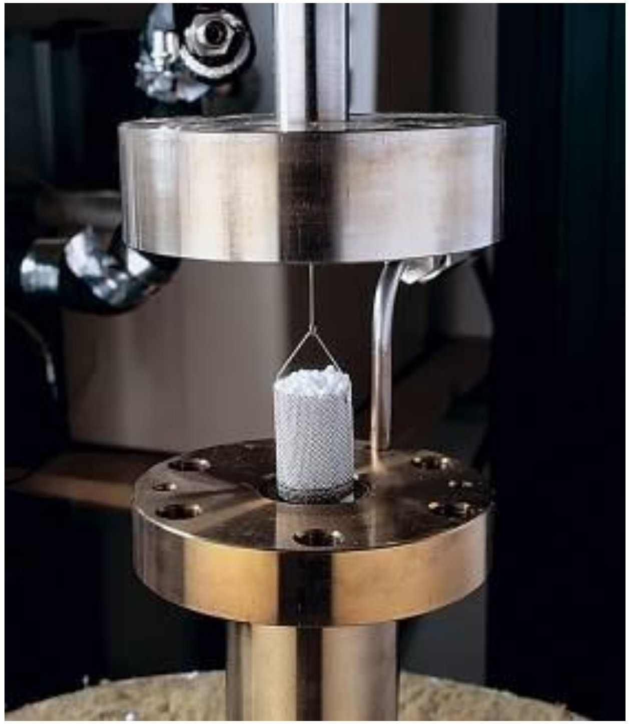
Organisational Structure of ISPRE



ISPRE Panel

Organizational support:

- ICSU
- Fraunhofer ISE

ISPRE web page www.ispre.org

ISPRE activities 2007/2008:

- An analysis of renewable energies R&D strategies
- Consolidate (harmonize) and spread information on R&D strategies world wide
- Identify critical gaps in R&D
- Approach R&D organizations and funding institutions to foster activities in the field of renewables
- Advocate for R&D on renewables world wide

Perceived demands on RE

1. Energy for cooking
2. Electricity for illumination, fans and refrigerator
3. Electricity for Productive industries
4. Fuel For Transportation (Liquid Fuels)

Perceived demands on RE

These aspects identified by ISPRE in discussions as early as mid-2005 are consistent with the important conclusions of the report of Inter-Academy Council. To quote:

"***Conclusion 1:*** *Meeting the basic energy needs of the poorest of the people on the planet is a moral and social imperative that must be pursued in concert with sustainable objectives.*

Conclusion 2: *Concerted efforts must be made to improve the energy efficiency and reduce the carbon intensity of the world economy.*

Conclusion 6: Renewable energy in its many forms offers immense opportunities for technological progress and innovation

Conclusion 7: Biofuels hold great promise for simultaneously addressing climate-change and energy security concerns"

What we address now are the S & T tools on some of these aspects.

Energy for cooking

- Societies in developing/emerging communities need to have more than one fuel (some times three options) to ensuring security of energy for cooking
- LPG, Kerosene, biomass/charcoal are the order of priority of options. [Features: Clean operation (includes combustion), power control, Quick start-up and shut-down]
- Most rural communities (2.5 billion people) depend on biomass/charcoal

The Size and nature of the problem

- About 500 million families cook on biomass using 5000 Million Tonnes of biomass/year (IEA World Energy outlook,'06) => 10 tonnes/family/year (may be, about 8 tonnes of dry biomass/family/year)

- This translates to 1.5 to 2.0 tonnes per person per year.

- Cooking in several countries (Indo-Chinese culture) depends on wood-charcoal produced at 16 to 20 % of wood. The amount of charcoal used by a family for cooking is about the same as wood by other families. Just changing the cooking fuel can help conserve fuel.

- The cooking is done with "such" devices in "such" kitchens that there are an estimated million deaths due to poor indoor air pollution issues

- Can we not make cooking from solid biofuels as good as in LPG?

Biomass Cooking devices

- Biomass stoves are widely explored. There is even a website on this subject. Informative and interesting.
- Stove designs are enthusiasts' field area.
  Very little relevant science is used in designs.
  Simple specifications like power level, burn time, vessel size effects are usually outside the domain of exploration.
- Even the scientists involved seem to get immersed in the variety with little attention to science of the designs
- What is that scientific understanding and current technology can do……..

