INSTITUTO SUPERIOR TÉCNICO

IDMEC – IST - RGESD - Research Group on Energy and Sustainable Development

Technologies à bas coût pour améliorer l'accés à l'enérgie dans des zones rurales

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- Objectifs de la présentation
- Energies Renouvelables et les OMD
- Technologies disponibles
- Avantages des principales options

Presentations of Course and scope

- Information et methodologie pour créer une base de connaissances locales.
- Renforcement des capacités locales – generate multipliers.
- *Demystification* de la technologie:

C'est simple et facile – il faut tout simplement faire un *road map* → Plannification et Direction

Les solutions technologies

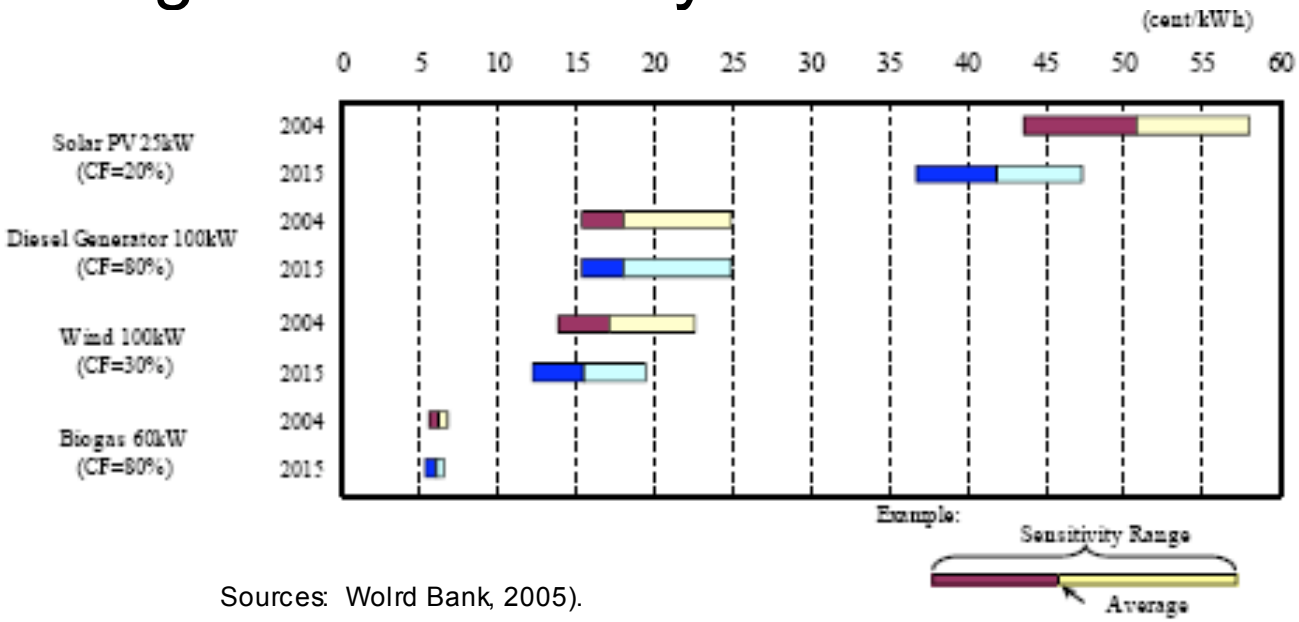
- Il faut bien comprendre les besoins en enérgie
- Enérgie dissociée du devéloppement économique et sociale n'est pas efficace.
- Doivent englober le plus grand nombre d'usages possibles:
  - Cuisson, eclairage, small réseaux, industries, pompage d'eau, activités agricoles, transports, communication, santé, éducation, administration, etc..
- Les solutions existent déjè, experimentées dans plusieures régions, il faut les connaître et les adapter à nos propres → il ne faut pas reinveter la roue.
- Normalement divisées en trois catégories:
  - Genération distribuée;
  - Transmission et distribution de bas coûts; et
  - Èquipements locaux et efficience energetique.

Examples de technologies

- Generation distribuée
  - Turbines hydro mycro
  - Eoliennes (surtout pour le pompage d'eau)
  - Technologies modernes de la Biomasse
    - Biogas
    - Residus Agricoles
- Transmission and distribution bas coùt
  - SWER - Single Wire Earth Return
- Equipements locaux et efficiencience energetique
  - Illumination / éclairage (high-mast flood lighting)

Pourquoi sont elles importantes

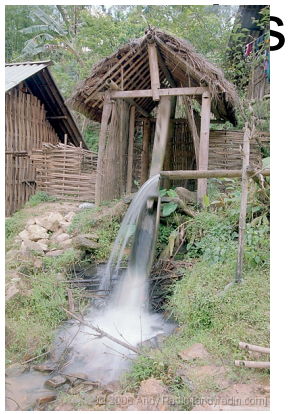
- Potentiel pour des options *bon marché* pour des applications des mini-réseaux.
- Isolés (off-grid) – ER plus économiques que les solutions conventionelles.
- → village- et niveau-foyer → 5 kW ~ 500 kW.



Sources: Wolrd Bank, 2005).

Système d'Energies Renouvelables

- Energie: conversion des sources disponibles en quelque chose d'utile
  - Solaire pour Chaleur /Fro
  - Vent pour pomper l'eau
  - Courant d'eau pour puissance méchanique
  - Energie chimique de la Biomasse pour chaleur et sance



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Distributed Generation

Micro and Pico Hydro
Wind Mill
Biomass

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Generation distribuée

Isolé/Off-grid → Mini-réseau independent → connexion au réseau national

- Dépend de:
  - nombre de foyers à être sérvis,
  - consommation domestique,
  - Intensité de la charge, charge productive,
  - projection de la demande future,
  - courbe de charge,
  - disponibilité des ressources (renenouble ou pas),
  - coûts des combustibles,
  - distance du réseau le plus proche, et
  - planification politique
- Dans la plupart des régions et villages des zones isolées, ce sont les options les plus écnomoiques.

Micro and Pico Hydro

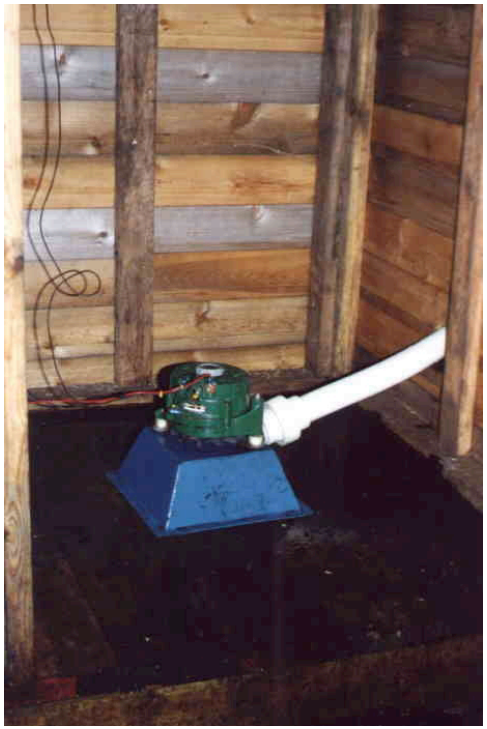
- Options for Mini Hydro
- Options for Pico Hydro
- Point is what to do with the energy generated:
  - Small business
  - Improve quality of life
  - Combat isolation

On what price ?

