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Economies of scale in biogas and organizational consequences: Common case study

October 28, 2014

Joint BioChain and BioValueChain workshop October 27-29, 2014 Aarhus University, Foulum

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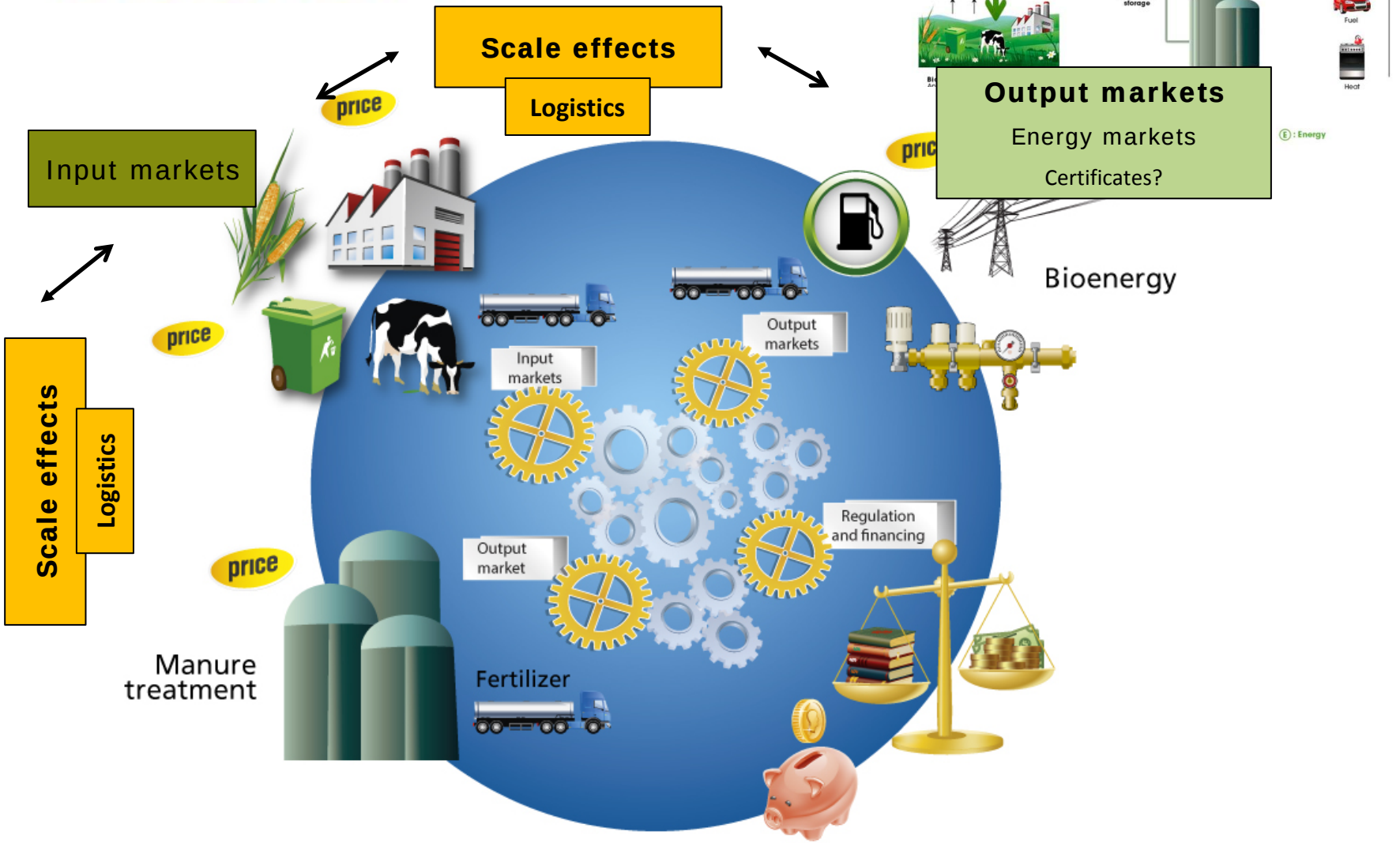
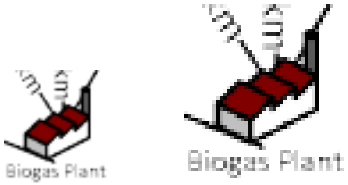
biochain