Science of stoves with an eye on high performance

- In 1985 – 87, research was conducted at Indian Institute of Science on stoves
- Kerosene and LPG stoves recorded utilization efficiencies of 65 % and 70 % and wood stoves from elsewhere showed efficiencies of less than 30 % (water boiling tests).
- Question was asked: What is it that limits the utilization efficiency in wood stoves
- Experimental, modeling and computational studies showed that better efficiency could be obtained with:
  - Higher peak temperature in the flame and larger vessel with a flat bottom

Science of stoves with an eye on high performance

- Kerosene and LPG stoves have steady flame temperatures of 1400 – 1500 °C and this is because of their cal value and a near-constant air-to-fuel ratio
- Wood burning stoves with air inflow by free convection have flame temperatures fluctuating between 800 and 1000 °C
- Experiments on wood stoves with forced convection (air supplied by a fan into the combustion zone showed temperatures of 1000 °C and water boiling efficiencies of 40 %.
- Inducing a gasification process (converting solid fuel to gas locally) with air supply from a fan and subsequent combustion of the gases led to steady flame temperatures up to 1200 °C and efficiencies of 40 to 55 %

Science of stoves with an eye on high performance

- Solid bio-fuels for stoves are non-standard. This is often extolled as a virtue – they are considered affordable as they are picked by the poor by travelling distances – the general principle being “finders – keepers”

- All other fuels are processed to specs, sold commercially and they perform to specs.

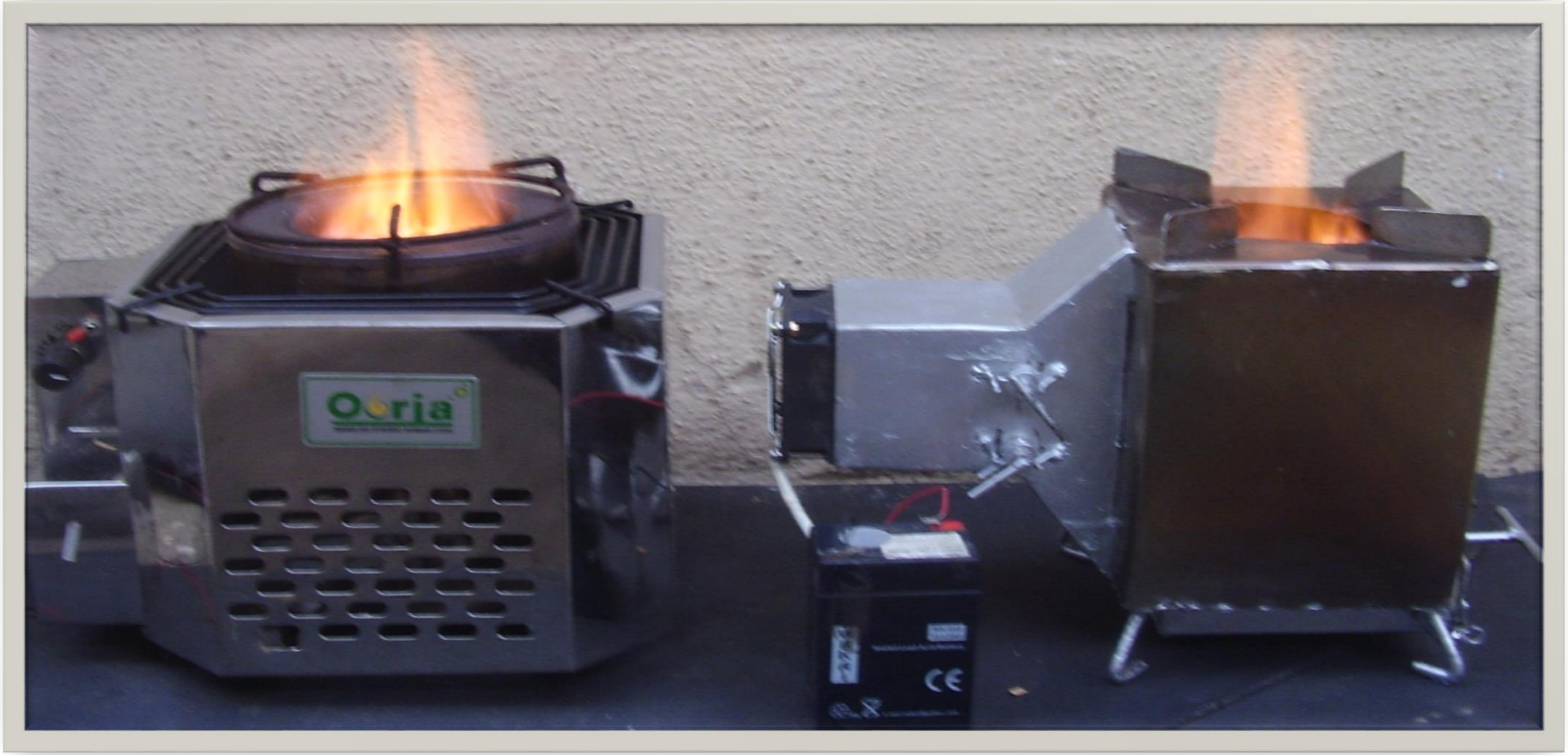
- Would it be scientifically appropriate to expect a wood stove to accept wood fuel what ever size, shape and moisture fraction and perform with high eff. and low emissions?

