# Optimizing the GHG benefits of bioenergy and carbon sequestration systems

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# Overview

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- Methodology for GHG balances
- Frequently used measures of “GHG efficiency”
- Broadening systems boundaries
- Focusing on the limiting resource(s)
- Non-GHG factors
- Liquid biofuels directive
- Conclusions

# Carbon flows

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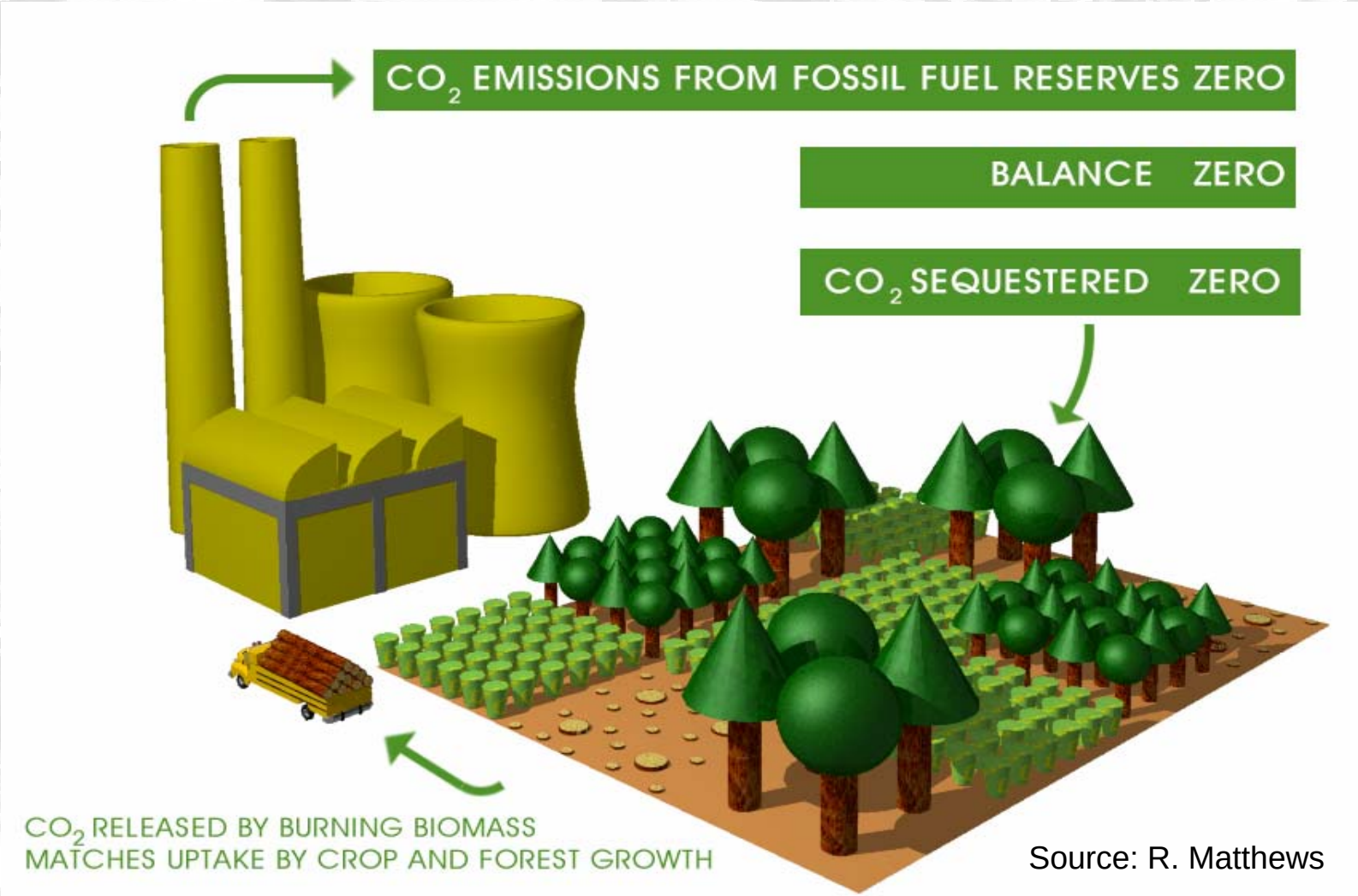


Source: R. Matthews

# Fossil-fuel inputs



- Energy inputs for biomass fuels from ag. or forestry residues: 2-5% of energy content
- Dedicated energy crops and refined fuels (e.g., pellets): around 10%
- Liquid biofuels significantly higher, studies differ considerably
- Fossil fuels also require considerable energy to mine, refine, transport (5-10%).

