

# *Biomass Energy: Cost and Scale Issues*

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# Background

- 25 years in energy industry, mainly in Alberta: oil sands and power industry (Epcor and Balancing Pool).
- Our knowledge of fossil fuel power costs is 10 times higher than offset costs.
- The search is for the “least negative”, and “do it all” isn’t good for society.

# Key Observations

- Biomass processing has fundamentally different economics than fossil fuel utilization.
- Scale has an enormous impact on the cost of biomass energy.
- Some current guidelines for project scale are questionable.

**Focus is on transportable waste.**

# Outline

- Cost components in using biomass for energy:
  - Fuel acquisition (harvesting): get it.
  - Fuel delivery (field to plant): move it.
  - Fuel conversion: use it.
- Why does an optimum size exist, and how significant is it?
- Implications for biomass utilization.

# Biomass in the Broadest Sense

- Forest harvest residues.
- Otherwise unusable standing trees.
- Agricultural residues: straw, corn stover.
- Animal manure.
- Food processing wastes.
- Municipal Solid Waste

**Mill waste is largely spoken for.**

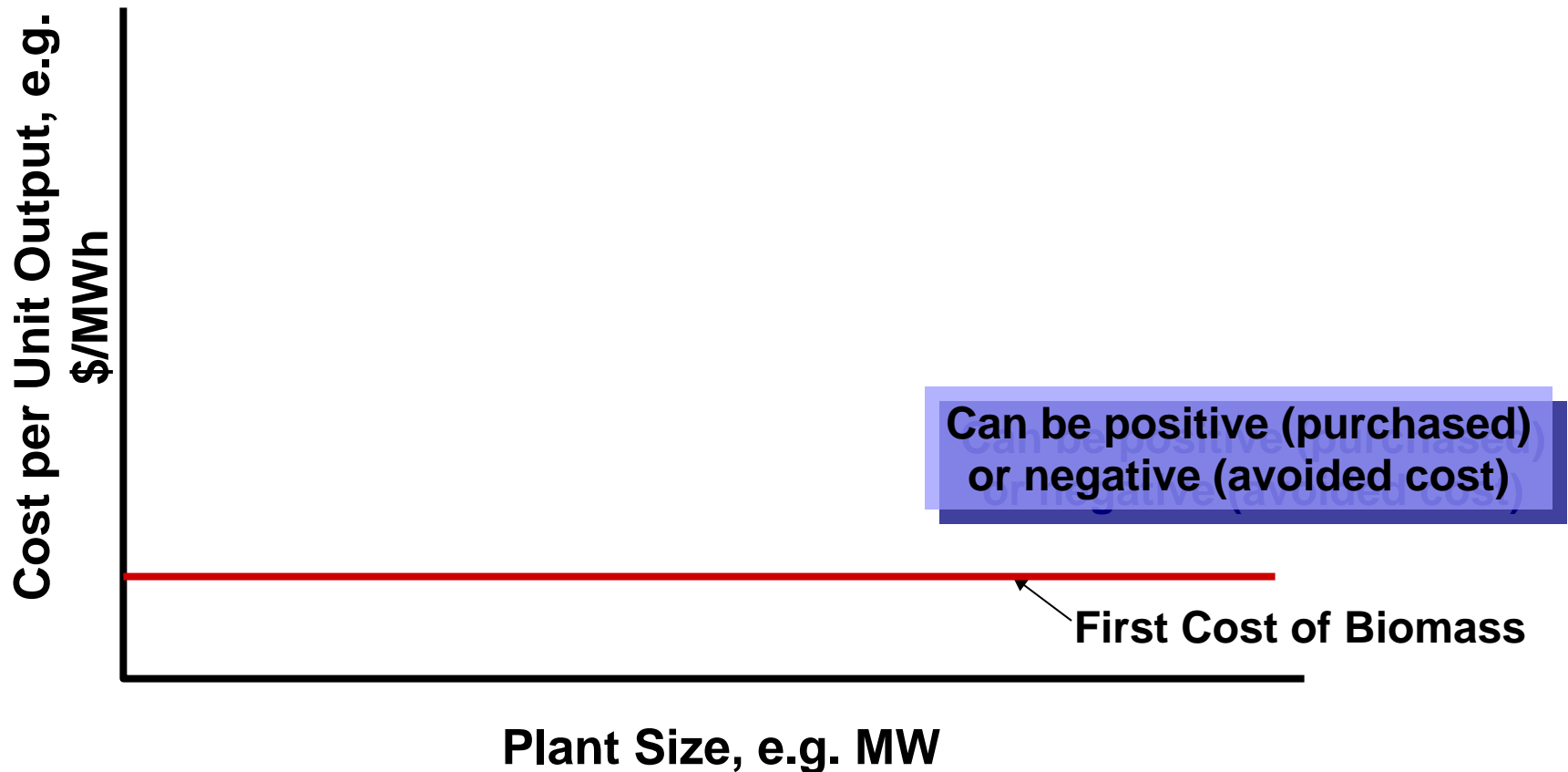
# Biomass Costs Vary

<b>Biomass</b>	<b>Get it</b>	<b>Move it</b>	<b>Use it</b>
MSW	-	0	Rare
Mill Res.	-	0	Common
Ag. Res.	+	+	Growing E
For. Res.	0/-	+	Finland
Manure	+/0	+	Growing E

# Does the Biomass Have a First Cost?

- First costs include:
  - **Field processing** (if any): e.g. straw baling.
  - **Transport** to the side of the road/feedlot.
  - **Processing** (if any) at roadside: e.g. tarping of straw, chipping of forest harvest residues.
  - **Payments** to the owner: e.g. nutrient replacement, royalty to crown.
- Costs are **independent of scale / distance.**

