BIOMASS LOGISTICS

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Biomass Securing A Sustainable Supply
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OUTLINE

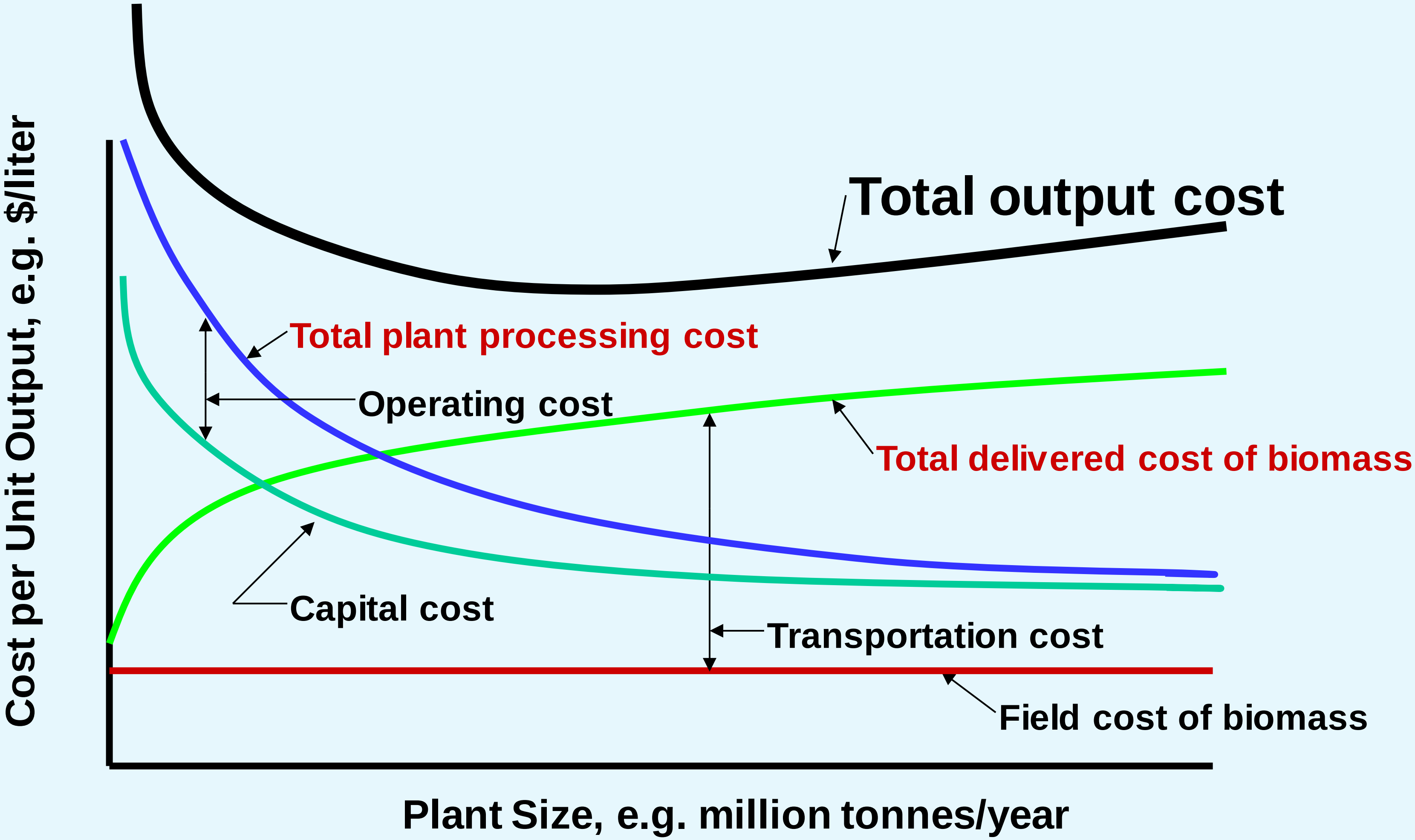
- Current status.
- Scale issues in lignocellulosic biomass-based facility and biomass supply logistics.
- Current R&D needs in biomass supply and logistics.
- Role of BCN in biomass supply and logistics feedstocks.
- Key observations.

COMPARISON WITH LARGE SCALE FOSSIL FUEL FACILITIES

- Typical petrochemical refinery capacity 250,000 barrels/day or 12,000 million liters/yr.
- Fossil fuel power plants – 450 MW – about 1.3 million tonnes/yr.
- Oil sands processing 500,000 tonnes/day.

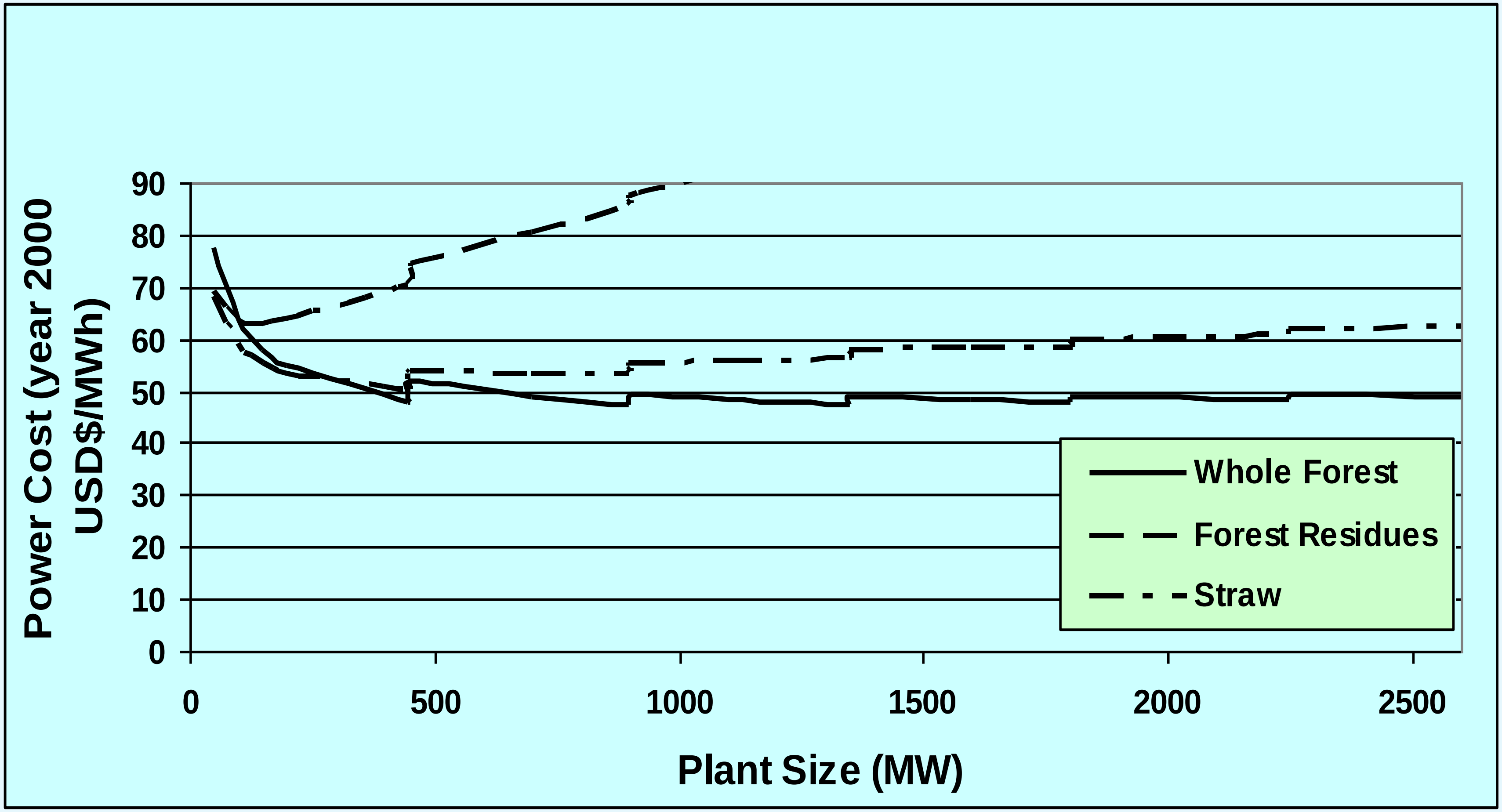
Aggregation of Feedstock and Its Transportation

