Energy and environmental analysis of biogas systems

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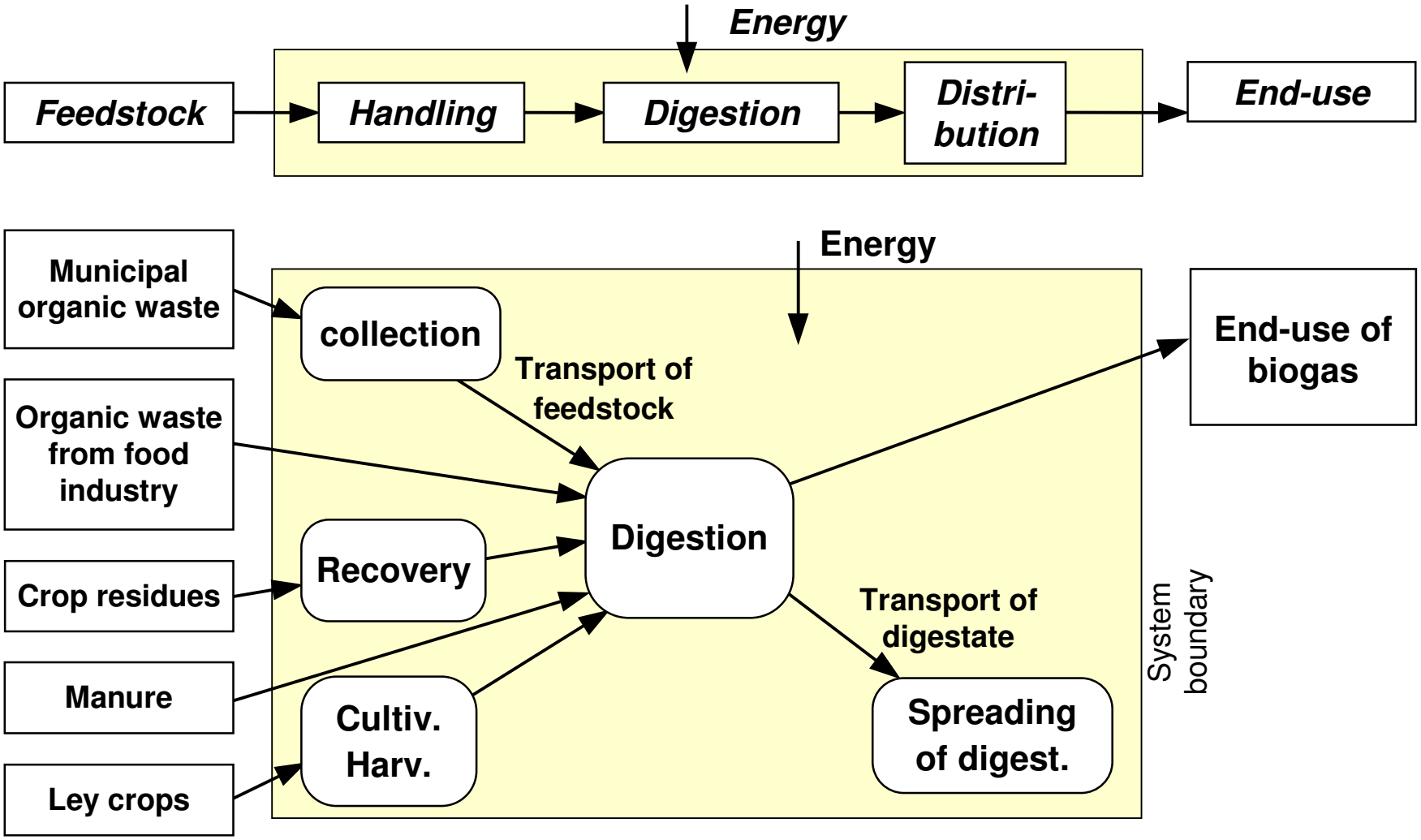
Biogas systems

