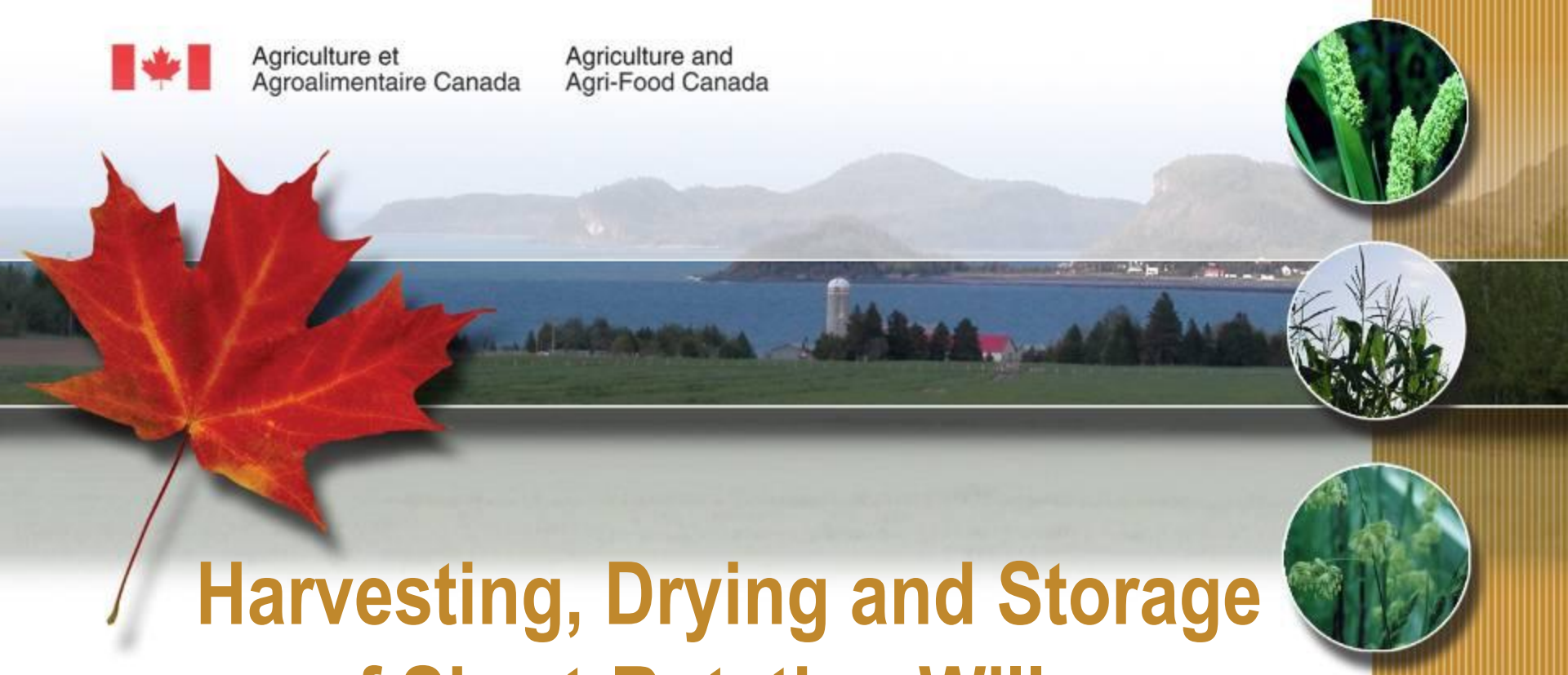

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Harvesting, Drying and Storage of Short-Rotation Willow

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Canada

Presentation Plan

1. Introduction: R&D on short-rotation woody crops at AAFC (2005-2013)

2. Harvesting: self-propelled forage harvester (SPFH), billet harvester, biobaler, pull-type forage harvester

3. Drying and storage; small vs. industrial scale projects

4. Conclusions

Introduction: (a) Plantations and natural SRWC

SRWC are planted or natural shrubs, with multiple stems usually less than 4” (100 mm) in diameter