# Frequently used measures of "GHG efficiency"

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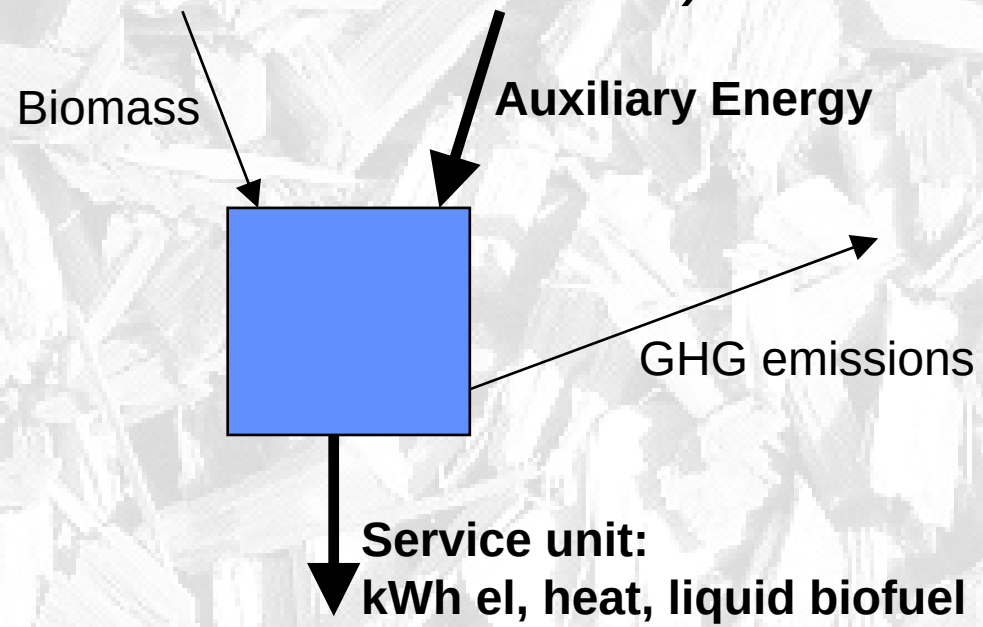
- **input-output ratios or cumulative energy invested per energy delivered**
- emissions per unit output (kWh electricity, heat, liter of fuel …)



