Advantages and Disadvantages of Bioenergy for Off-grid Electrification

The case of Jatropha-based small-scale power supply in Indonesia

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Research:

Postgraduate program

'*Microenergy Systems for Decentralized, Sustainable Energy Supply in Structurally Weak Areas*'

Hosted at the Center for Technology and Society at the TU-Berlin, Germany

Funded by Hans-Böckler-Foundation since 2007, 2nd Phase starts in 2012-2015

Currently seven PhD projects at 7 institutes and 4 universities

International Conference on "Micro Perspectives for Decentralized Energy Supply", 7-8 April 2011 in Berlin

www.tu-berlin.de/microenergysystems

Consulting:

SiNERGi GmbH

Consultancy services for projects and events in renewable energies and climate protection

Founded in 2007 by M. Gaul, M. Schröder, and M. Seißler

Interdisciplinary team looking at economy & markets, policy & regulation, and technology

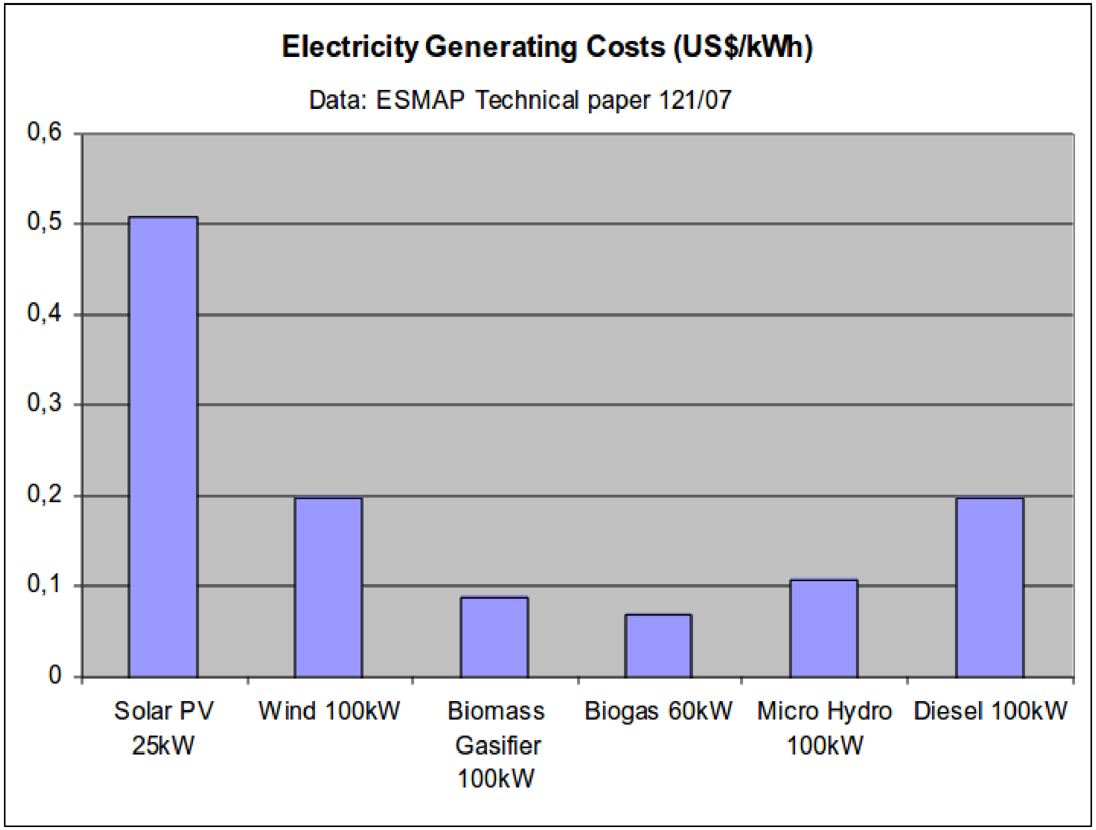
Focus on decentralized energy services and rural development

Clients: public ministries and agencies (GIZ 'Energizing Development', KfW) and the consulting sector (e.g. Ecofys)

www.sinergi.de

Often stated advantages of bioenergy

- Competitive costs
- Biomass is storable (in opposite to wind and solar energy)
- Electricity can be generated when it is needed
- Biomass based generators produce enough power for small machinery and productive use (in contrast to PV)
- Potential for local value chains with income generation for rural population
- Incentives for re-forestation