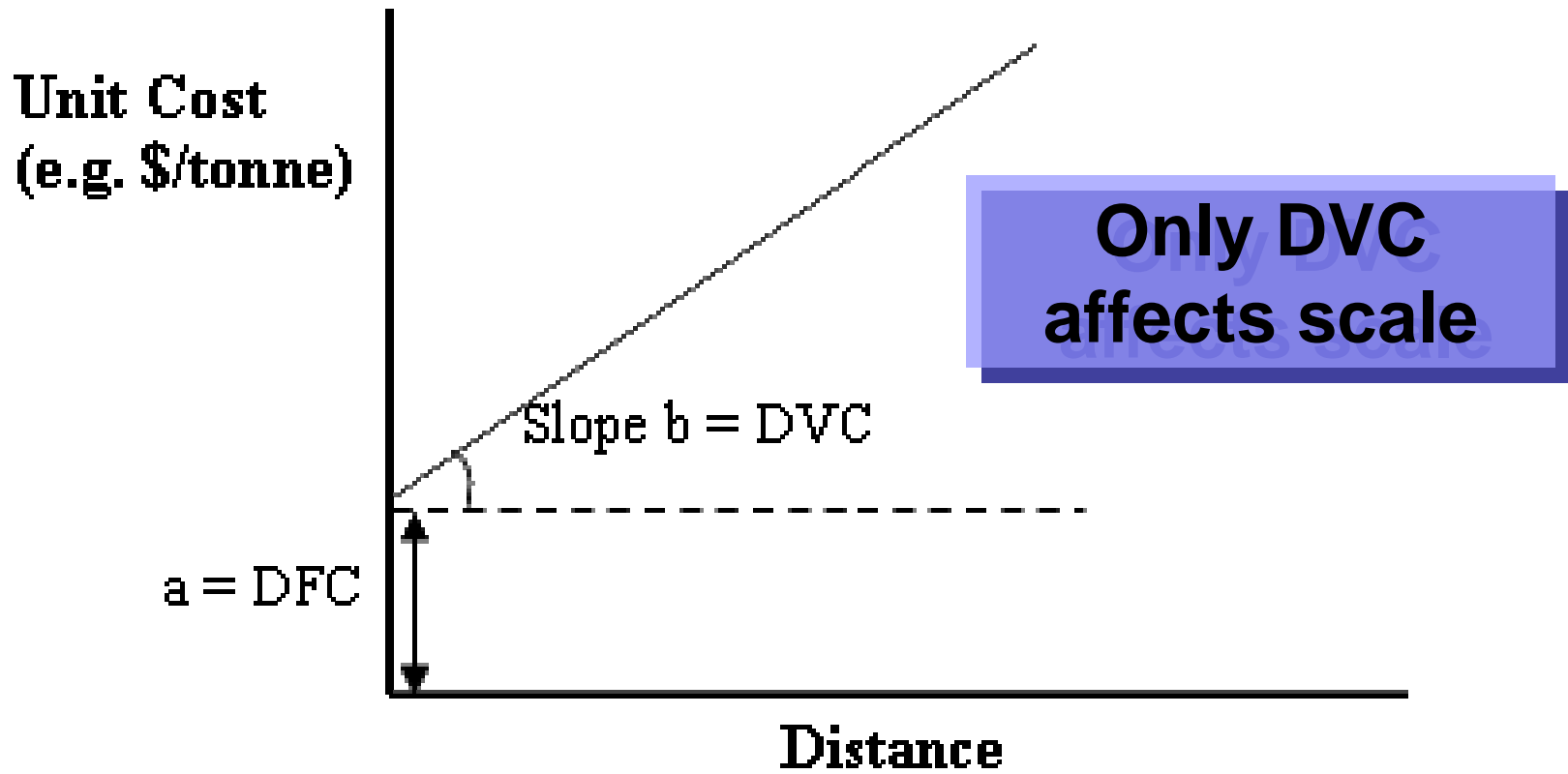
# Cost Per Unit Output



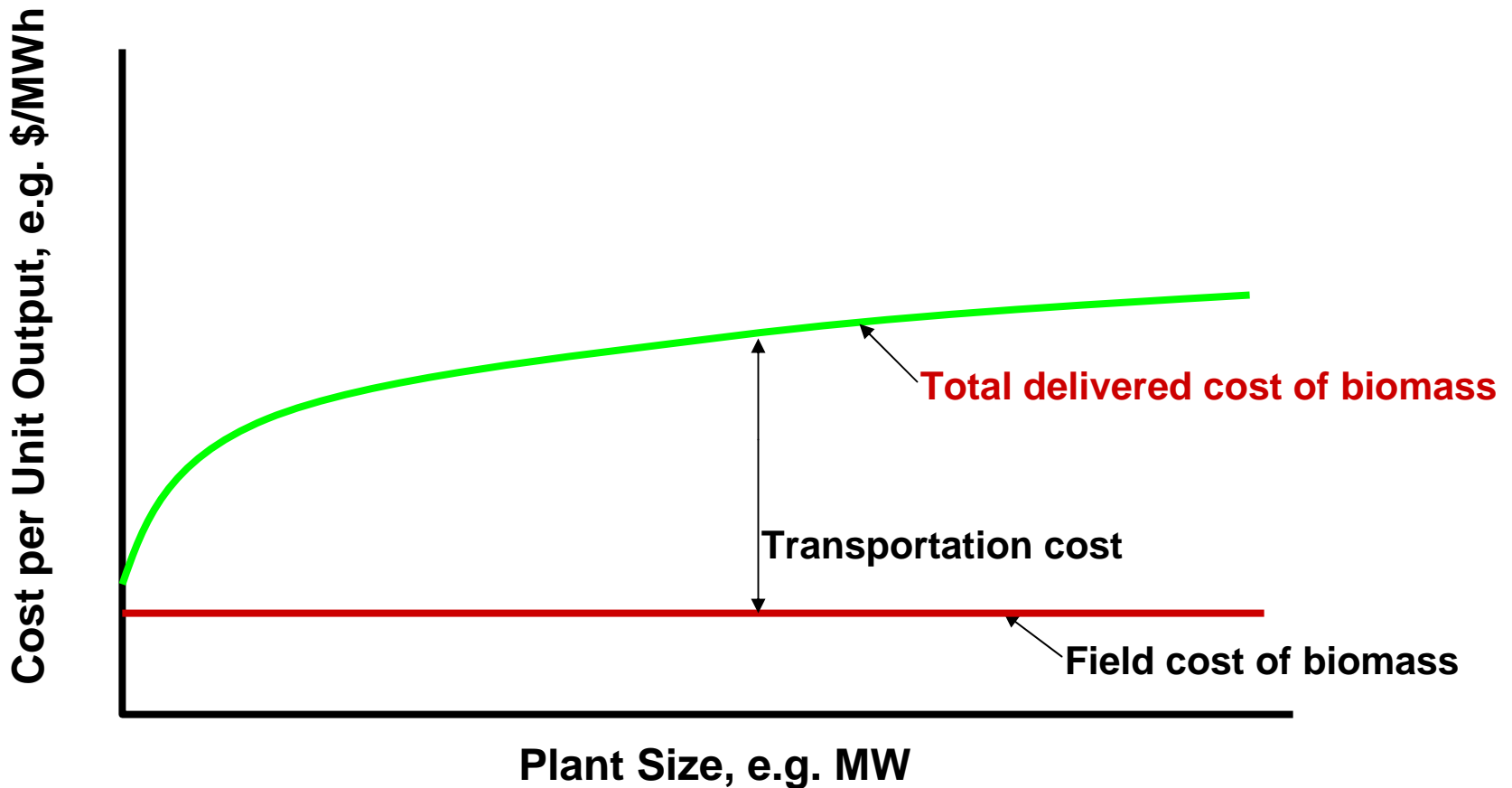
# Biomass Transportation by Truck

- Costs include:
  - **Loading and unloading**: distance fixed.
  - **Shipping**: distance (scale) variable.
- Typical values are \$5 per tonne (distance fixed) and \$0.09 per tonne km (one way) (distance variable).
- Increases ~ with (scale)<sup>1/2</sup>.

# Distance Fixed vs. Distance Variable Costs



# Cost Per Unit Output



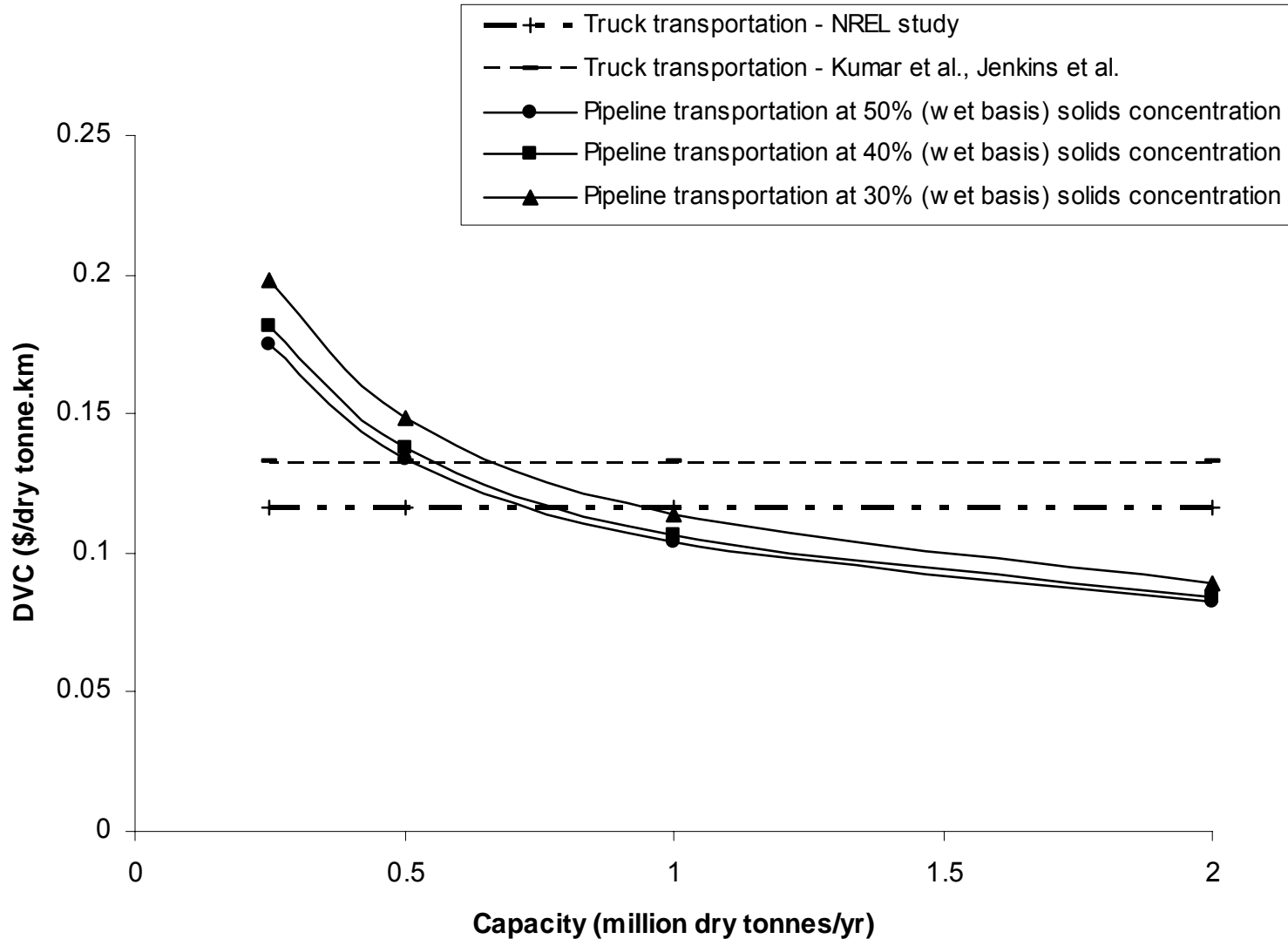
# Other Modes are Similar in Cost Pattern

- Rail and pipeline are options for moving very large amounts of biomass.
- Pipeline doesn't work for a combustion application: carrier fluid uptake.
- Pipeline is ideal for fermentation applications: ethanol or biogas.
- Rail DVC is <\$0.03 per tonne km (<half of truck) for unit train.

# Scale Effects in Transportation

- Truck has negligible economy of scale: more biomass = more truck trips.
- Rail has “step” economies of scale: e.g. single car to unit train.
- Pipeline has very strong economy of scale.

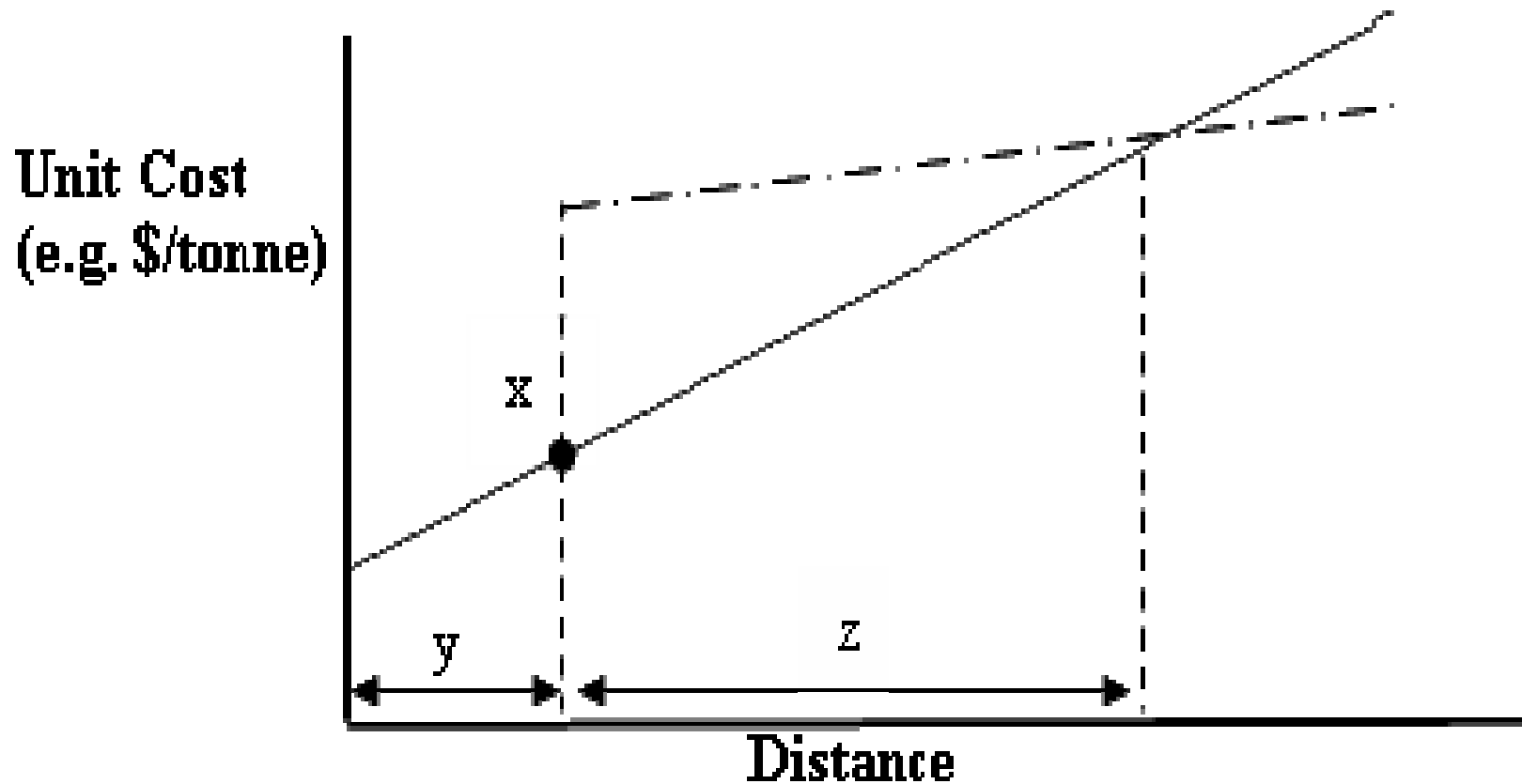
# Pipeline Cost vs. Scale



# Trans-shipment

- Field biomass starts its journey on a truck.
- Can you afford to remove it from the truck?
- Do the savings (reduction in DVC) offset the extra cost (incremental DFC).
- Hence, a minimum economic shipping distance (MESD).
- Road congestion is also an issue.