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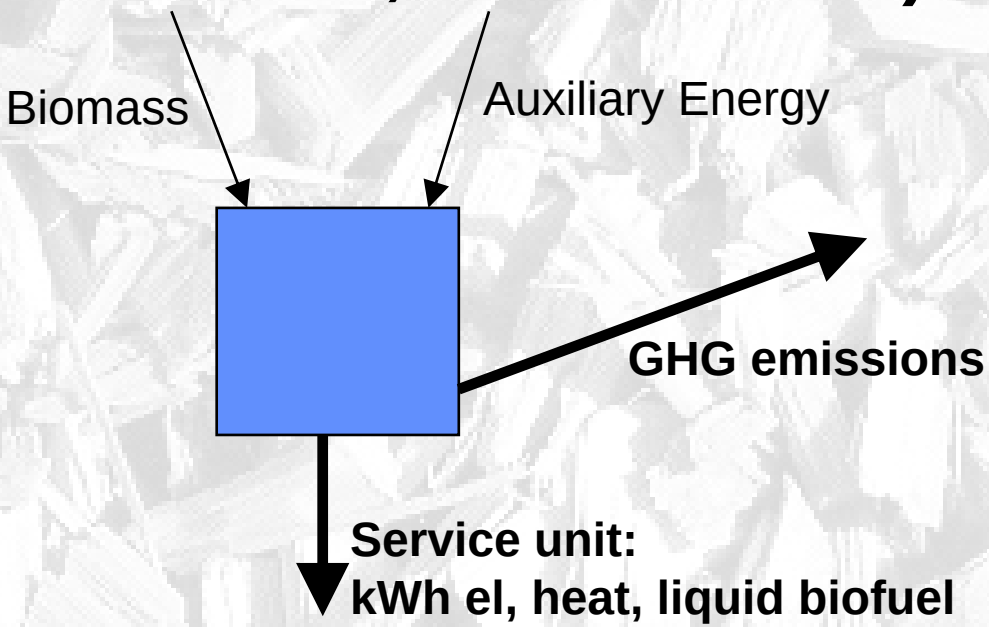
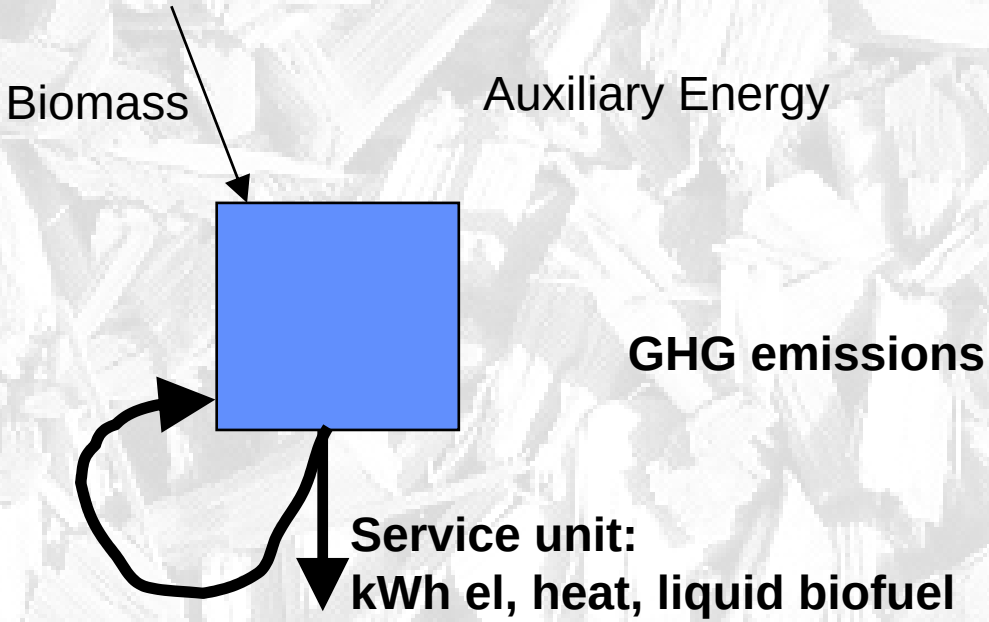


