



Biomass transport for energy: Cost, energy and CO₂ performance of forest wood and manure transport chains in Switzerland

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Biomass for Swiss Energy Future
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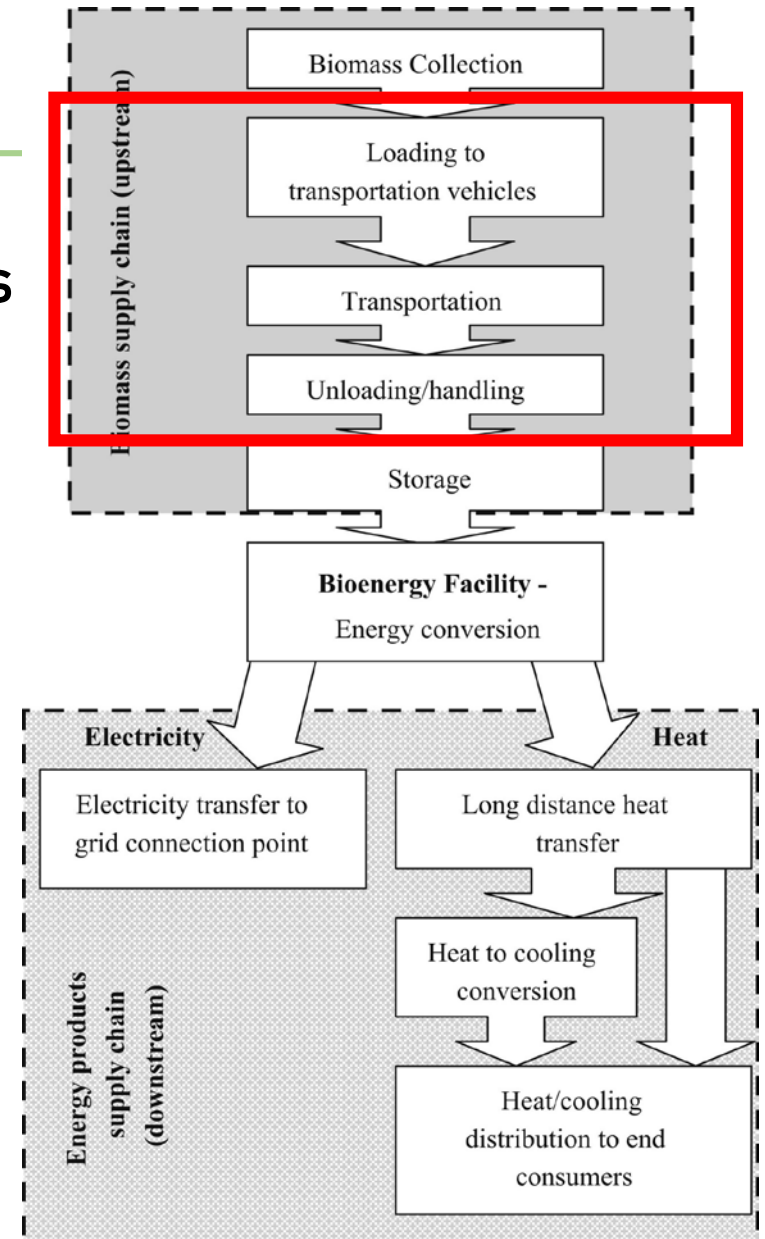
Objectives

- Forest wood and manure still have the highest potential for energy
- Lack of data on biomass transport chains
- Estimate the costs, energy requirements and CO₂ emissions