They grow in various environments: fallow land, utility lines, riparian buffer, forest understory, plantations

They can provide an abundant biomass for bioenegy, bioproducts

Introduction (b) Situation in 2005

1. Willow plantations existed in Europe, mainly in Sweden, UK and Poland
2. SPFH had been modified to harvest SRWC: Claas, CNH, John Deere had equipment for > $ 500,000
3. Little small scale harvest technology or versatility to collect both plantations and natural shrubs

Introduction (c) R&D by AAFC (2005-08)

AAFC developed a versatile harvester, the “Biobaler”: baler with a cutter-header able to operate in plantations or in natural stands (U.S. Patent 7,743,595)

The Anderson Group of Chesterville, QC developed a commercial version in 2009 which sells for ≈ $150,000 $ (+ 140 kW tractor)

Introduction (d) R&D at AAFC (2009-2013)

AAFC showed that the “Biobaler” can harvest plantations at an average rate of 35 bales/h [between 25 and 45] (bale mass ≈400 kg WM, 200 kg DM), about 14 t WM/h or 7 t DM/h

On brush land, harvest rates range between 2 and 20 bales/h as a function of topography, yield

Custom rate (≈$175/h): $25/t DM in plantations; > $45/t DM in natural stands

Introduction (e) R&D storage (2009-12)

1. Willow bales dry naturally outside from 50 to 35% moisture; well-aerated wood chips dried from 50 to 20% (in mini-cribs)
2. Important DM loss, 1 to 2%/month when exposed outside
3. Grinding 60-70 bales/h; 12-15 t DM/h; cost $250/h ($20 /t DM)

Introduction (f) Understanding the energy market

Cost of energy in Québec (2013):

(i) Electricity at 7 ¢/kW.h => 17 $/GJ
(ii) Propane at 60¢/L => 24 $/GJ
(iii) Heating oil at 80¢/L => 20 $/GJ
(iv) Natural gas at 35¢/m³ => 10 $/GJ

One tonne (1000 kg) of wood chips at 15% moisture contains 15 GJ
If it replaces heating oil, it is worth $300/t

If wood chips are sold to a pulp or board plant, the current price in QC is ≈ $80-100 /t DM ($40-50/t wet at 50% moisture)

Introduction (g) Understanding SRWC markets

Nurseries can sell stems as ornamental plants ($1/stem) or 20 cm cuttings at 10 ¢ each: a field produces 100 000 stems/ha; 300 000 cuttings/ha (niche market)

Bulk biomass from willow ≈10 t DM/ha/yr; industrial market pays about $80/t DM; production costs > ≈ $100 /t DM

Conditioned biomass (dried, ground, pelleted) : $120-200/t DM

Biorefineries: under developed at the present time; there may be opportunities for biomass electricity plants (e.g. Port Hawkesbury, NS)

Main harvest methods

1) Self-propelled forage harvester
2) Billet harvester
3) Biobaler
4) Pull-type forage harvester

SPFH: (a) Technical parameters

Variable capacity (10 to 70 t WM/h), average 35-40 t WM/h (Spinelli et al. 2009); max. capacity of 120 t WM/h with CNH FR9090 (824 HP)

Average invest.≈ $600,000; variable costs of R&M $50/h, labour $20/h, fuel $35/h => $105/h ($7/t DM)

Fixed costs: $90,000/yr; if used 100 h/yr (2000 t DM), $900/h ($45/t DM); if used 500 h/yr (10000 t DM), $180/h ($9/t DM)

SPFH: (b) Costs

Harvest crew includes 2 or 3 trucks, as a function of distance

Hourly cost (excl.transport): between $285 and $1000/h ($16-54 /t DM)

Importance of scale: management of wood chip pile

Multiple uses of SPFH with other headers (forages, corn silage)

Billet harvester: Parameters, cost

Sugar cane harvester modified to harvest willow billets, i.e. chopped sticks of 20 cm length