# … can be misleading:

- **emissions per unit output (kWh electricity, heat, liter of fuel …)**



# Expand system boundary: fossil reference scenario

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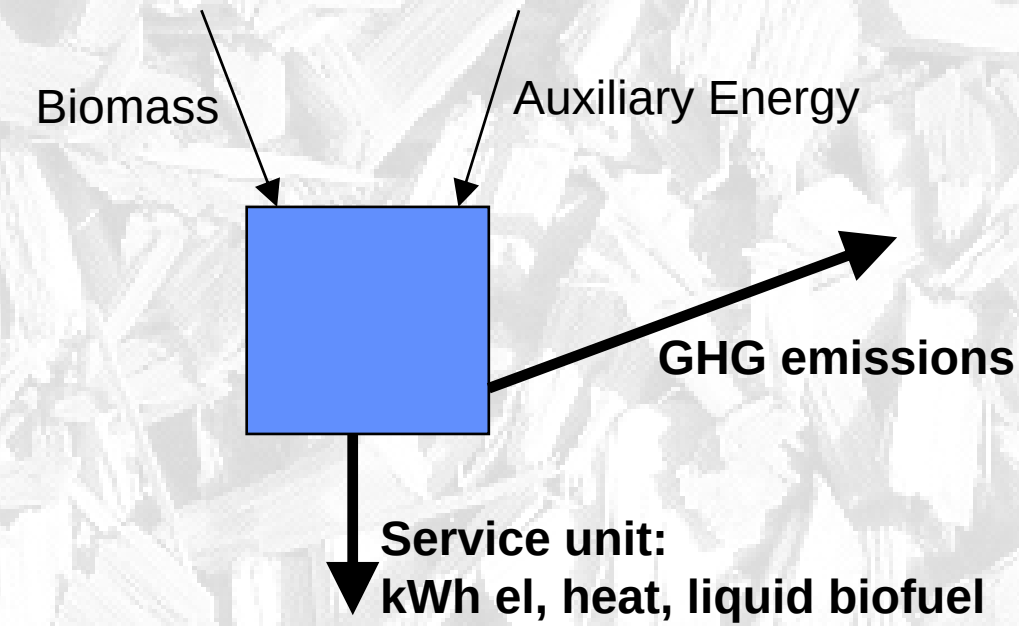
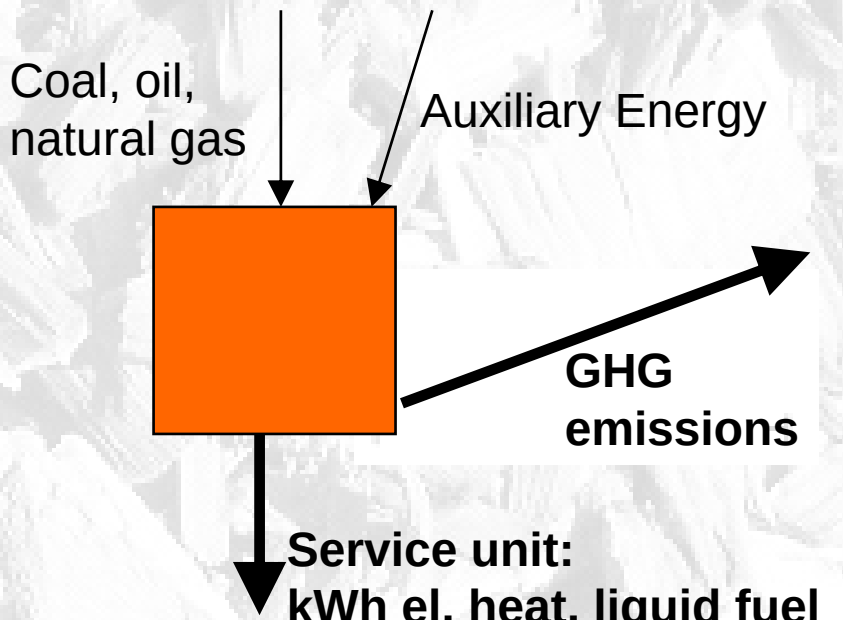
- **Emission reduction per unit output (kWh electricity, heat, liter of fuel …)**



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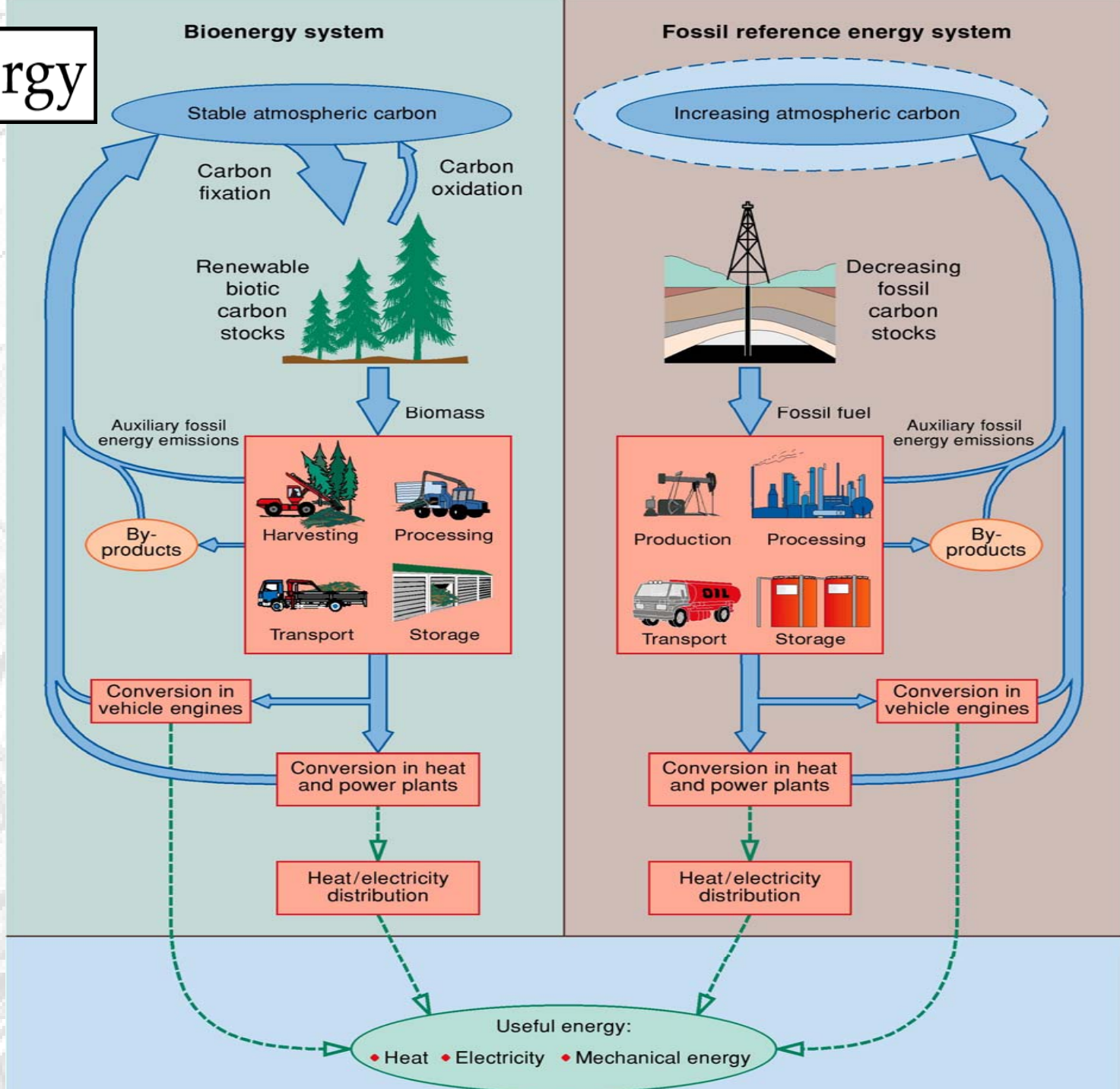