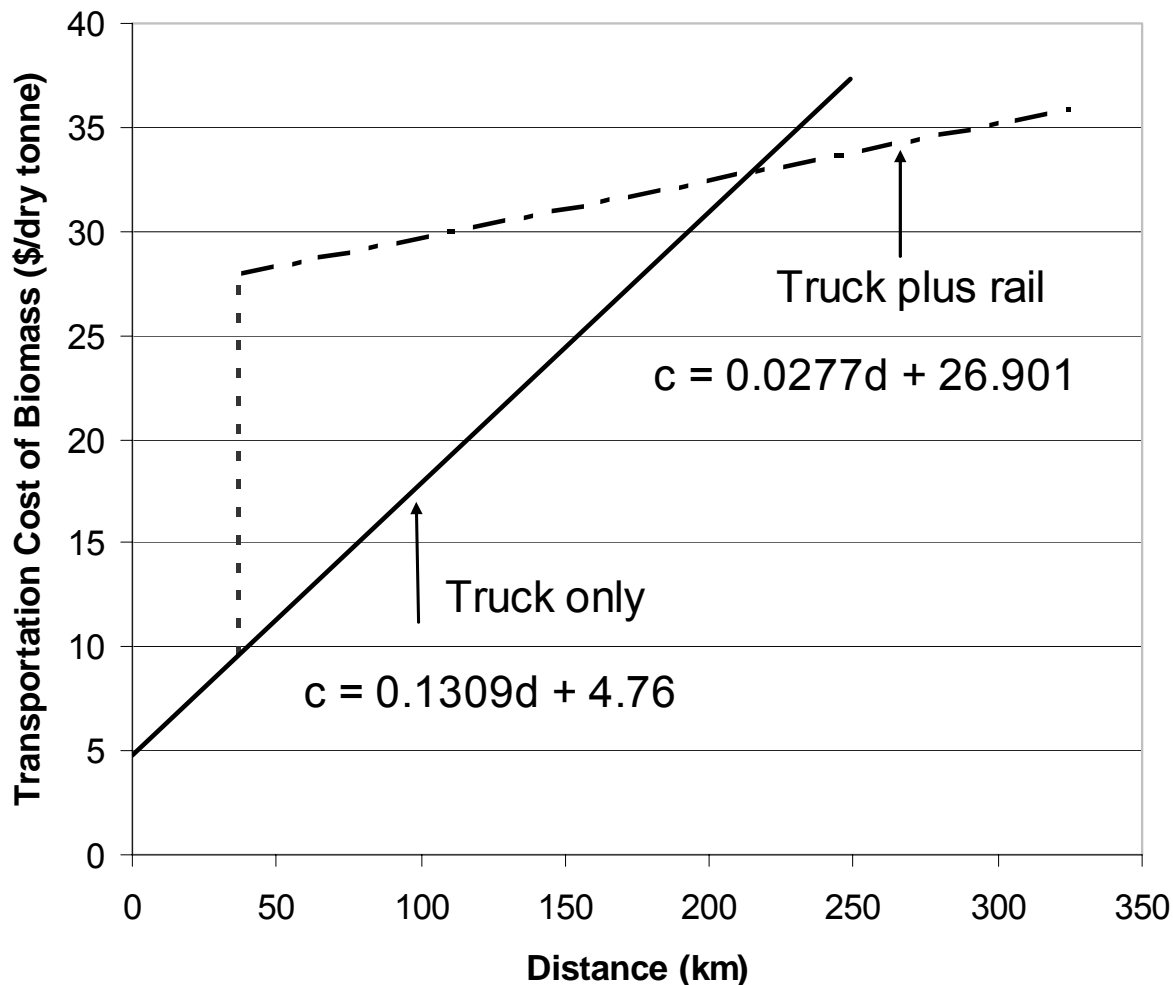
# Trans-shipment: the Concept



# Rail shipment to a power plant?

- For straw at 250 MW, the draw area in Alberta is smaller than the MESD. The rail savings don't justify the cost of trans-shipment (but road congestion might).
- For wood, the rail lines restrict location of the power plant to a non-economic choice.

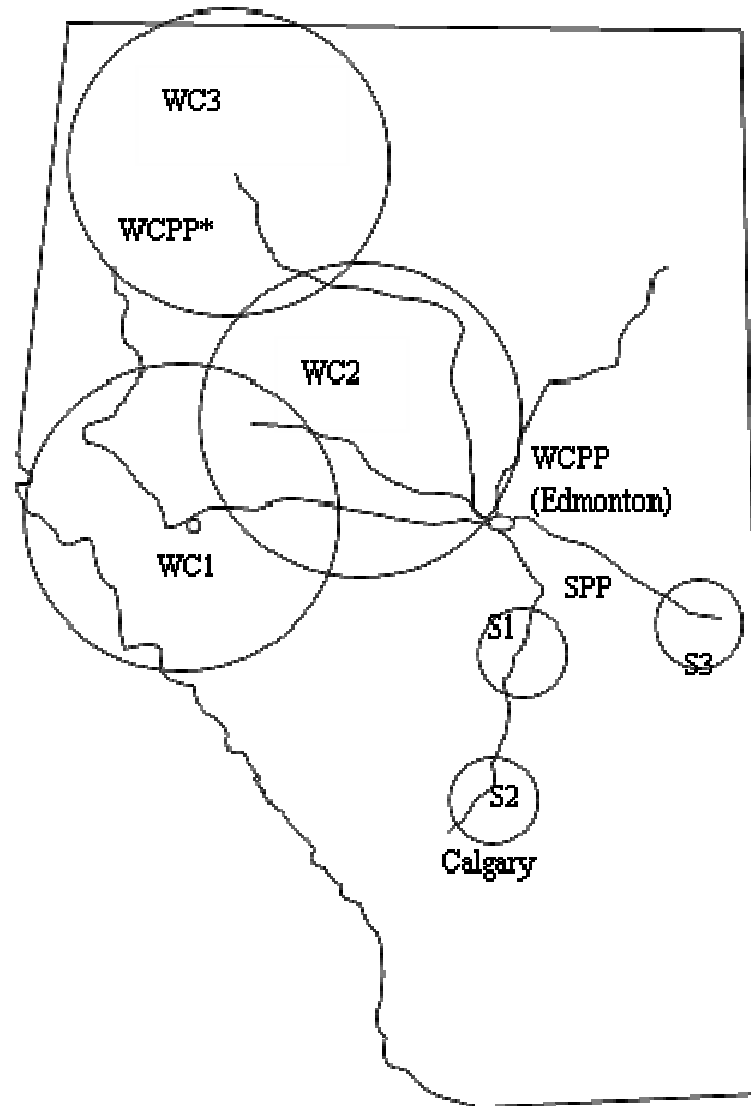
# Trans-shipment: Alberta Based Straw Power Plant



**Minimum economic rail shipping distance exceeds draw area: rail is not economic.**

# Rail Lines Limit Site Location: FHR in Alberta

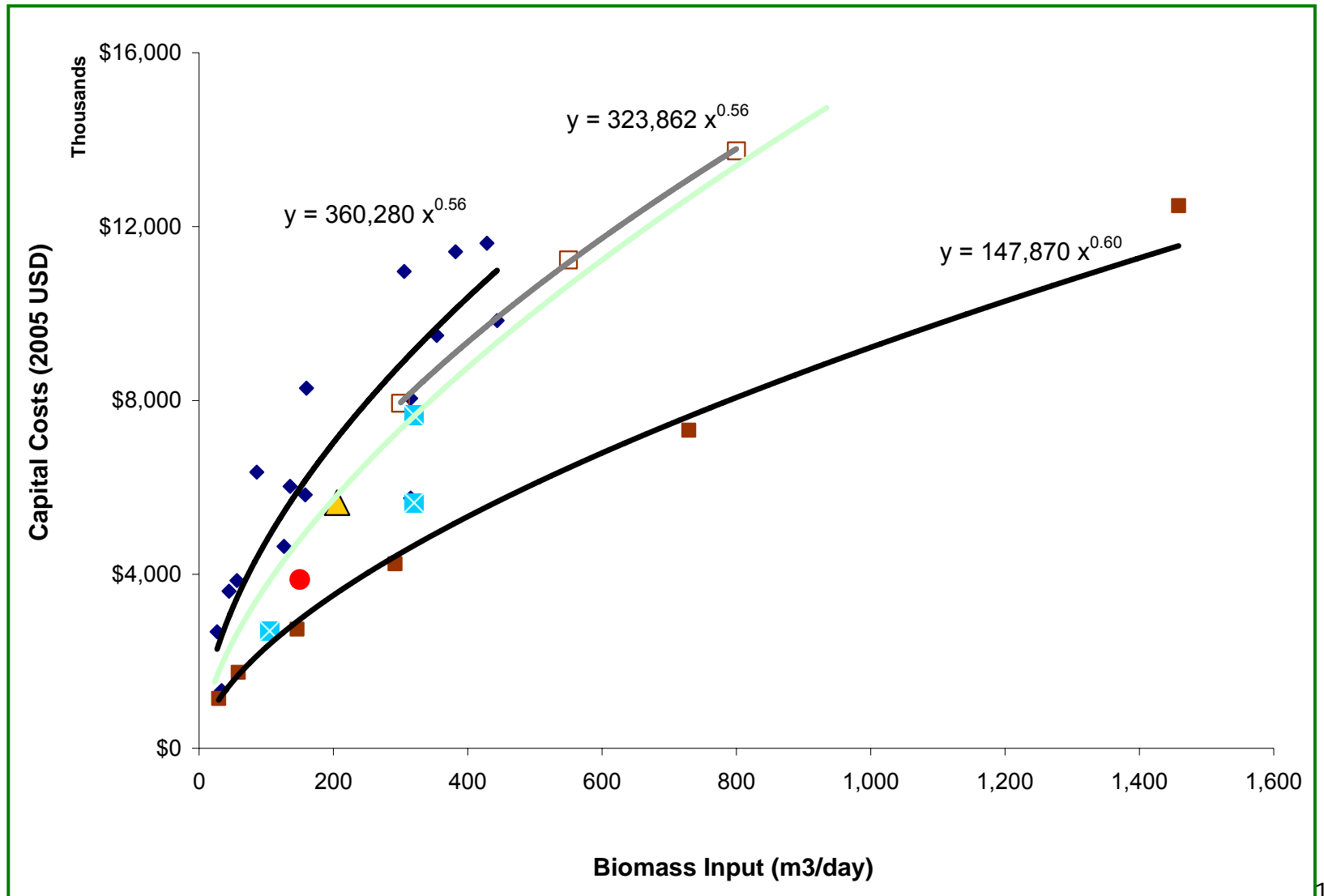
**A Grande Prairie location can't practically be served by rail.**