Investment cost estimated at $200,000; little technical information on the system used in UK

All subsequent operations must be adapted to billets: transport, storage, handling, processing

Harvest with the biobaler: (a) in plantations

Average of 35 bales/h (7 t DM/h)

Variable costs: R&M $15/h, labour $20/h, fuel $15/h, tractor rental $40h => total VC, $90/h

Fixed costs (biobaler): about $22,000/yr; if used 100 h/yr (700 t DM), $220/h; if used 500 h/yr (3500 t DM), $44/h

Total cost: from $134 to $310/h ($19 to $44/t DM)

Biobaler harvest: (b) in natural stands

Average of 10 bales/h (2.2 t DM/h), average total cost $175/h; average harvest cost: $80/t DM

In natural stands, biomass harvest must represent an additional value: e.g. brush fire risk reduction, environmental management, clearing invasive species, cleaning riparian buffers

W/o such benefits, value of biomass is not worth its harvest cost

Harvest with the biobaler: (c) uses, grinding

Round bales can be used directly for some applications (e.g. heat source in Farm 2000 boiler)

Otherwise, round bales must be shredded or ground (e.g. HayBuster shredder); this is an extra cost of about $20/t DM

Other factors: moisture content, drying, particle length and shape

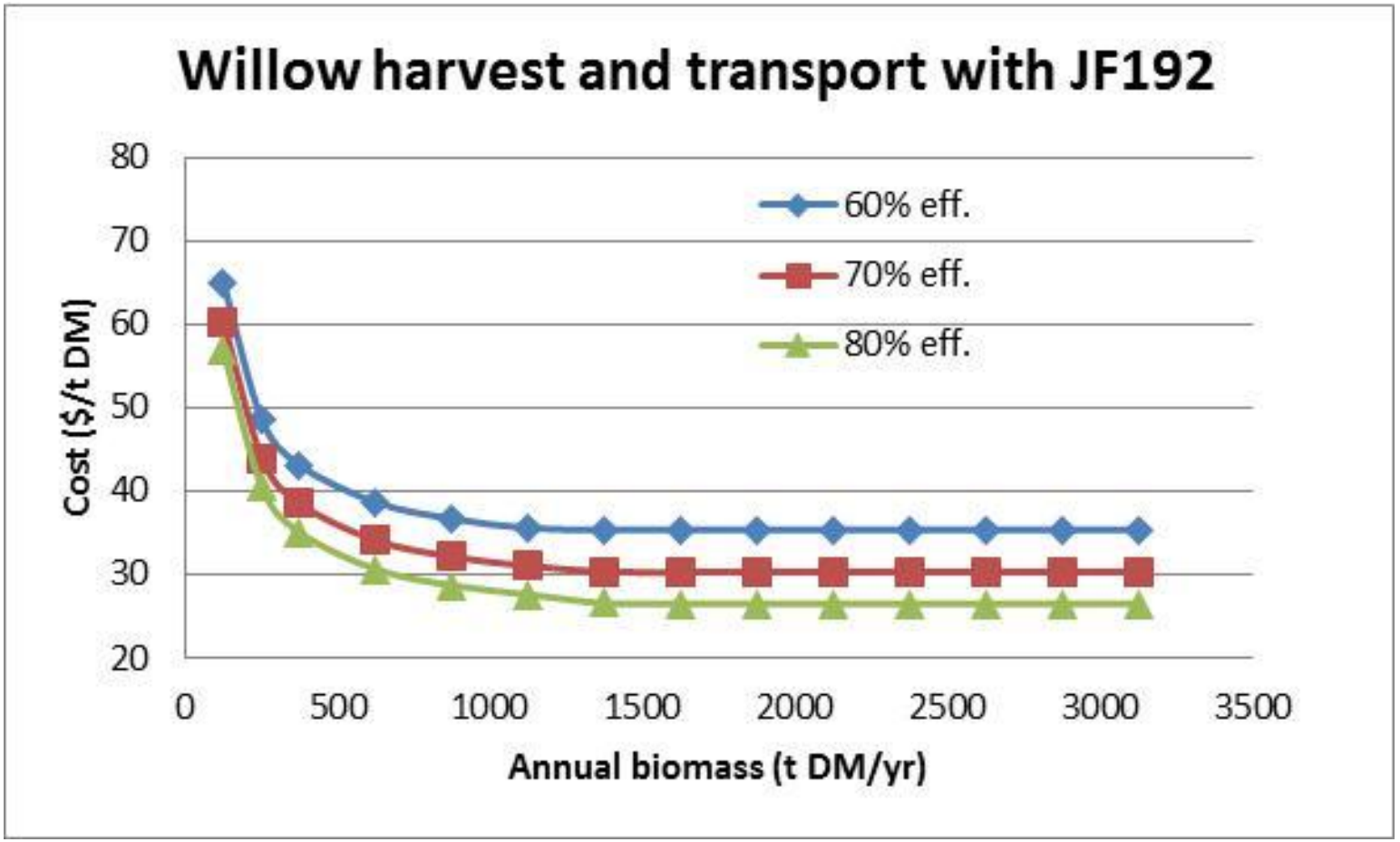
Harvest with a pull-type forage harvester