# Example:

- **System A**: 1 unit energy In,  5 units Out
- **System A (no imports)**: 0 unit energy In, 4 units Out
- **System B**: 3 units energy In, 10 units Out
- Biomass replaces coal with equal efficiency

| | Energy in / Energy Out<br>GHG / Energy Out | Net energy gain and emission reduction |
|---|---|---|
| **A** | **20%** | **4** |
| **A (no imports)** | **0%** | **4** |
| **B** | **30%** | **7** |

# Reference energy systems

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- Country or region specific
- Could be coal, oil or natural gas based
- Efficiency can differ
- Marginal or average?
- E.g., baseline scenarios of CDM project
- Robust methodologies are being developed (Meth. Panel)

# Limiting Resource: Biomass

- Forestry or agricultural residues
- Wood processing residues
- GHG Emission reduction / ton of biomass used
- Can be used in policy planning
- Factored into the economic calculation through fuel prices and opportunity costs

# Limiting Resource: Land

- Agricultural or forestry energy crops
- GHG Emission reduction / ha of land used
- Example: biodiesel from rapeseed less efficient than biofuel from lignocellulosic materials
- Can be used in policy planning
- Factored into the economic calculation through fuel prices and opportunity costs

# Limiting Resource: Capital

- Emission reduction / additional capital invested
- Example: emission trading markets, JI / CDM projects (€ / ton emission reduction)
- Can be used by policymakers, as well as project developers

# Other factors influencing the GHG balance

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- (Limited Resource)
- (Macro or micro economic perspective?)
- Time Frame
- Which GHG's included
- Non-energy co-products or by-products
- C sequestration included?
- Avoided emissions (sequestration) of biomass reference use
- Optimization at global / national / project level?
- Cradle-to-grave or only conversion plant?