2. Short introduction into biomass-based electrification

Comparison of the current status of approaches for rural electrification based on gasification, anaerobe digestion (biogas) and straight vegetable oil (SVO)

- High costs in relation to fossil fuels and in absolute terms, too expensive for the target group (as other renewable or fossil energy services too)
- The technologies need long-term professional support for their proper operation
- Challenge: complex conversion technology (in case of gasification)
- Challenge: low productivity (in case of SVO)

→ **None of these technologies is fully commercial for decentralized small-scale electrification and consequently cannot yet be recommended as a standard solution for projects with the objective of rural electrification.**

However, in principle the practicability has been proven and in some cases cost are not very far from being competitive

→ **Hence, more pilot applications with a research component are needed.**

Based on a study by Elmar Dimpl on behalf of GIZ focussing biomass gasification, anaerobic digestion (biogas), and straight vegetable oil (SVO) as fuel for power generation (<100 kW), http\\:energypedia.info

The challenge of biomasses-based rural electrification is not only the development of a specific conversion technology, but how to address complexity:

Energy resources

Land use, water, and input competition

Biomass competition:
- Food, Fodder, Fibre, Feed, Fertilizer, Finance and **Fuel**

Competing resources:
- Solar, water, wind, hydro, fossil & grid

Conversion pathway

Solid, liquid, gaseous fuels, heat, electricity compete for the same biomass resource

Alternative competing pathways based on solar, water, wind, hydro, fossil & grid

Energy demand

Demand for light, heat, mechanical power, and ICT

Non-standardized technologies & fuels for energy services

Variation of demand and purchase power

How can specific bioenergy-based services be compared?

3. Jatropha-based Rural Energy Service Pathways (RESP)

A rural energy service pathway describes the full energy conversion chain from extraction, conversion, distribution, and end-use to provide a specific energy service

Jatropha Curcas L.

Claimed potential for small scale bioenergy (the Jatropha system)

Plant oil can be used for all 3 bioenergy services (light, heat, mechanical power)

Scenarios of service pathways

1. Baseline for wood, kerosene, diesel and gasoline
2. Jatropha-based options for liquid, and gaseous pathways
3. Alternative options with other renewables

Energy service demand categories

1. Lighting
2. Cooking
3. Mechanical power

For which energy service is a specific Jatropha-based RESP competitive compared to the baseline, other Jatropha, or other renewable RESP?

3. Jatropha-based Rural Energy Service Pathways (RESP)

Case Study Indonesia/Sumbawa

Scenario analysis

- LCA (GEMIS 4.6)
- 1 Baseline, 3 Jatropha (HH, VI, RE), 1 Alternative RET
- Comparison present case vs. best case
  (interest rate decreased, fuel price & efficiency increased)

Energy efficiency

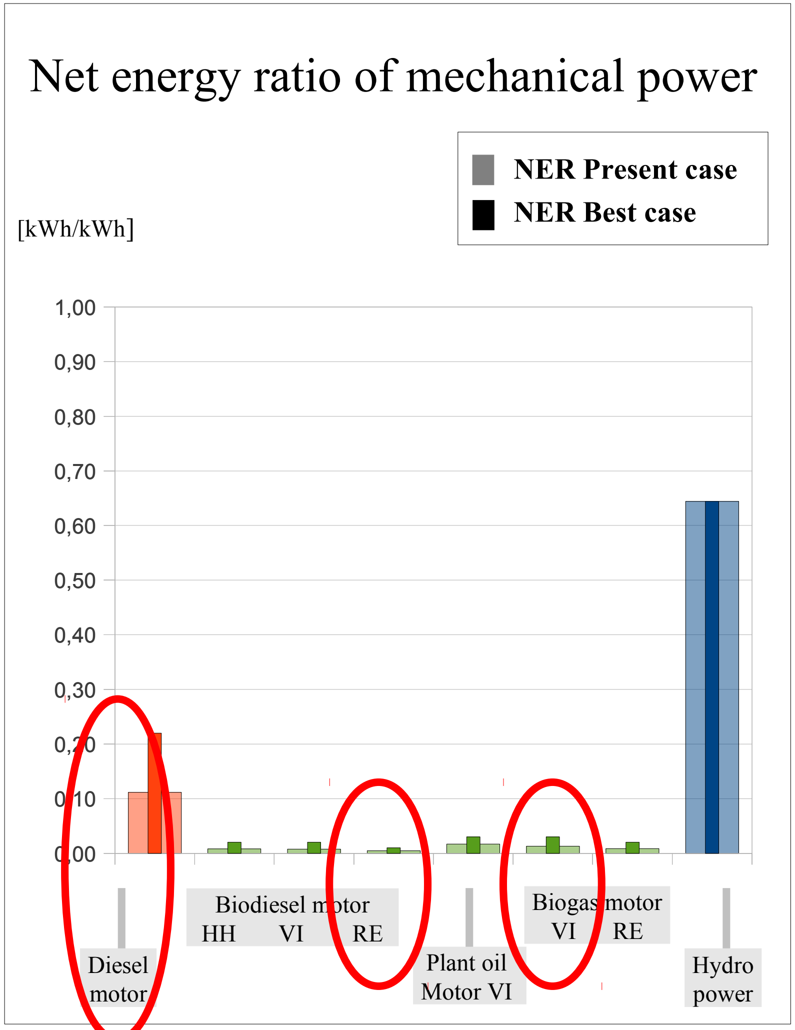
- Net Energy Ratio (NER)