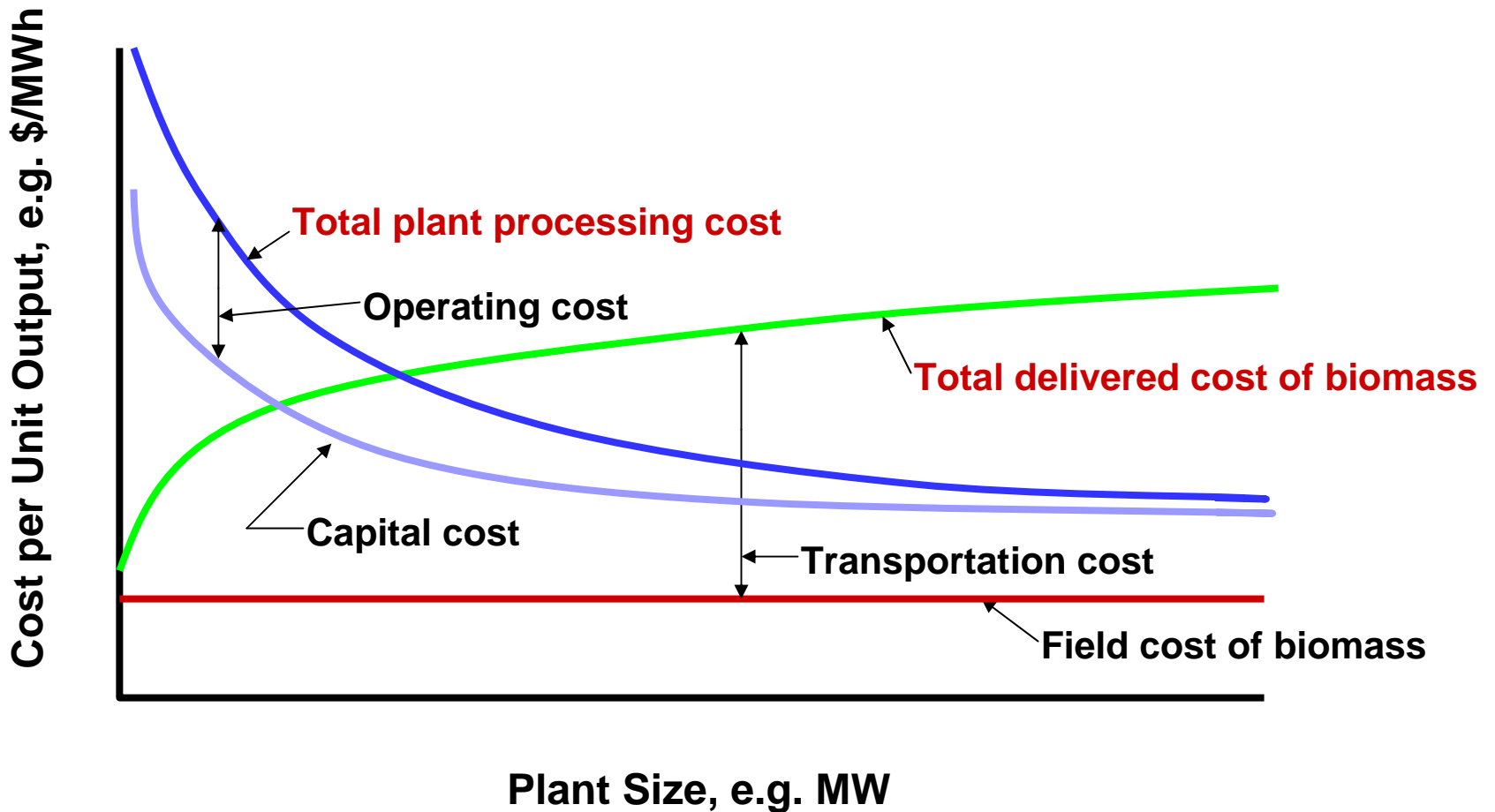
# Biomass Processing: Use It

- **Economy of scale** in capital equipment and operating costs, typical scale factors in the range of 0.6 to 0.8.
- All evidence is that scale factor is valid up to very large processing sizes (>500 MW); road congestion limit is the prior constraint if delivery by truck.

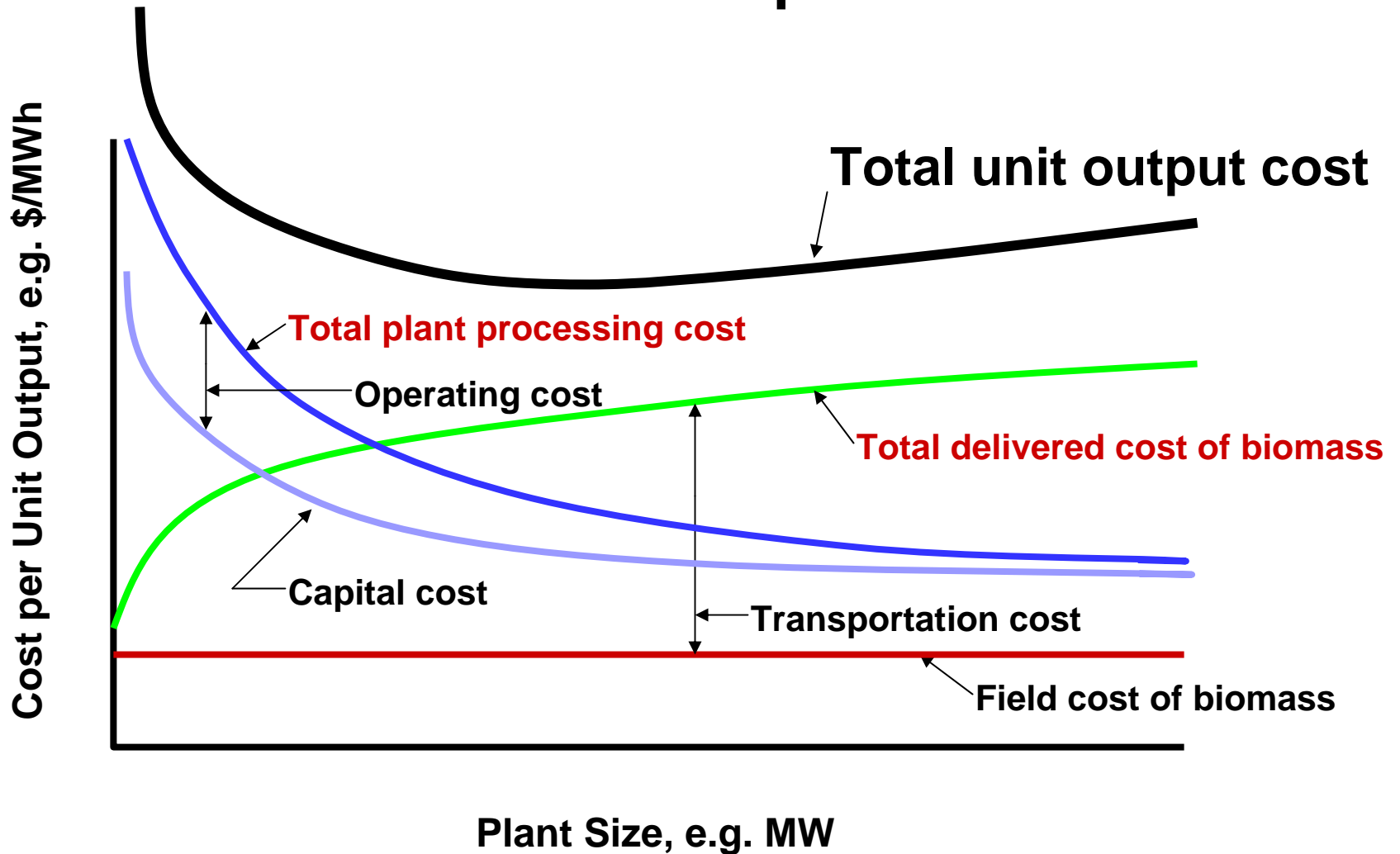
# Scale factor for Manure AD Plants



# Cost Per Unit Output



# Cost Per Unit Output



# Field Sourced Biomass Projects:

- Have **competing cost factors**: capital savings per unit output vs. higher transportation cost.
- **Fossil fuel plants are different**: delivery cost of fuel drops with increasing size. Other factors constrain plant size.