→ **must be affordable**

Options for Pico Hydro

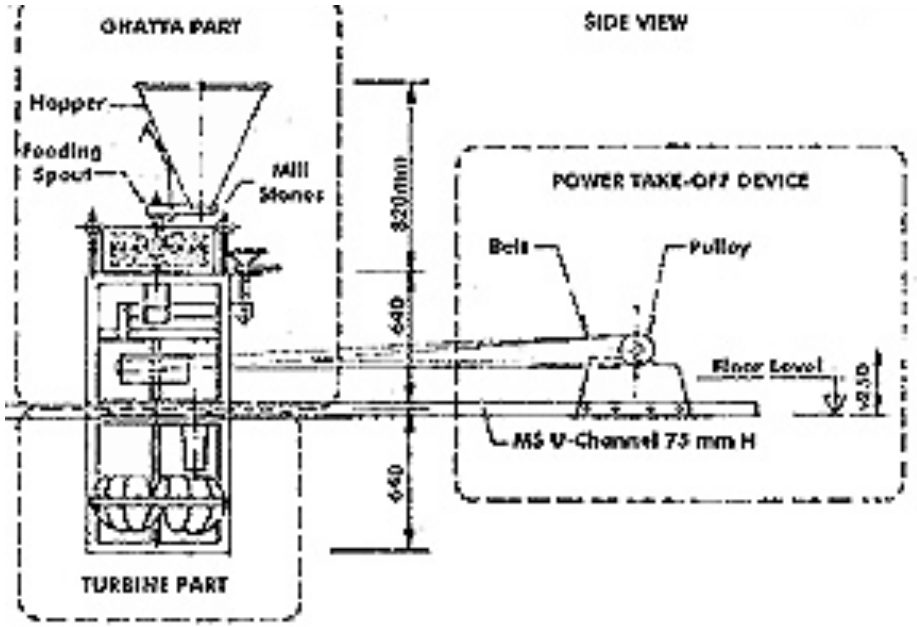
- Pico-hydro covers a range of turbine technologies, applicable to different heads:
- Nepal - tiny pelton wheels ('Peltric' sets) for 220 V from induction generator on 40-300m head – only a hose-pipe penstock.

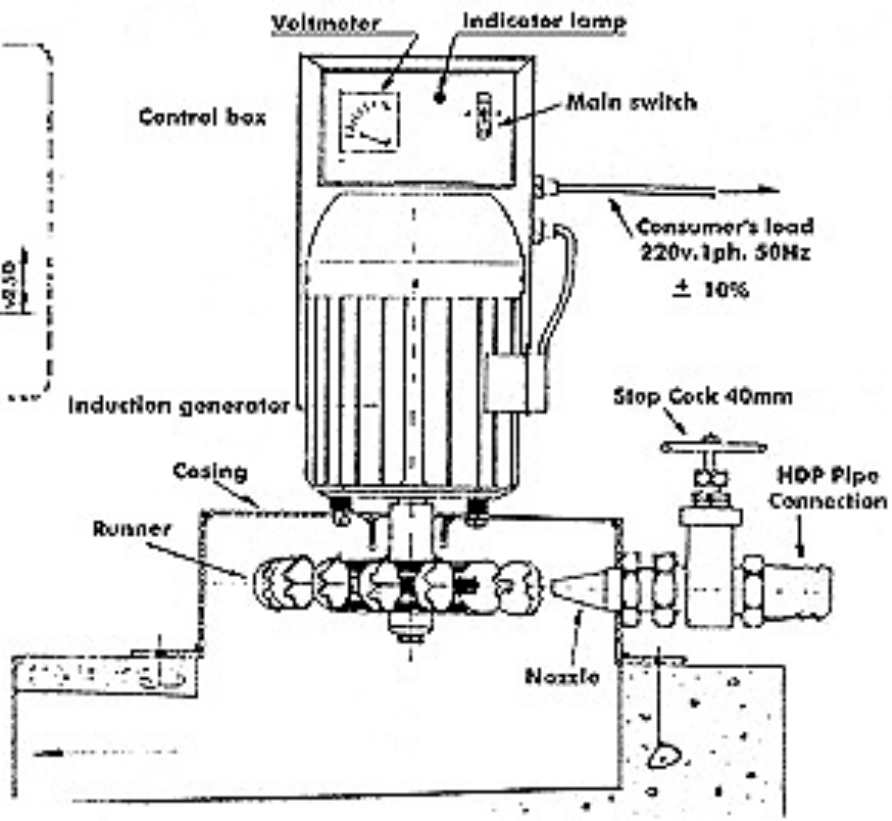


Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

Options for Pico Hydro

- Peltric sets





http://www.bagelhole.org/?page=254

PH Overview

- USA, Canada and Australia - companies offer turgo turbines for medium and high head sites. China and Vietnam developed tiny turgo turbines for 5-12m head.

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

PH Overview

- Philippines - tiny crossflow turbines ('Fireflies') for 12 V battery charging on 5-20m head (also in Colombia).

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

PH Overview

- China and Vietnam - low-head propeller turbines, suitable for only 1-2m head

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

PH Overview

- Low-head sites (<5m) are most widespread, on irrigation canals and streams (both in hilly and plain areas)

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

PH Overview

- Low head type of propeller pico-hydro

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

Low head (LH) PH

- Intake flume
  - screen at entrance to inlet flume can be metal mesh or bamboo (30-40mm spacing)
  - water control at intake flume can be wood slat
  - vortex should not be sucking air
  - water should not overspill flume and no turbulence

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

Low head (LH) PH

- Draft tube
  - head is generated and vortex is encouraged by draft tube
  - preferably fabricated of tin plate, thickness that can be welded
  - possible to mould in concrete at site, or made from glassfibre

Source: http://wsln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

Low head (LH) PH

- Turbine - mechanical
  - 4 bladed propeller runner (1500 rpm @ runaway) bolted to 20mm shaft
  - 12 Guide vanes with 200mm diam casing
  - Lower bearing is teflon and lubricated by water
  - 700mm long shafting
  - 16 kg

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

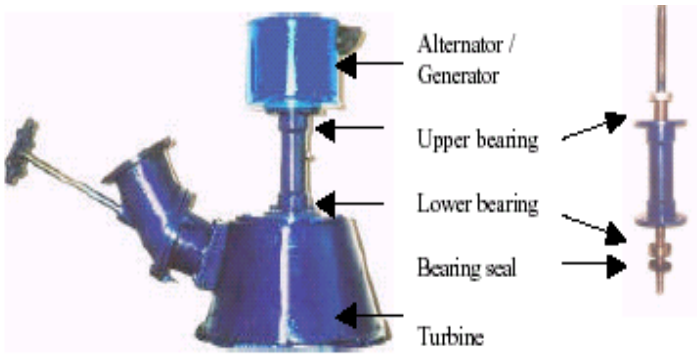
Low head (LH) PH

- Site choices are:
  - 1) side channel
  - 2) dam
  - 3) waterfall

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

High head (HH) PH

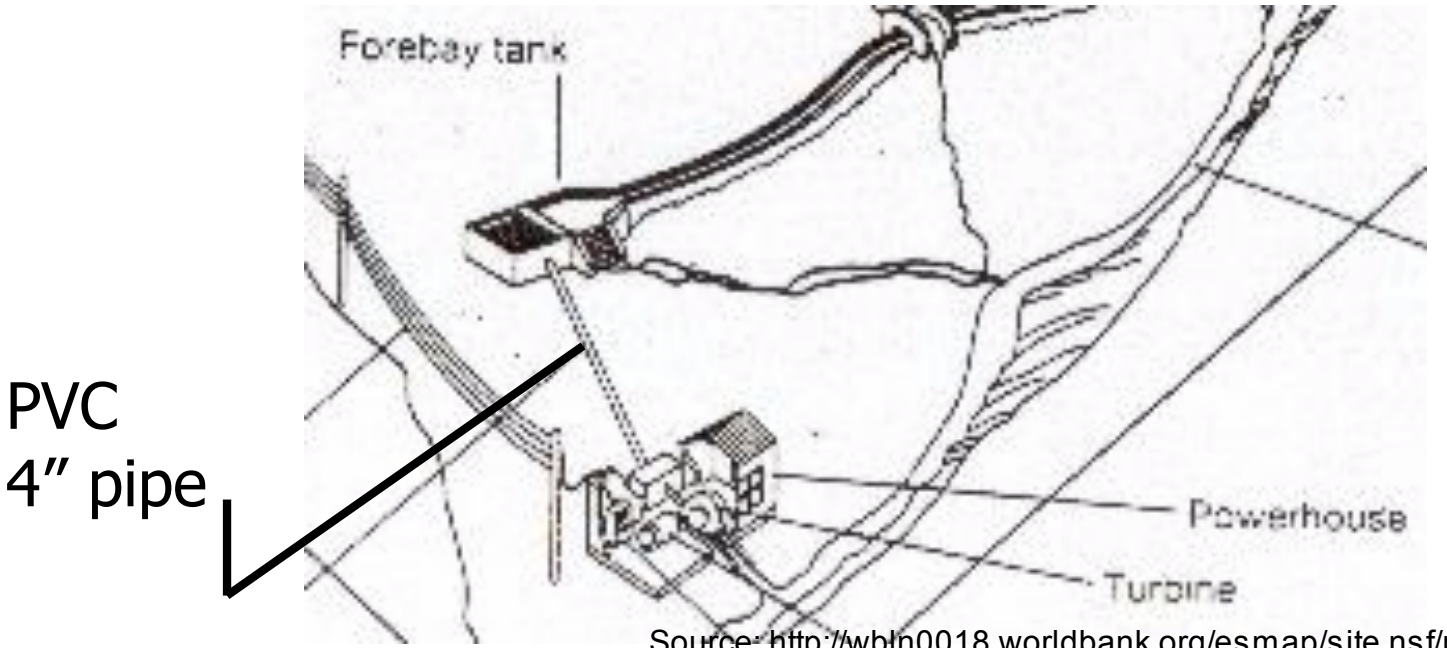
- Turbine - mechanical
  - 20 bucket 'turgo' runner (210mm diam) (1400 rpm @ runaway) bolted to 20mm shaft
  - 1 spear valve nozzle with jet diameter of 28.5mm
  - Lower bearing and seal replaced every 2 years.
  - 21 kg



Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

High head (HH) PH

- Penstock
  - recommended penstock is PVC 4 “ pipe
  - penstock should follow the shortest route and be as straight as possible



Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

High head (HH) PH

- Civil works
  - site choices are 1) waterfall, 2) side channel with drop, to achieve the head of 5-6 metres
  - installation in waterfall is easy and quick to install but prone to flood damage
  - side channel is longer lasting and water is controllable

Source: http://wbln0018.worldbank.org/esmap/site.nsf/pages/BBL_Hydro

Wind Mill

- Been done for centuries
- Can provide a valuable opportunity for meeting water/energy needs in rural areas

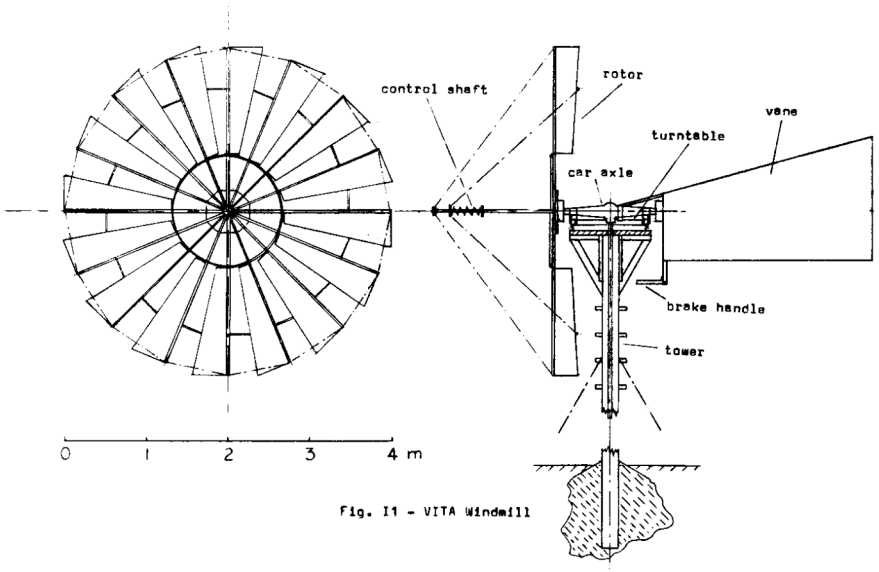
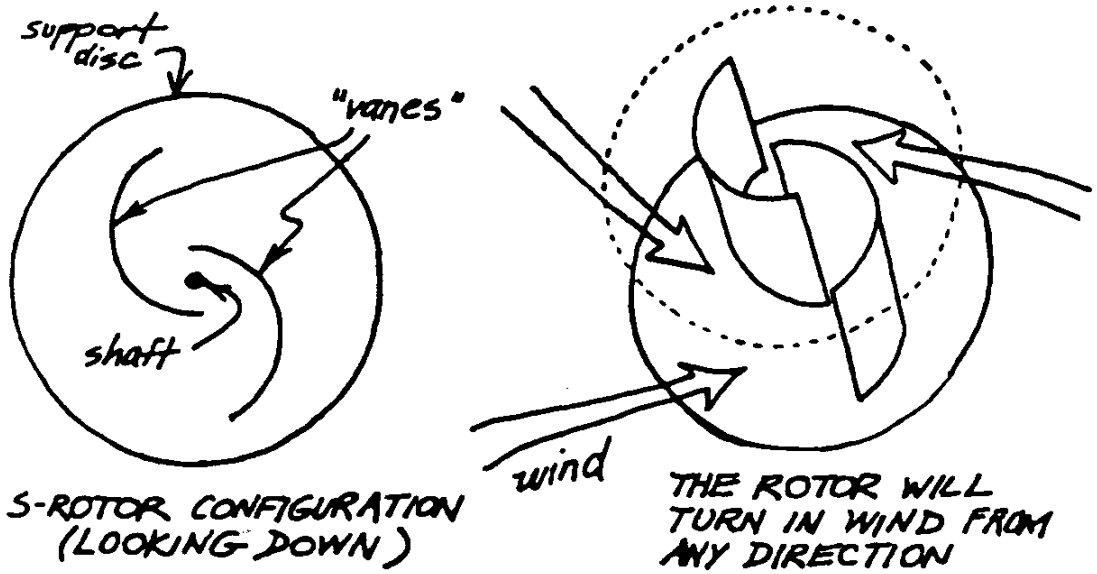


Fig. I1 - VITA Windmill

http://www.cder.dz/galerie/eolien/pages/site03.htm

Wind Mill – Vertical - Savonius

- Multi direction
- Can be made with local resources
- Local development industry



http://sleekfreak.ath.cx:81/3wdev/VITAHTML/SUBLEV/FR1/SAVROTOR.HTM

http://www.southcom.com.au/~windmill/

Wind Mill – Vertical - Savonius

- Can be made basically with fuel drums and one differential from an old car

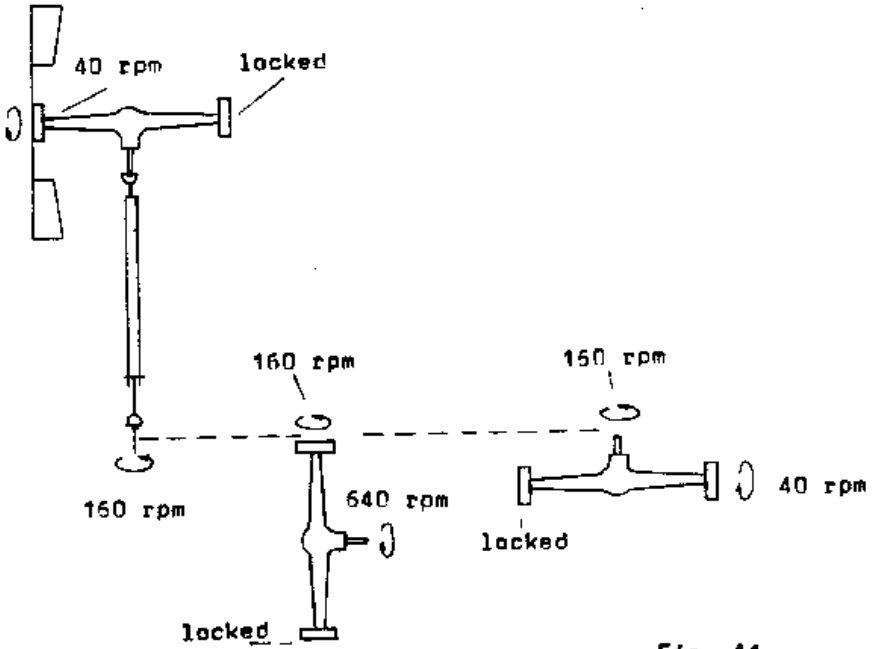
http://www.southcom.com.au/~windmill/sail.html

Wind Mill – Vertical - Savonius

- Vertical axis machine designs can only put out about 30% of the power output that a comparable horizontal axis machine
- Minimum Wind speed – 3 to 6 m/s
- Savonious - 15% efficiency X 30 ~ 50% for horizontal
- Vertical rpm is significantly lower than Horizontal ones
- maximum ratio of height : diameter:
  - Single bearing machine (1 roller bearing) = 4:1
  - Double bearing machines (top & bottom + frame) = 6:1
- Up to 10 meters from any building

