# INDONESIA BIOFUELS case study

## GRASS BIOGAS FOR RURAL DEVELOPMENT APPLICATIONS

Biofuels for Local Development

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# The Grass Biogas CHP system

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# The Problem of Rural Marginalization

The tremendous challenges ahead:

- 1.4 billion people lacking modern energy services such as cooking gas or electricity
- 420 billion USD required for energy infrastructure in Developing countries
- Urban areas will get priority over rural areas due to lower costs/connection
- Rural people will be last to be served at high costs

# The Solution for the Problem

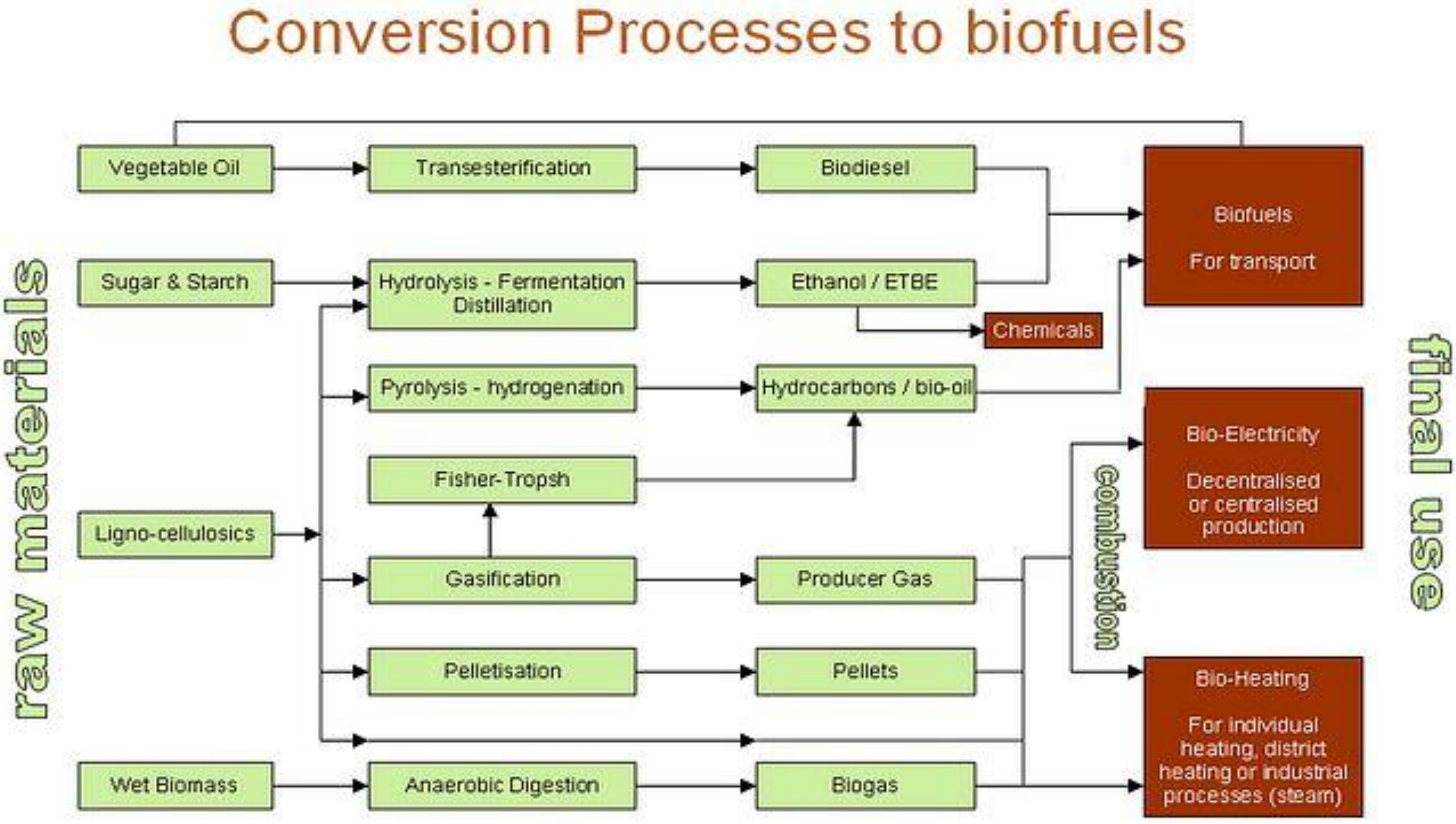
- Economic development by energy and infrastructure using low cost alternatives:
  - Decentralized systems
  - Productive energy to add economic value
  - Renewable energy where feasible

# Technical Alternatives

- Decentralized diesel generators;
- Micro and pico hydro;
- Wind generators;
- Concentrated Solar Power;
- Geothermal;
- Biomass energy.