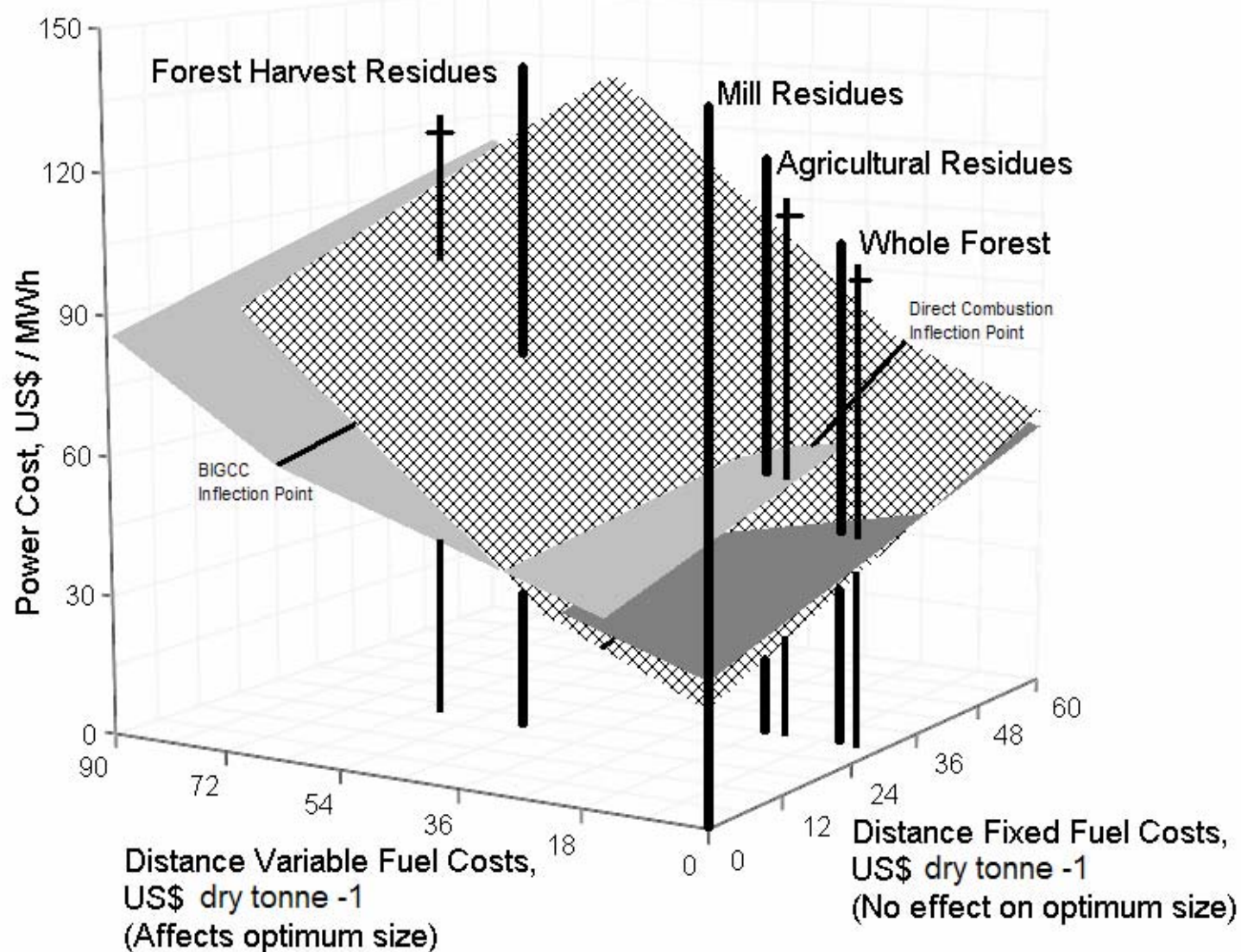
**Small distributed biomass plants are not economic: capital savings trump transportation cost.**

# Picking a Technology

- Q: Is it better to generate power by direct combustion of biomass, or by gasification.
- A: Yes (it depends on the delivered cost of the feedstock).

**High cost feedstocks justify higher investment in capital to get a higher yield. If the fuel is low cost, the investment doesn't make economics sense.**

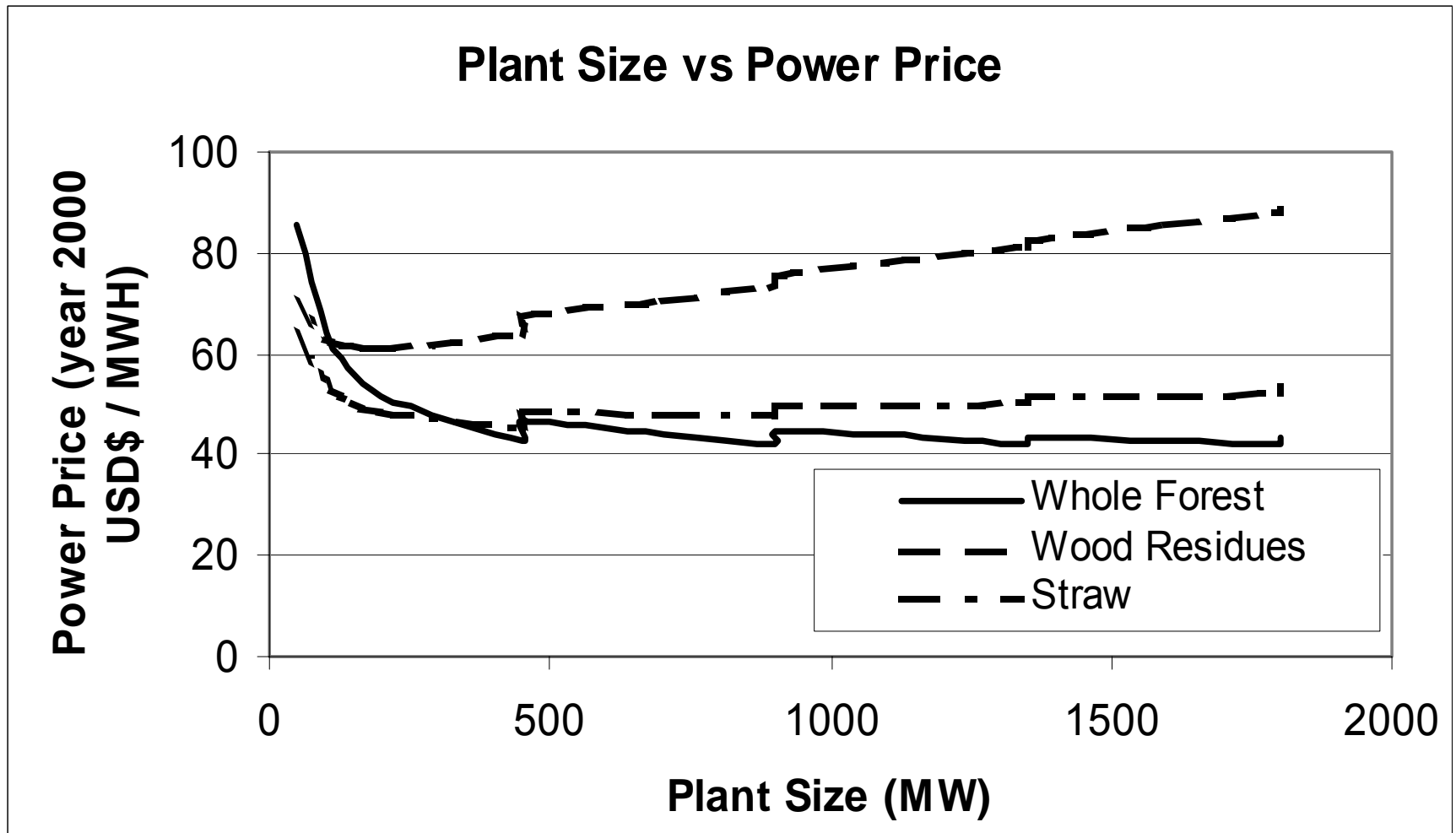
# Gasification vs. Direct Combustion



# Studies of Real Cases (1)

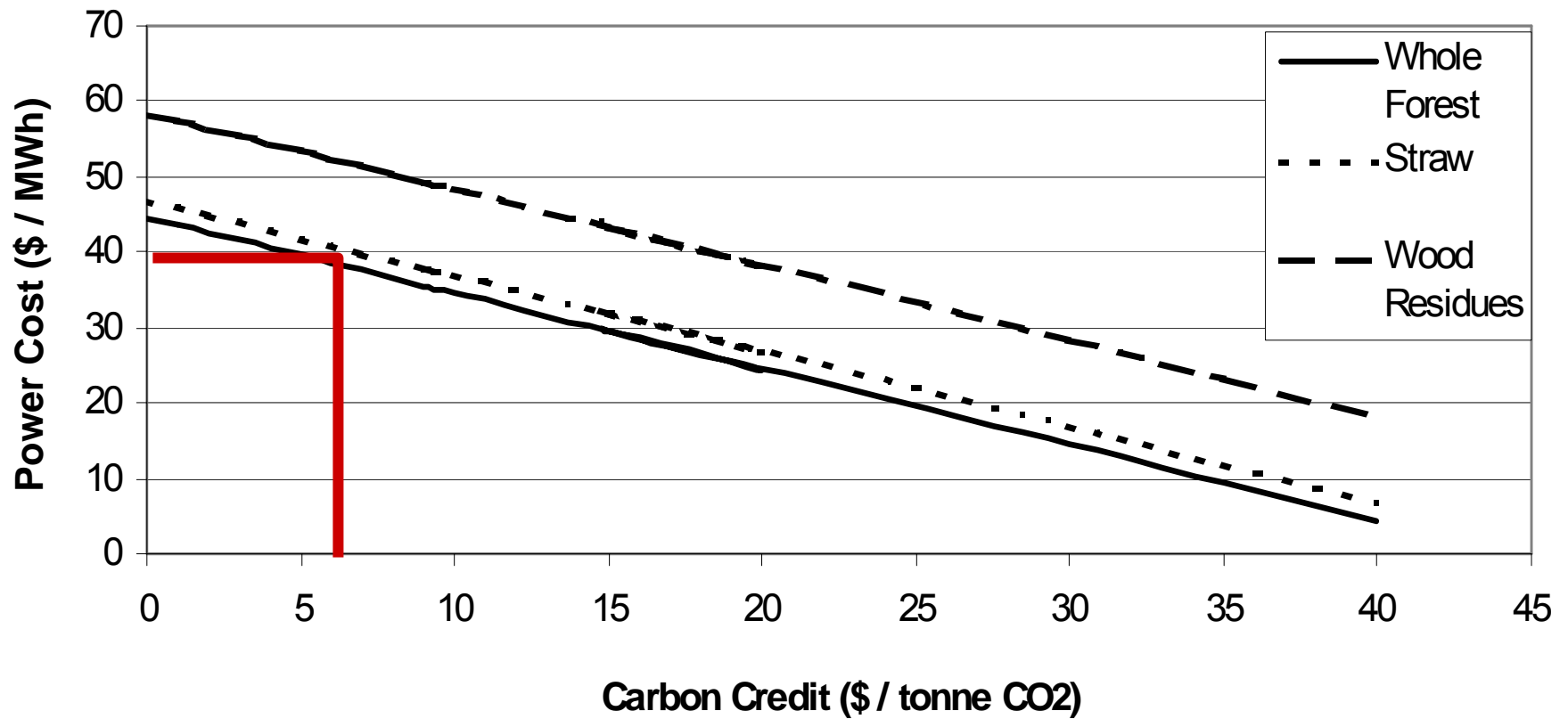
- Power from biomass from three sources:
  - The **whole boreal forest**, harvested as a fuel source rather than a fiber source.
  - **Forest harvest residues**: limbs and tops of trees cut for lumber/pulp (~20% of the tree).
  - **Straw** from grains (does not reduce soil carbon in black soils).