WP1
Value chain optimisation

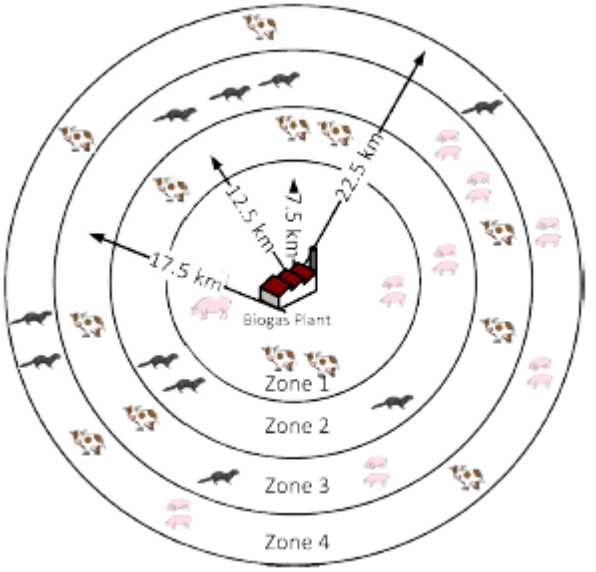
Scale effects – economies of scale

- Collection costs and density of resources
  - trade off between distance and size of resource



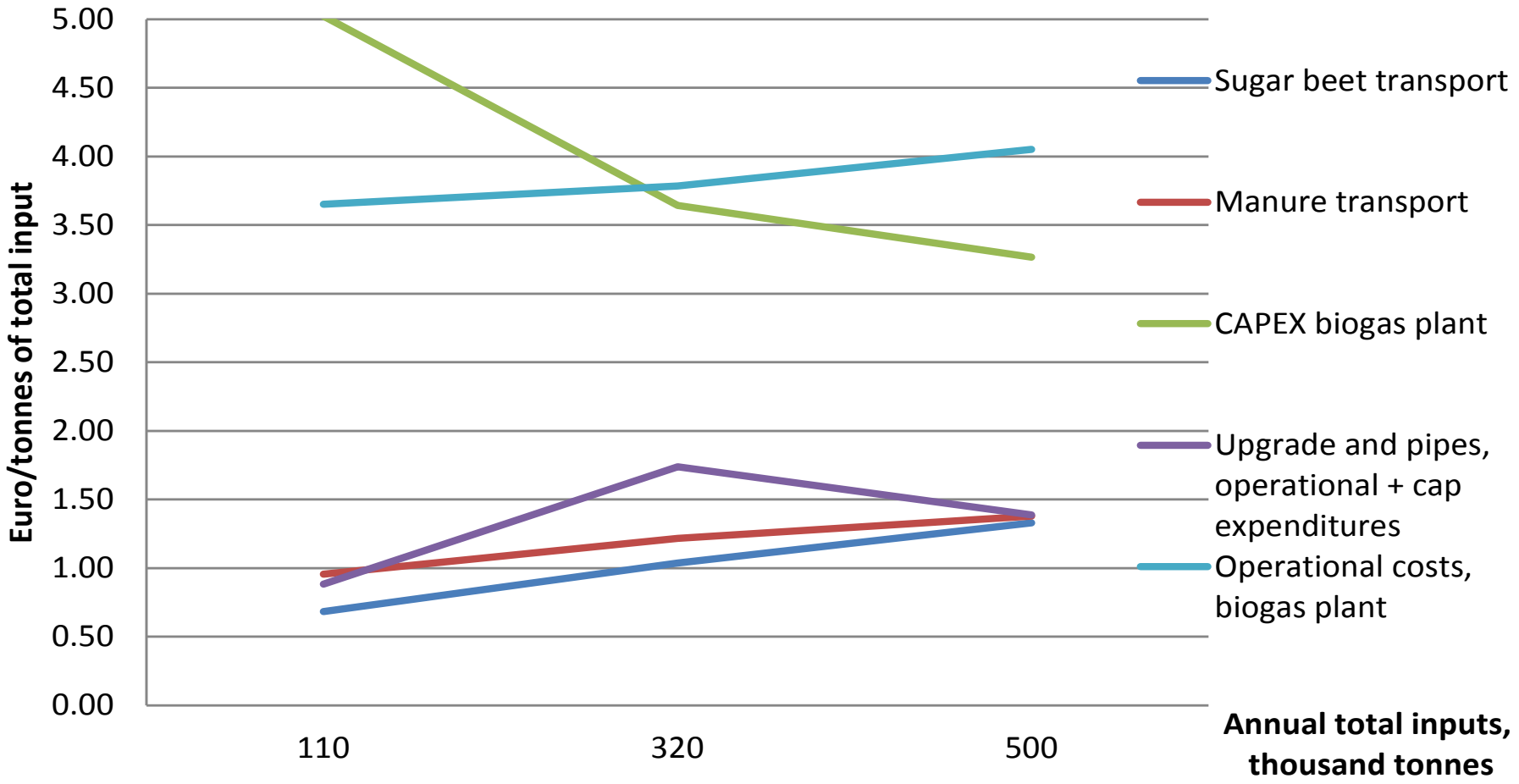
- Scale of biogas plant
  - economies of scale - capex expected