*Depending on the resources and needs of the people there is always a best option in terms of costs and management*

# The Biomass Array of Options




EUBIA 2007

# Criteria for selection of community based system

- Proven technology for biomass production and conversion to enduse;
- System enables raw plant material storage to overcome intermittent or non-continuous supply over the year.
- Technology available for the rural communities: eg.sizes from 20 to 200 kW depending on the village size.
- Experience in the country for operation and maintenance (simplicity of use; eg. car or engine mechanics).
- Requirements of the crop or plant or the simple residues: apt for climate conditions/the soils that exist in the locality.
- The technology should allow for easy nutrient recycling system.
- Availability of extensive area for biomass production or residue with no existing uses (food fuels)
- Biomass available at competitive costs.
- The technology for stand alone mini grid.
- Preferable low investment and operation costs if in mass production.

# Application of Criteria Grass/Biogas/CHP

- For the conversion step all technologies using Internal combustion engines interesting  PPO fuelled, biogas fuelled, ethanol fuelled, producer gass fuelled.
- For the conversion step all systems based on IC engines with diesel or gasoline, ethanol or natural gas engines have O&M experience available.
- Easy nutrient recycling: Ethanol production and Biogas systems are relatively good in this area: (digestate or process slurry remain in tact and recycled) In case of thermal processes (steam, gasification or pyrolysis) not;  first ashes do not contain the nitrogen compounds, secondly the structure and organic matter are lost completely.
- Independent operation: All conversion systems using IC engines qualify.
- Technology available for village scale range: although ethanol production, thermal syn-diesel processes can be designed for all scales, the technology only financially attractive at larger scale.
- Costs and competitiveness: system of oil producing plants and use of PPO in IC engines still expensive,(as the PPO has to be priced in relation to the fossil fuels). Raw material for biogas is normally at lower cost, as it does not loose value when used for biogas.
- Energy yield per ha per year: production of grass 15 to 30 MT of dry matter/ha/a and is on per ha basis as attractive as high yielding forestry.  It by far exceeds production of oil plants

# System Design Conversion Part

Biogas based systems seem attractive:

- Gasmotors (MAN, Jenbacher GE, Capstone) proven track record,
- Gas motors are IC motors familiar to technicians,
- Low cost of raw material for biogas is achievable,
- Biogas cleaning sturdy as compared to Gasification.
- Biogas slurry well recyclable

# System Design Raw material

If raw material is to be produced for biogas, desirable:

- High yields comparable to woody biomass (30 MT/ha/yr);
- Not on agrisoils;
- Fast to get first yield within a year;
- Preferable continuously yielding reducing storage and labor peaks;
- Easy to grow; not much attention
- Easy to recycle;
- Improving soil organic matter (C)