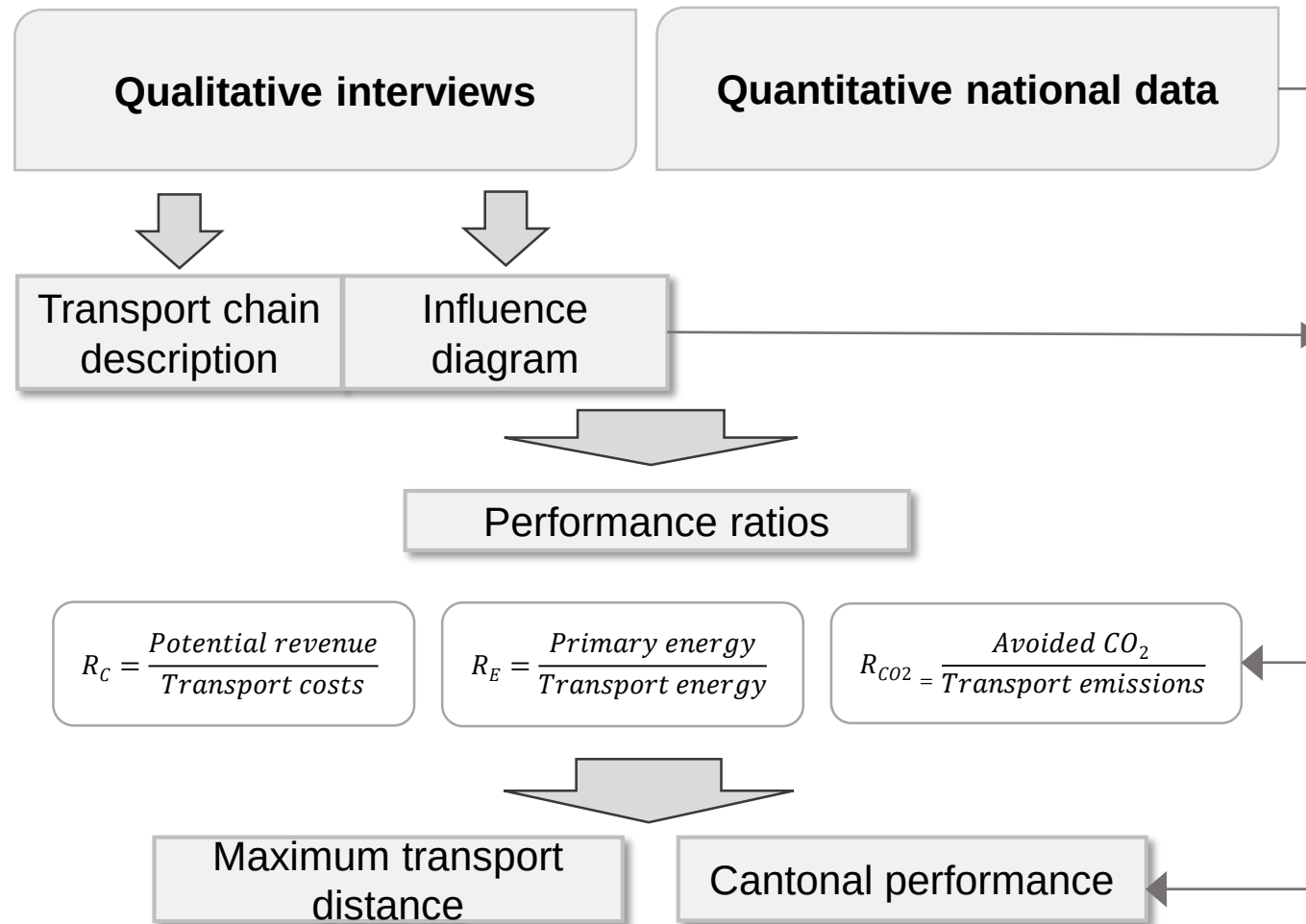
Biomass supply chain

- Many possible supply chains due to the specificities and variabilites of treatment of each biomass type
- Transport as part of the upstream supply chain
- How do we define it?
- Transport = Loading and unloading (when applicable preparation time)
 - + Transport
 - + Transport to fields (manure)
 - + Empty run