# Terrestrial C stocks

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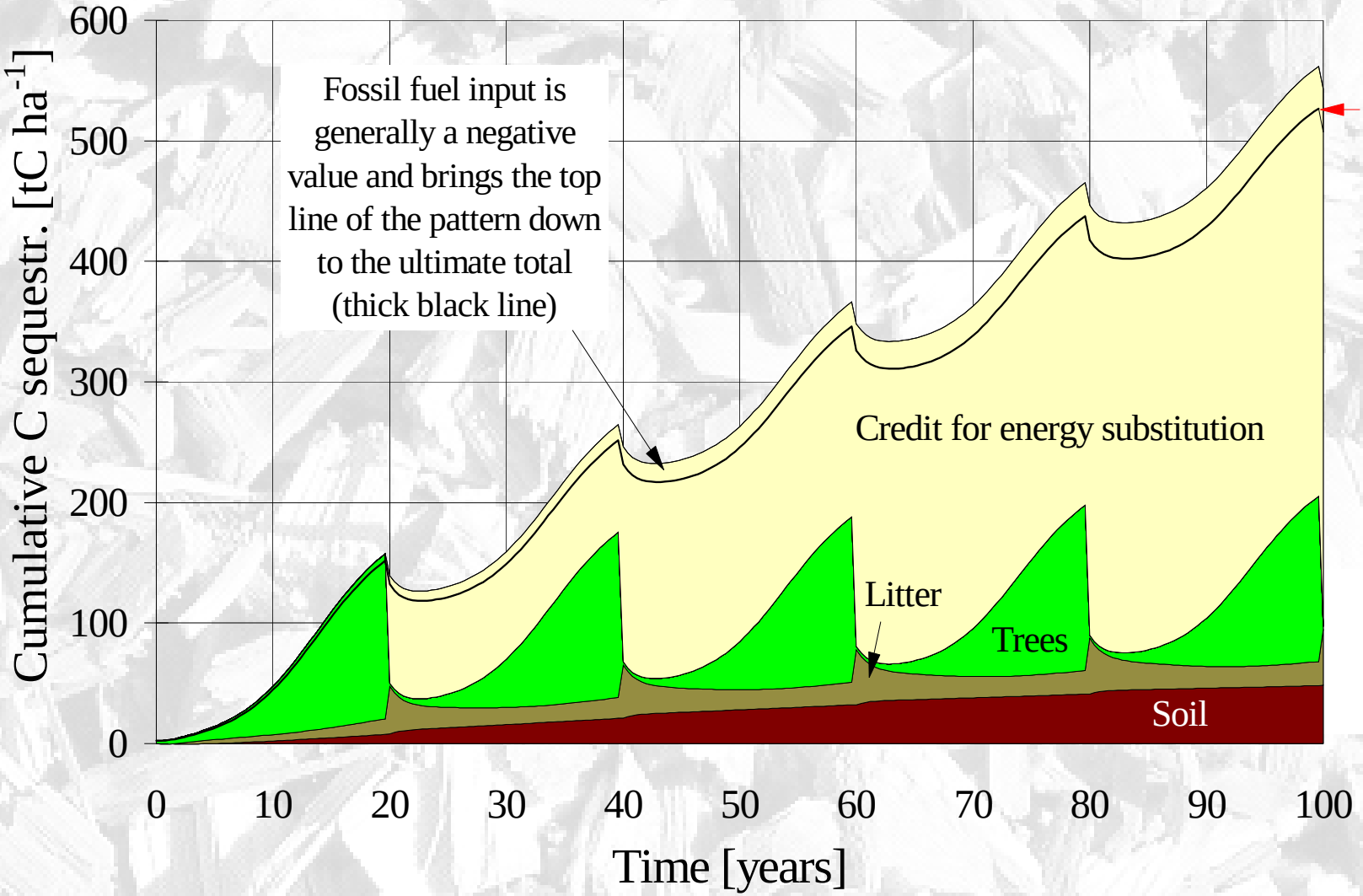
## Model results: fuelwood plantation on agricultural land