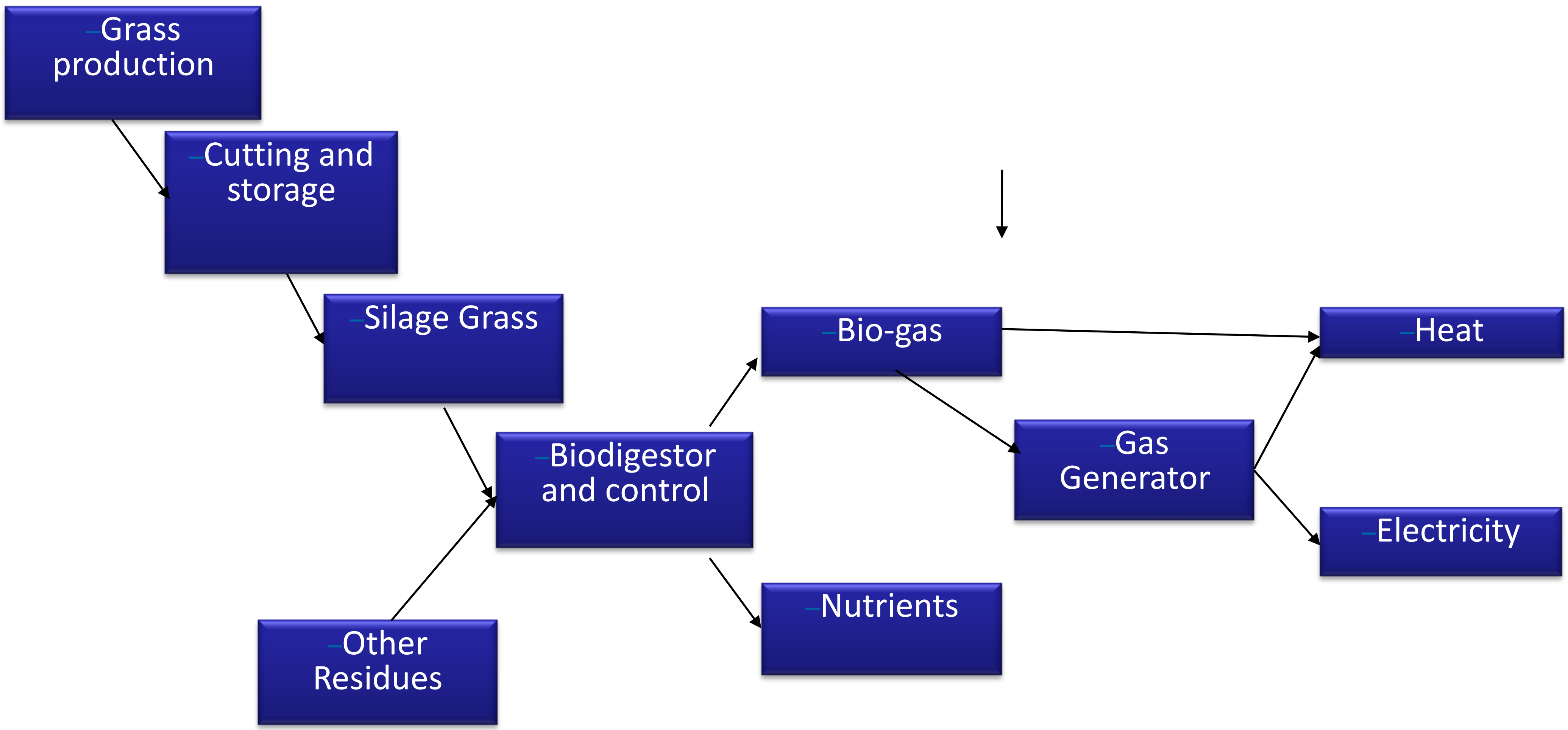
- **Grass or energy pastures comply with the above!!!!**

# System design for End use

The more flexible the end-use the more interesting the system: biogas can provide:

- Electricity for productive use (SME development)
- Gas for Cooking and Heating (low Ngas quality)
- Biomethane for transport (in Austria 1 ha for 45000 km with a car)

# The Grass Biogas CHP Concept



# Benefits and drawbacks

- Biogas is a multi-use fuel easy for IC use to make electricity, and makes a good clean cooking fuel,
- Biogas systems combined with sanitation, and handling organic waste,
- Biogas sources can be residues that do not loose nutrients,
- Biogas process: conversion from raw material to Biogas is relative simple process to manage (is as a cow stomach), feeding consequently;
- Conversion from biogas to electricity is simple technology (IC engine generator): track record 4000 systems in DE)

# Drawback of Grass Biogas

- Grass land is normally grassed by animals and thus has value for animal production,
- Grass land is currently often extensively used, so this is totally different as with an energy grass,
- Climate conditions, water availability and nutrients determine the suitability of energy grass: humid conditions seem to qualify best;
- To restore soil fertility external nutrient gifts might need to be applied, adds to costs;
- Irrigation can be considered to increase yields in semi arid conditions, this adds costs.

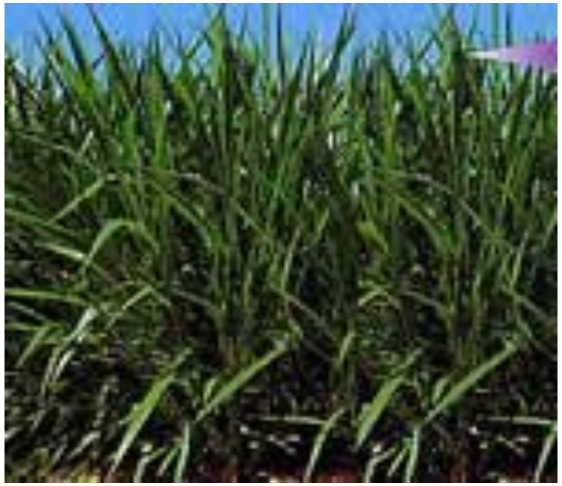
# Benefits of grass use

- Environmental advantage: soil conservation value, carbon capturing in root mat);
- not on prime agri-land;
- not affecting basic staple food land;
- fast growing (1 year);
- high yield upto 30 MT/ha;
- low investment;
- low storage needs and simple silage;
- low peak labor;
- not many agri risks (hail, diseases, pests):
- easy cultivation system: low labor and simple harvesting