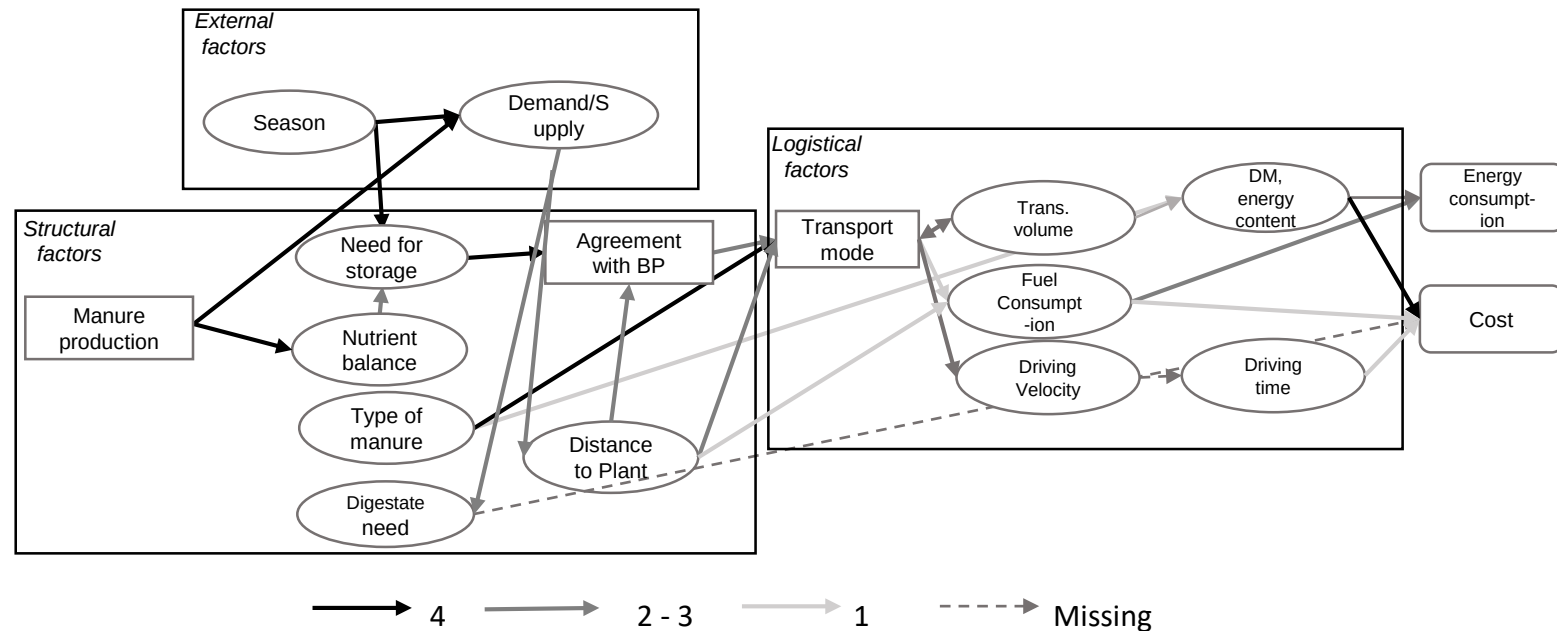
From Rentizelas, 2010 : «Locating a bioenergy facility using a hybrid optimization method»

Conceptual framework



Identification of transport chains using expert interviews

- Selection of interview candidates
- Selection of interview style – Mental models
 - Semi-structured
 - Sketching
- Creation of influence diagrams to understand the most important factors



Quantitative data

➤ Scientific literature

- **Process duration**
- **Energy use** (Fuel consumption according to driving velocity and road type)
- **Energy content**
 - Forest wood: Broadleaves and coniferous wood energy contents according to water content
 - Manure: previous research WSL, IPCC & KTBL biogas yields

➤ Other data

- **Costs** (Specialist magazines, discussions)
- **Forest wood**: Cantonal forestry statistics 2018
- **Manure flows**: Anonymized FOAG datas (HODUFLU year 2018)
 - Identification of agricultural biogas plants
 - ArcGIS for distance calculation between municipalities and plants

Transport chains

- Forest wood



Firewood



Woodchips

- Manure



Slurry
(liquid manure)