# Fuel cycle analysis Biogas

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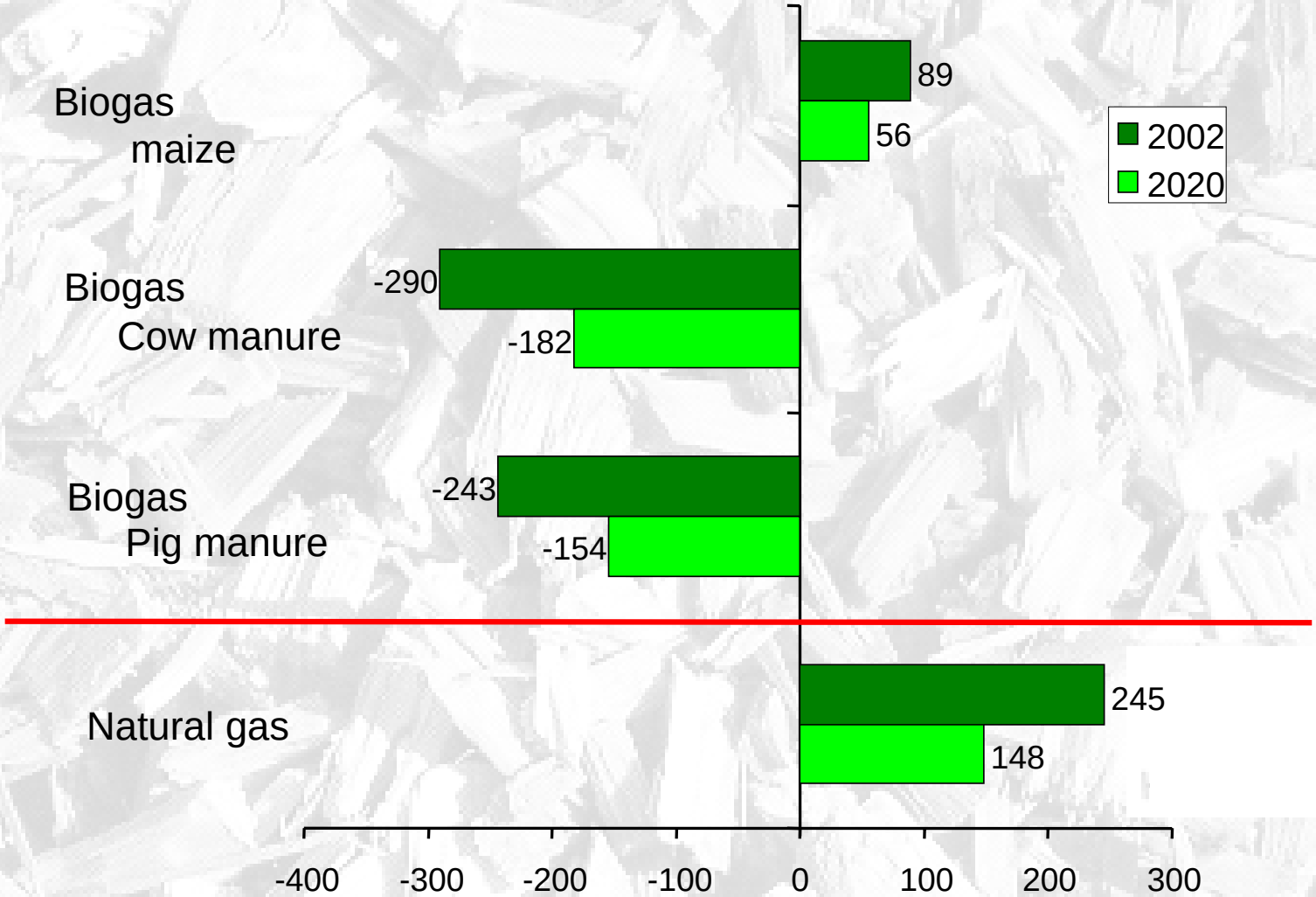


*Source: Jungmeier et al. 2003*

# Non-GHG Factors

- Other climate-relevant factors (surface energy balance; aerosols)
- Positive and negative externalities:
  - Energy Security
  - Local environmental issues (air pollution, biodiversity, …)
  - Socio-economic considerations (e.g., job creation)

# Optimizing use of financial resources, example

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- Case 1: 200 € / ton CO2 reduced
- Locally sourced biomass
- Replaces imported oil / gas
- Increases energy security, net gain in local jobs

- Case 2: 50€ / ton CO2 reduced
- Imported biomass (or CDM project)
- Replaces domestic coal
- Reduces energy security, net loss in local jobs

# Example: Liquid Biofuels Directive

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- 5,75 % liquid biofuels by 2012
- Reference system is diesel or gasoline, thus biofuel produced a proxy for emission reduction
- Questions:
  - Minimize LCA emissions of biofuels?
  - Minimize the use of land?
  - Minimize subsidy (tax reductions)?
  - Import biofuels or use domestic fuels?
  - With all this, maximize co-benefits
  - Should liquid biofuels obligations be made tradable?

# Conclusions

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- The optimal choice among bioenergy systems for GHG mitigation is not trivial
- Design details in projects will be driven by economics (in many cases including GHG prices)
- Design details in policymaking can greatly benefit from methodologies for optimizing GHGs reductions and other externalities
- Core topic for methodological work in Task38
- Decision support tool?