Wind Mill - Horizontal

- Design can be simple, and would need the erection of the tower → Can be “home made”
- Can use from Car engines / washing machines / etc
- More expensive – but bigger power output



http://sleekfreak.ath.cx:81/3wdev/VITAHTML/SUBLEVIPOT/WINDMILL.HTM

Use of washing machine gear

http://www.southcom.com.au/~windmill/14ft_alston.htm

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Modern Biomass Technologies

Biomass
Bio Gas
Briquetting Agricultural Residues
Jatropha Oil

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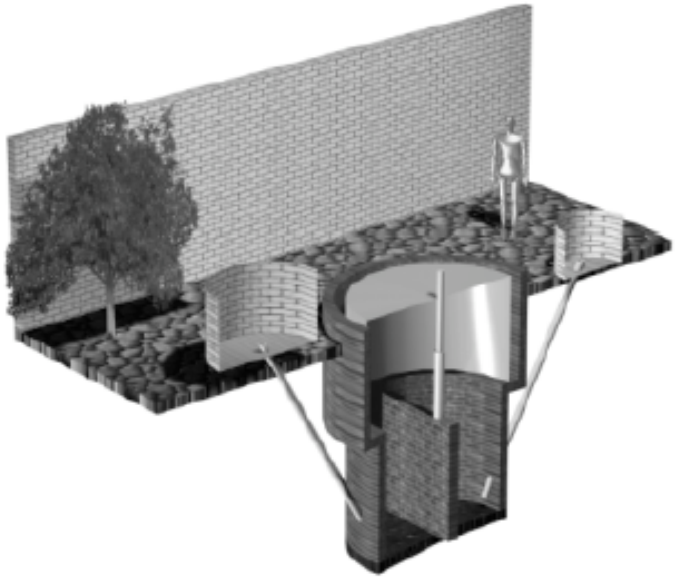
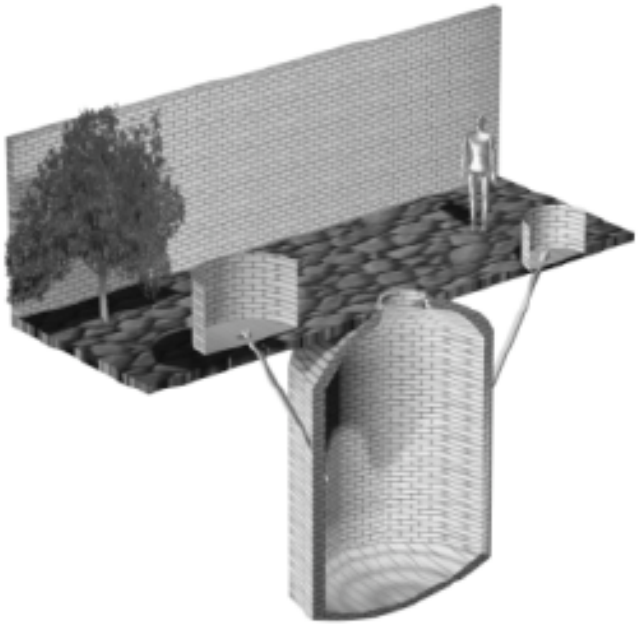
Modern Biomass Technologies

- What is modern – By incorporating new technology
- New Materials
- More extensive knowledge and expertise
- Would depend on:
  - type of raw material
  - Space available
  - Capital available
  - Knowledge

Small Biogas System – Indian x Chinese

- Main two types in the globe
- Old design, well know features, brick made,





- Once installed – no move, no upgrade
- If you don't own the land you would never install

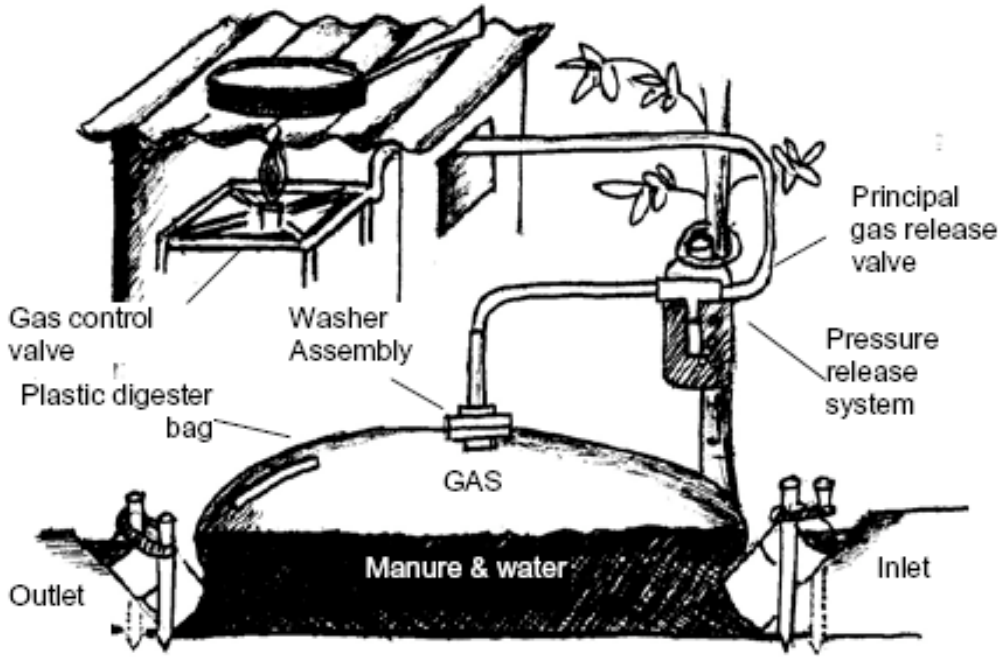
Bio Gas

- What for → heating or electricity production
- Using human and/or animal dung
- Combined with natural soil enhancement material
- Problems:
  - Collect the material
  - Maintenance
  - Initial costs

Bio Gas – New Trend - Polyethylene

Use on new materials → polyethylene biodigester

- Lower useful life but you can take it with you, can sell if necessary– become an asset



Costs:

Total - 30 $US/m^3

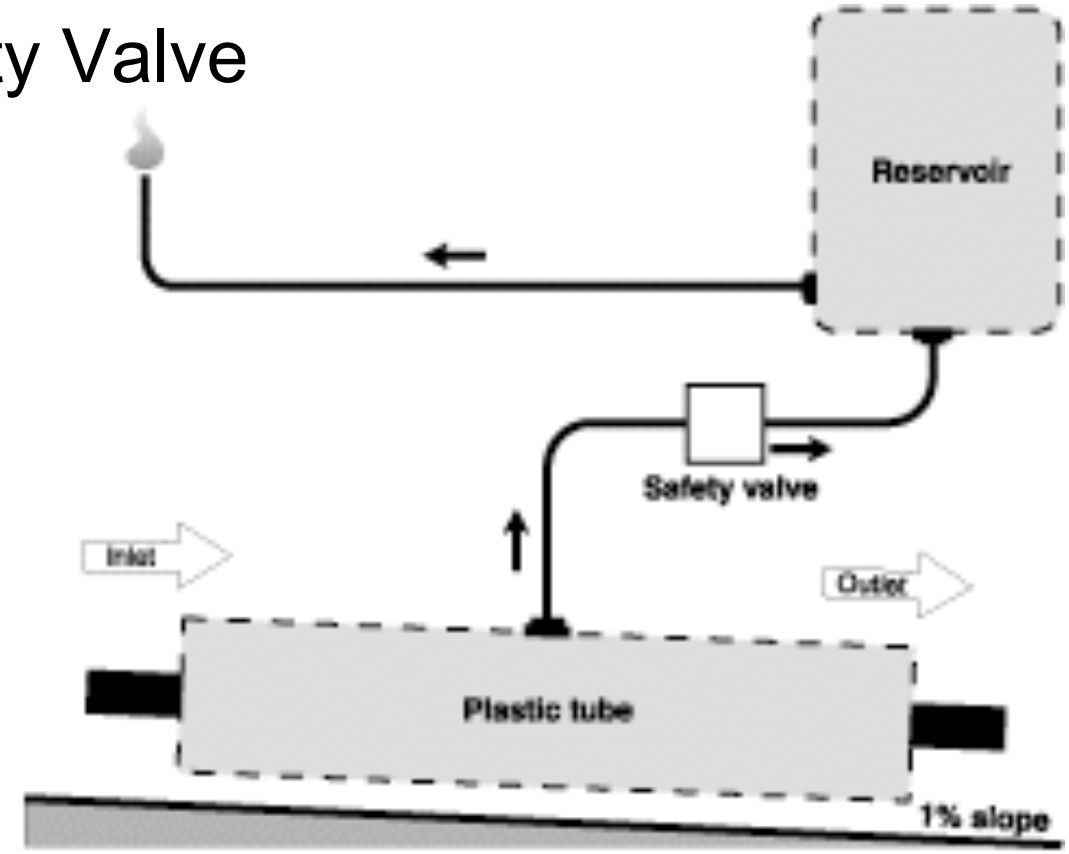
Only Material 7 $US/m^3

Bio Gas

- Advantages to low-income rural communities, including:
  - Reduction of the physical workload, especially of women;
  - Reduction of the pressure on natural resources → fuel wood and charcoal;
  - cheap energy production → cash savings;
- Improve the farming system by recycling manure to produce gas for cooking & fertilizer
- Use waste which would cause pollution (especially in urban areas)

Bio Gas – Main Elements

- Biodigester
  - Inlet / Outlet
- Safety Valve
- Gas storage reservoir
- Burner

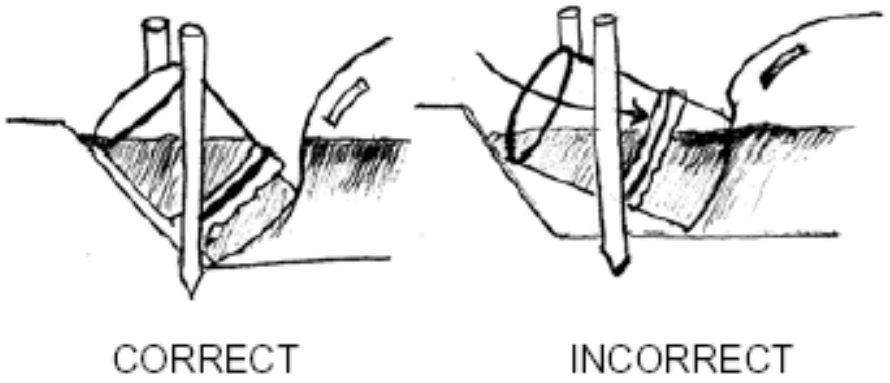


Bio Gas - Biodigester

- Polyethylene plastic Tube
- Diameter 80, 125 and 200 cm
- Can be accommodated in a trench or floating in a pod
- Normally from 5 to 10 meters (one family up to 10 pigs raising)

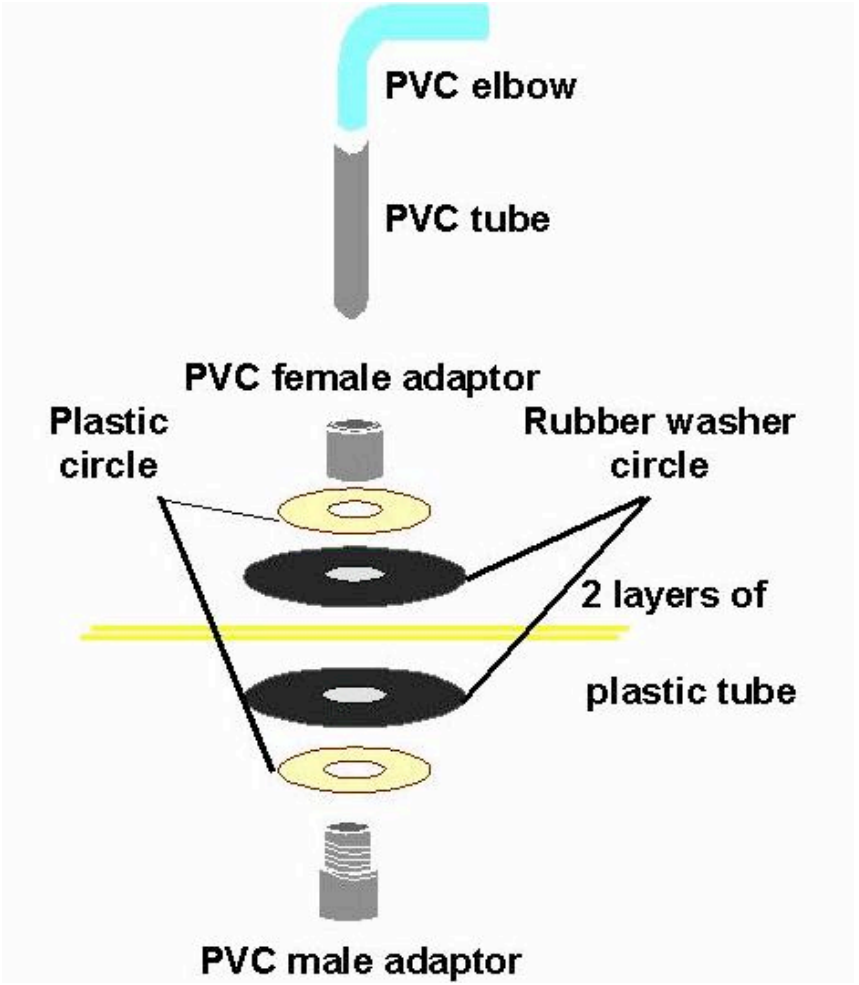
Bio Gas – Biodigester – Inlet / Outlet

- Must be in the correct angle
- In level with the ground
- Fixed so don't damage the bag wile load / unload