- Scale of upgrading facility and costs
  - storage cost
  - small scale no upgrade
  - large scale upgrade opex and capex



Trade off between rising operational and transport costs against reduced capital costs

Cost contribution and scale 12½% sugar beet



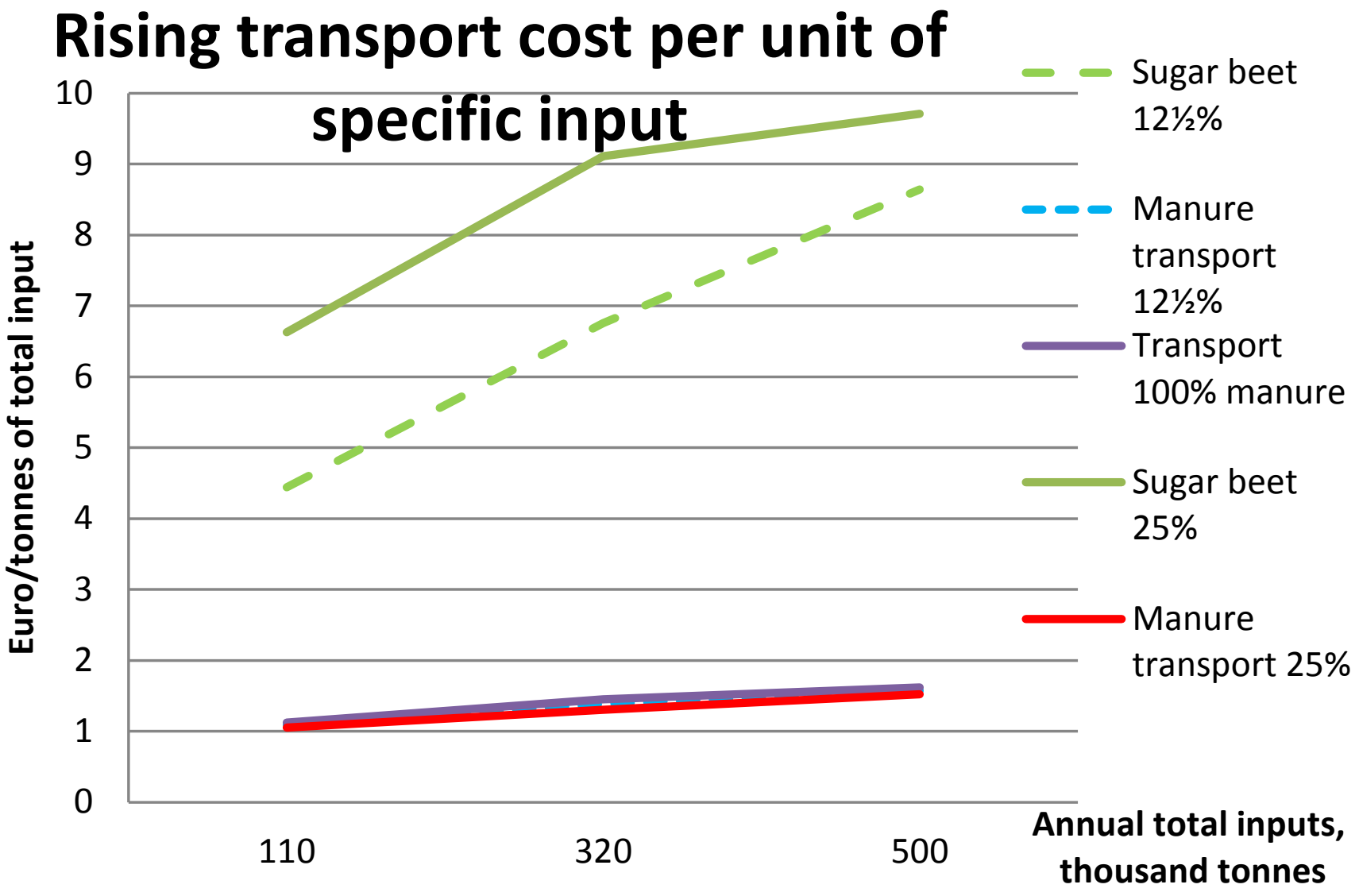
Transport costs: Tree scales of plant size and 3 cases of sugar beet inputs