# Power from Field Sourced Biomass in Alberta



# Reasonable Carbon Credits

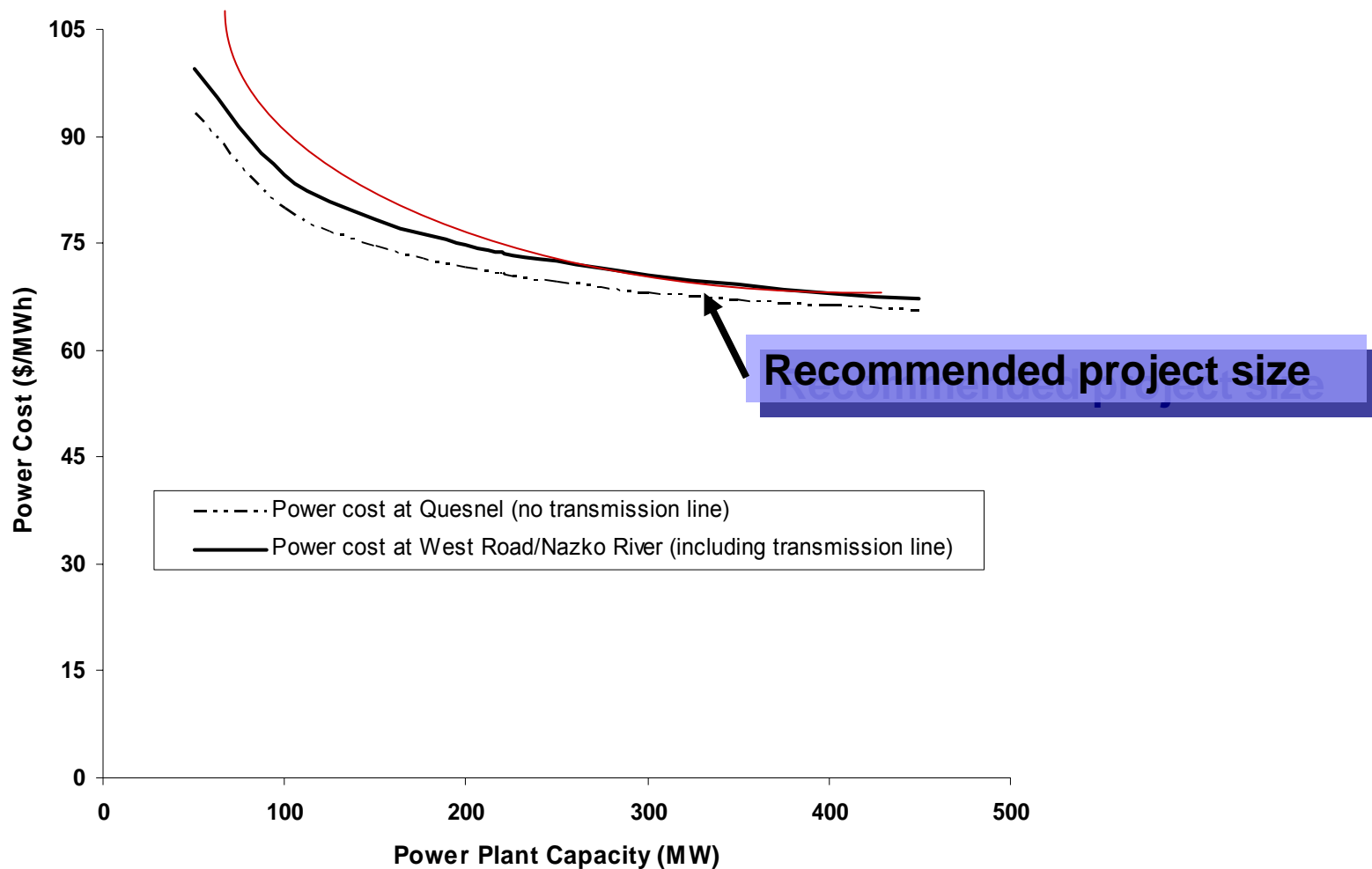
Cost of Power Cost vs. Carbon Credit



# Studies of Real Cases (2): BC's Mountain Pine Beetle Killed Trees



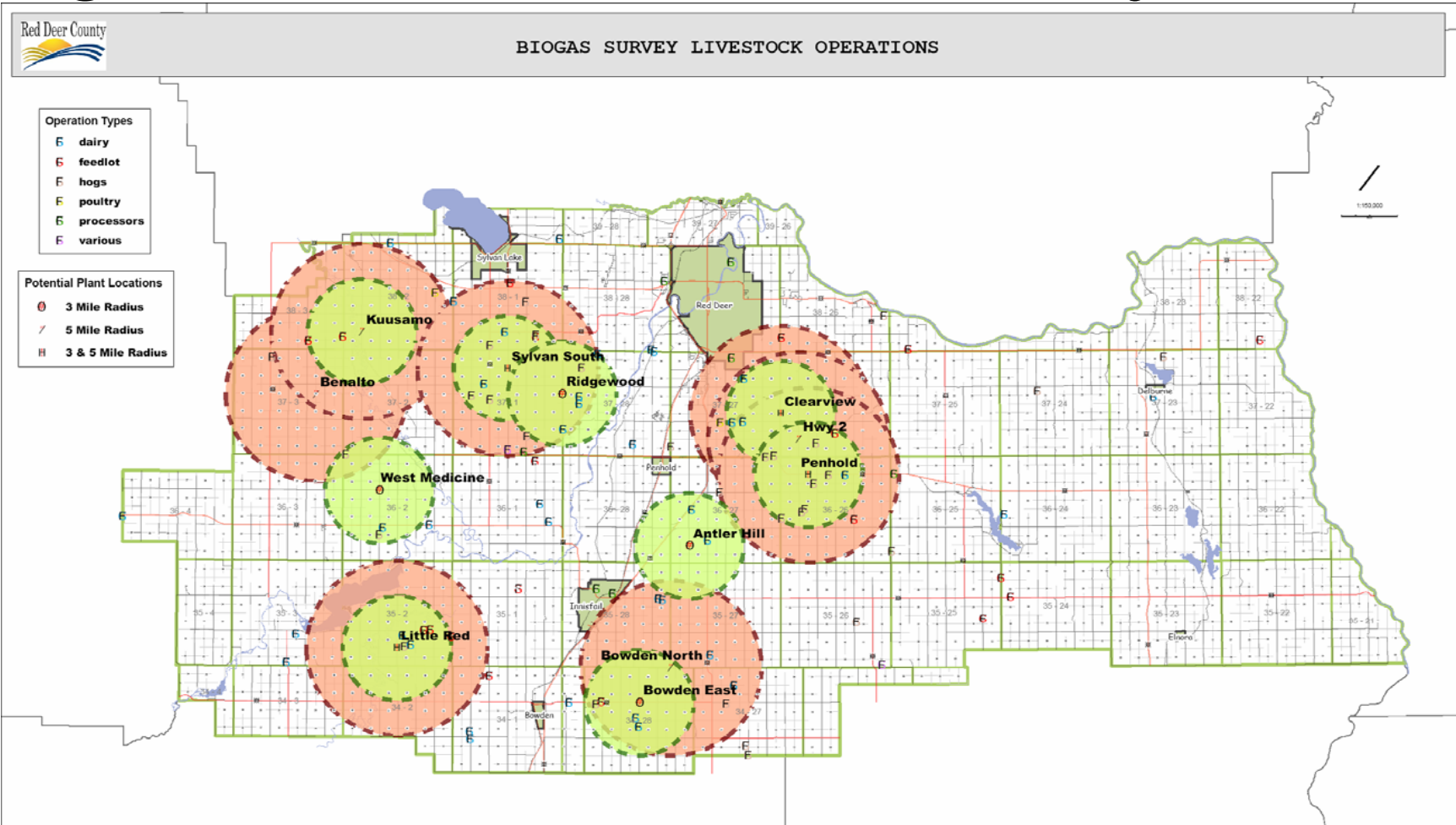
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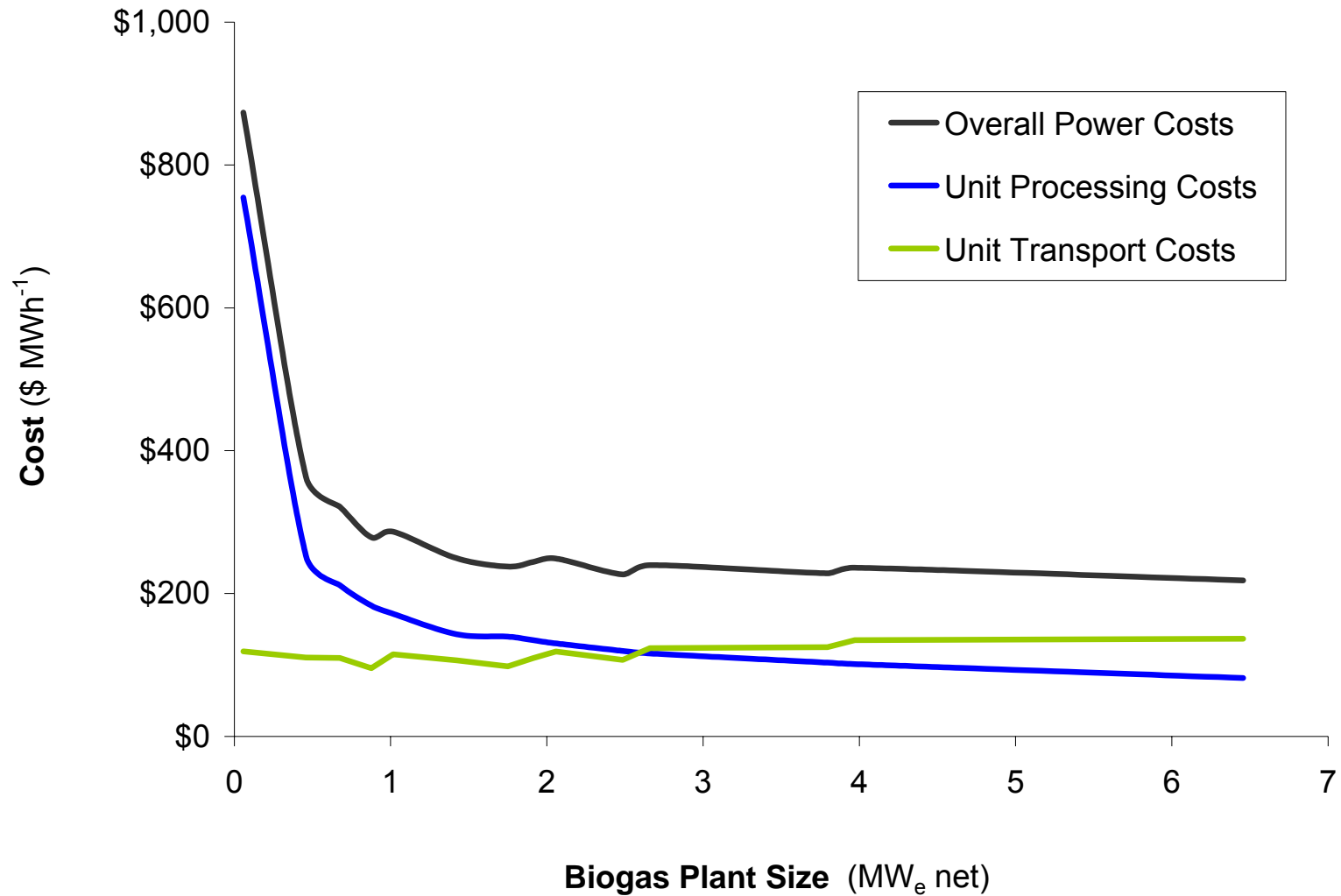
# Large Scale Power Production From Wood Waste: Finland 240 MW