- The answer is a clear NO. Unfortunately, All the stove programs of the world (other than the one addressed at IISc recently) disregard the issues.

- Hence – No stove commercialization effort will work unless the fuel is standardized and supplied commercially (perhaps with a subsidy to the “poor”)

Science of stoves with an eye on high performance

- Stoves were built and tested with prepared pellets from agro-residues all to a size of 10-11 mm dia, 15 mm long, ash content ~ 6 – 10 % and moisture content of 5 to 7 %. The average density of these pellets is 900 to 1100 kg/m^3 .
- The higher density allows packing the required amount of fuel in a smaller space.
- These stoves used fans obtained largely for computer industry (so, inexpensive)
- These provide a ceramic walled combustion chamber.
- Water boiling efficiencies of 40 to 55 % for vessels of practical range (200 – 320 mm)
- Cooking for a family gets completed with 600 g in one hour – 1.2 kg/day.
- Tech transferred to BP (India) who have commercialized it.
- Over 100,000 stoves have been sold to rural households in over 2000 villages in 4 states of India. The expectation is that a million will be sold before 2009 – a clear landmark when it happens, as I see.



Design 1 (Valveless); Modified Design 2: Two valve type with ash removal tray at the Bottom

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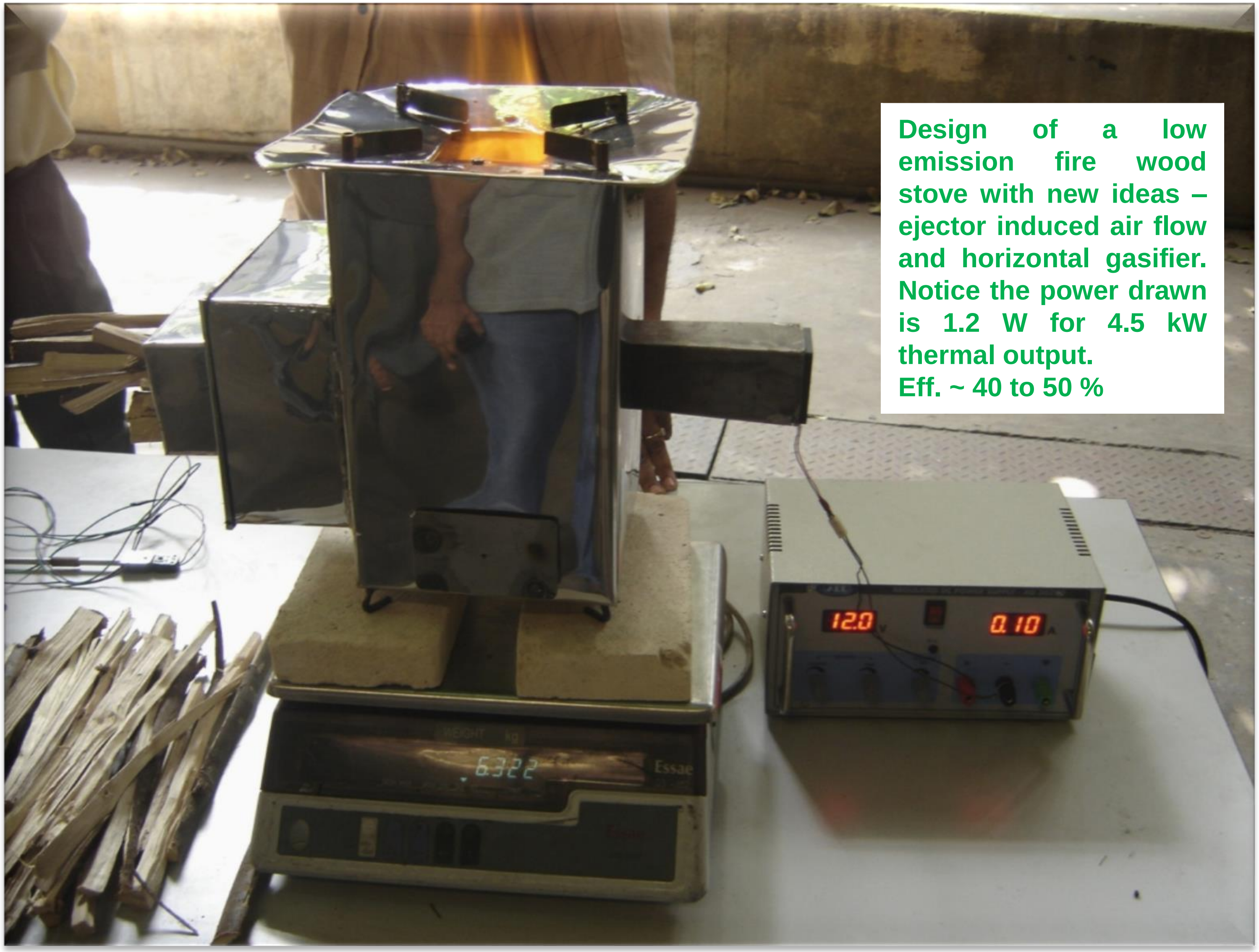
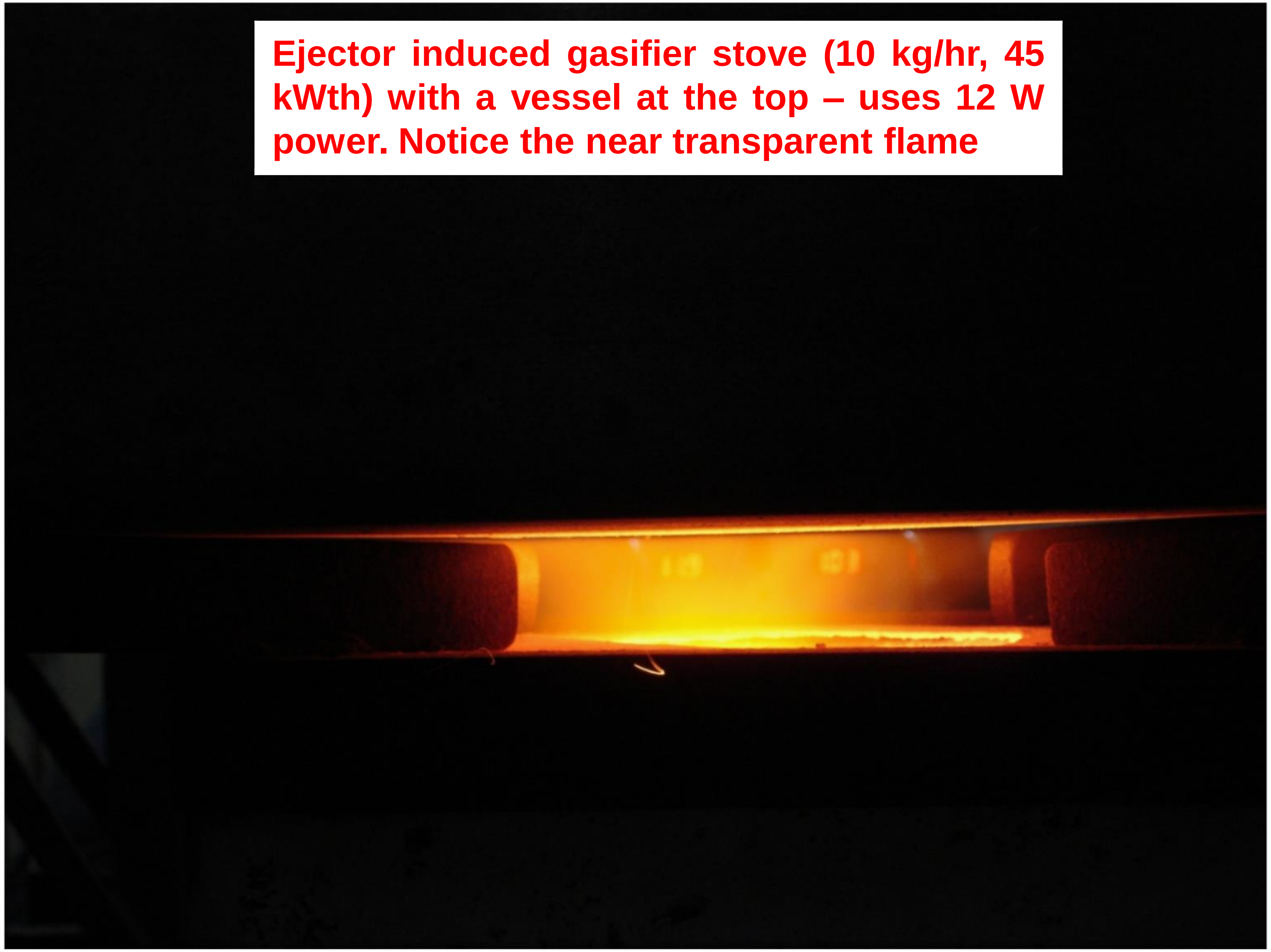