- **Cost consist of transport time and loading**
  - Loading costs independent of scale but much higher for beet
  - Transport time only dependent on distance (50 km/h)
  - Capacity of beet carrier slightly lower than for manure but hourly costs also lower

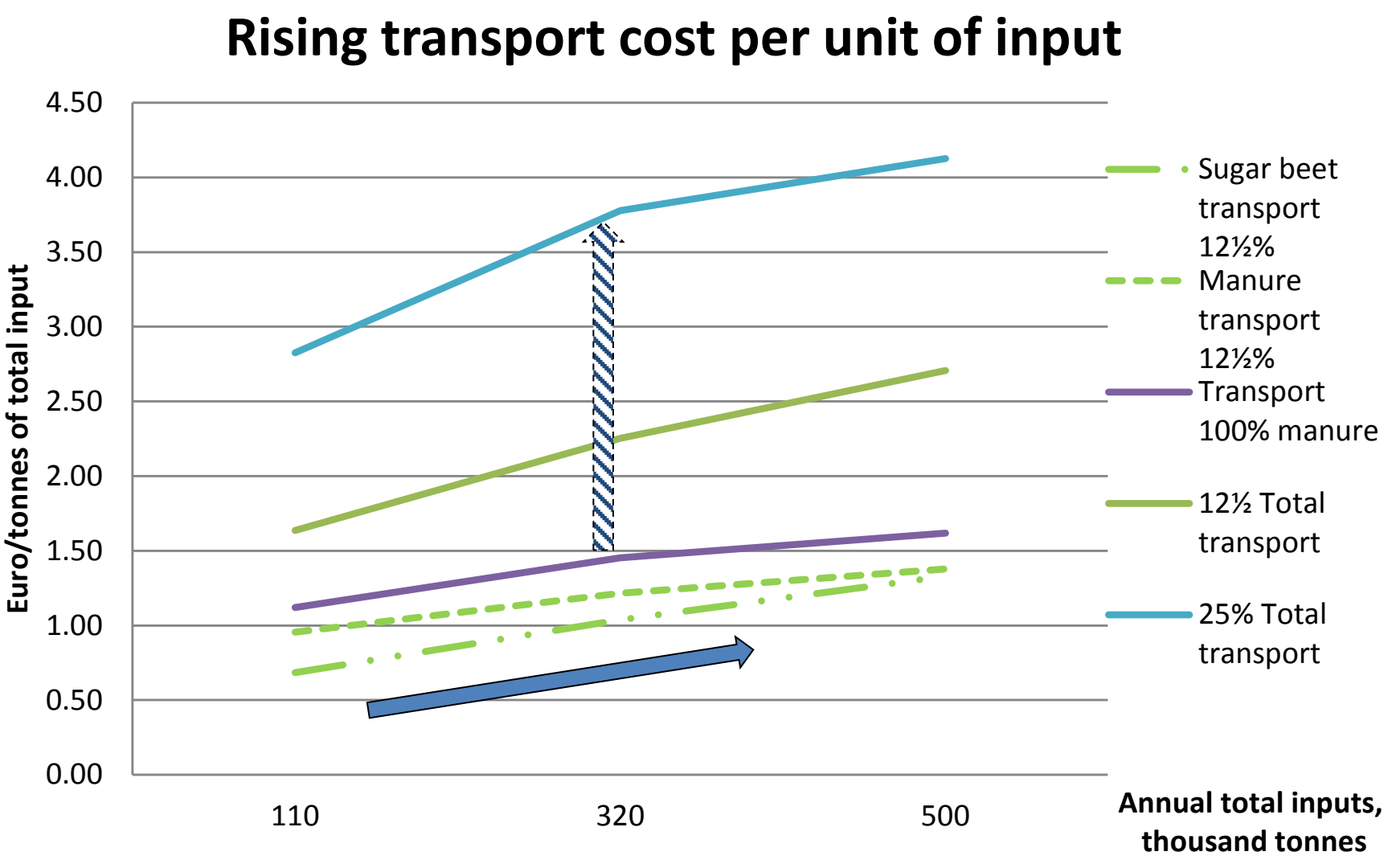
- **Scaling up the plant size**
  - Per unit cost increase for all 3 cases because average transport distance increase: from 6 km to 10 km for manure 100%; from 23 km to 61 km for beet in the 12½% case; and from 43 km to 71 km in the 25% case