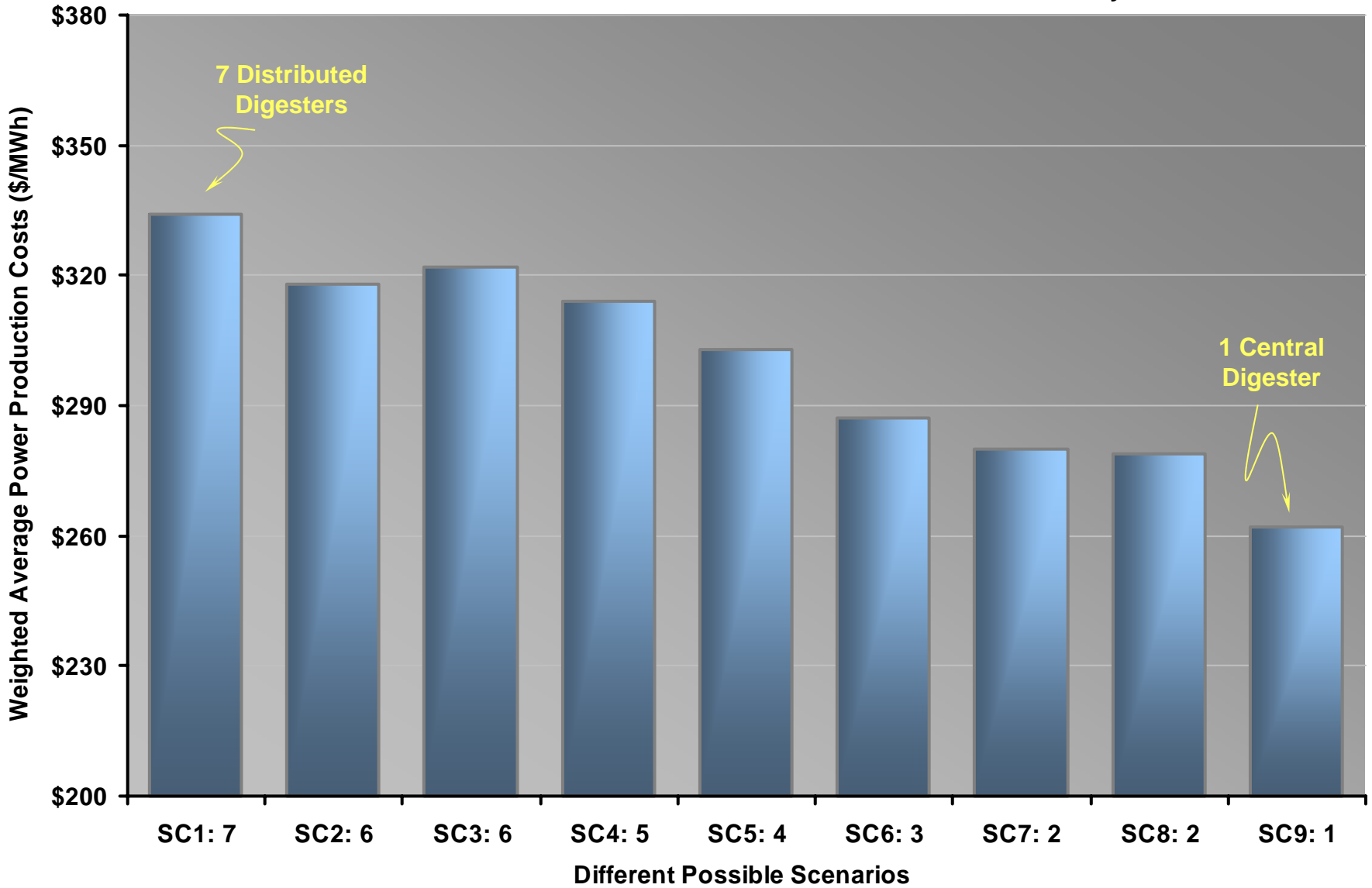
# Studies of Real Cases (3): Anaerobic Digestion in Red Deer County