# The Grass System

- The energy grass system is a mix of grasses with high protein and sugar content and nitrogen fixation plants that can be regularly cut (every 6 to 10 weeks) to avoid lignocellulose and cellulolse in stems;
- Mx is very much dependent on the climate conditions and soil type: For each condition there are alternatives;
- Examples of the grass mixtures for the humid tropics:
  - Grass: *Brachiaria*, *Digitaria*, *Panicum*, *Setaria* and *Pennisetum*
  - Legumes: *Pubescens de Centrosema*, *Ovalifolium de Desmodium*, *Pueraria phaseoloides* and *Leucocephala de Leucaena* (Wong *and others*.,1982).
- Energy grass yields 15 to 30 MT/ha/yr;
- Energy grass on depleted soils needs a starter gift with nutrients;
- Choice of irrigation depending on feasibility.

# Grass types



# Example of Silage Austria ReitBach

# Cuting, Transport and Silage

- The grass is cut normally by finger nife cutting bar machine (or hand) and freshly brought to a chipper that refines the size of the grass:
- Then there are two options:
  - direct feeding in the digester (requiring more work for the internal digester mixter ( paddle mixer), or
  - silage under plastic for 6 weeks where after it can be used in the digestor

# The Conversion System: Biogas

- The biogas digester is fed with chopped grass 2 to 3 times/day The feeder can be gravity fed as tested in Austria. Digestate is washed over the grass and takes it in the digester;
- The digester is best insulated to ensure even temperature. Shape used in Austria is round tank, but FACT works with parties on alternatives using EPDM, reinforced PE, etc,;
- The digester has a strong paddle mixer that cuts the foam layer (it is used 5 min/hr) Low revs and large diameter); additional is high re mixer;
- Biogas yields can be 500 to 600 m3/MT Dry Matter, 70 to 80%;
- Process temp can be from 38 to 48 D Celsius;
- Retention time is 50 to 70 days;
- Gas Sulfur cleaning can be done with air inflow;
- Gas can be dried with simple condensation pits.
- Digestors costs can be ca 25 to 50 Euro/m3 tank content, depending on size and materials

# Grass digester in Austria, Reitbach

Peter Stiegler, Energiewerkstatt, Eugendorf

# Biogas digester bags with propeller type mixers

# Plastic bag design, using Jatropha cake

# The Conversion System: Electricity

- The biogas is fed into a gas engine generator
- The gas engine is an adapted IC engine, that can run 100% on gas
- Suppliers take garantees on the functioning with biogas (GE Jenbacher, MAN): in Germany at least 3000 systems running
- Also trackrecord technology with Capstone micro turbines that can on low quality MWG
- System cost are low, similar to ordinary engines

# –400 kWe gas generator MAN

# The applications Combined Heat and Power CHP

Biogas can be used for:

- Electricity generation: for productive, social and household use: electricity company and grid are to be established
- Cooking: through a mini biogas grid, or with small individual systems directly fed to cooking stove

# Uses of electricity: multiple!

# Organizational Aspects

This communal system can only be successful if:

- If system is first priority need or demand of village;
- Ownership of system is clearly defined;
  - Community ownership, system management, operation and maintenance clearly defined (contracted);
  - Grass suppliers are partners in the benefit of electricity and gas sales or have long term contracts;
- Beneficiaries pay for energy services to cover M&O&M costs and reserve for new hardware.
- Productive uses can be engaged in by SME based on e.g. saving and credit facility for SME.

## Economic Feasibility

- Assumptions general: 30 MT DM grass yield Labor unskilled 3 USD/day to qualified 10 USD/day
- Grassland biogas digester and generator and electricity grid, not the biogas grid for cooking.
- Income of system only electricity sales not slurry.
- Size of system calculated 1 ha
- Cashflow over 10 years

# Investment and operational costs USD/ha

| Table 10 | Investment costs | |
|---|---|---|
| **Inversion** | Unit | Value |
| **Land, preparation and sowing** | USD | 1293 |
| **Irrigation pump and lines** | USD | 885 |
| **Chipper and mixer** | USD | 740 |
| **Biodigestor complete with cleaning and tubing and control** | USD | 6212 |
| **Electric generator complete with control** | USD | 8476 |
| **Minigrid** | USD | 3021 |
| **Total cost of inversion** | USD | 20628 |

| Table 11 | Operating costs | | |
|---|---|---|---|
| **Parameter** | | Unit | Value |
| **Operation of the energy grass land** | | | |
| | labour | daily cutting&transport% irrigation | 147.50 |
| | annual inputs | 10 % of nutrients initial and electricity | 152.35 |
| | total | | 299.85 |
| **Chipper and mixer** | | | |
| | labour | | 5.70 |
| | annual inputs | | 2.37 |
| | total | | 8.07 |
| **Biodigester** | | | |
| | labour | | 25.00 |
| | annual inputs | | 186.36 |
| | total | | 211.36 |
| **Generator** | | | |
| | labour | | 182.50 |
| | annual inputs | | 254.28 |
| | total | | 436.78 |
| **Minigrid** | | | |
| | labour | | 182.50 |
| | annual inputs | | 90.64 |
| | total | | 273.14 |