COST VERSUS SCALE IN A BIOMASS FACILITY



Source: Flynn, 2006

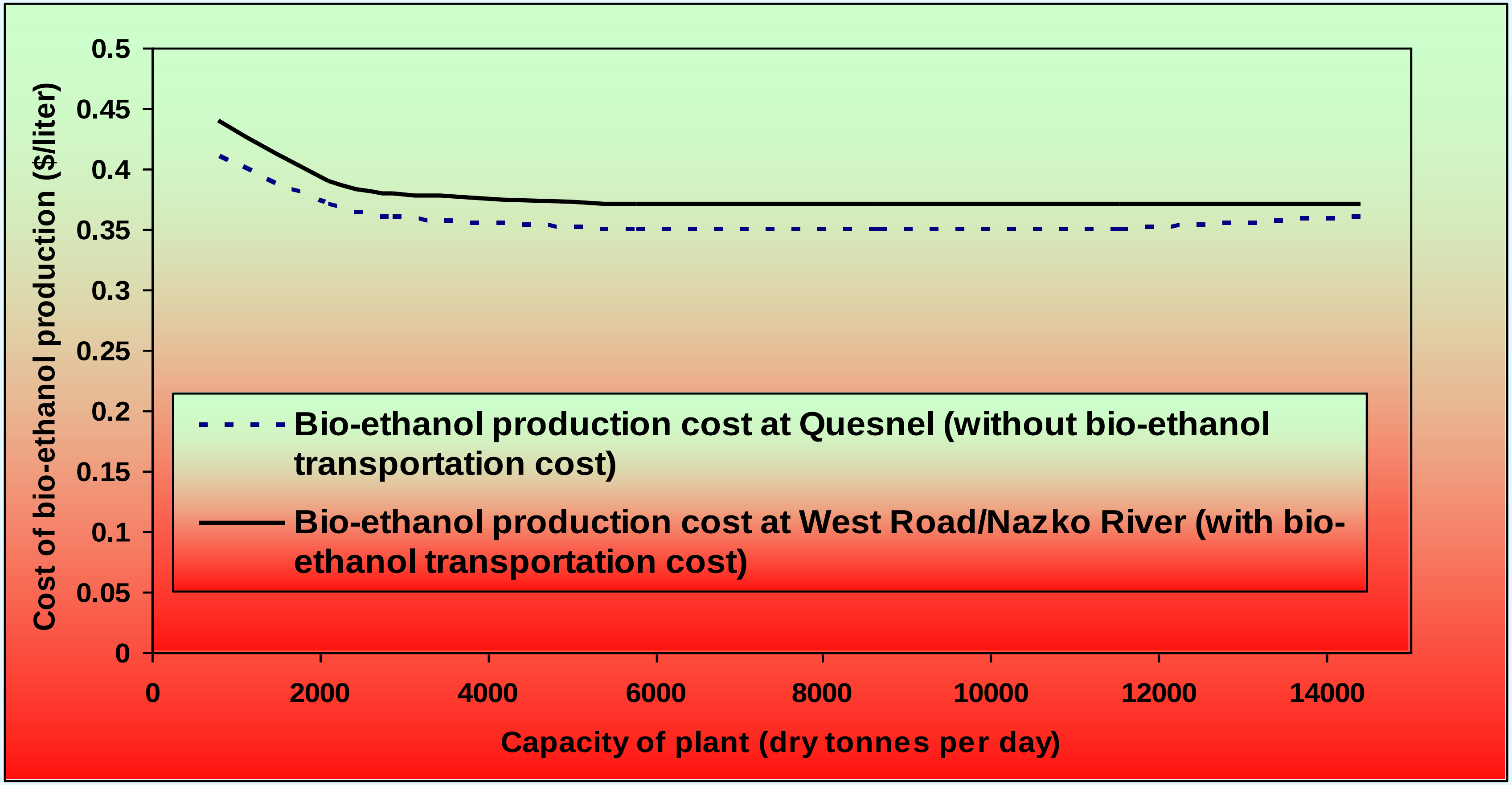
BIOPOWER IN WESTERN CANADA



Kumar et al., Biomass and Bioenergy 2003, 24, 445-464

BIOETHANOL IN WESTERN CANADA

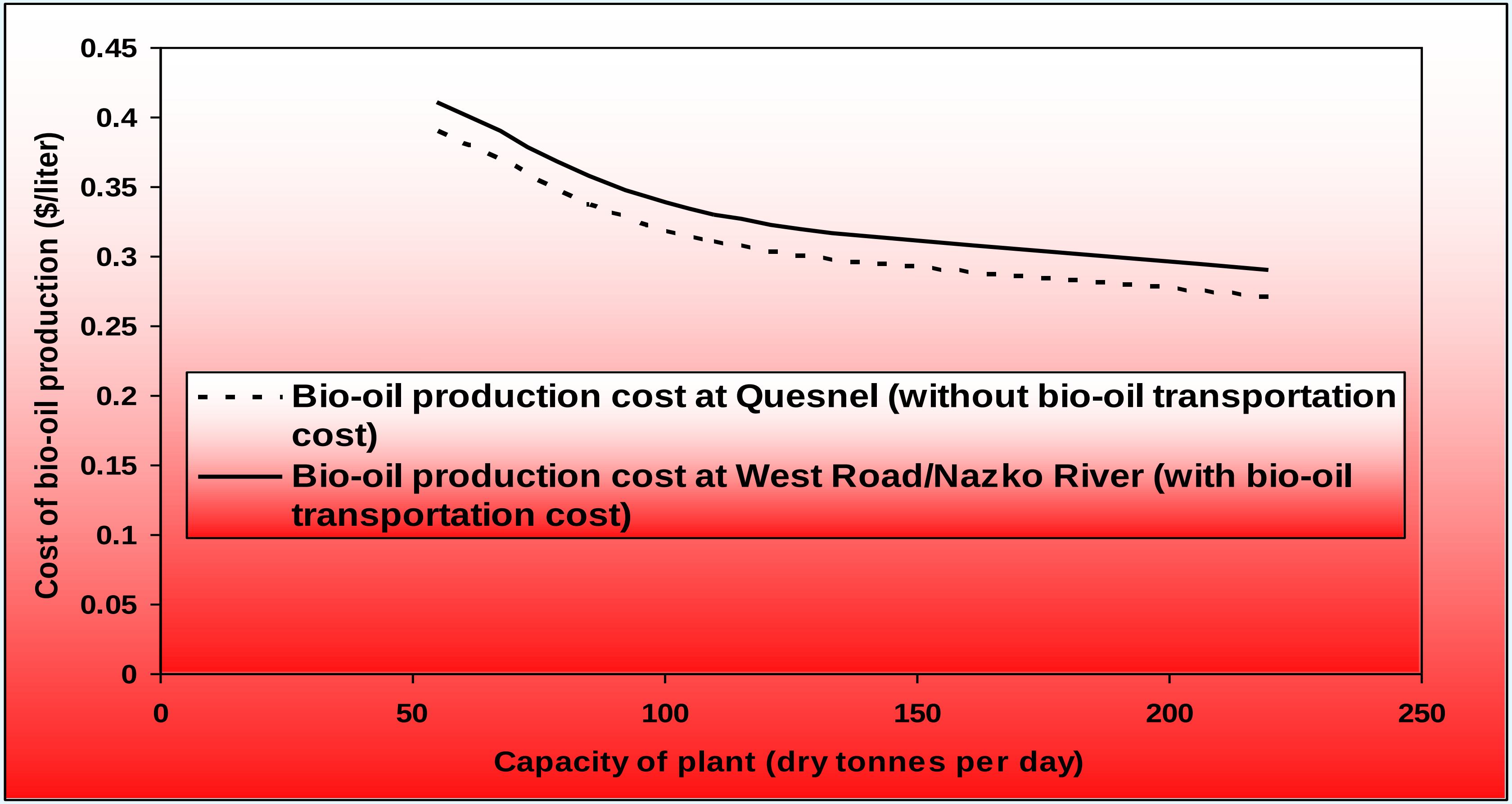
- Feedstock Mountain Beetle Infested Wood