Cost efficiency

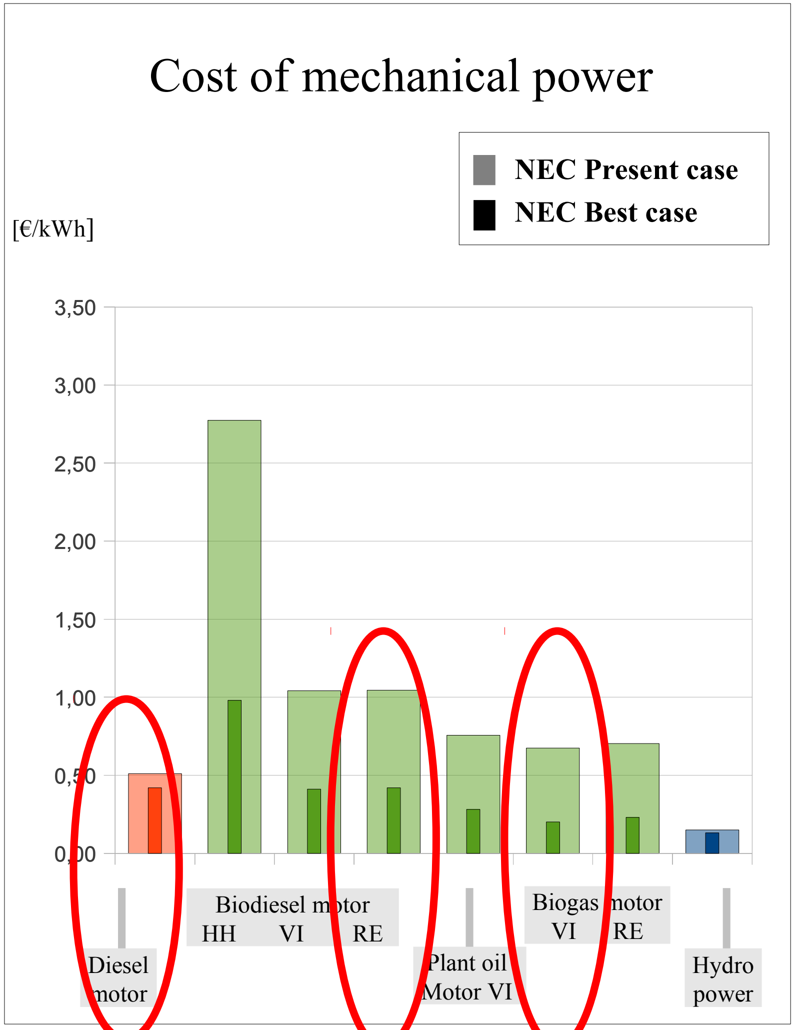
- Net Energy Cost (NEC)

Overview on selected energy service pathways

Scenario	Cooking	Lighting	Mechanical power
Baseline	Wood stove	Kerosene lamp	Diesel motor
Jatropha	Plant oil stove (HH, VI) Biogas stove (HH)	Plant oil lamp (HH, VI) Biogas lamp (HH)	Biodiesel motor (HH, VI, RE) Plant oil motor (VI) Biogas motor (VI, RE)
Alternative RET	Solar stove Improved wood stove	LED solar lamp	Hydro turbine