# Income stream

| Table 8 | Benefits of electricity production | |
|---|---|---|
| **Parameter** | Unit | Value |
| **Electricity produced** | kWh/a | 23527 |
| **Electricity not sold per %** | % | 0% |
| **Electricity sold** | kWh/a | 23527 |
| **Sales price of electricity** | USD/kWh | 0.15 |
| **Benefits** | USD/a | 3529 |

# Cashflow

| Table 12 | Cash flow analysis | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Financial Cash flow** | | year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Activity** | Description | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Incoming** | Sales of electricity | | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 |
| | | | | | | | | | | | | |
| | Others | | | | | | | | | | | |
| | Subtotal | | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 | 3529 |
| | | | | | | | | | | | | |
| **Investment** | | | | | | | | | | | | |
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| | Electric Generator complete with control | 8476 | | | | | | | | | | |
| | Minigrid | 3021 | | | | | | | | | | |
| | Sutotal | 20628 | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Operating costs** | | | | | | | | | | | | |
| | Operation of the energy grass land | | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| | Chipper and mixer | | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| | Biodigester | | 211 | 211 | 211 | 211 | 211 | 211 | 211 | 211 | 211 | 211 |
| | Generador | | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 | 437 |
| | Minigrid | | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 | 273 |
| | Subtotal | | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 |
| | | | | | | | | | | | | |
| **Subtotal costs** | | 20628 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 | 1229 |
| **Benefits - costs** | | -20628 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 |
| | | | | | | | | | | | | |

# Internal Rate of Return (IRR)

- IRR of 2 % with E price of 15 USDcents/kWh
- This is for small system, and likely reduced to 7 USDcents/kWh for systems of 100 ha

# Conclusions Technical Aspects

- Biogas grass system makes on site feedstock grass: so grass production needs to be assured and managed.
- If fresh grass feeding, steady yield over months needed, so spread rain pattern or irrigation.
- Research Organisations such as CGAR, IFAD, FAO and institutions know best grass mixes.
- Testing on structure, texture, PH, OM, macro and micro nutrients is needed. Farmers training is needed on this grass production, harvesting and silage.
- In the electricity generation, the operation includes an understanding of the gas engine, which is basically a spark plug engine adapted to gas. Specific training for operation is required. Finally the minigrid needs to be maintained and customers be educated in appliances and the payment for the service. Education and training for both operators and customers is needed for a sustainable system.
- The beneficiaries of electricity require education as well (peak shaving, ee lighting, etc..)

# Conclusions: Economic aspects

- The grass biogas electricity system has comparative prices or lower than the national service, if such system is based on diesel without subsidies. It can arrive at a low level of 0.07 USD/kWh.
- As low cost electricity is produced continuously the system also serves to be integrated the interconnection network, if they are of size e.g. of 500 ha with a capacity of 10 MW.
- Important that system costs are covered, reserves build up, that grass input insured at fixed price,
- Important that revenues are collected based on the agreed tariff structure

# Conclusions Social Organisational

- For any autonomous generation system installation is not difficult, and first months systems can work without problems.
- If not managed well or and if there is not a good operation and maintenance, for reasons of shortage of funds or lack of qualified staff, lack of management training, trouble starts.
- With emerging problems, community can become discouraged and even lower its support to correct the problems.
- Therefore a system serving the community is to be owned by it: management and O&M might be better off with SME involvement.
- Track record in other assets management preferred to reduce risks.
- Interaction between those that produce energy grass, and those who produce the biogas and those who generate the energy.
- Organization and communication for this system are even more intense than in a conventional system. Important such organizational qualities exist and that acceptable organisational structures be used for management
- Requires training at several levels: to beneficiaries, to managers, farmers and technicians.

# The Challenge

Invitation for students/universities/companies to join R&D to:

- design low cost reliable communal size biogas digester for grass/silage;
- Elaborate energy grass guideline;
- To field test such systems under suitable conditions;
- Questions.

**Thank you for your attention.**

**Questions?**

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