Kumar, Bioresource Technology 2009, 100(1), 387-399.

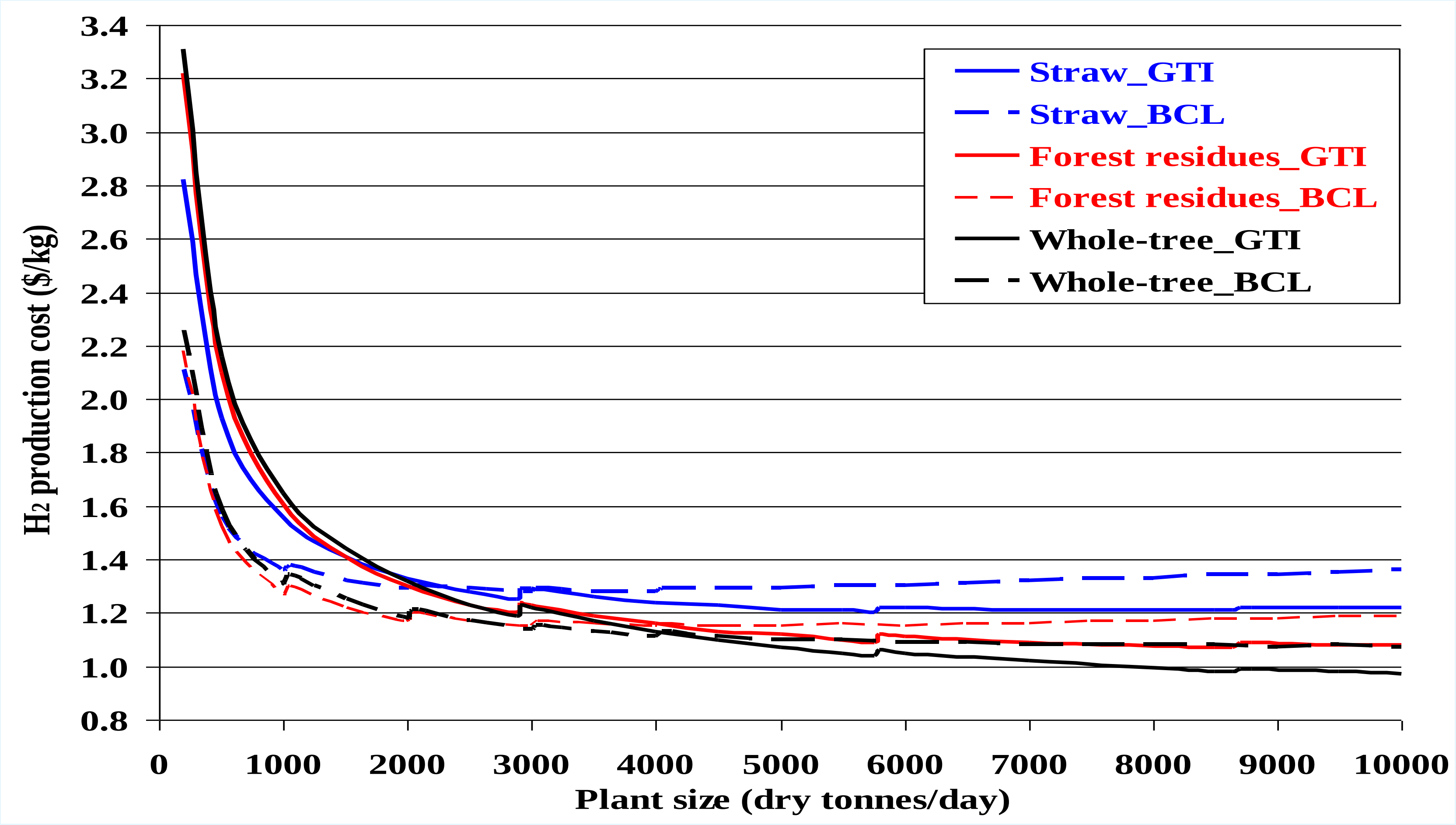
BIO-OIL IN WESTERN CANADA

- Feedstock Mountain Beetle Infested Wood



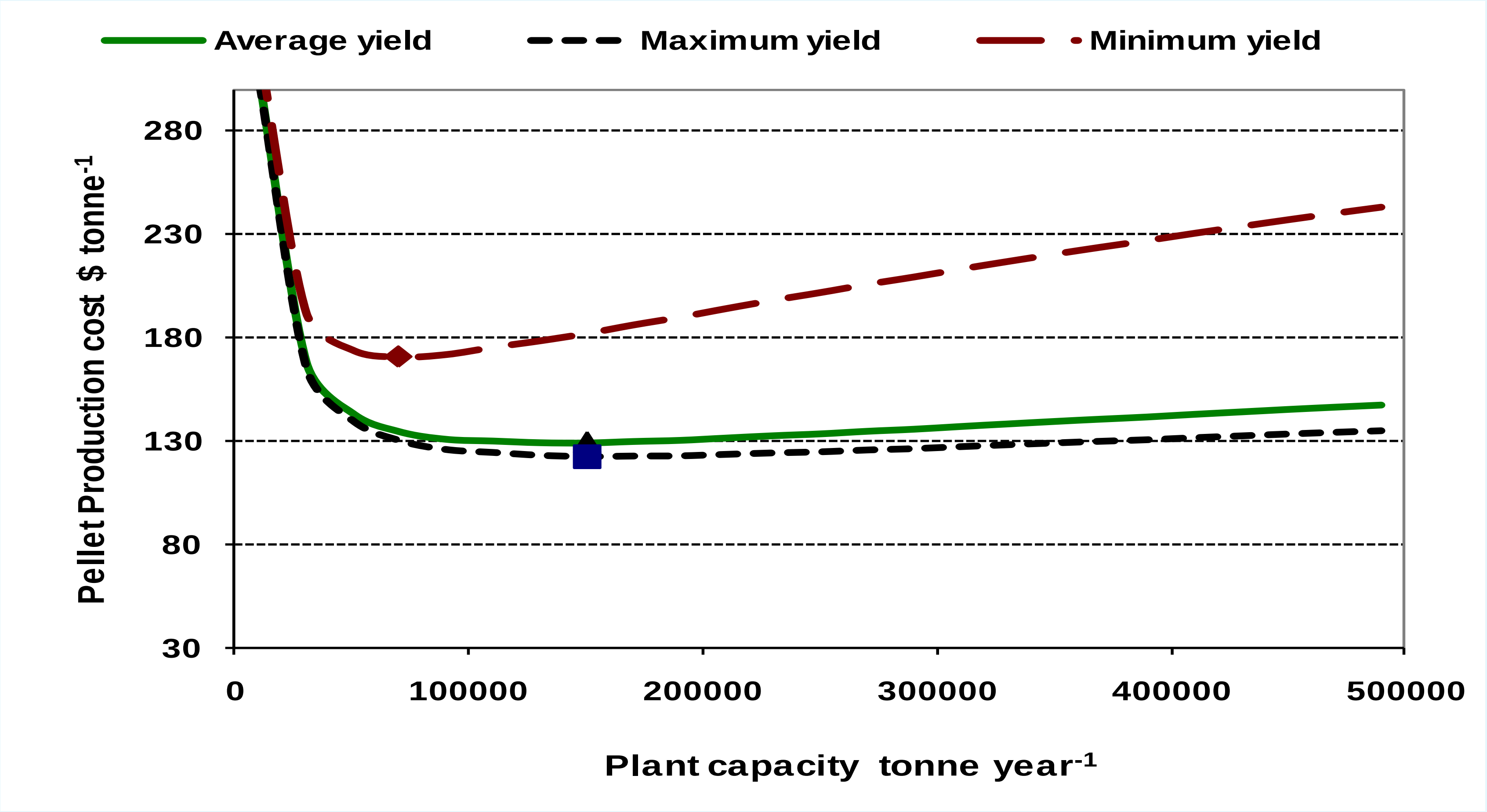
Kumar, Bioresource Technology 2009, 100(1), 387-399.