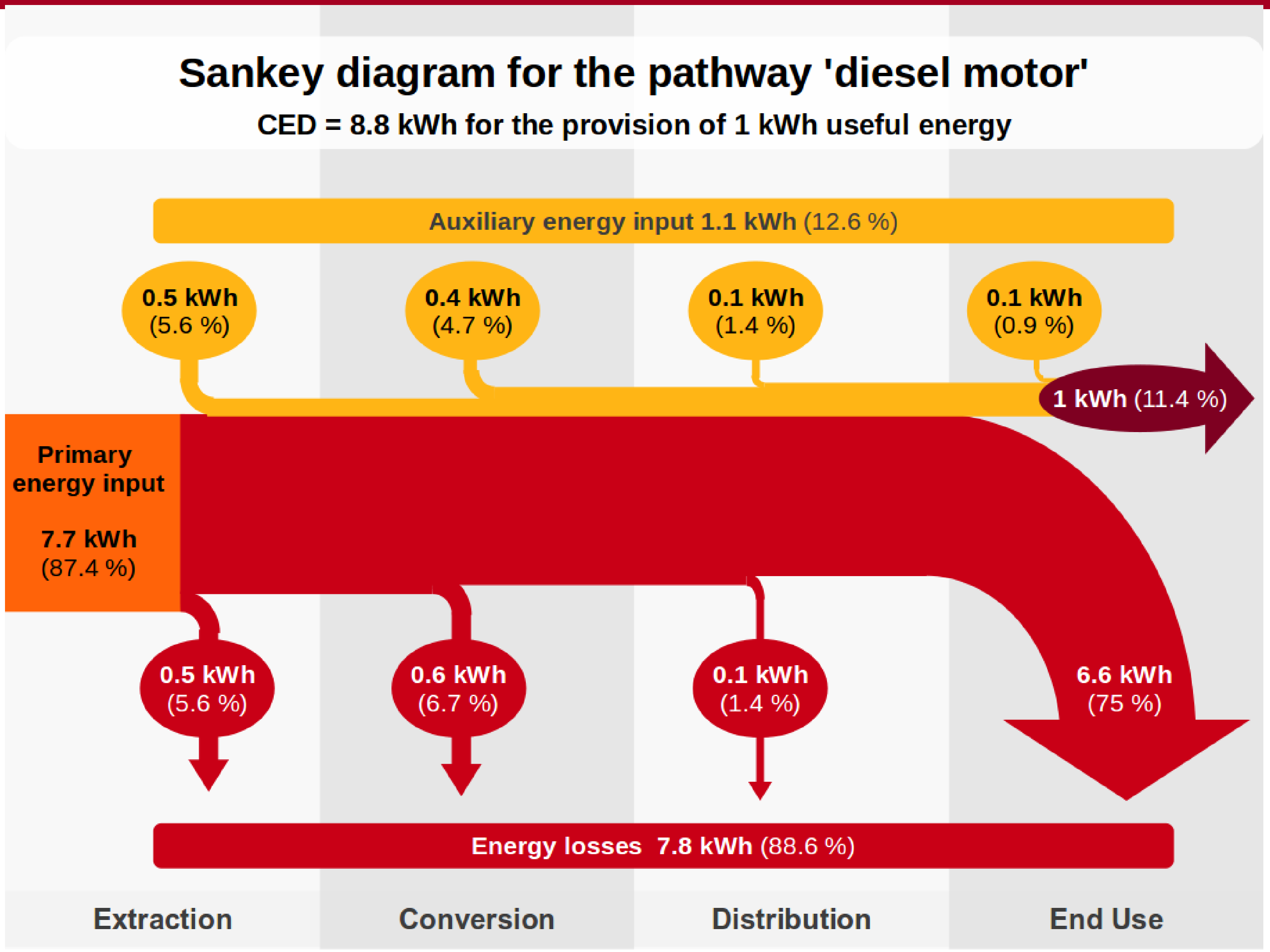


Net energy ratio of mechanical power
NER Present case
NER Best case
[kWh/kWh]
1,00
0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
Diesel motor
Biodiesel motor
HH
VI
RE
Plant oil Motor VI
Biogas motor
VI
RE
Hydro power



Cost of mechanical power
NEC Present case
NEC Best case
[€/kWh]
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
Diesel motor
Biodiesel motor
HH
VI
RE
Plant oil Motor VI
Biogas motor
VI
RE
Hydro power