Solid manure

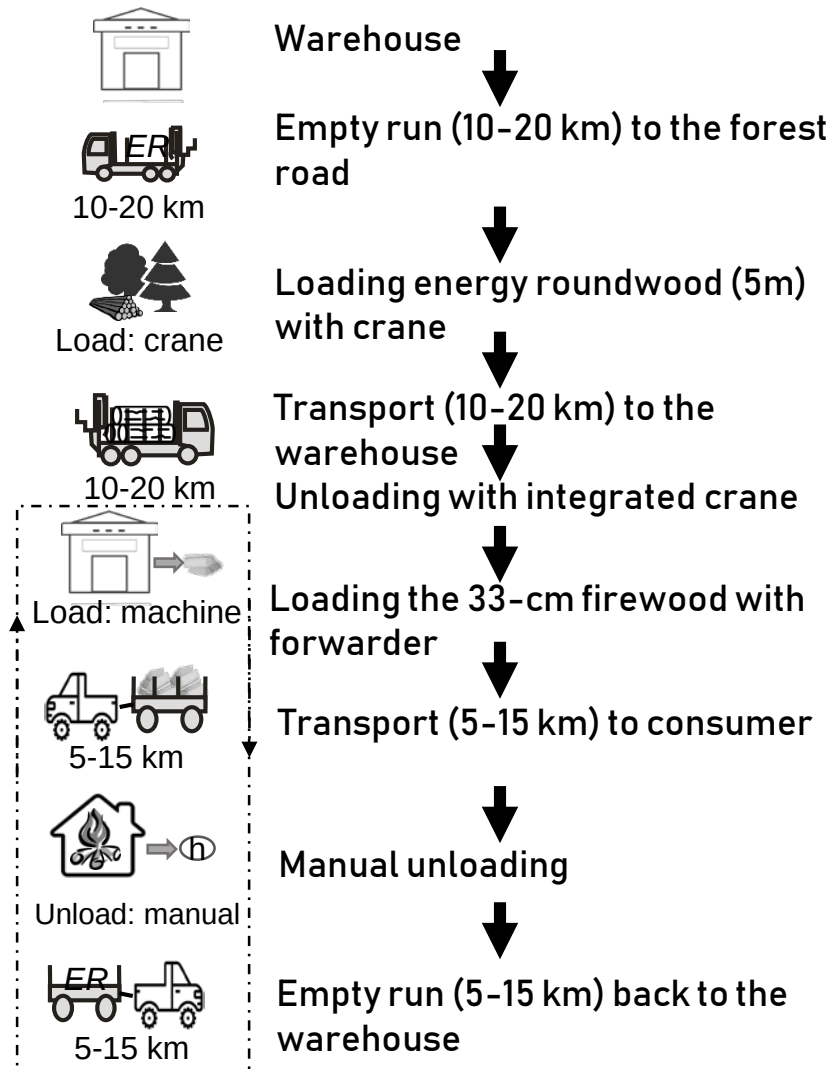
- 7 transport chains + 1 optional additional transport

- 5 transport chains

Differences

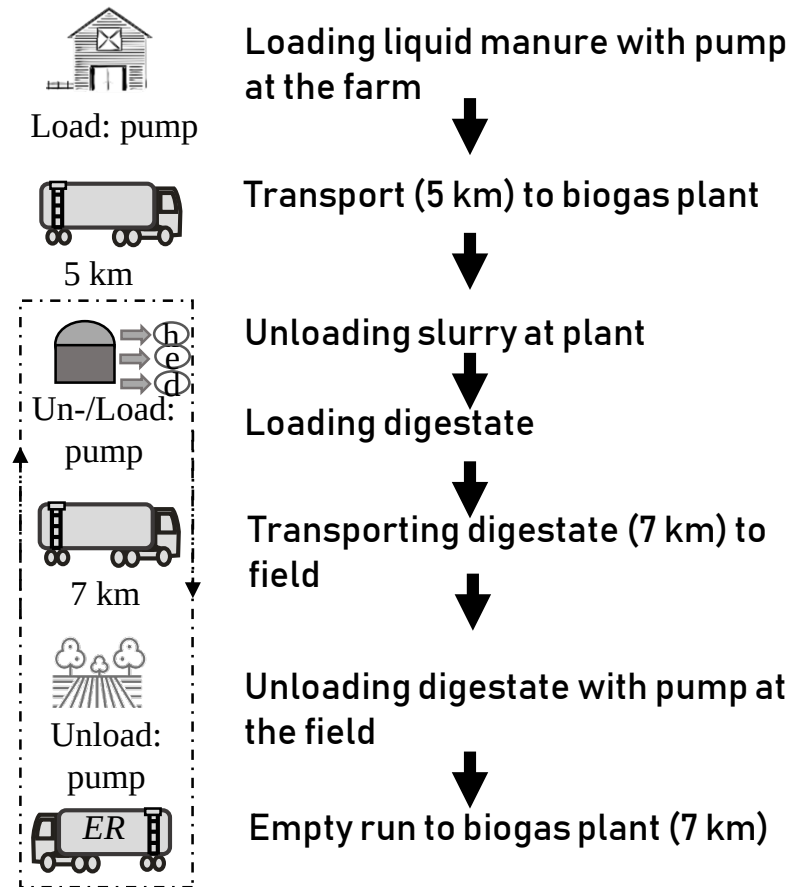
- Vehicles and transported volumes
- Distances
- Empty runs
- Service providers and consumers

Example transport chains (forest wood)