Brazil-made JF Maquinas (JF 192) harvester can cut and process stems up to 50-60 mm diameter; Danish version by Ny Vraa

Measurements were made in Dec. 2012 in St-Roch-de-l'Achigan, QC: filled a 7 t wagon in 30 min. => continuous capacity of 14 t WM/h; at 70% eff. capacity is 10 t WM/h or 70-80 t/d

Limitations: 2-yr old stems; many uncut stems; $45,000 cost

Cost to operate a pull-type forage harvester



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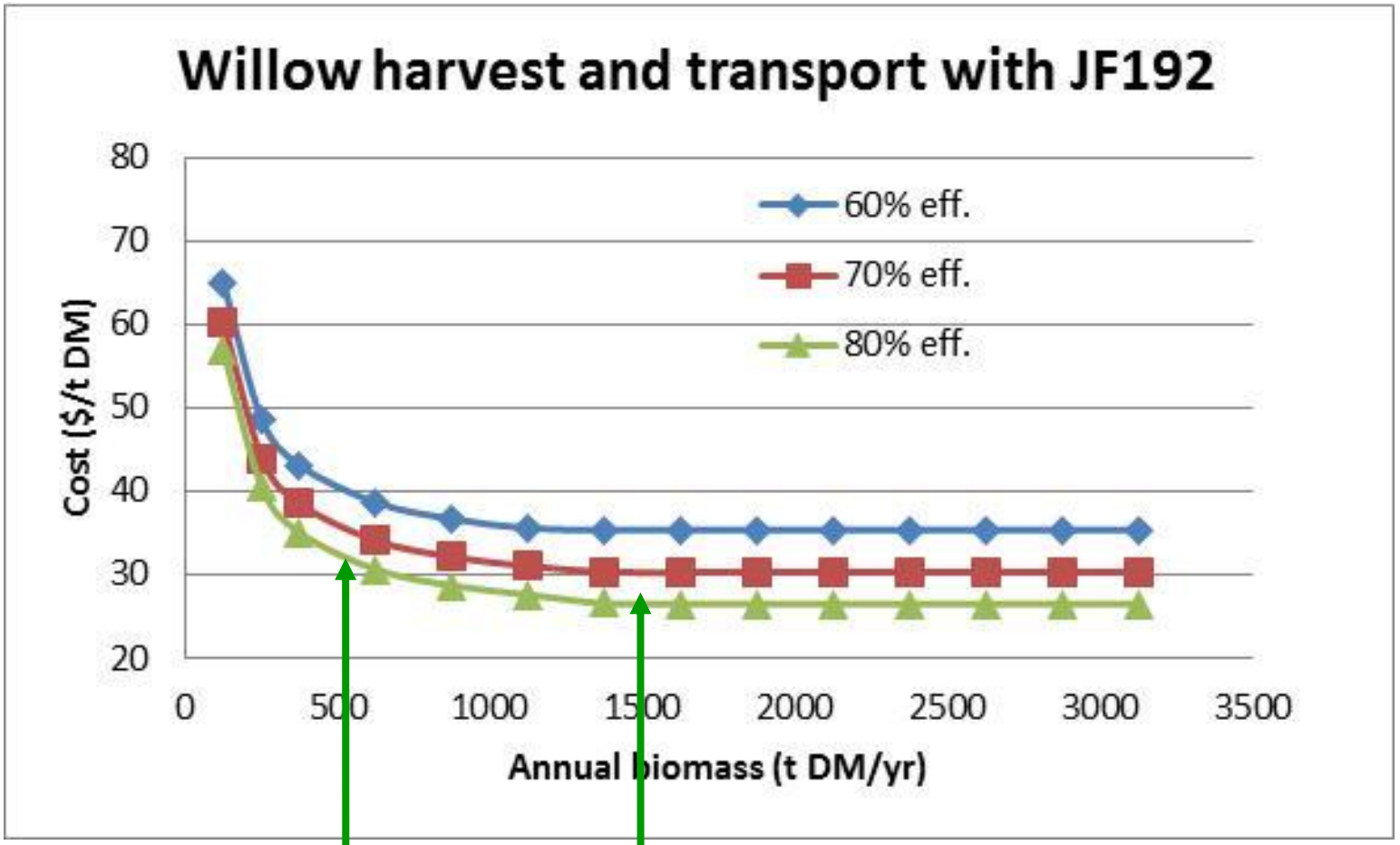