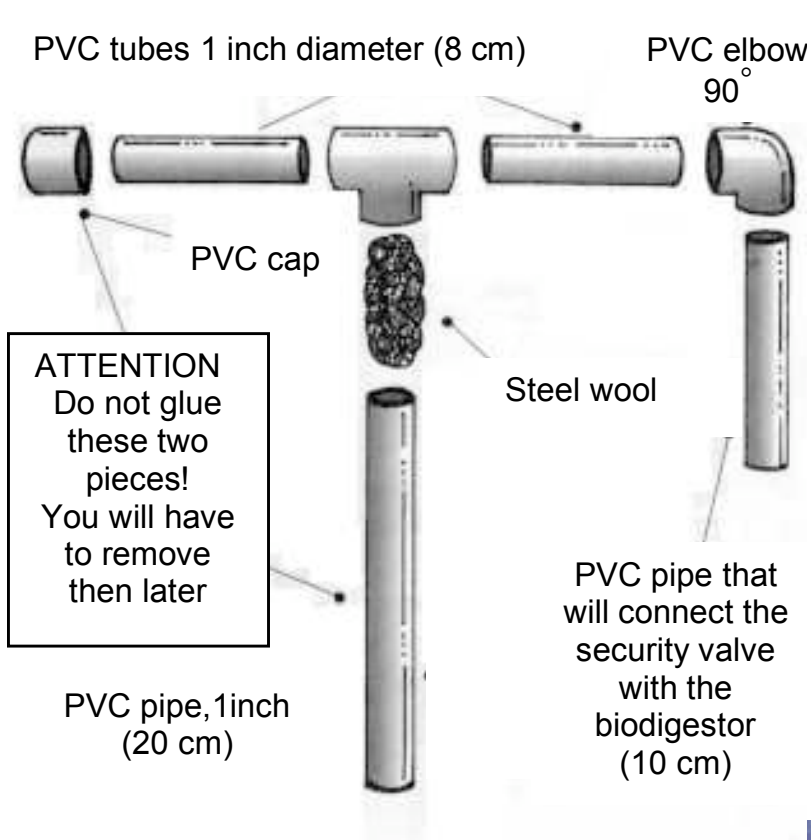
Bio Gas – Biodigester – Inlet / Outlet

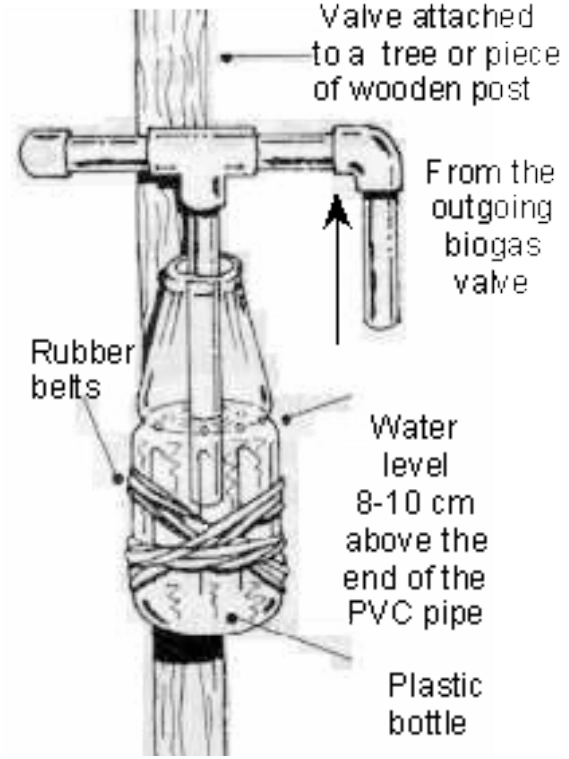
- Gas Outlet



Bio Gas – Safety Valve

- Made with PVC and Plastic bottle
- Steel Wool will remove the Sulphur smell





Bio Gas – Gas Reservoir / burner

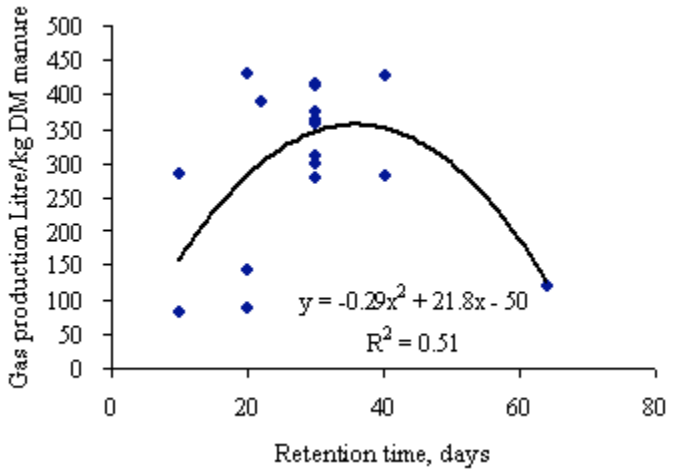
- From single Iron tube to gas burner

burner made from a beer can
un brûleur réalisé au moyen d'une cannette métallique

Bio Gas Design

- Volume 0.4 m3 per living being
- Practical use, distance between 3 up to 10 m, 0,8m diameter
- biogas technology is

  99 % management and 1 % technology
- Biodigester is a 'living' technology - needs daily fed and needs manure and water
- Need farmer - extension - scientist relation



http://pigtrop.cirad.fr/en/scientific/environnement_LRRD1105_1.htm

Bio Gas reference

- Installation and performance of low-cost polyethylene tube biodigesters on small-scale farms
  - http://www.fao.org/ag/AGAinfo/resources/documents/WAR/war/W5256T/W5256t06.htm#TopOfPage
- Installation de biodigesteurs tubulaires en polyéthyléne à faible coût dans les petites exploitations et résultats obtenus
  - http://www.fao.org/ag/AGAinfo/resources/documents/WAR/war/W5256T/W5256t06.htm#P7_1007
- Instalacion y rendimiento de biodigestores de tubos de polietileno de bajo costo en granjas pequeñas
  - http://www.fao.org/ag/AGAinfo/resources/documents/WAR/war/W5256T/W5256t06.htm#P13_2299
- CRAT BIOGAS Program - PRODUCTION TECHNOLOGY
  - http://crat.africa-web.org/Biogas/technology.htm

Agricultural Residues

- Goal is to transform Residues into assets
- Need to process in order to add value

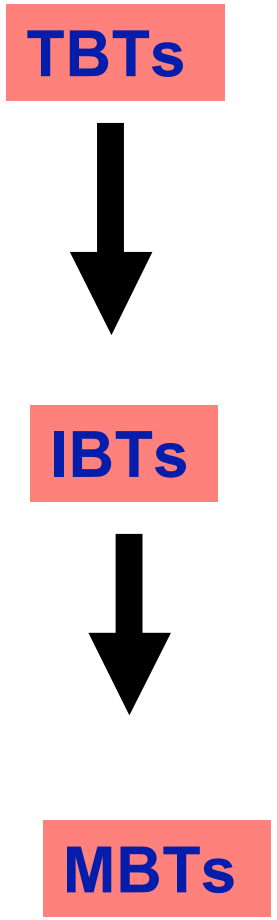
- Main process:
  - Densification
    - Compress → facilitate storage → briqueting
  - Characteristics change
    - Thermo chemical process → Better fuel → Charcoal

Why is Biomass Energy Important?

- Improved & more efficient use beneficial to poor
- Biomass & agriculture
  - Agriculture: key income source for poor
  - Solves problem of collection
- Biomass & health/environment
  - Improved & efficient use reduces indoor air pollution
- Biomass & gender
  - Main collectors & direct users are women/children in Africa
- 4 MDGs of poverty, health, environment gender

Three Categories

- Traditional Biomass Energy Technologies (TBTs)
  - Inefficient use of wood, charcoal, leaves, agricultural residues, animal/human waste & urban waste
- Improved Biomass Energy Technologies (IBTs)
  - Improved and efficient technologies for direct combustion of biomass such as improved cooking/heating stoves and improved biofuel kilns
- Modern Biomass Energy Technologies (MBTs)
  - Conversion of biomass energy to advanced fuels/forms namely liquid fuels, gas and electricity



Traditional Biomass (TBTs)

- Readily available
- Meets energy needs of significant proportion of population – particularly rural poor in Africa
- **Significant drawbacks**
  - Indoor air pollution – major health problem in dev. countries
  - Environmental degradation (charcoal & deforestation)
  - Social burden on women and children
- **Challenges**
  - Better data
  - Ensuring it is obtained from sustainable resources
  - More rapid substitution with improved & modern biomass energy technologies and other energy alternatives

Improved Biomass (IBTs)

- Significant dissemination of improved biomass energy technologies (IBTs) in developing countries but …
- Potential for wider dissemination of IBTs could be increased – almost every country in Africa & Asia has improved cookstove programme
- Successful dissemination of improved biofuel heating stoves in a few industrialised countries - notable example being Austria (500,00)

Include efficient stoves, charcoal kilns and dryers

Those stoves can be found in Uganda, Tanzania, Rwanda, Burundi, Sudan, Ethiopia, Senegal & Ghana

Modern Biomass (MBTs)

- Biofuels for transportation in Brazil
  - Reduced fuel imports ($55/barrel – landlocked African countries)
  - Contributes to reduced lead in vehicles fuels - major health hazard

- Bagasse-based cogeneration in China, India, Thailand & Mauritius (25% of electricity supply)

Modern Biomass (MBTs) - Challenges

- Cost & reliability of modern biomass vs conventional fossil fuel options
- High up-front capital investment
- Skills intensive remember