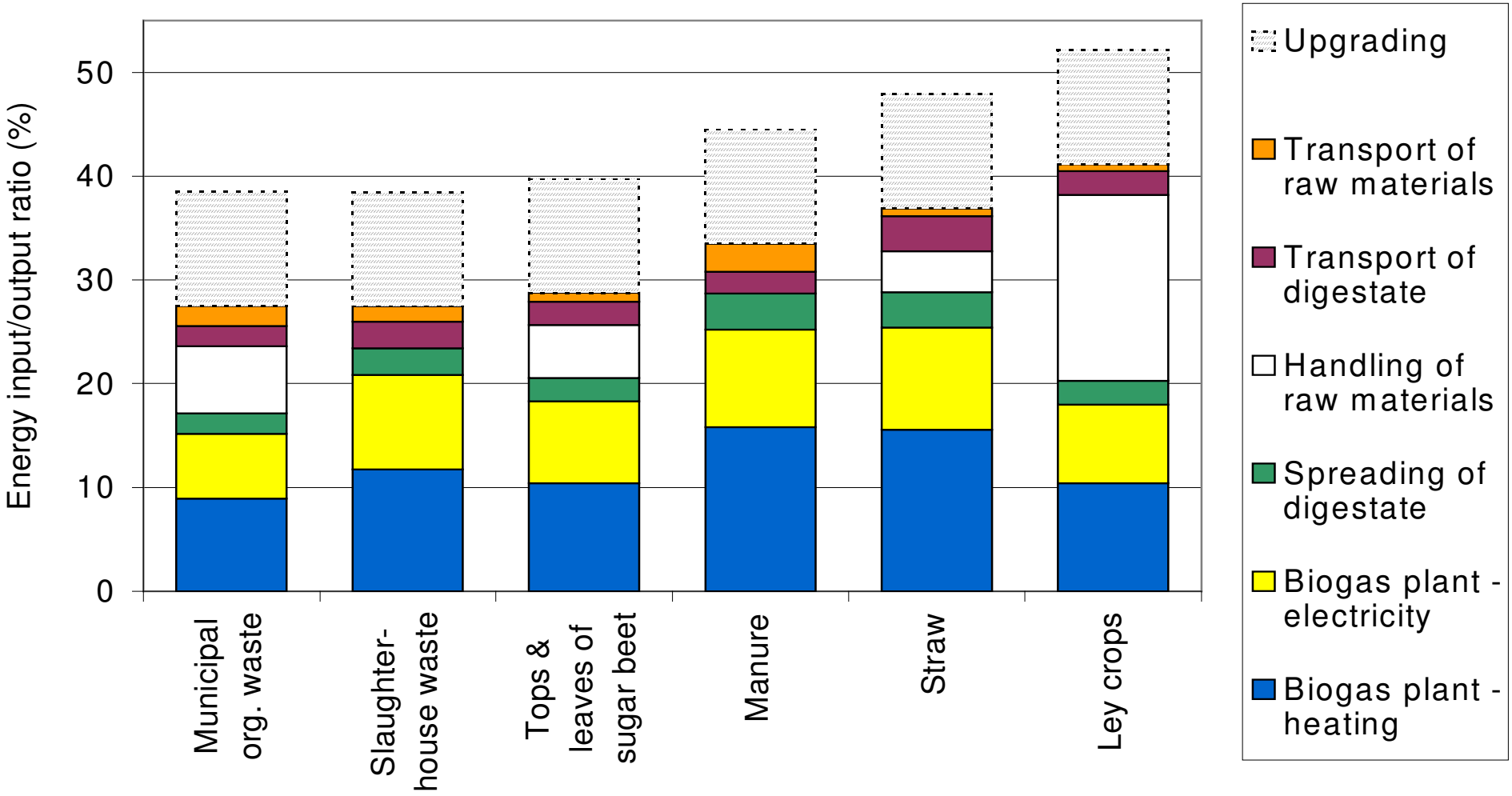
- Different types of feedstock
  - Waste and by-products, crop residues, energy crops
- Different digestion technologies
- Different end-use alternatives
  - Heat, electricity, transportation fuel (natural gas grid)
- Indirect environmental impact
  - Changed land-use, waste treatment, nutrient recirculat. etc.

∨ Complex systems to analyse -
the choice of systems boundaries and reference system will have a significant impact on the results

Energy systems analysis



Energy efficiency

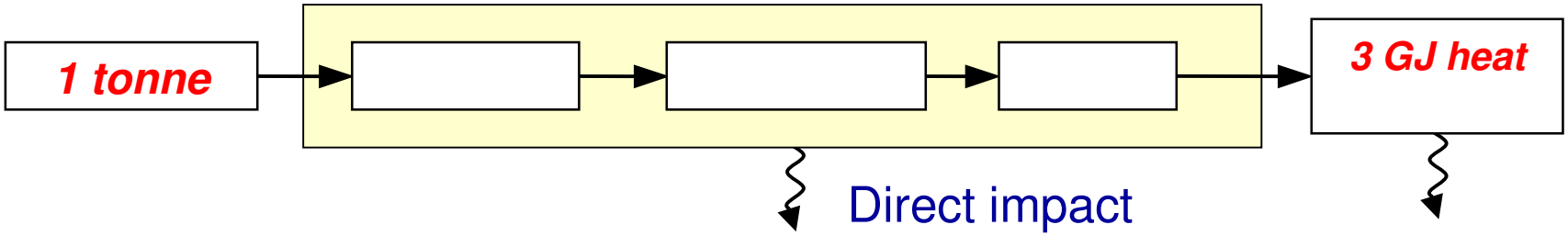


Energy input= Total input of primary energy

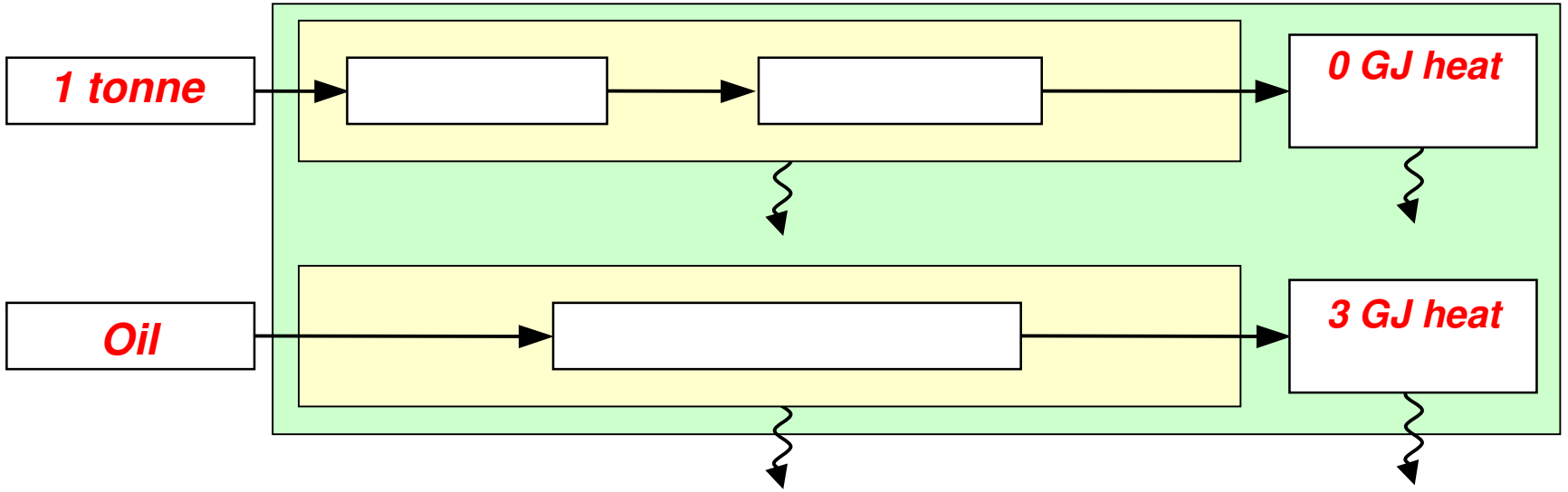
Energy output= Energy content in form of biogas