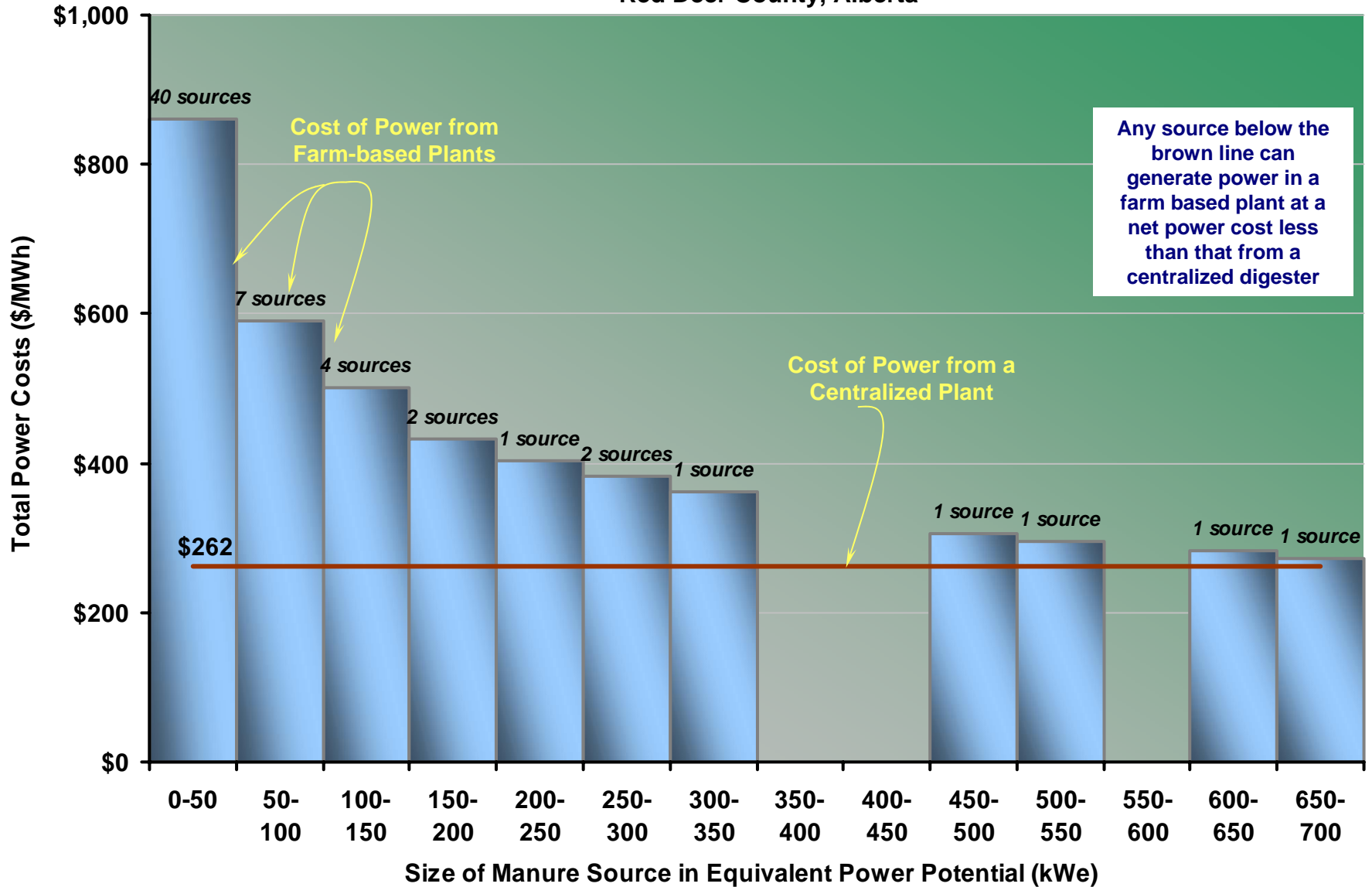
# Cost of Power from Biogas Plants



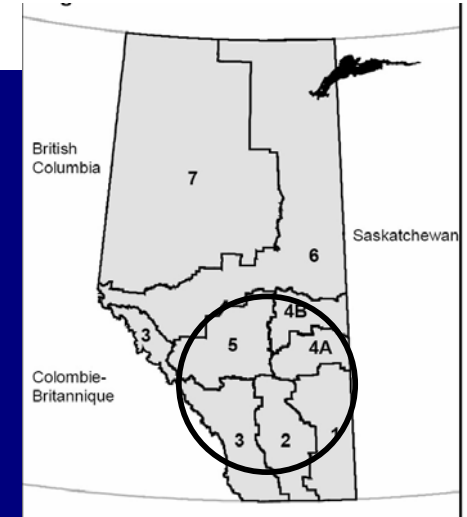
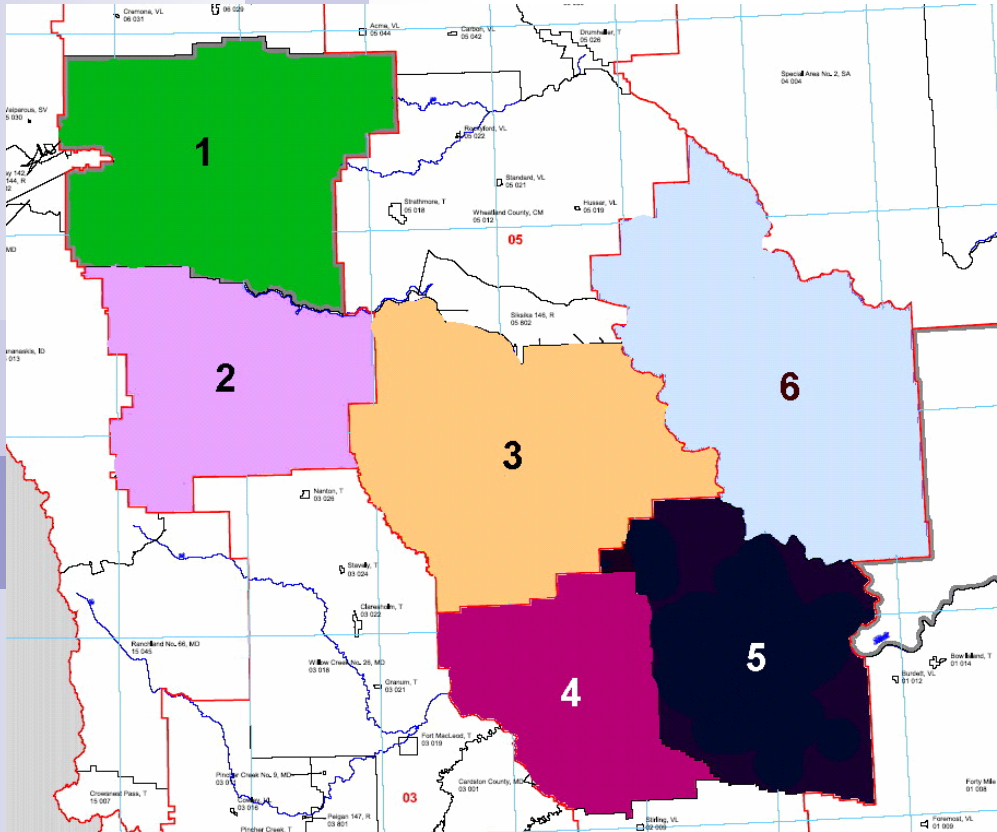
## Economics of the Different Scenarios for the Red Deer County



Power Cost from Farm-based Generation as a Function of Size:  
Red Deer County, Alberta

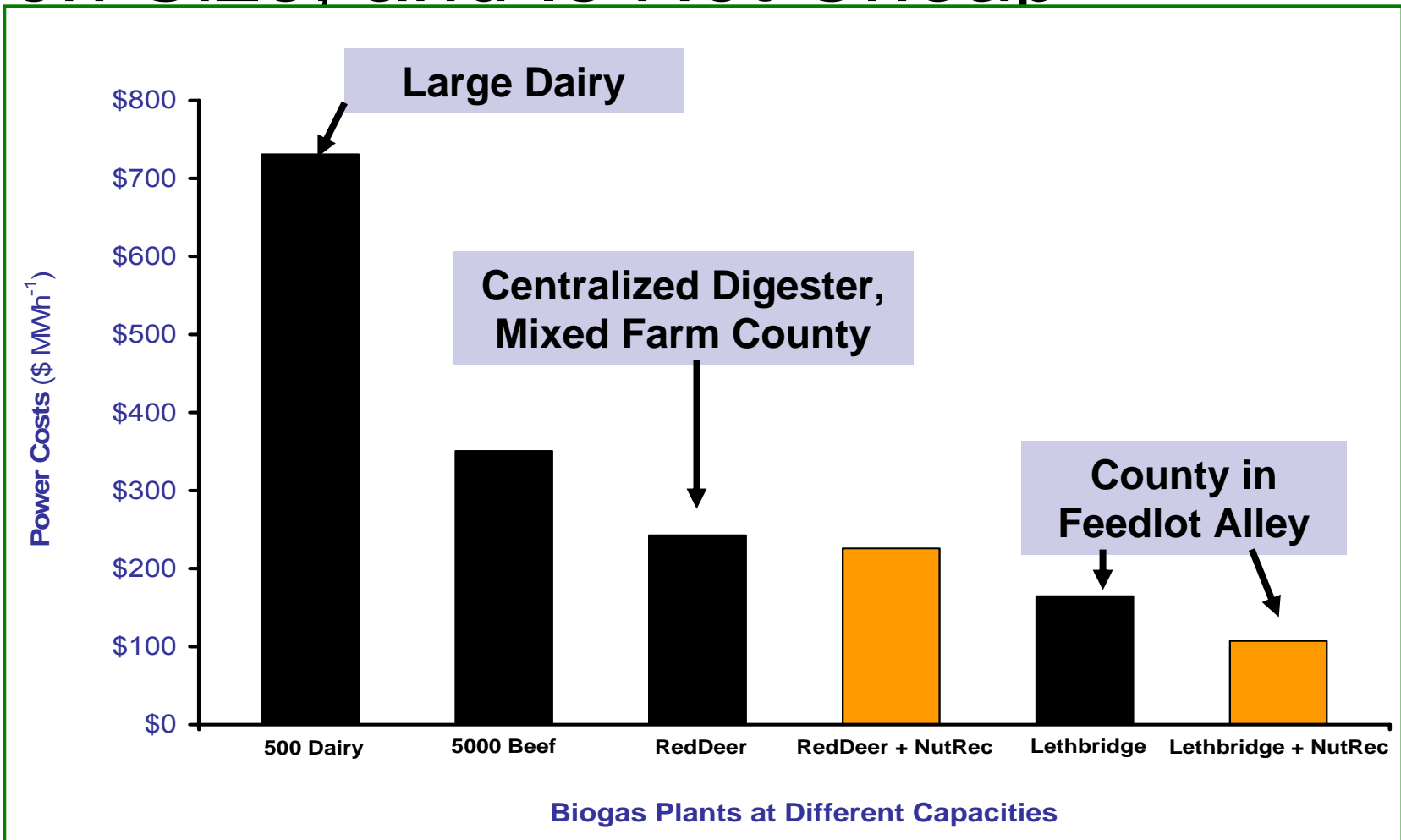


# Feedlot Alley: Concentrated Feedlots



- |                      |              |                      |              |
|----------------------|--------------|----------------------|--------------|
| 1. Rocky View County | 180,000 head | 4. Lethbridge County | 570,000 head |
| 2. Foothills County  | 130,000 head | 5. Taber County      | 60,000 head  |
| 3. Vulcan County     | 80,000 head  | 6. Newell County     | 120,000 head |

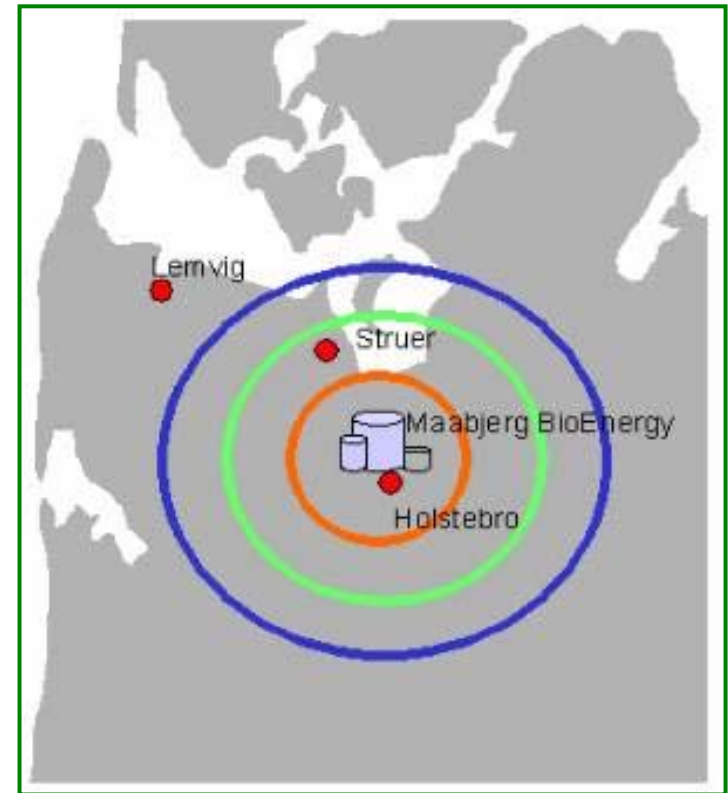
# Power from Biogas: Cost Depends on Size, and Is Not Cheap



# Denmark: Centralized Biogas Plants

## ■ Proposed Maabjerg Plant

- ❑ World's largest biogas power plant (~ \$45 million investment)
- ❑ 14.5 million m<sup>3</sup> biogas/year sold to a CHP plant
- ❑ Mixed feed (manure, silage, industrial waste, dead animals, sludge and organic waste)
- ❑ Combination of pipeline and truck for manure transport
- ❑ Co-op of over 200 farmers



○ 10 km    ○ 20 km    ○ 30 km

Source: <http://www.maabjerg-bioenergy.dk>

# A Key Conclusion, Said 2 Ways

- Capital trumps transportation for field sourced biomass:
  - Optimum size is 450 MW for straw, draw area is ~300 by 300 km.
  - Centralized anaerobic digesters are more economic than farm/feedlot based units.
- Small plants have a severe economic penalty (mill residues with negative feedstock values conceal this).



# So:

- “Flat” optima are forgiving, but only down to a point; size is still large at that point.
- A 50 mile / 80 km constraint on transportation is not evident from detailed economic analysis. Finland haul distances are longer.
- Truck congestion could constrain some projects to less than optimum size.

# A Second Key Conclusion

- Not all biomass projects are equal: some are very costly compared to others.
- Alberta's interest is served by creating the largest reduction in carbon at the lowest net cost.


# For Biomass Energy to Grow:



**Drayton Valley, AB: 12 MW**



**Alholmens, Finland: 240 MW**



Copies of the presentation  
are available at:

[www.aeri.ab.ca/news&resources/presentations](http://www.aeri.ab.ca/news&resources/presentations)