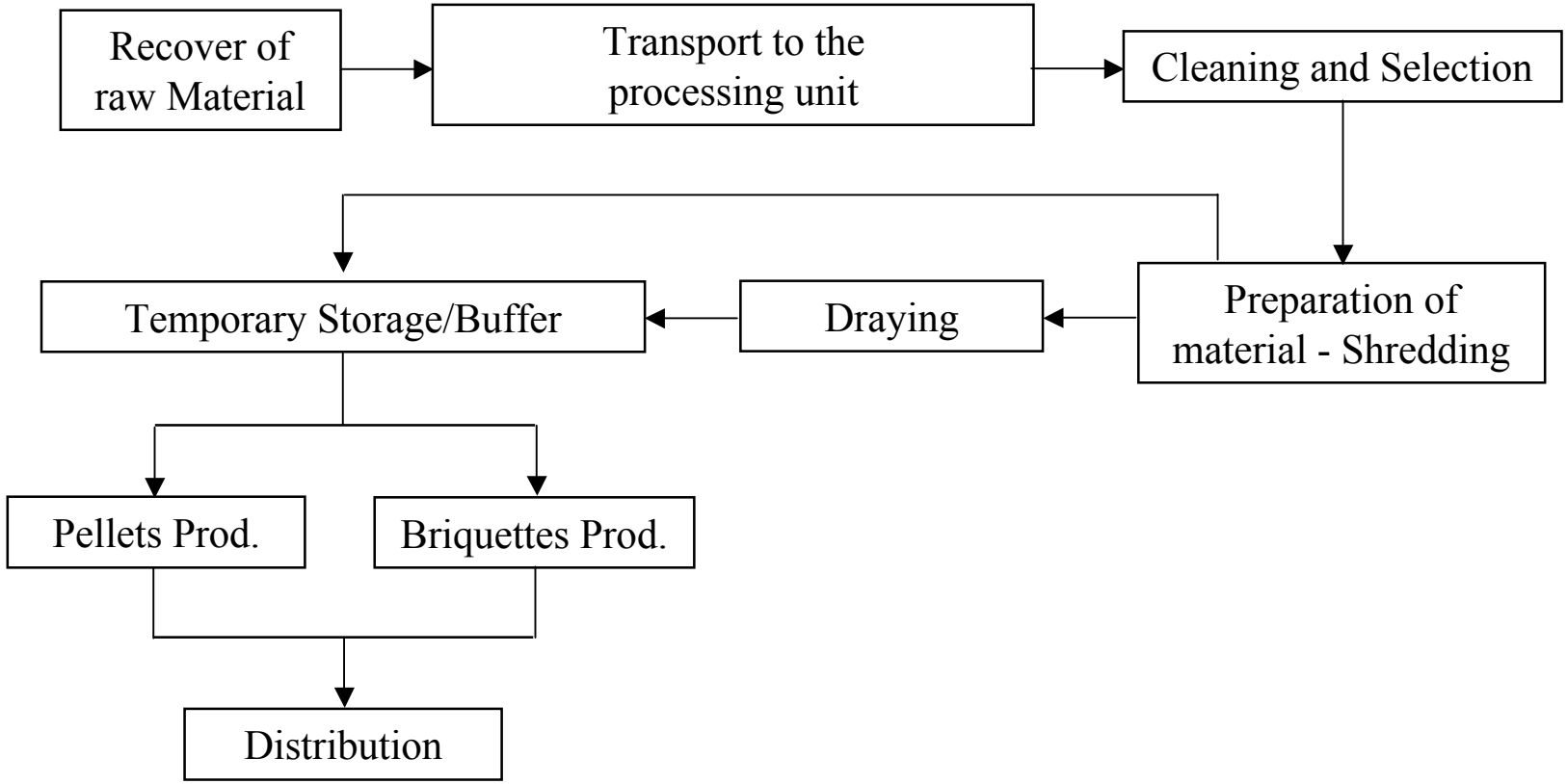
  → 99 % is technology and 1 % management
- Absence of legal & regulatory framework that ensures access to grid and fuel markets
- Possible loss of biodiversity and soil fertility
- Competition for land with food production

Agricultural Residues - Briqueting

- Densify
- Help Transport
- Secure smaller space for storage
- Enhance the energy content
- Raise the value
- Easy the handling
- Can be al home level → small scale → small business → General adoption

Big Picture – Associated technologies

- Process Flowchart



Equipments

- Shredders
  - Blades – Hammers
- What for
  - Grind the material
  - Homogenise the size of the particles
  - Easy the drying process
- Design Criteria
  - Strong enough for different materials
  - Not too big, so can be further modulated
  - Goal is to avoid unused capacity

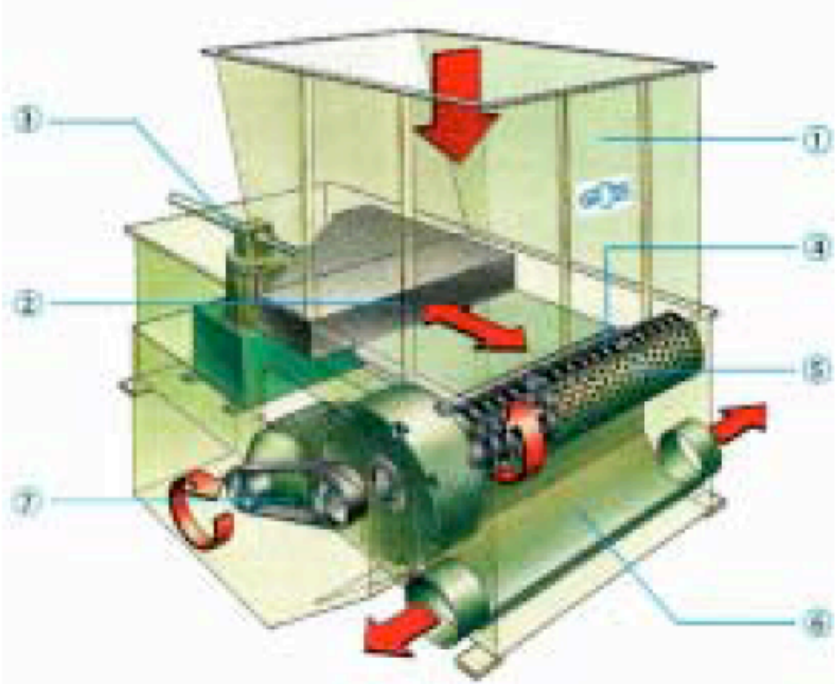
Equipments

- Hammer shredders
  - **Possibilidade de utilizar diferentes materiais**
  - **Não há tanto controle de granulometria**
  - **Aceita melhor resíduos (terra, cimento, etc.)**
  - **Menor desgaste e menos manutenção**

Bruks - BK-HM700 hammer mill @ http://www.bruks.com/English/index.asp

Equipments

- Blade shredder
  - Feeding slide
  - Hydraulic cylinder
  - Cutting Rotor
  - Outlet screen
  - Chip transporting pipe
  - Driver



- Characteristics
  - Greater Homogeneity of final product
  - Need better raw material (few impurity)
  - Bigger wear – more maintenance

Equipments

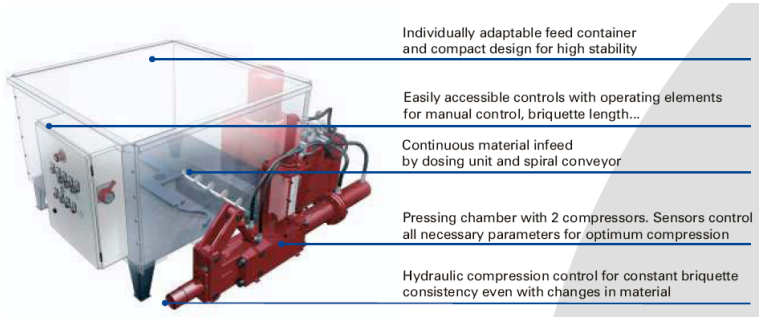
- Briqueting Machine
  - High Pressure – Medium Pressure – Low Pressure (need binding element)
- Piston x Screw (more maintenance)
- Lower quality of the raw material when compared to pellets
- Moisture 6 to 12%

Equipments

- Comparisson Piston x Screw

Equipments

- Briqueting Piston
- Hydraulic two ranges:
  - Low-scale - 50 até 120 kg/h
  - Bigg-scale - 400 kg/h
- Mechanical - from 200 up to 2500 kg/h.
  - Excentric piston



http://www.gross-zerkleinerer.de/shared/download/gross-gp-eng.pdf

Bhattacharya, S.C., Sett, S., Shrestha, R. 1989. State of the Art for Biomass Densification. *Energy Sources 11*, 161-182.

Equipments

- Pellet machine
- Need better raw material – Only wood and cellulose
- 5 - 40 mm length, 5 - 12 mm Diameter
- Moisture 8 to 10 %

Bhattacharya, S.C., Sett, S., Shrestha, R. 1989. State of the Art for Biomass Densification. *Energy Sources 11*, 161-182.