BIOHYDROGEN IN WESTERN CANADA



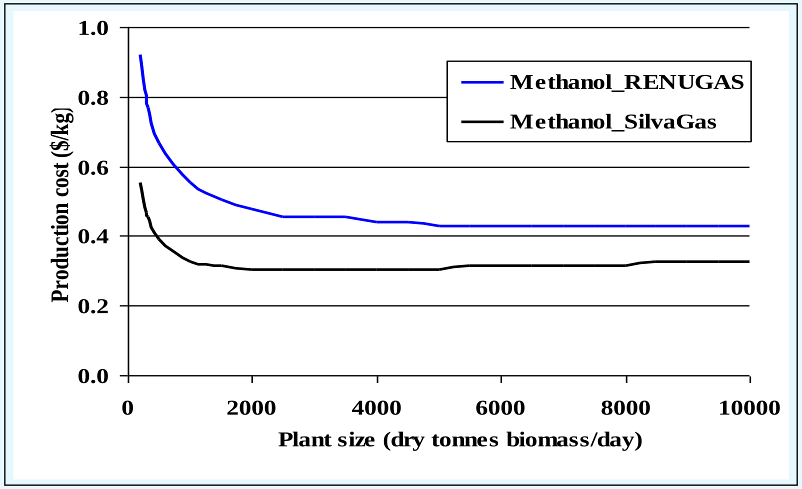
Sarkar and Kumar - Transactions of ASABE 2009, 52(2), 519-530; Energy 2010, 35(2), 582-591.

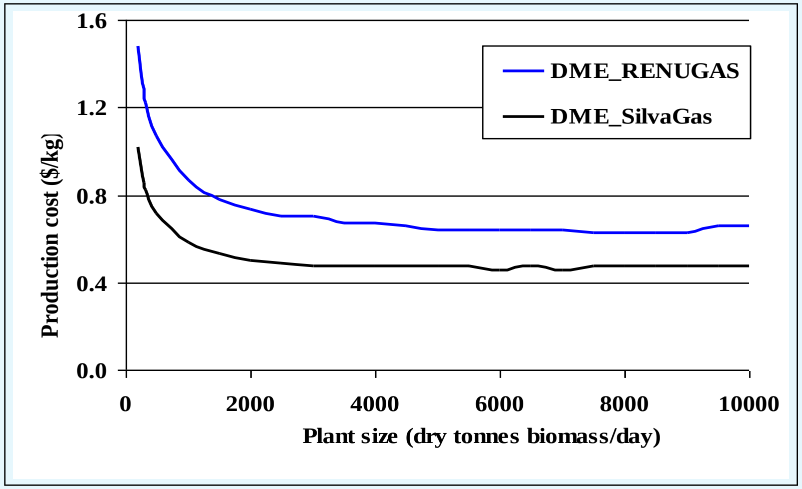
AGRI-PELLETS IN WESTERN CANADA

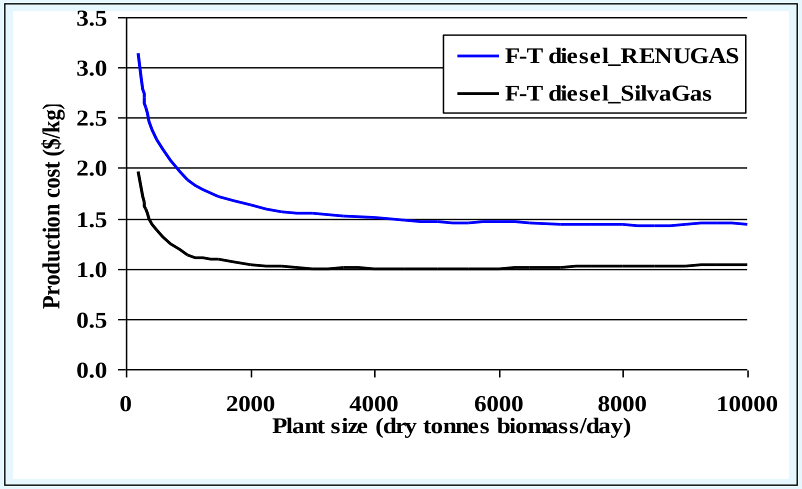


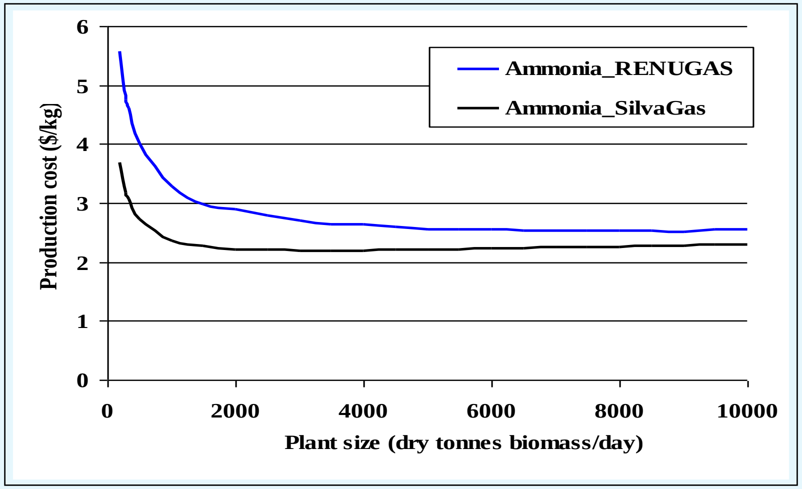
Sultana and Kumar – Bioresource Technology 2010, 101(14), 5609-5621.

BIOCHEMICALS IN WESTERN CANADA









Sarkar, Kumar, Sultana, Energy 2011, 36(10), 6251-6262.