- **Increasing the share of beet**
  - With increased beet share the unit cost increase a lot - *since the unit cost for beet transport is much higher than for manure*
  - For high beet share the unit cost also increase faster with larger plant size - *because the effect of inceased transport distance is more pronounced for beet* (especially from 110-320kt)

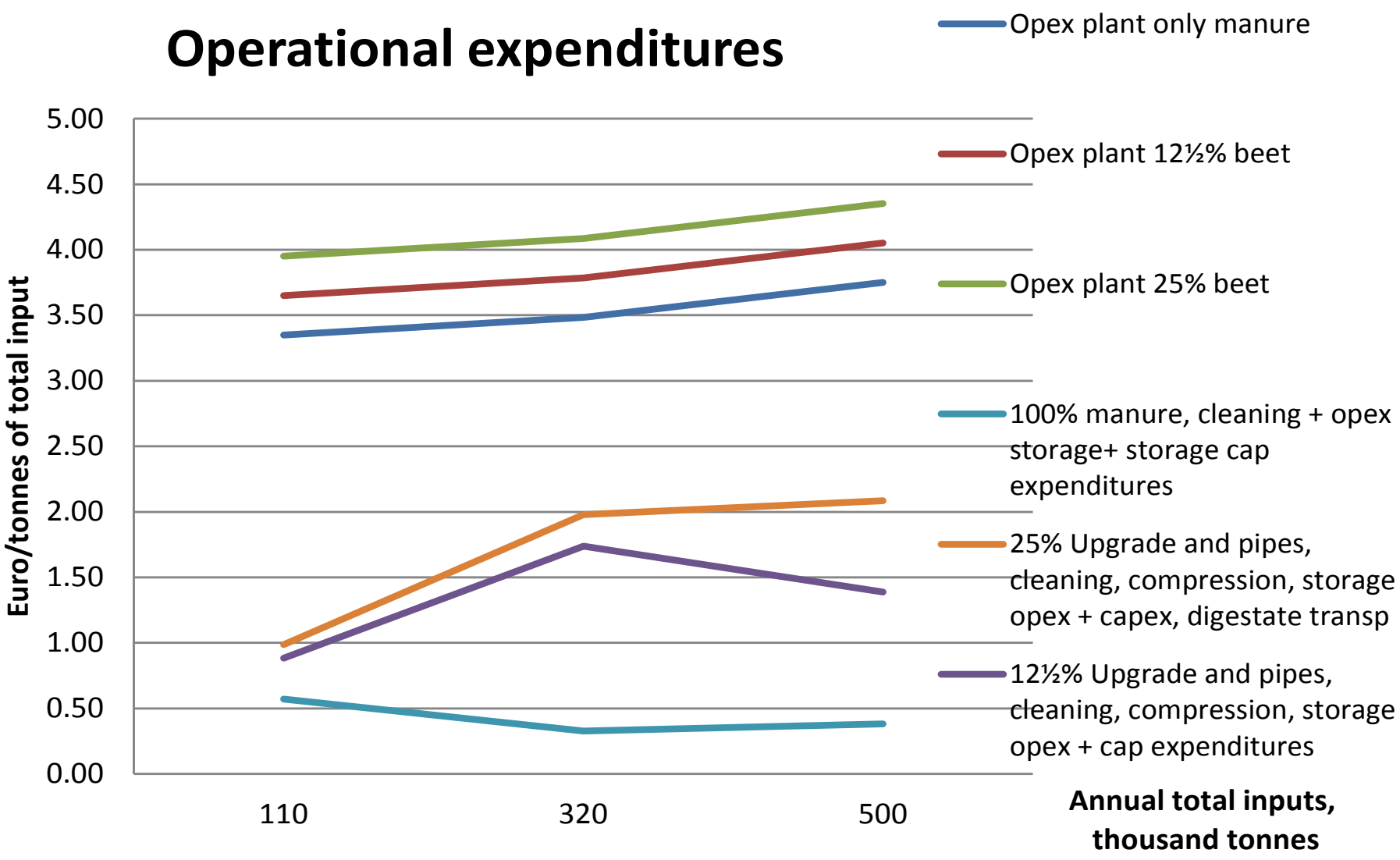
Tree scales of plant size and 3 cases of sugar beet inputs