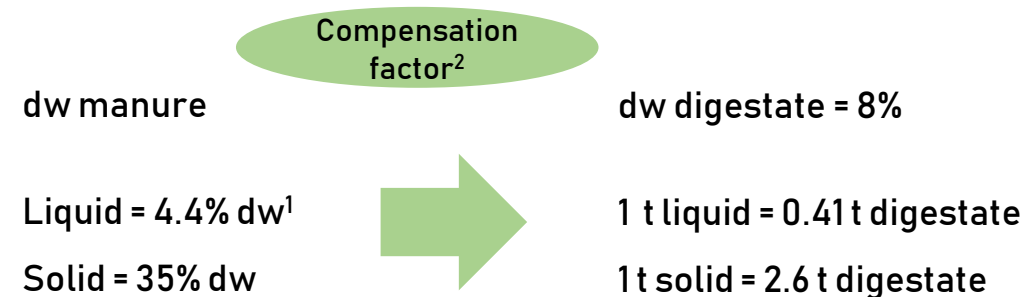
- Difference between professional, agricultural, and «small-scale individual» transport
- Distances estimated by the interviewed experts (min/max)
- Number of deliveries to final consumer according to the amount of roundwood brought to the warehouse in the first place

Example transport chains (Manure)



Professional liquid manure transport

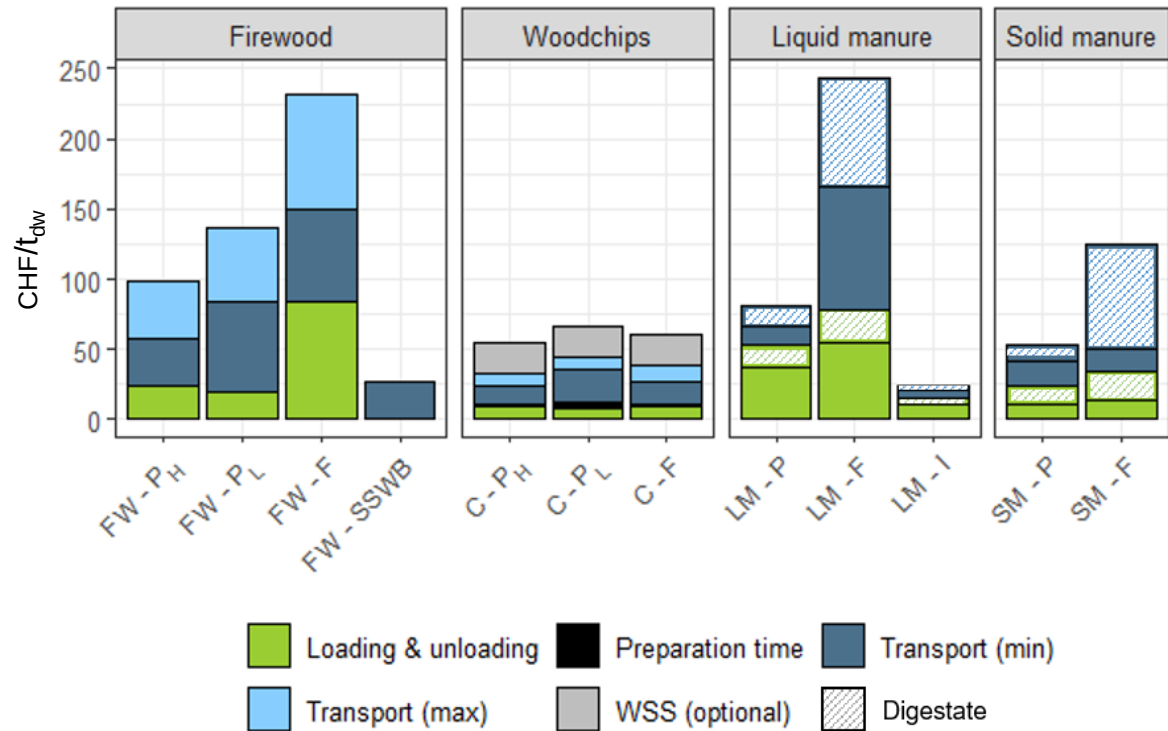
- Difference between professional and agricultural transport, as well as infrastructure-based on (underground pipes)
- The number of transport to fields according to the dry weight of the input and the output