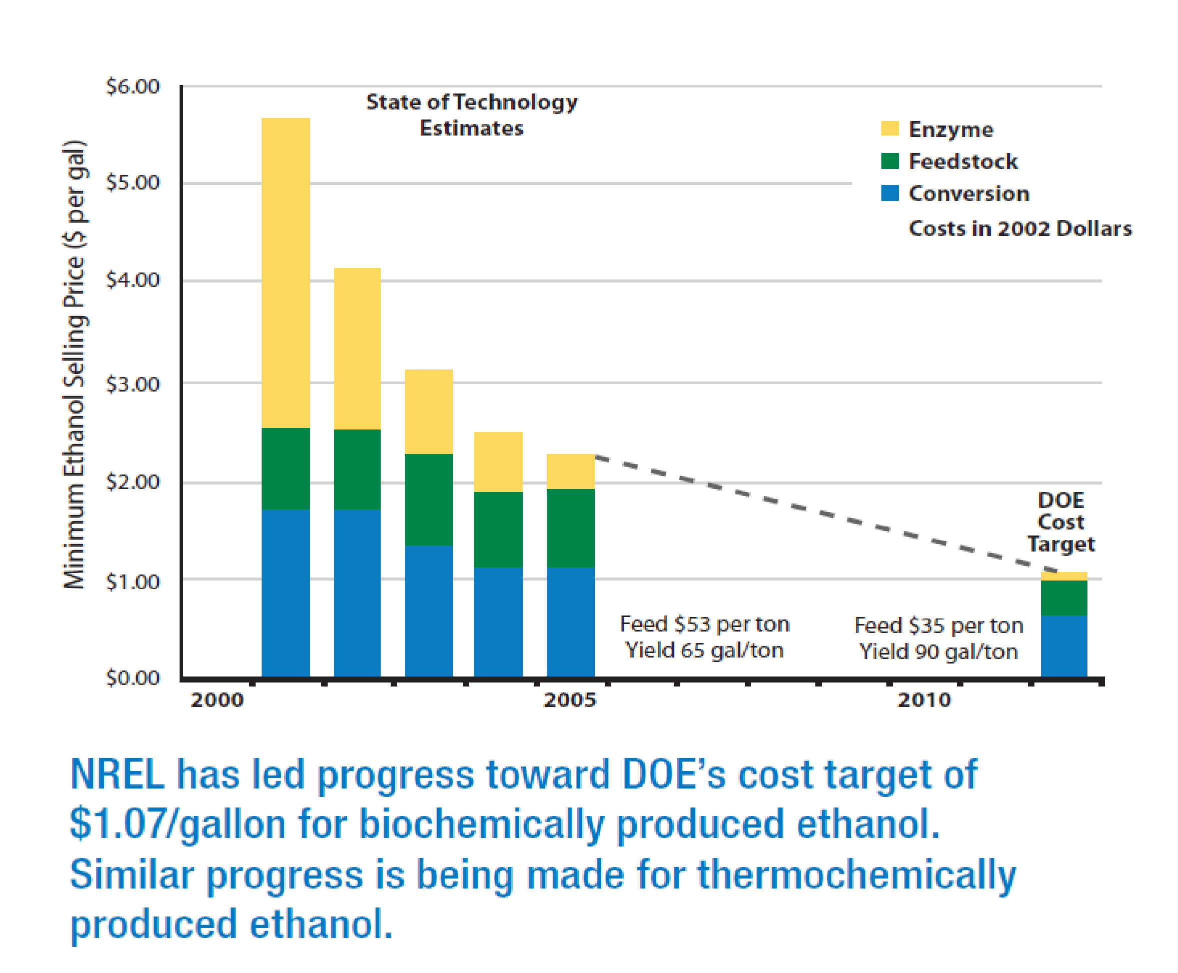
FIELD SOURCE BIOMASS UTILIZATION FOR FUELS, CHEMICALS and MATERIALS

- Competing cost factors: capital savings per unit output vs. higher transportation cost.
- Economy of scale in capital equipment and operating costs, typical scale factors in the range of 0.6 to 0.8.
- Fossil fuel plants are different: delivery cost of fuel drops with increasing size. Other factors constrain plant size.

DEVELOPMENT OF A BIOMASS-BASED FACILITY AT OPTIMUM SCALE

- Typical optimum size of biomass based facilities: 5000 - 6000 dry tonnes/day or 2 MT/yr.
- Biorefinery size less than 5% of typical petrochemical refinery (250,000 barrels/day).
- Issues in building biomass-based facility at this scale:
    - Availability of lignocellulosic biomass
    - Transportation and logistics of biomass supply
    - Suitable forms of delivered biomass

US DOE's Feedstock Cost Targets



Source: NREL, 2007 (http://www.nrel.gov/biomass/pdfs/40742.pdf)

US DOE's Feedstock Cost Targets (Cont'd)

Funding Opportunity Announcement (FAO)- 2013

Technical Barrier Area 1: Feedstock Logistics Costs

BTO's overarching goal is to develop and validate thermochemical and biochemical biomass conversion technologies capable of producing drop-in biofuels at $3 per gallon of gasoline equivalent ($3/GGE), or less, by 2017. A contributing goal is to develop feedstock logistics technologies and systems that can reliably and sustainably deliver on-spec feedstock(s) to the conversion reactor throat at or below $80/dry ton (i.e., $80/DT) by 2017. Therefore, at 60 gal/DT conversion yield, the BTO's 2017 target for feedstock cost will consume up to $1.33/GGE (~44%) of the $3/GGE overall target production cost for advanced biofuels. Lower feedstock costs (i.e., <$80/DT) are, of course, preferred.

The $80/DT target includes all costs associated with feedstock up to the point where it is introduced into the throat of the conversion process reactor. It is comprised of a grower payment plus logistics-associated costs. **For the purpose of this FOA, a target of $50/DT, or less, is being set for all cumulative logistics costs (i.e., all costs incurred between harvesting the biomass through to the throat of the conversion reactor, including those associated with harvest , collection, preprocessing (e.g., drying, grinding, blending, etc.), and transportation and handling costs).** Subsidies or other forms of Federal, State of Local government aid shall not be applied to achieve the $50/DT cost target.

US DOE, 2013 (https://eere-exchange.energy.gov/default.aspx#FoaId8a1308fc-be1d-4e20-b6dd-c42a46c7fd5c.

European Commission – 2012-13 ENERGY Call

SEVENTH FRAMEWORK PROGRAMME

Topic ENERGY.2013.3.7.1: Developing regional and pan-European schemes for the sustainable delivery of non-food biomass feedstock in a pan-European integrated market: up to one project may be funded

– ENERGY.2013.3.7.1: Support to the sustainable delivery of non-food biomass feedstock at pan-European level.

The development of these SRT will have to confront and make use of a large number of available information including:

- Geographical and environmental (e.g. soil, water, climate, protected areas);
- Agronomical (e.g. best available and identified plant/tree varieties, agricultural and forestry practices including effect of biomass extraction on carbon cycle);
- Industrial (e.g. best available pre-treatment and conversion processes, considering also relevant pilot and demo projects[11]);
- Logistical (e.g. hubs and transportation routes);
- Economic and regulatory (e.g. CAP, RES Directive, strategies for rural and regional development, national support schemes, workforce).

Due consideration will be given to the development of small-scale plants suitable for decentralized operation with associated benefits to rural communities besides the centralized large-scale units involving long distance biomass transport.