Design of a low emission fire wood stove with new ideas – ejector induced air flow and horizontal gasifier. Notice the power drawn is 1.2 W for 4.5 kW thermal output.
Eff. ~ 40 to 50 %



Ejector induced gasifier stove (10 kg/hr, 45 kWth) with a vessel at the top – uses 12 W power. Notice the near transparent flame

Comparison of stoves for bringing to boil 5 liters of water

Stove	Fuel g	CO g	PM g	CO g/MJ	PM g/MJ
Three stone Fire	**1118**	56	2363	3.13	42.27
Ghana Wood	**996**	50	4287	3.14	68.32
20L Can Rocket	**733**	15	1289	1.28	15.12
Wood Flame Fan	**626**	**9**	48	**0.90**	**0.48**
Wood Gas Fan	**459**	**7**	**27**	**0.95**	**0.20**
Mali Charcoal	**674**	113	260	10.48	2.80
Gyapa Charcoal	**694**	135	587	12.16	6.52
Indian VITA Test 1	**1135**	38	1490	2.09	27.06
T-LUD	**933**	25	694	1.67	10.36
Institutional 310 Rocket	**483**	6	414	0.78	3.20
Lutfiyah's Improved Stove	**823**	16	1231	1.22	16.21
T-LUD	**1296**	18	437	0.87	9.06
BP Stove (IISc)	**380**	**4.5**	**6**	**0.75**	**0.06**
EIGAS – 1 (IISc)	**400**	**7.2**	**9.6**	**1.12**	**0.1**

What does all this mean?

- The current estimated biomass use is 1.5 to 2 tonnes/family/year. This implies 10 to 12 tonnes/family/year in some countries using charcoal as the cooking fuel and perhaps, 1.5 to 2 tonnes/family/year in others.

- The use of advanced stoves that are equivalent of gas stoves reduce the consumption to 1.2 to 1.5 kg/family/day (0.4 to 0.6 tonnes/person/year). Except for barbecuing, one can replace the charcoal by processed biomass to obtain mind-boggling savings – From the current 5000 million tonnes per year (3000 million tonnes dry) to 1000 to 1500 million tonnes per year with good indoor air quality.

- These are possible only with the vision and drive of a large organization. The Emerging Consumer Markets group of BP is committed to driving scale for this in India as well as entering other markets such as Vietnam and China.

Electricity for homes and industry

- There are large number of (over 50,000) villages without electricity in India.

- Similar is the situation in other regions of the Asia-Pacific region. In particular, the large number of hamlets and villages in the inhabited islands of the archipelago in the Asia-pacific region get their electricity supply for the quality of life and some minimal productive activities from diesel-generator sets. This electricity is very expensive (~25 US cents/kWh)

- Distributed electricity generation or small IPPs are the answer, a subject encouragingly discussed in many parts of the world.

- The minimum-most need (~150 W/family for a few hours a day) can be met with by SPV or wind along with battery storage.