Problems with Biomass

- There is not problem in the use of the resource
- Yet in the lack of a strategy of one clear development model
- Solution (?)
  - Improvement of life conditions of poor,
  - Reduction of disparities between the rural, urban and rurban,
  - Opening of isolated zones, and
  - More education and health...
- Biomass development strategy must be set as a global approach, secure coordination of different actors and avoid loosing efforts and means.
- Main paradigms
  - improving governance
  - Improve energy efficiency / energy access
  - diversity of supply and minimizing environmental impacts of energy

Agricultural Residues - Briqueting

- One possible path – part of a bigger strategy
- Home – Small Scale (start at 1865)

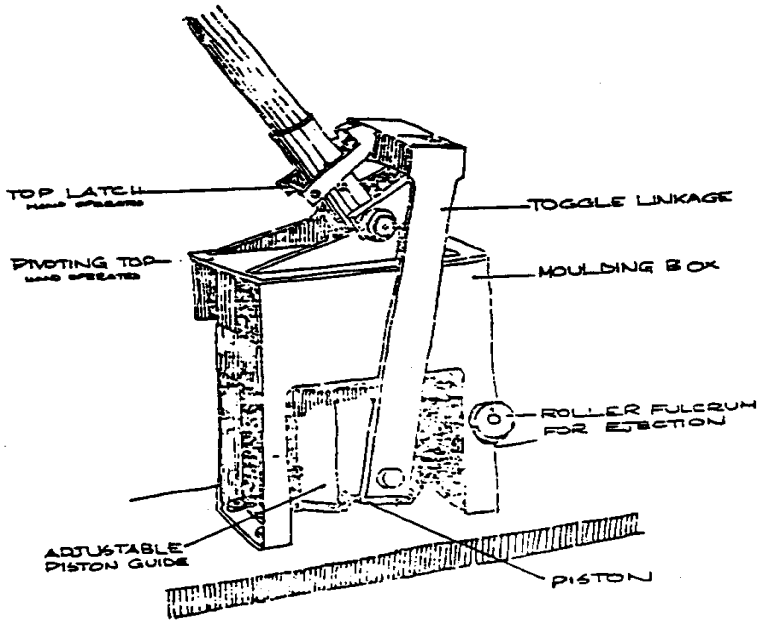


Figure 5. Combustaram

http://sleekfreak.ath.cx:81/3wdev/VITAHTML/SUBLEV/PO1/BRIQUETT.HTM

http://www.iitb.ac.in/~ctara/product.htm#briquetting

Once case study - Nigeria

- Agro-waste briquette-making machines for rural energy and pollution reduction in Nigeria
  - Manually operated briquette machine
  - Use sawdust and other agricultural wastes
- Developed and tested by the Center for Industrial Studies (CIS) of the Abubakar Tafawa Balewa University (ATBU), Bauchi, in collaboration with the Raw Material Research and Development Council (RMRDC), Abuja in 1996.
- Problems:
  - Due to various constraints

  No further commercialization of this locally developed alternative energy technology.

Another Case - Bhutan

Biomass Wastes Briquetting implemented by the National Women's Association of Bhutan

- Objectives:
  - Install and operate a biomass briquetting unit
  - Contribute to the natural resources conservation policy
- Activities
  - Procurement of the Briquetting Machine
  - Use of the machine → Collection of Saw Dust → Production of Briquettes
- Weakness of the Project
  - Was confined to briquette production on experimental basis → Need strategy to go to economically scale
  - Heat generated by the briquettes is high → not suitable for the existing stoves → consumers would need new stoves
  - The briquetting unit is too small for larger scale
  - No marketing strategy

Main Steps

- Locating and Evaluating Local Raw Materials
  - Collection of Raw Materials
  - Quality Control and Storage for Raw Materials
  - Fuel Briquette Energy Content
- Size Reduction
  - Materials Mixing → Screening → Drying → Conveying
- Briquetting
  - Cooling Briquettes → Strapping → Storage of Finished Briquettes
  - Packaging Briquettes
- Storage of Large Quantities Of Briquettes
- Management
  - Marketing
  - Record Keeping for Your Business
  - Training Workers
  - Controlling Losses
  - Reinvesting Profits → Expanding Your Production

KEY ISSUES

- Raw Material Source
- Quality + price + handling + transport (where to install the machines → close to the source)
- Working Flow – who will do / what when why

  99 % is technology and 1 % management
- Structure – Fixed – movable (start with machines that would go where the biomass is?)
- Ownership is THE KEY ISSUE

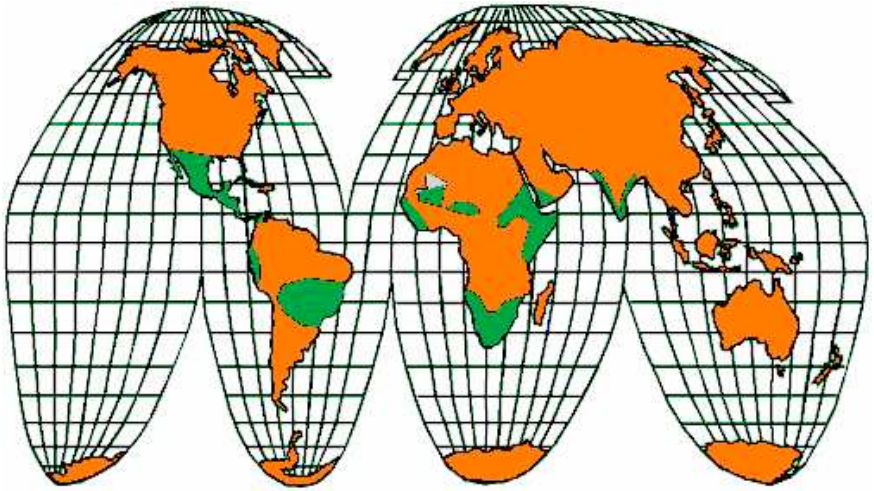
  →so the business would move towards

  → Some one must be held responsible

It most be done in a way that someone make profit so briqueting came to be understood as good idea

Biodiesel diesel engines - jatropha oil

- Where → (green areas)



- What it is:

Biodiesel diesel engines - jatropha oil

http://www.malifolkecenter.org/assets/A_lowersection/jatropha_conference/4.jpg

Biodiesel diesel engines - jatropha oil

- Base: diesel engines, runed with Jatropha Oil
- Jatropha is a plantation – suitable for several regions of the Sahel
- Need “only” to collect, press and filter the seeds
- Productivity:
- 660 up to 825 litres of oil per hectare per year

- Reference at: http://www.jatropha.de/.

INSTITUTO SUPERIOR TÉCNICO

IDMEC – IST - RGESD - Research Group on Energy and Sustainable Development

Low Cost Transmission and Distribution Options

SWER - Single Wire Earth Return community lighting

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SWER - Single Wire Earth Return

- What is it?

To do what normally use three wires – to do with only one

- Who already use:

New Zeeland, Australia, Canada, India, Brazil, Asia, Botswana, Cote d'Ivore, Gabon, Morocco, Uganda, Eritrea and South Africa

SWER - Single Wire Earth Return

- Why:
  - Cost Reduction → One conductor, less equipment;
    - Long distance between the posts (hilltop to hilltop spans); and
    - Fewer switching and protection devices.
  - Design Simplicity plus Speed of Construction;
  - Reduced Maintenance costs
  - Reduced bushfire hazard

- Why Not:
  - Need a good earthling system
  - Voltage control can be difficult;
  - Power quality can be compromised
  - Has load density limitations.

- Need: to secure that the appropriated regulation

SWER – Main Elements

- Line
  - Single iron wire (no copper nor Aluminium)
- Isolating Transformer
  - To make 22 kV, 2 phase, 2 wire to →12.7 kV line to earth on one wire
- Distribution transformer
  - To make 12.7 kV down to 230 X 230 Volts, two phase 16 kVA transformer
- To home / Machine house etc

SWER - Single Wire Earth Return

- Design Line
  - Resistance is

    wire + earth

- Savings in Capital cost:

  - 50% less than 2-wire, single-phase

  -70% less than 3-wire, 3 phase

- Save around 50% of maintenance cost

Provision of community lighting

- Community floodlight is focused in providing light to households
- Main goals are:
  - Safety –also good practice in urban environment
  - Can be made in conjunction with urban development / tourism / safety program / cultural development / economical development / support to SMcEs
  - Normally associated with: market places and fish landing sites, tourism spots
- It is not a waste of light – but a designed project to offer energy services for the population

High-mast flood lighting

- Light only **where** needed
  - Don't overlight
  - Don't waste light
  - Shine light down with full-cutoff fixtures or shields

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