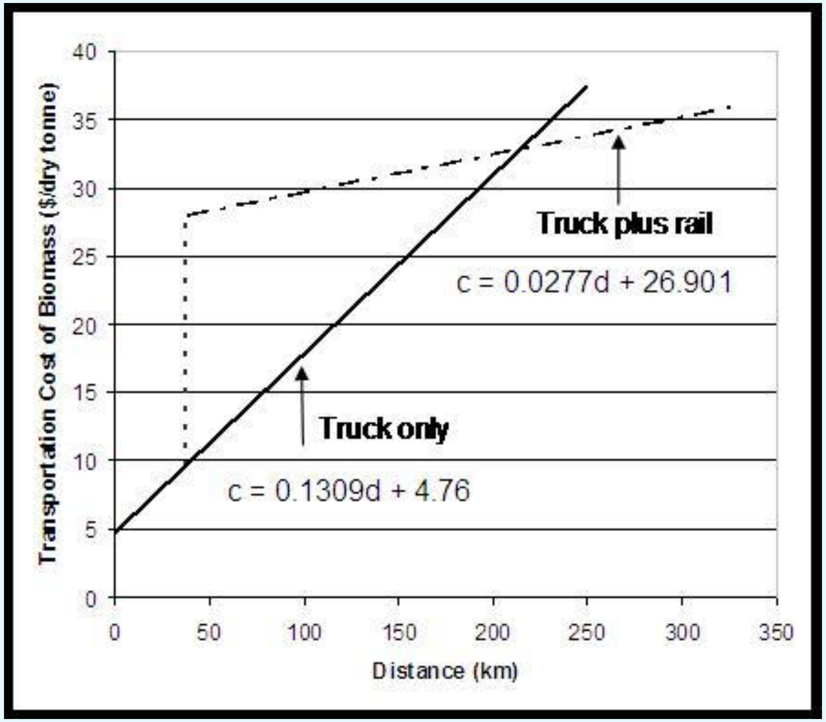
Source: EC, 2012

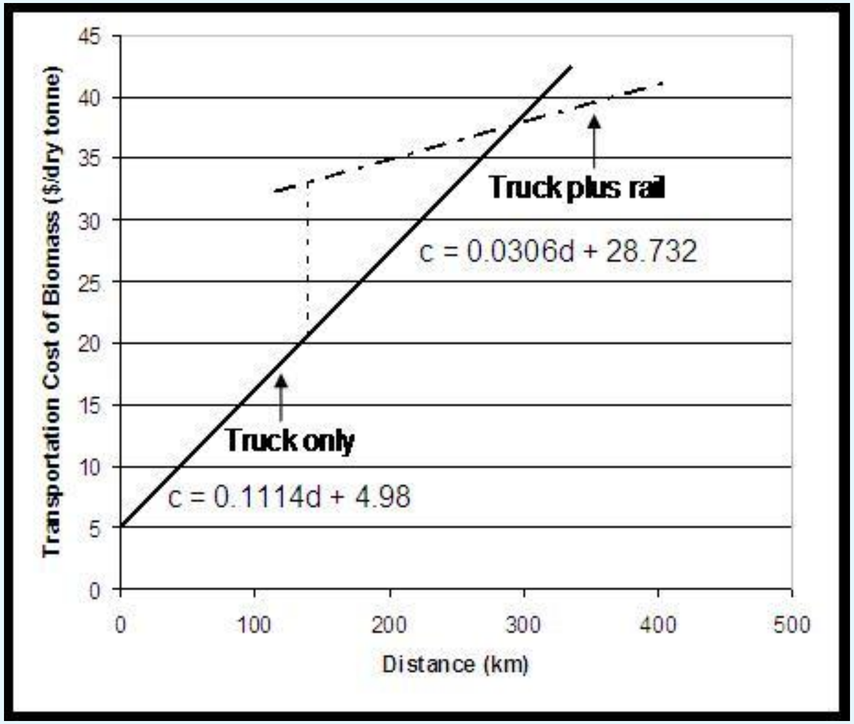
TRANSPORTATION AND LOGISTICS OF BIOMASS SUPPLY

- Transportation cost by truck a major component of total biomass processing cost.
- Truck transportation cost of field sourced biomass for a bioenergy facility depends on:
  - Type of biomass (e.g. wood chips, straw etc.)
  - Facility size
- Typical range 25-45% of total processing cost for truck transport of biomass.

Transportation Cost a Major Component

TRANSPORTATION AND LOGISTICS OF BIOMASS SUPPLY





Transport of straw

Transport of FHR wood chips

Mahmudi et al., Applied Biochemistry and Biotechnology, 2011, 129, 88-103.

TRANSPORTATION AND LOGISTICS OF BIOMASS SUPPLY

- Truck congestion limit - 2 MT/yr (5000-6000 dry tonnes/day capacity biomass facility) - 1 truck every 5 - 10 minutes.
- Rail transportation – 100 car unit train, capacity about 2500 tonnes, two units trains required per day
- Fossil fuel power plants don’t depend on highway truck delivery.

Aggregation of Biomass and Its Transportation

SCALE EFFECTS IN TRANSPORTATION

- No economy of scale for truck transport of biomass (more biomass = more truck trips)
- Rail has “step” economies of scale: e.g. single car to unit train.

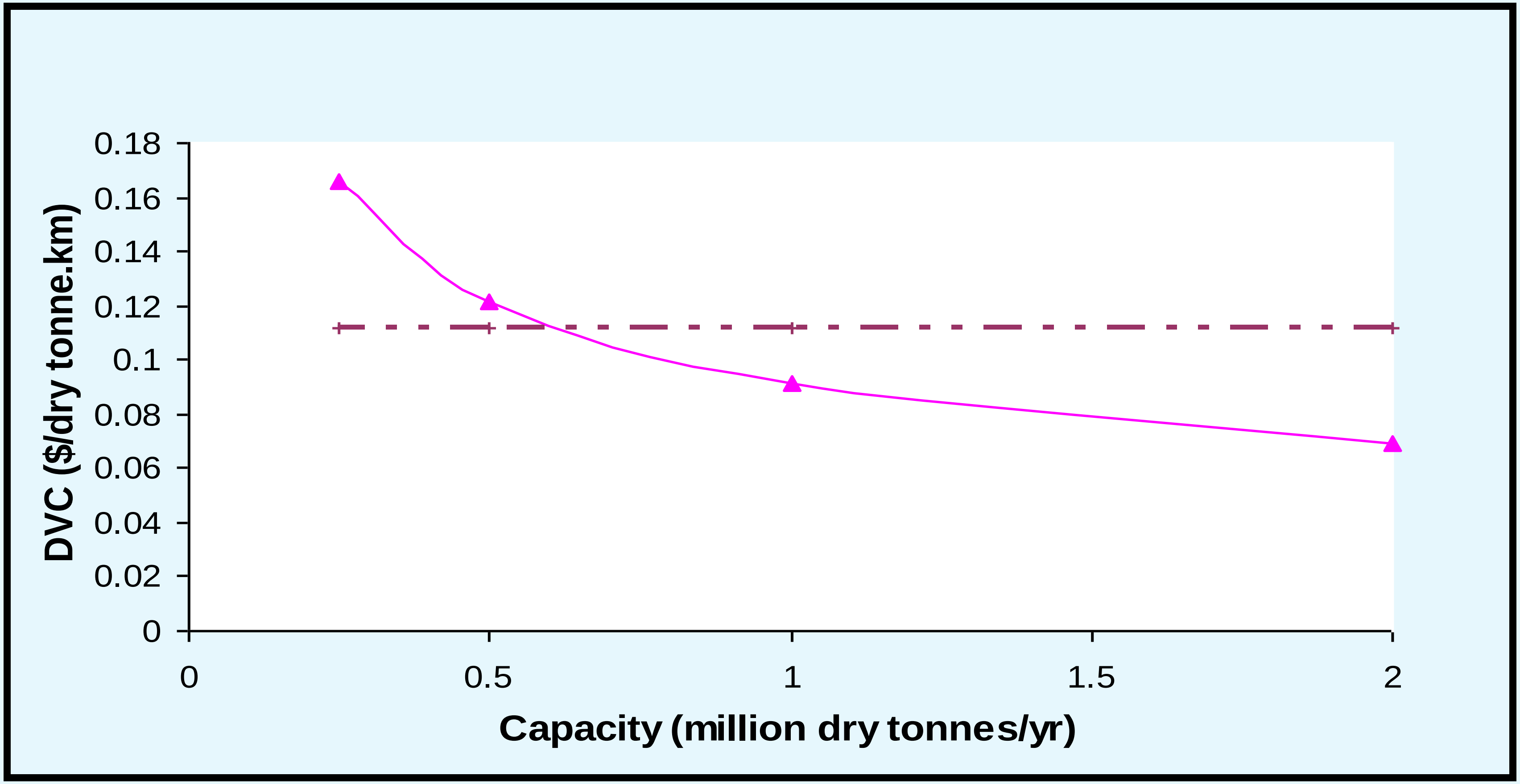
Pipeline Transportation Has A Very Strong Economy of Scale