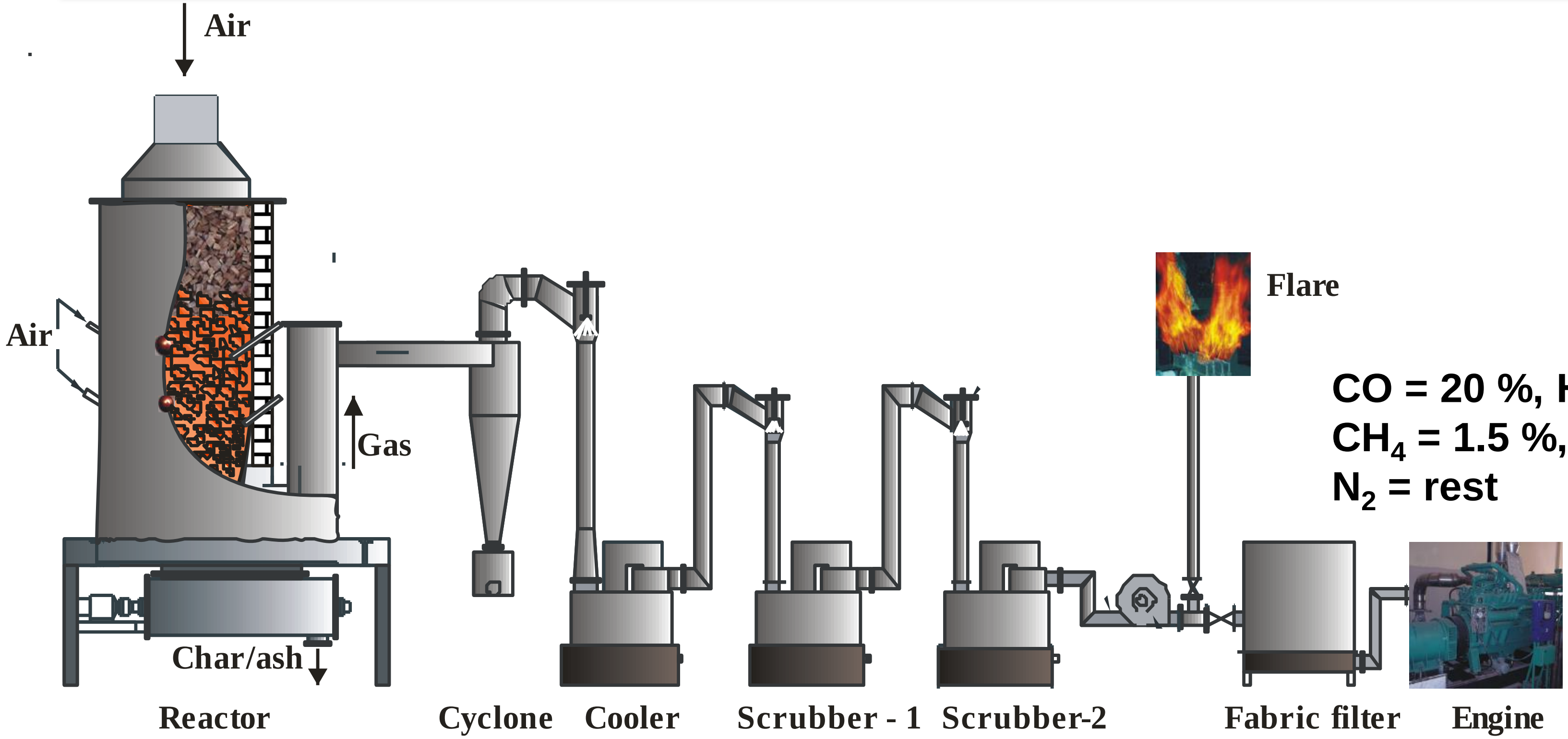
Electricity for homes and industry

- When the demand goes beyond just of quality-of-life electricity including those For production processes and when islands have biomass, they can use biomass based electricity from gasifier-reciprocating engine route from 10 to 1000 kWe.

- These turn out to be just about as expensive as centralized power generation of fossil fuels. Installation costs of 1200 to 1600 USD per kWe, biomass use of 1 –1.4 kg/kWh and energy generation costs of 6 to 10 cents/kWh (from large to small power levels)

- Power packages of biomass-electricity using gas engines in the range 10 to 1000 kWe have been built, tested at various power levels in different environments and are marketed in India. They can service village electrification and mini-grid linked systems

Fuel-flex open top downdraft re-burn gasifier (IISc design) for electricity on 24 x 7 operation



CO = 20 %, H_2 = 18 %
CH_4 = 1.5 %, CO_2 = 12 %
N_2 = rest (dry gas)