Environmental system analysis

Biogas system



Reference system



Expansion of system boundaries:

**Energy per tonne or hectare*

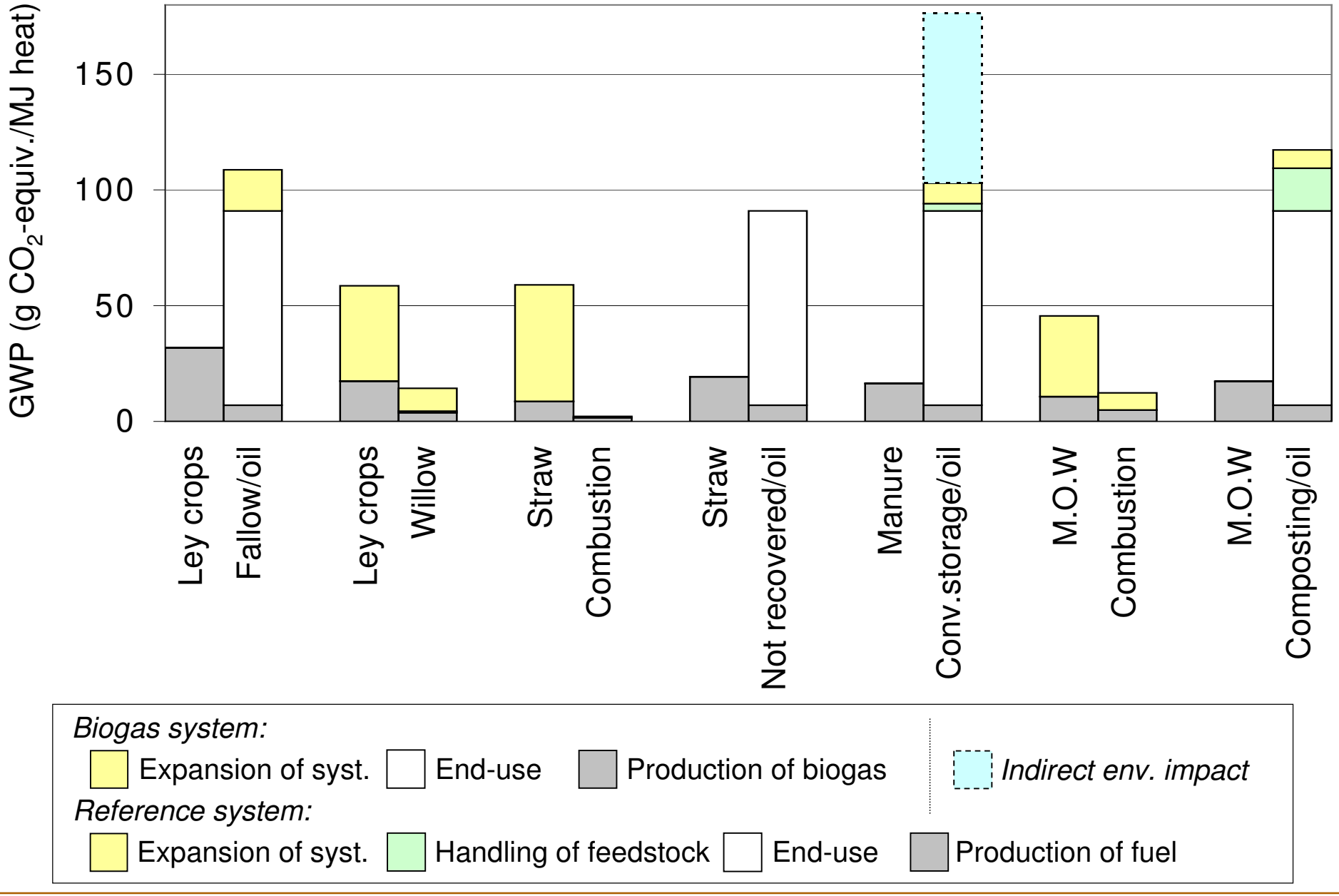
**Use of plant nutrients*

Indirect impact:

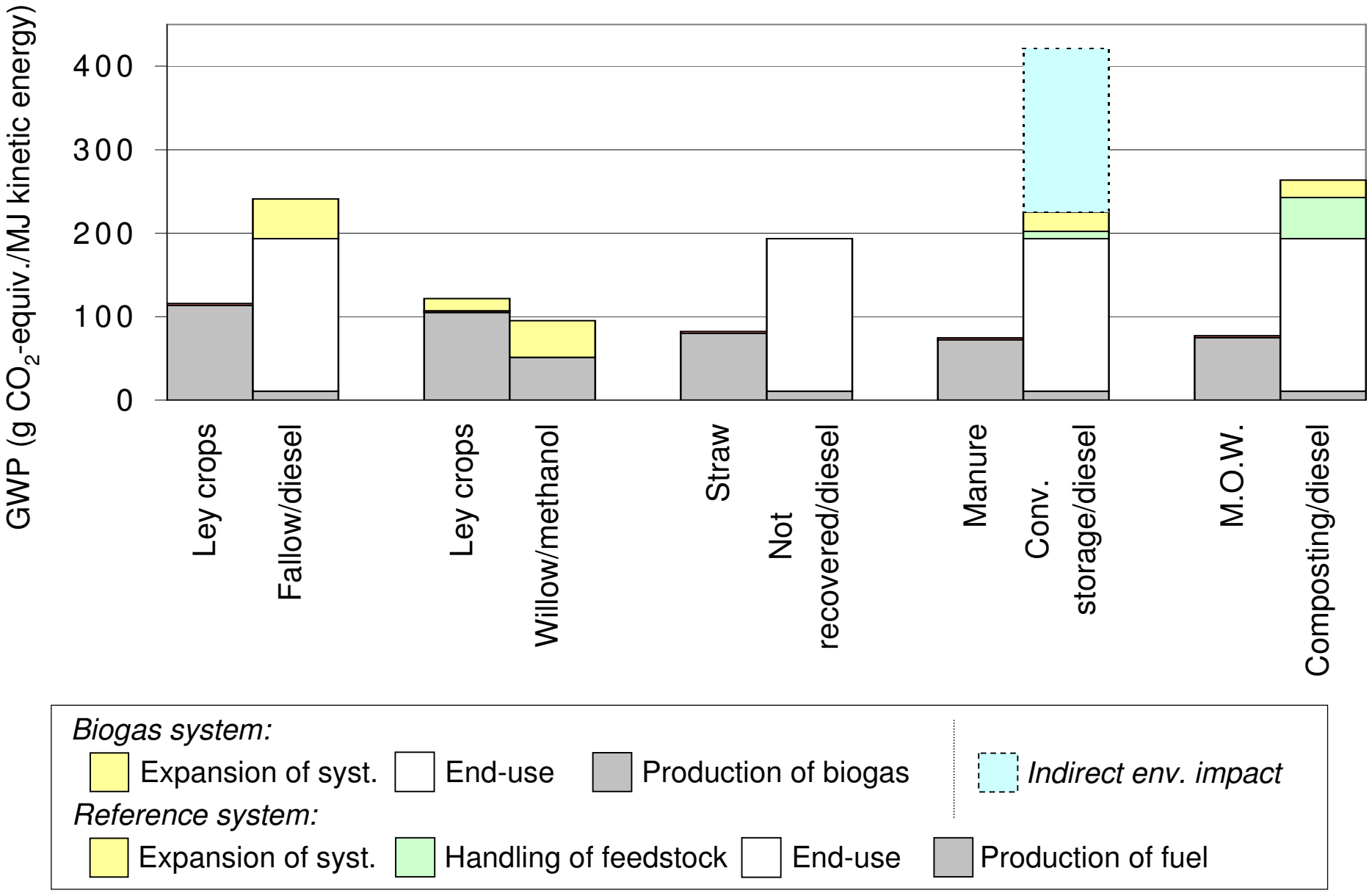
**Losses of nutrients*

**Losses of methane etc.*

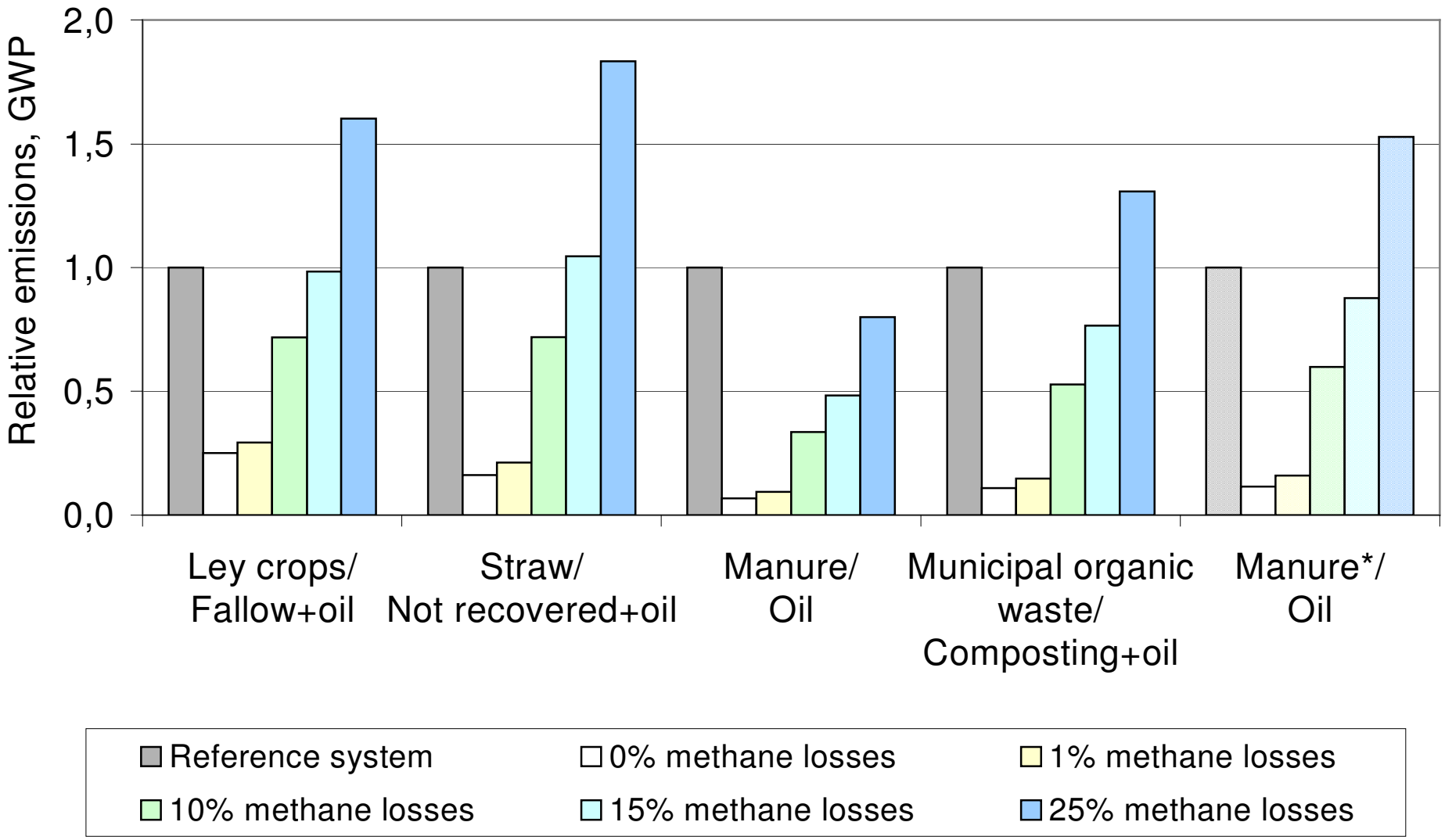
Greenhouse gases, large-scale heat



Greenhouse gases, heavy-duty vehicles

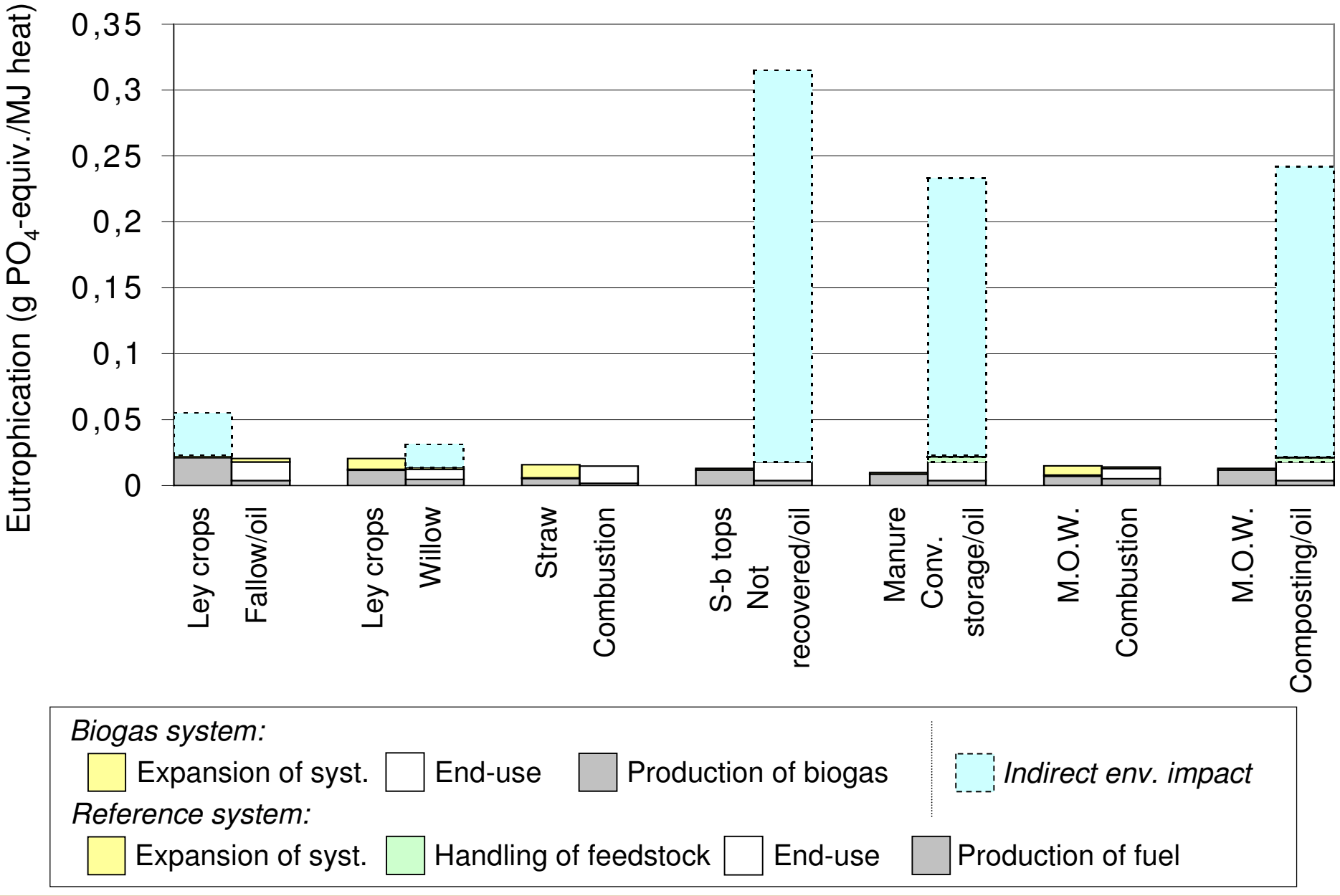


Losses of methane & GWP – large-scale heat

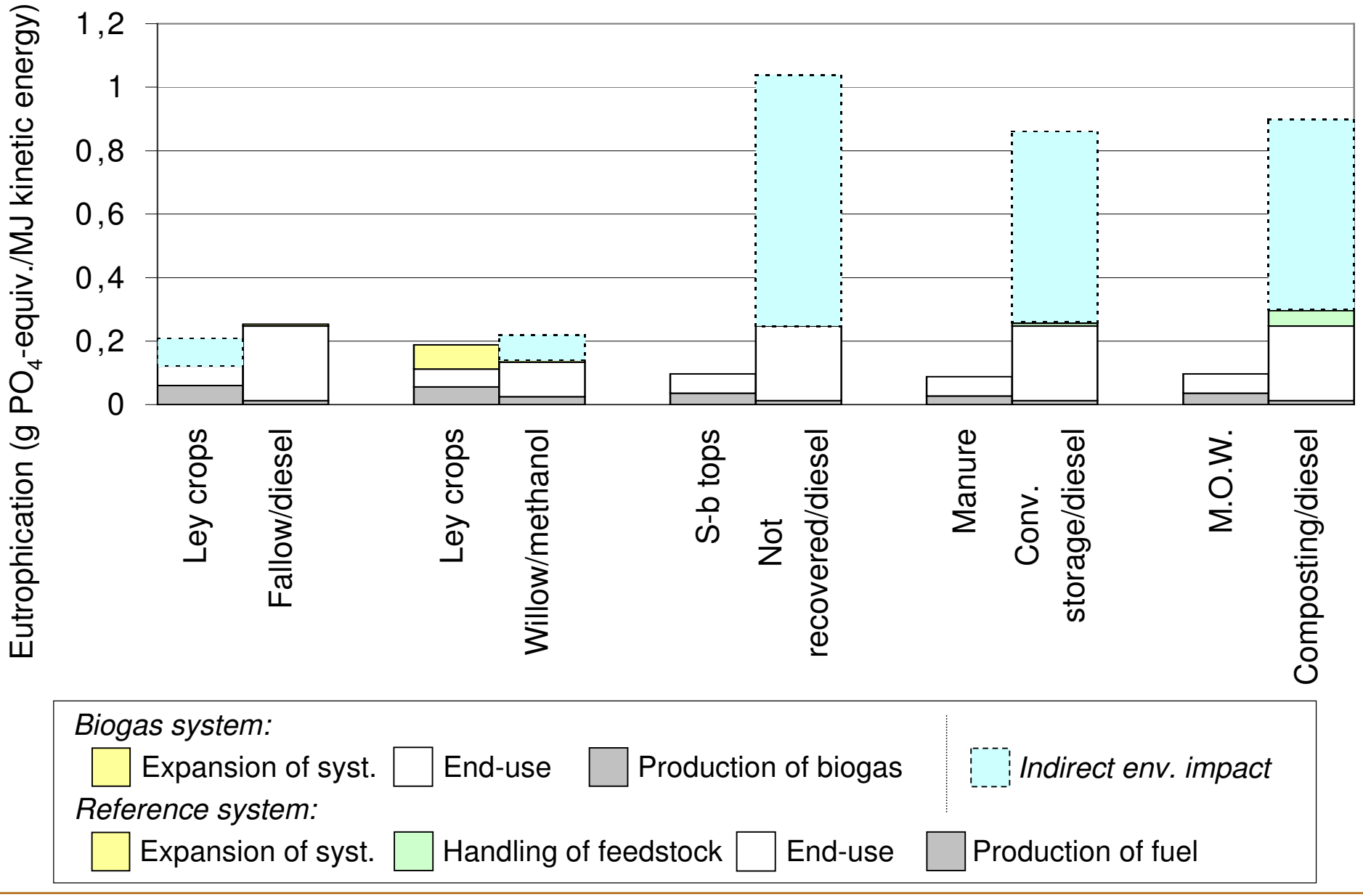


* *Without indirect env. effects*

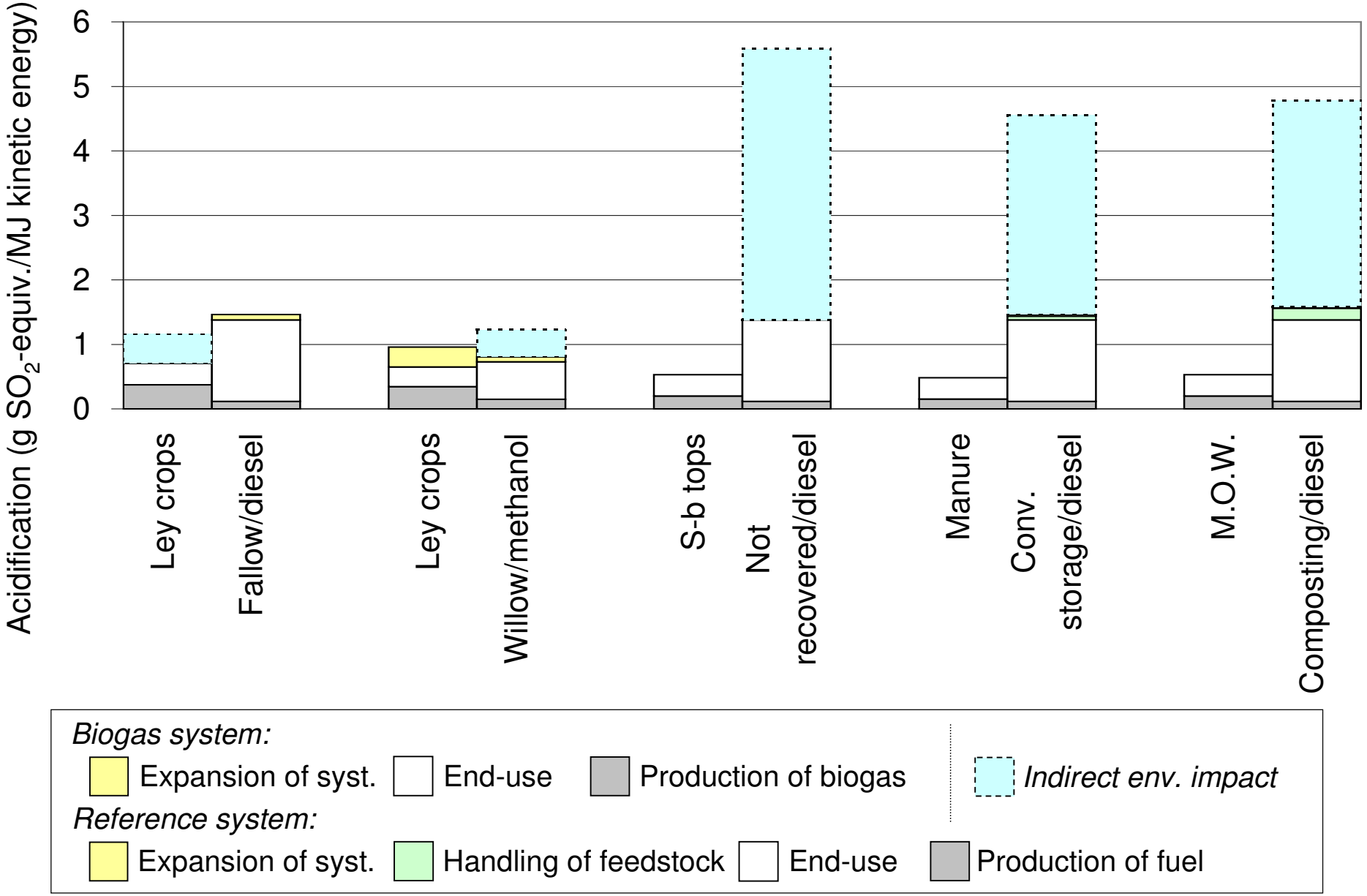