COMPONENTS OF PIPELINE TRANSPORT

- Truck Transport Cost
  - Fixed cost: loading and unloading.
  - Distance variable cost: driving time, fuel.
- Pipeline Transport Cost
  - Fixed cost: inlet and outlet equipment.
  - Distance variable cost: pipeline, booster
  - stations, pumping power.

TRANSPORTATION AND LOGISTICS OF BIOMASS SUPPLY

- ***Distance Variable Cost Truck vs. Pipeline***

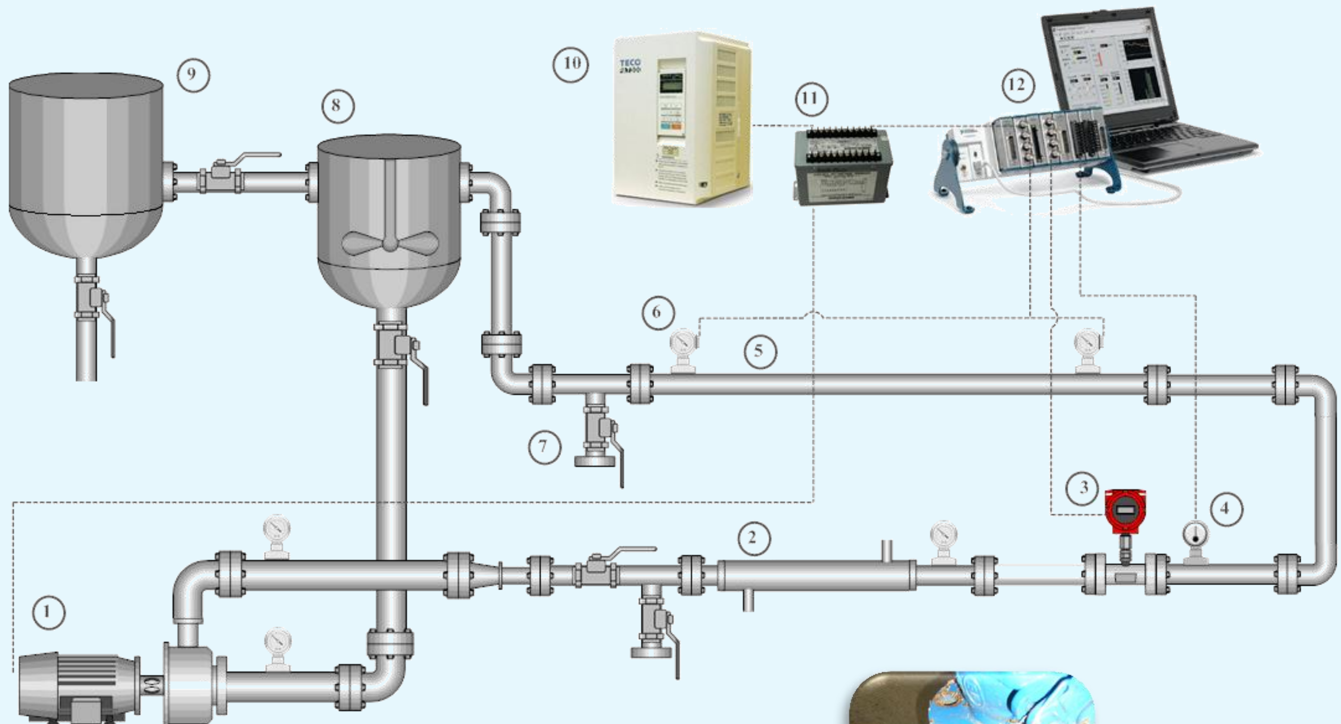


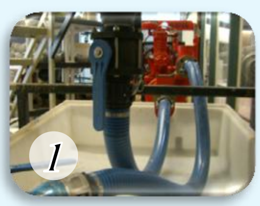
Kumar et al., Bioresource Technology, 2005, 96, 819-829.

Approaches to Pipeline Transport

- Two-way pipeline transport
  - Pipeline for biomass slurry.
  - Pipeline for carrier fluid return.
- One-way pipeline transport
  - Pipeline for the biomass slurry.
  - No pipeline for carrier fluid return.
  - Carrier fluid used in the process.

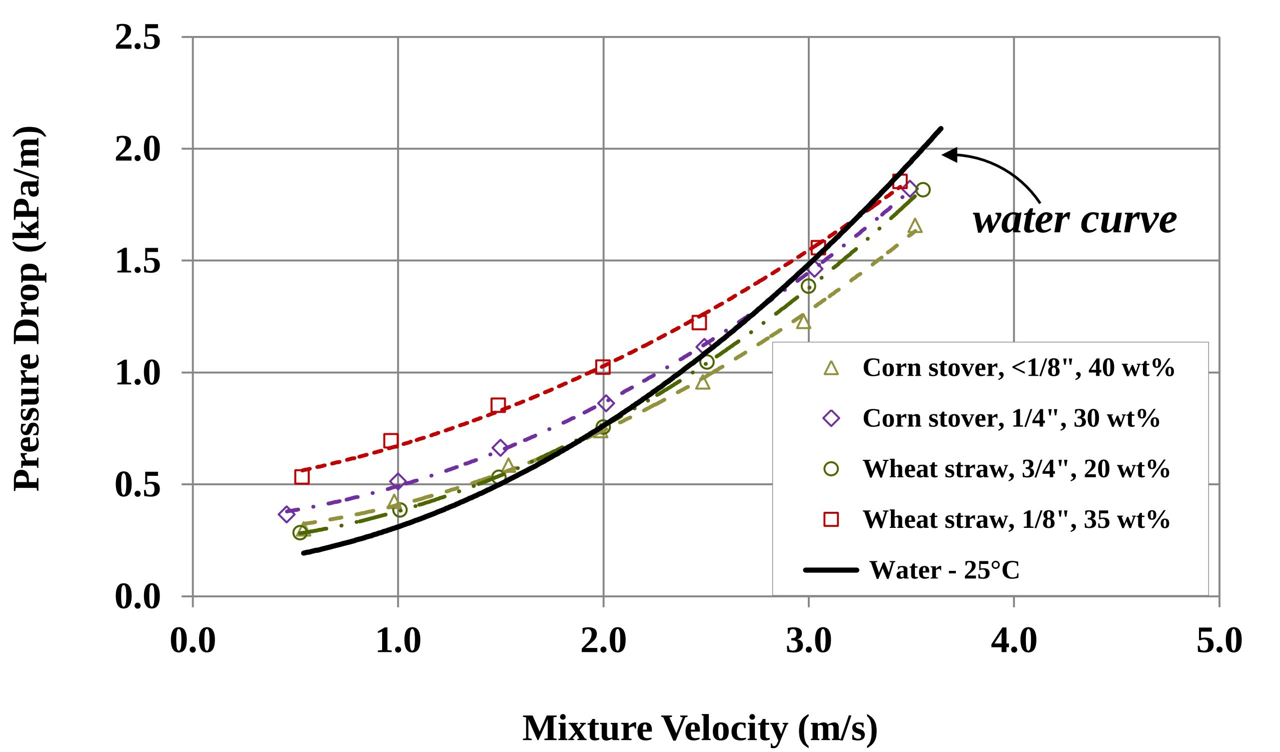
Experimental Pipeline Loop





Pipeline Transportation of Biomass

- ***Experimental Results***
  - ***Pressure Drop of Various Particle Sizes, Types, and Slurry Concentrations vs. Pure Water***



Practical Applications

- Integrated truck and pipeline transport.
- Transportation of biomass by truck for short distance to pipeline inlet.
- Can you afford to remove it from the truck?
- Do the savings (reduction in DVC) offset the extra cost (incremental DFC).
- Further transport of biomass by pipeline.