Tree scales of plant size and 3 cases of sugar beet inputs



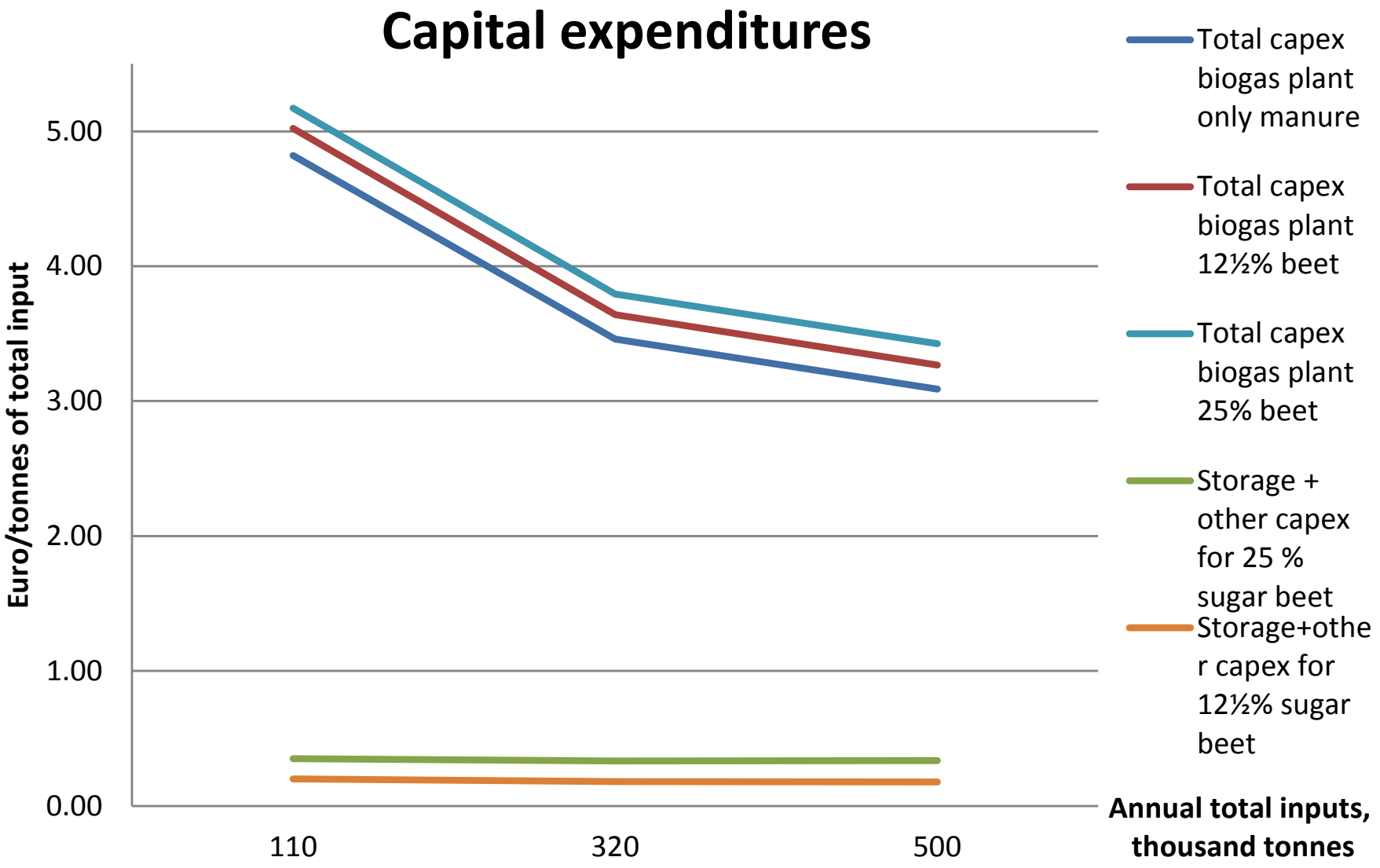
Operational expenditures and scale effects