- Ceramic reactor to withstand high temp oxidizing and reducing environment; bottom screw system meant for ash extraction (hi ash biomass)
- Generation of activated carbon with surface area of 450 to 550 m^2/g in the bottom section (600 to 800 C)
- Cooling and cleaning train to get dry gas at (P + T) < 5 ppm

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Varieties of plantation and agro-residues that can be used in the gasifier

Sized wood pieces 20 to 100 mm size and briquettes from light residues

The gasification system

100 kWe system

12 hours a day

Load ~ 60 to 90 kWe

Biomass ~ 1.2 – 1.4 kg/kWh

Investment ~ 105,000 USD

Generation cost ~ 8.5 US cents/kWh

The building housing the system

The power delivery panel

System testing, Operational experience and manufacturing

- Three systems,100, 300 and 1000 kWe have been rigorously tested in the laboratory at IISc, in field in India and in Switzerland with third party laboratories for analysis, all aimed at eliminating the “secrecy” approach used by most developers of gasifiers in Europe and the USA.
- These results are published in refereed journals and presented and discussed in several conferences in Europe, Canada and Latin America.
- Persuading and collaborating with a leading engine manufacturer – Cummins (India), a number of their engines have been rigorously tested.
- Based on these successful tests, they have agreed to supply engines with guarantee and warranty for power generation with IISc gasifiers.
- There are 8 licensees in India and one each in Japan, Switzerland and Brazil

Results and publications: website - http://cgpl.iisc.ernet.in

Systems built, Operational experience and manufacturing

- 40 electrical and 20 thermal systems have been built by the licensees over the last seven years amounting to a total of 10 MWe and 20 MWth. Systems have been built for Brazil, Thailand, Japan and Zambia.

- Total operational experience is over 30,000 hours (each) of several systems including the large ones (1 tonne/hr and 1 MWe systems closely monitored) and over 250,000 hours on all the systems – electrical and thermal.

- Plant availability is up to 90 %, better values achieved by better discipline in assuring biomass quality and O & M practices.

- About 6 million USD of private investment has gone into commercial systems. More projects are in the offing.

***Way forward*: "Strong" licensees for greater outreach are awaited.**

Liquid bio-fuels for transport

- Ethanol and blends for spark ignition engines, .
  Biodiesel from Jatropha, Pongemia, rapeseed, corn, soybean and blends
  .
  are all well known and pursued in Brazil, Germany, USA and other countries.

- Oil importing developing countries (like India) need to recognize these as essential for economic survival and act seriously. Sub-minimal efforts, but well meaning statements are made.

- In this area, it is more important to act than look at research since much that is known remains to be practiced for economic well being.

- There are developments on 2nd generation liquid fuels obtained from gasification via FT synthesis that will perhaps be pursued by some countries with substantive research funding (EU, USA, Brazil, India).

New options

- Stirling engine for distributed power is an interesting and useful concept (at power levels of 10 to 50 kWe).
- Much research and development continues to be done for military and space applications.
- It appears that production in large quantities (preliminary investigation showed this to be less than a thousand) may bring down the market costs to < 1500 USD per kWe.
- This needs consideration by a Governments, donor agencies and multi-national corporates

New options

- Developments in reciprocating engines has led to large scale production of turbo-superchargers of high CR (~5)
- The turbo-superchargers are therefore not expensive.
- If one replaces the compressor by a high speed alternator, and operates the turbine by superheated steam with condensing steam option, one can expect to get “efficient” power package.
- The high pressure steam raising can be done with efficient modern stove designs.
- Thus, a new relatively simple power pack can be produced for use by disparately located communities for servicing electricity. This will be the modern version of a 10 to 20 kWe power station.
- Again, cooperative arrangements for new research and development are called for.

Way forward

- Science and Technology developments will continue to be dominated by countries with S & T culture and infrastructure (men and material).
- Even if we ignore native R & D competence as essential for ensuring societal access to new and useful technologies for better quality of life, and claim technology transfer as an adequate medium for this purpose, tech transfer can only be effective when the recipient country has a minimum of intellectual strength. S & T culture and other infrastructure.
- If this can be inculcated through ICSU/ISPRE activities at least in those areas where the benefits are directly visible (as in the cases brought out here), then I believe we have made some progress.
- For achieving this, mindsets of agencies and Governments need to be overcome and they should be made partners.

With these thoughts for your consideration,

May I thank you for your attention

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