Results in:
Increased Fixed Cost – Both Truck and Pipeline

Model for Biomass Plant Supplied by Pipeline Transport

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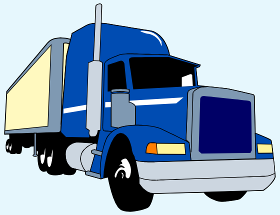
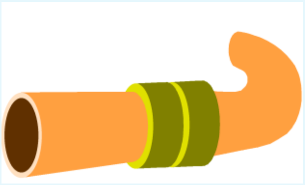
Biomass from field/forest by Truck Transport

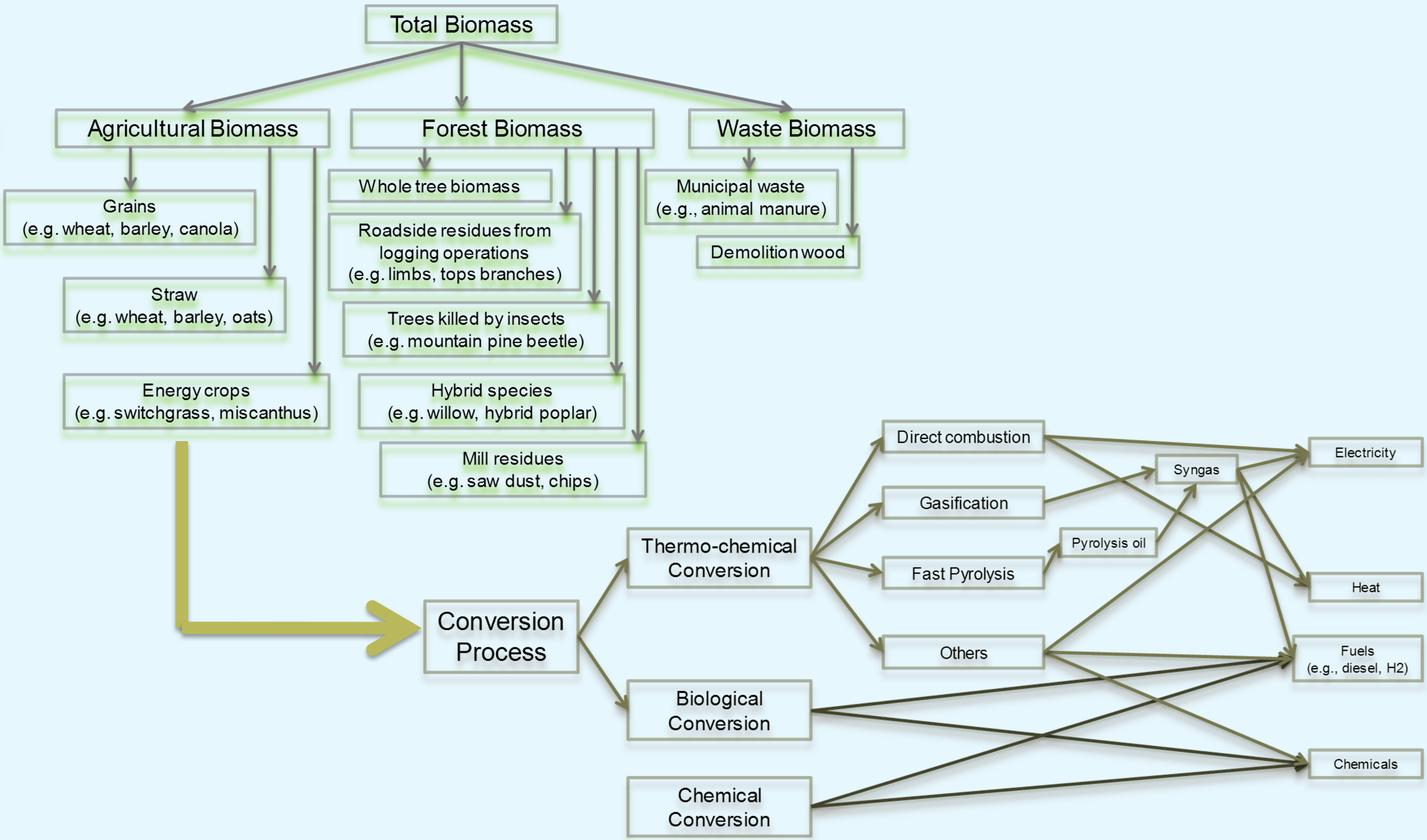


Pipeline inlet for initial processing and slurrying



BIOMATERIAL PLANT

Complexity of the Challange



AGRICULTURAL RESIDUE COLLECTION

System 1 – baling (round or square)




System 2 - loafing



System 3 – Chopping piling or ensiling



Source: Sokhansanj, 2005

FOREST BIOMASS COLLECTION AND TRANSPORTATION

Felling

Chipping

Chip Transport

Piling

Forwarding

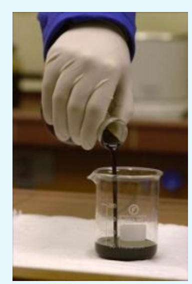
Bundling

Bundle Transport

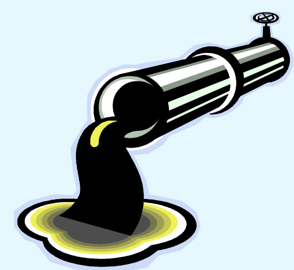
Pellets

Torrefied Wood

Biochar



Bio-oil



Pipeline

Tanker

Source: Sokhansanj, 2005

BCN’s Focus on Biomass Supply & Logistics

- Pre-processing of Feedstocks for Conversion
  - Characterization of biomass feedstocks for different conversion processes.
  - Aimed at answering questions:
    - Should the biomass feedstock be converted to liquid, gas or other solid form before conversion?
    - What is the density or moisture content or size required for the conversion process?
    - What process is suitable to bring it to a suitable specification?

BCN's Focus on Biomass Supply & Logistics

- Biomass Supply and Logistics of Feedstocks for Conversion
  - Biomass delivery cost is a significant portion of processing cost.
- Aimed at answering questions:
  - What should be the form of transportation?
  - What is the mode of transportation?
  - What combinations are more economically attractive and can be integrated to existing infrastructure?

Key Observations

- Biomass supply and logistics contribute significantly to the total cost of producing fuels and chemicals.
- Innovative supply and logistic systems which can address the economy of scale is key and needs to be developed.
- Economies of scale drive the size of the biomass utilization facility to be large.

Key Observations

- Trucks transport to a large scale plant results in road congestion.
- Pipeline transport helps in reducing congestion issues in large scale biomass utilization.
- We need a transformative technology to make it work.

Questions?

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