Operational expenditures and scale effects

- **Operational costs constitute an important part of total costs**
  - includes wages and salary (also for handling of inputs - transport)
  - includes other material inputs than input to biogas reactor
  - includes process heat and electricty
- **Scaling up the plant size**
  - Scale effects for opex at plant are slightly negative as they increase the unit costs (this deserves more attention/check)
- **Increasing the share of sugar beet**
  - only increases the plant unit costs proportionally for all the plant sizes
- **Scaling up plant size involves additional opex at output level**
  - cleaning of gas, storage very little for pure manure
  - cleaing, upgrade and compression (losses) increase when scale shifts to upgrade for natural gas grid
  - shift involve negative scale effect - but from 320 to 500kt positive scale effect for 12½% sugar beet (due to capex of upgrade facility)

Capital expenditures and economies of scale



Capital expenditures show large economies of scale effects

- **Plant size and capex**
  - Economies of scale primarily achieved for this cost component
  - Largest effect from 110 - 320kt size
  - This scale effect outweigh the negative scale effects from transport costs and the slightly negative effect from opex

- **Increasing the share of sugar beet**
  - adds a proportional cost per unit due to investment in storage and pretreatment/handling equipment
  - no cost advantages or disadvantages of scale in this investment (could be further investigated)

Sensitivity and main parameters

- **Transport costs**
  - Concentration of input resources in general - farm structure and economic conditions
  - Sugar beet will be cultivated closer to plant in time
- **Input costs**
  - Price of manure - uncertainty high and regulation dependent (environmental, animal restrictions)
  - Price of sugar beet - dependent on alternative use (biofuel) and cost of alternatives (for cattle etc.) - world market links
- **Output**
  - Volume - uncertainty of given process should be low? at annual output level
  - Price of gas - for upgraded quantity the uncertainty in this 1/3 of revenue is high
  - Price support - if granted/approved it is stable
  - Price digestate etc. - high uncertainty

Scale effect in total

All costs, Euro/Tonnes			
Ratio\Scale	**110**	**320**	**500**
0/100	15.89	14.75	14.87
12½/87½	20.69	20.91	20.91
25/75	25.90	26.60	26.95

The cost advantage from capex declining is outweighed by rising operational and transport costs

Scale effect conclusion

- Cost reducing effect in scaling biogas plant size 110 00 to 500 00 tonnes (capex per input unit is reduced 35%, 0/100 mix)
- Negative scaling effect for transport costs (increase 45% for manure and 96% for sugar beet)
- Net effect (trade-off) result in equal costs per unit of the 320 000 t case and the 500 000 t case:
  - the benefit of scaling to 500 000 t (biogas plant capex + upgrade plant capex) is outweighed by the increase in transport costs

Positive scale effects are only dominating the net result for the pure manure case

Overall economic results

Net-income, Euro/Tonnes			
Ratio\Scale	**110**	**320**	**500**
0/100	-0.42	0.72	0.78
12½/87½	3.99	**4.23**	**4.23**
25/75	-4.34	-4.68	-5.03

Table 1 Net annual result per tonnes of inputs

The case with the highest profit is the 12½ % sugar beet case with a capacity of 500000 tonnes even though there are no particular scale effect here