3. Jatropha-based Rural Energy Service Pathways (RESP)



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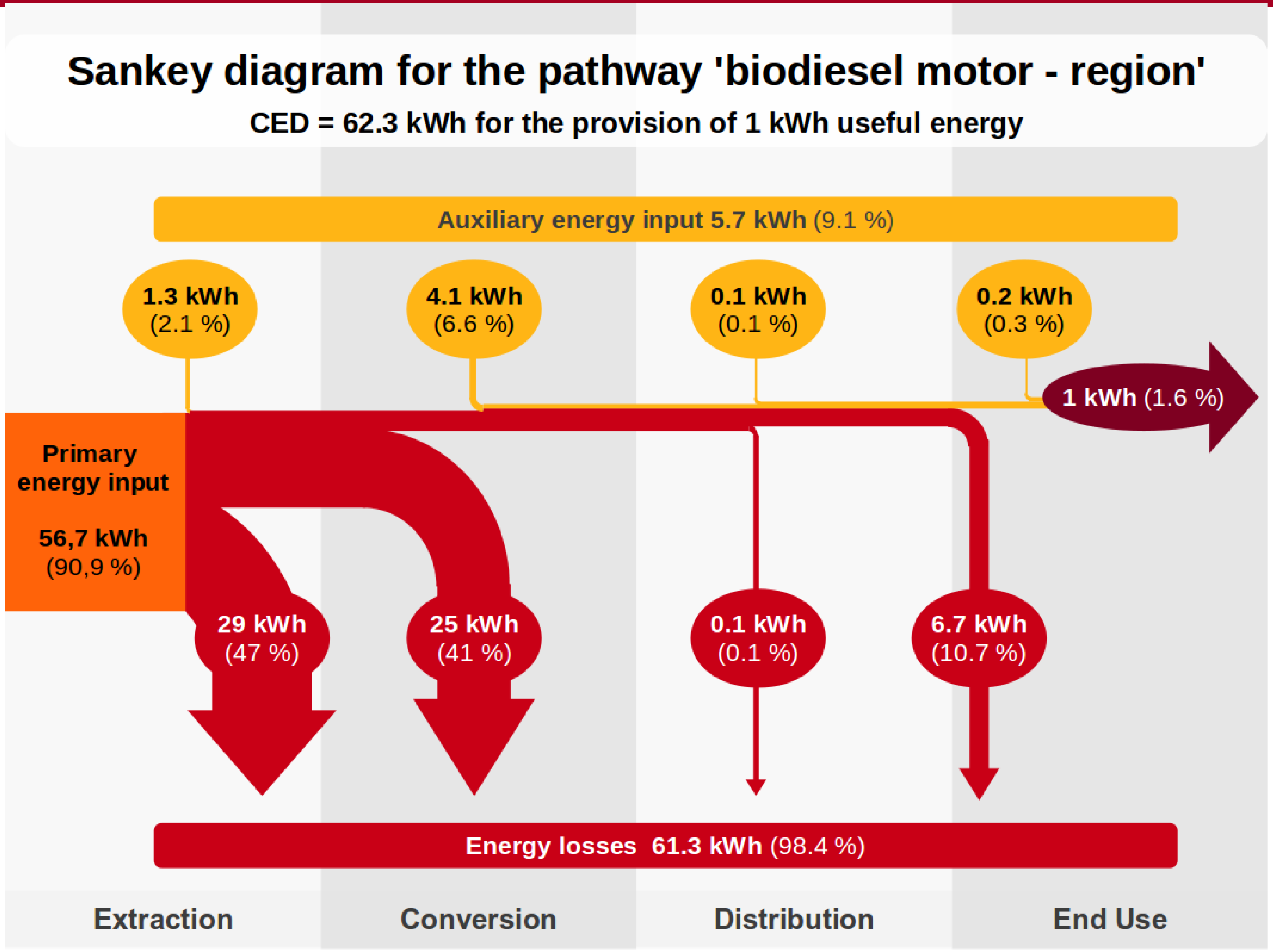
3. Jatropha-based Rural Energy Service Pathways (RESP)