¹per ton fresh mass

²considering mass reduction during fermentation process

Transport costs



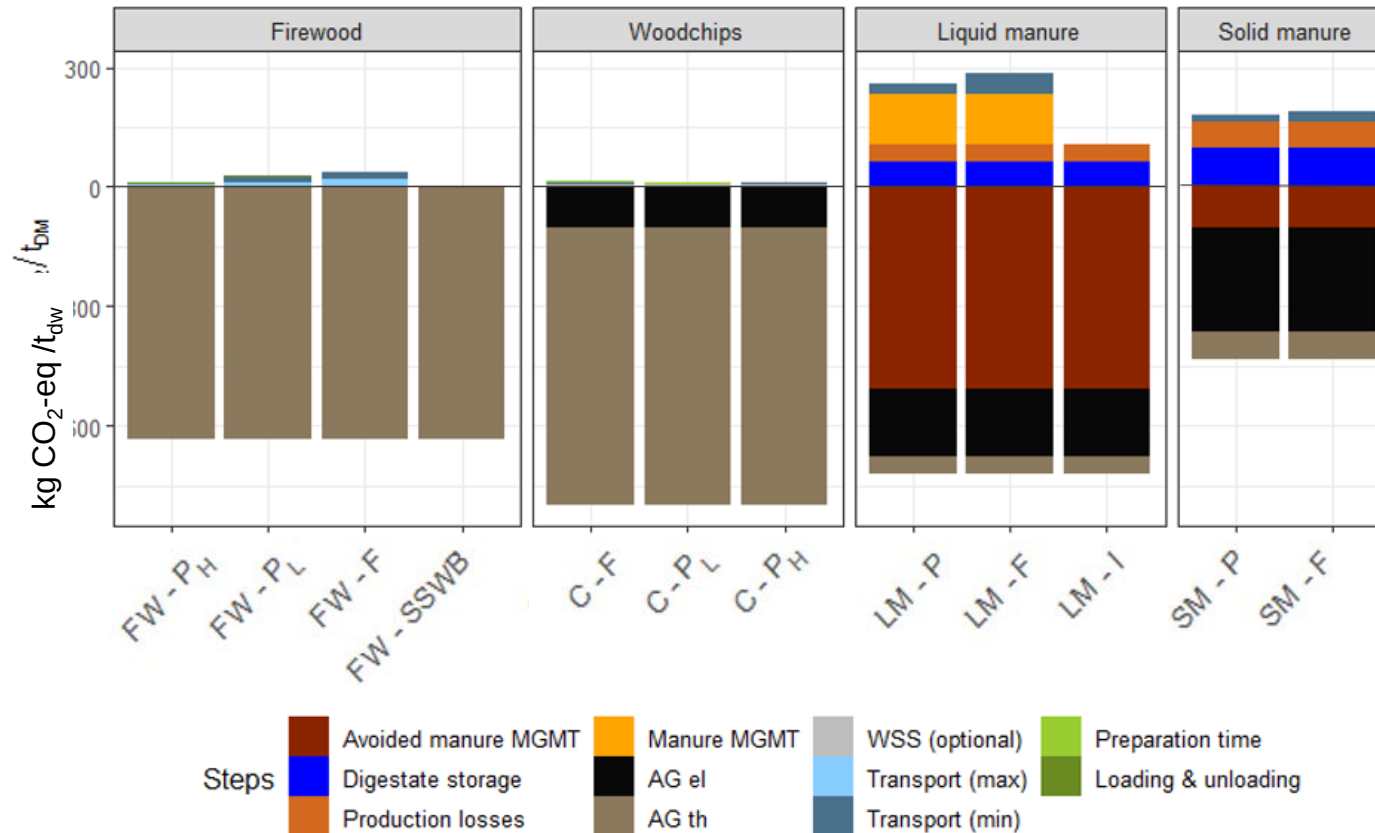
Results for broadleaves wood

- Costs vary between 24 and 244 CHF/t_{dw}
- Direct costs: salaries, machines fix+ variables costs
- Comparison with potential income from selling firewood (CHF/ster) or energy produced (Rp./kWh)