500 t MS, $32-40/t DM

1500 t MS, $25-35/t DM

North American pull-type forage harvester

Medium size FH (e.g. New Holland FP240, Dion F41) have capacities of 40 to 60 t WM/h in forage

Tests have been made with willow; easily chopped with such PTFH

"Light" investment: basic PFFH about $35,000, already available in dairy regions; header could be built for about $40-50 k; expected capacity of 30 t WM/h; saw blades could cut stems of 100 mm; cost would range $20-25/t DM

Small scale projects (on-farm heating)

Heating greenhouse or poultry coop: e.g 50,000 L of oil/yr => 2000 GJ => 133 t DM of wood chips => 13-15 ha

There should be at least 5 such projects (> 500 t DM) to bring harvest cost < $30/t DM with a JF192, and develop expertise on storage and conditioning

SPFH has a capacity to harvest up to 1000 ha => 10 000 t DM/yr => enough biomass to heat 60 poultry coops

PTFH: may be affordable for 10 projects (130 ha, 1300 t DM/yr)

Large scale projects

1. Biorefinery using 400 000 t WM/yr, 200 000 t DM/yr , ≈100 M litres of biofuel => 20 000 ha in plantations
2. Port Hawkesbury 60 MW (electric) biomass plant requires about 300,000 t DM/yr or 500,000 t WM/yr (at 40% moisture); wood from forest, but agriculture could contribute “if the price is right”
3. Use of agricultural land for large scale projects (> 10,000 ha) should be done on marginal land, underused pasture, low value brush land; large scale application less beneficial if displacing agricultural crops or high value forest

Drying wood chips

(1) Round bales dry in piles from 50 to 35%, then stabilize

(2) Wood chips in mini-cribs dry down to 20% moisture

(3) Wood chips in large cribs do not dry because air flow is limited

(4) Consider displacing pile under shelter to condition wood chips

Conclusions

Harvest of SRWC can be done with various harvesters
Widely variable costs: SPFH between $16 and $56/t DM + $5/t DM for transport; Biobaler, $19-44/t DM (+ $20/t DM for grinding); JF192, $25-35/t DM; PTFH could cost ≈ $20-25/t DM
Differences in moisture content during storage => cost of drying, quality of combustion, losses
Scale of project is important: will affect the choice of technologies for harvest, storage, handling and transport

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Thank you.

Questions?

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