Eutrophication, large-scale heat



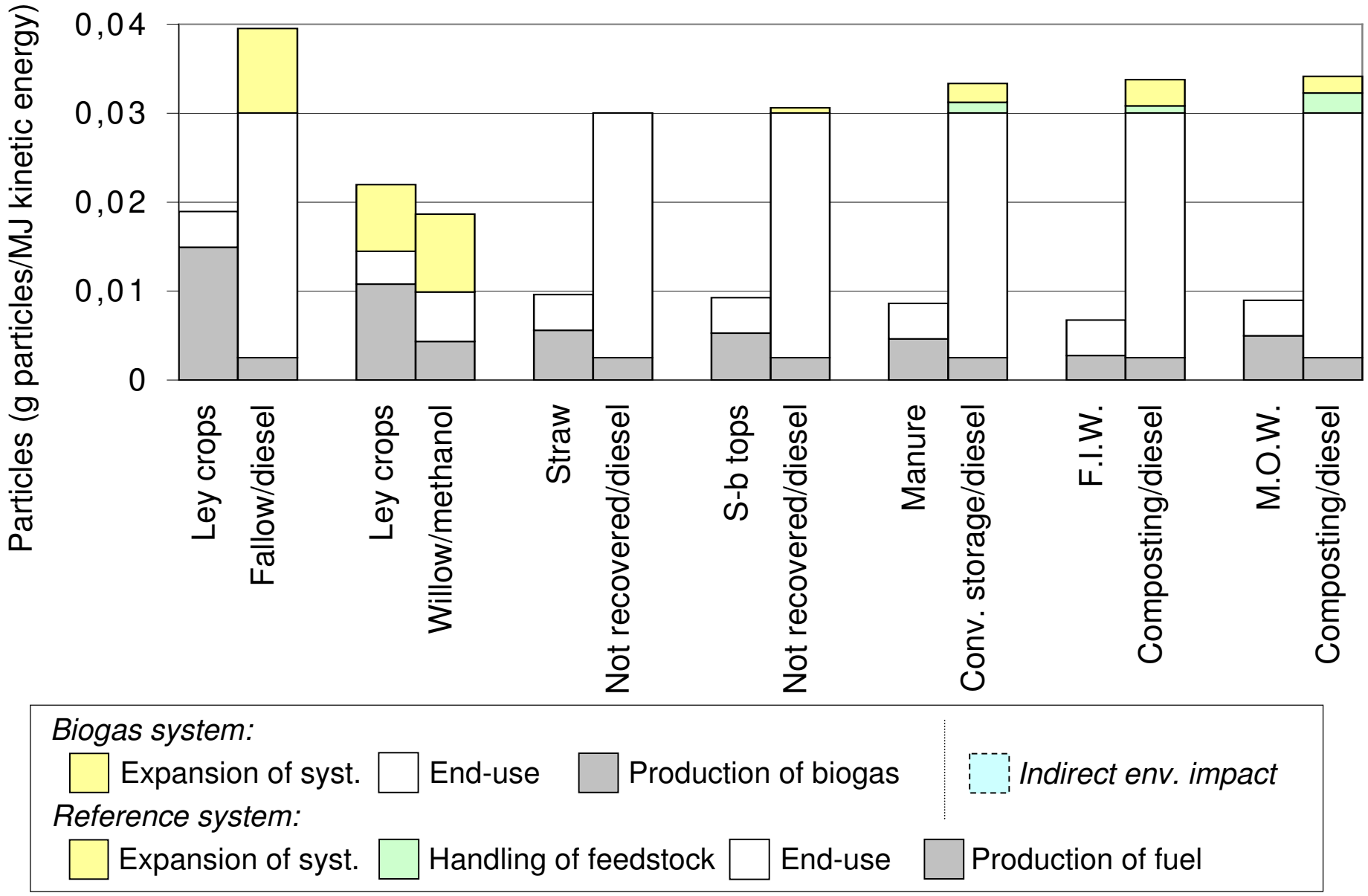
Eutrophication, heavy-duty vehicles



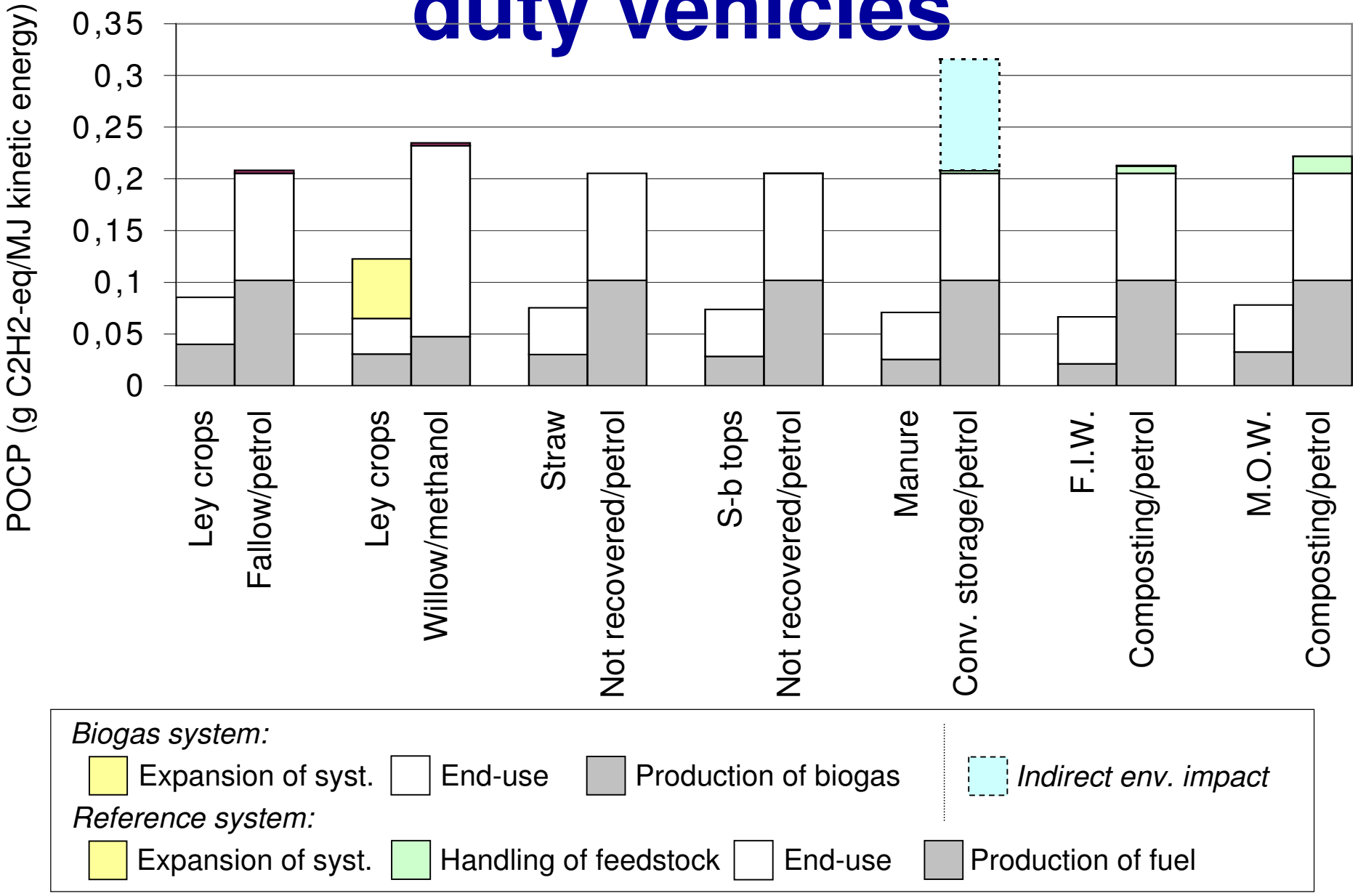
Acidification, heavy-duty vehicles



Particles, heavy-duty vehicles



Photochemical oxidants, light-duty vehicles



Conclusions from the systems analysis

Energy efficiency
- The energy input is normally equivalent to 20-40 % of the biogas output
- Some energy rich feedstock can be transported up to about 700 km before the energy balance turns negative

Greenhouse gases
- Biogas systems will lead to reduced GHG, except when the alternative is combustion of the biomass
- Important to minimize losses of methane

Eutrophication and acidification
- Significant benefits from indirect effects, which is this is often neglected in fuel-cycle analyses

Other air pollutants
- Reduced emissions in most cases, especially when the biogas is used as a transportation fuel

However
- There are considerable differences between different biogas systems and their environmental performance

Final conclusions

An extensive introduction of biogas systems has the potential to address several of our most serious environmental problems today – climate change, eutrophication and air pollution – in an efficient way

In order to maximise the various potential benefits, and to minimise potential negative effects, it is crucial that biogas systems are designed, located and utilised wisely

The complexity of biogas systems calls for special attention on the methodology employed in environmental studies (e.g. in setting the systems boundaries), and the correctness of the input data (assumed technology, specific local conditions etc.)