$$R_c = \frac{\text{Income}}{\text{Transport costs}}$$

- Economic performance ratios vary between 0.9 : 1 to 11.6 : 1

CO₂ Emissions



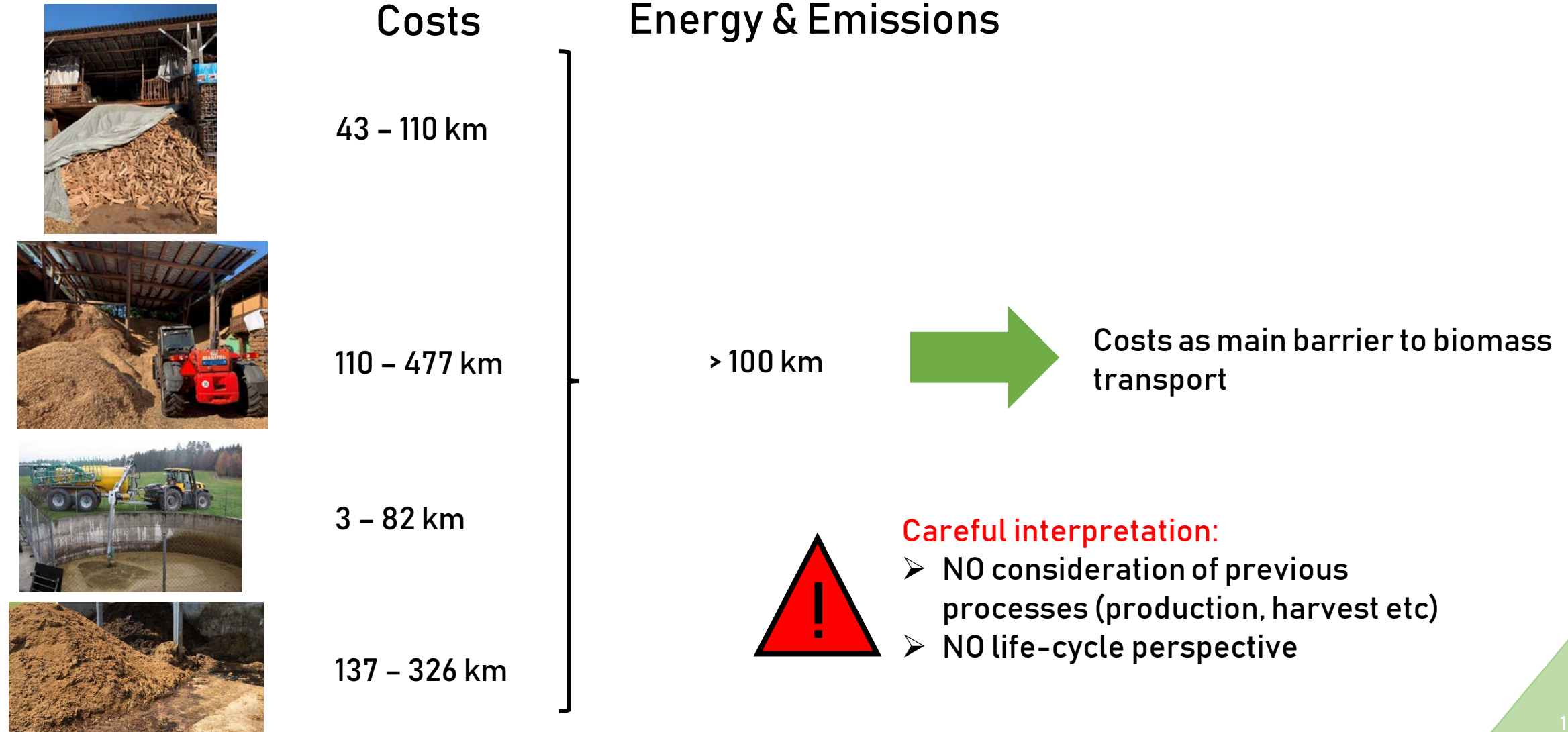
- Emissions reference case:
 - Energy from biomass substituted with imported electricity + fossil share of district heating
 - CH₄ and N₂O emissions from manure management
- Emissions project case :
 - Transport
 - Reduced CH₄ emissions from manure storage
 - CH₄ – from the biogas plant

$$R_{CO_2} = \frac{\text{Emissions from the project case}}{\text{Emissions from reference case}}$$

- R_{CO_2} wood → 16 : 1 to 253 : 1
- R_{CO_2} manure → 2.3 : 1 and 3.1 : 1 for manure

→ Similar trends for energy performance

Maximum transport distances



Conclusions

- Transport costs vary widely according to the feedstock and service provider
- Expect agricultural slurry transport, all analysed transport chains are performant
- Cost is the main barrier to biomass transport, NOT energy and CO₂ emissions



Thank you for your attention



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