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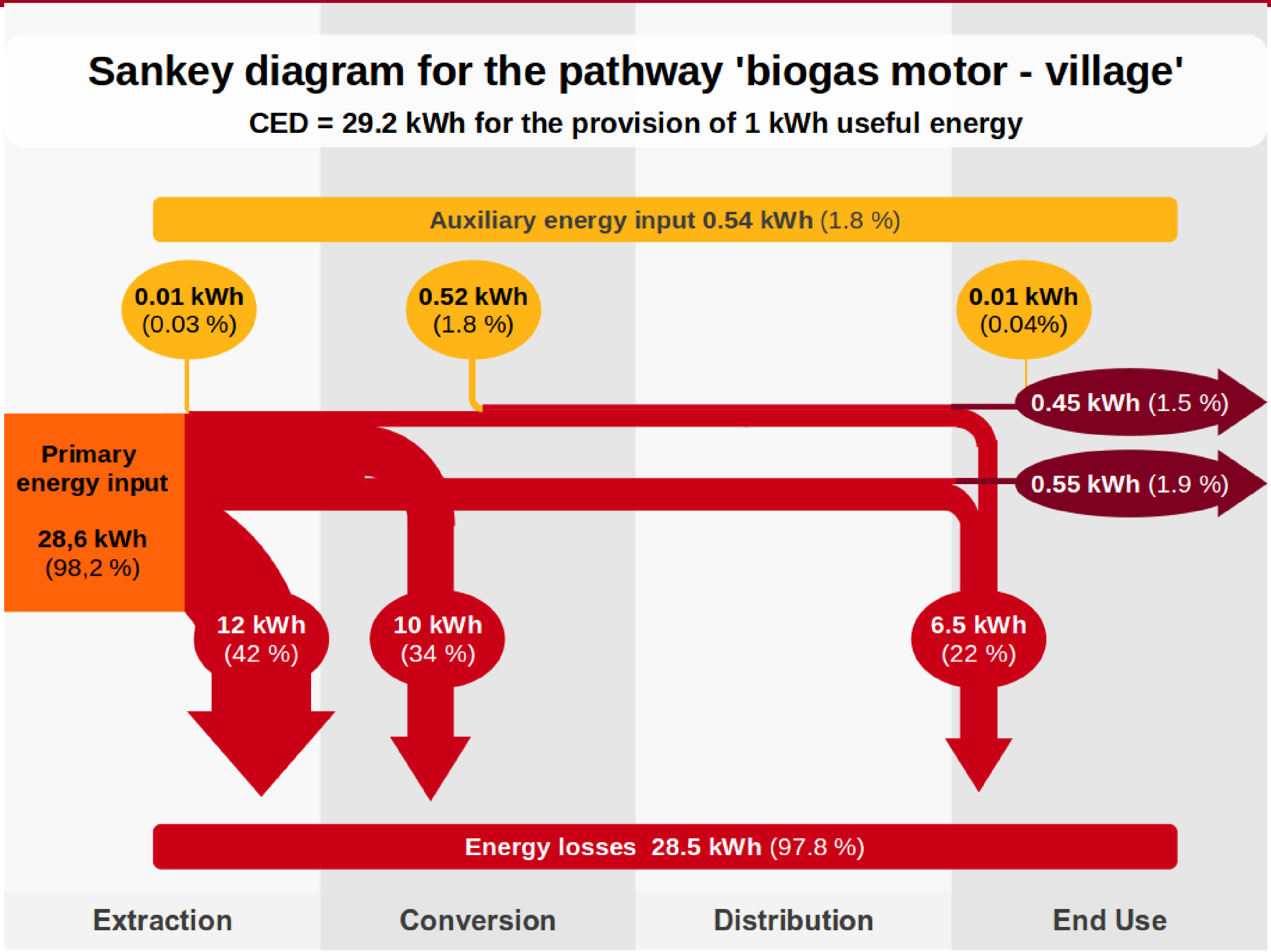

Balancing of labour, energy, and capital intensity

- Jatropha Household: high Net Energy Balance, but low productivity
- Jatropha Region + biodiesel: could become cost competitive but have low Net Energy Balances

Bioenergy has long and inefficient conversion chains

- Diesel baseline: Net Energy Ratio > 0.9 in all process steps beside end use
- Jatropha Net Energy Ratio only between 0.2 and 0.5 → total NER below 0.05!
- Low Net Energy Ratio multiplies the required amount of auxiliary energy!

Plant oil & biogas for mechanical power has the best potential, but..

- It is still an inefficient way of resource use: only if residues or side-crops are used, as well as byproducts (fertilizer/fodder/fiber), but no energy crops! However, competing uses for biomass residues might be more profitable....
- No 'one fits all' solution: viability of bioenergy systems depends on the kind of local resources, spatial data and scale, local demand etc. Extensive planning is required (but typically not affordable)!
- Other renewable energies (as hydro power) might be more competitive
- There are still significant technical barriers: reliability, service, O&M for machinery
- Additional institutional barriers: reliability of biomass supply, organization at village level (business and operation models)

Thank you for your attention!

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