The Potential for Biomass Energy Crop Production in Canada

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REAP-Canada

- Providing leadership in the research and development of sustainable agricultural biofuels and bioenergy conversion systems for greenhouse gas mitigation
- 14 years of R & D on energy crops for liquid and solid biofuel applications
- Working in China, Philippines and West Africa on bioenergy and rural development projects

Today's Seminar

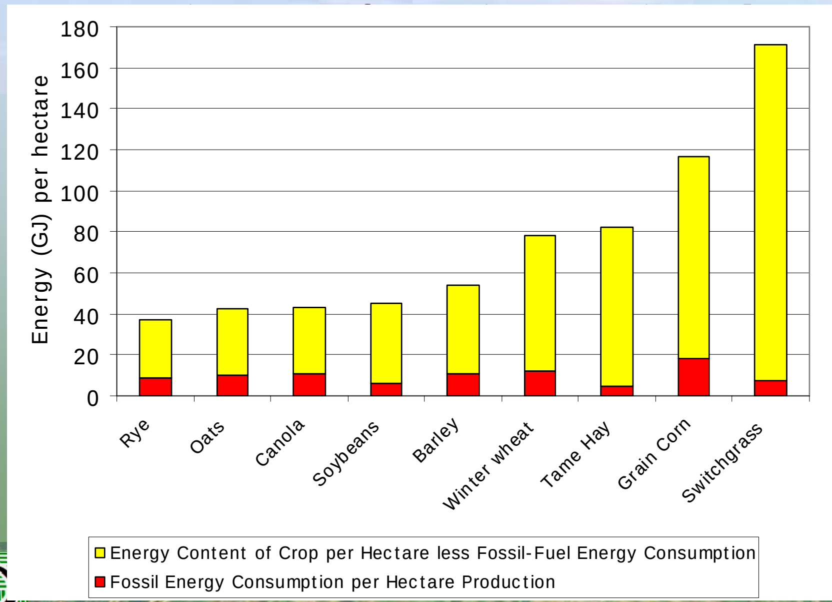
- Relative efficiency of annual field crops, vs biomass energy feedstocks as "solar energy collectors"
- Review some of the bioenergy feedstock development research in Canada
- Energy Production Potential of the Industry
- Future research needs

Optimizing Biofuel Development

To economically provide large amounts of renewable energy from biomass we must:

1. As efficiently as possible capture solar energy over a large area
2. Convert this captured energy as efficiently as possible into a convenient and low cost end use application

Solar Energy Collection and Fossil Fuel Energy



Biofuels Research at REAP-Canada

Switchgrass: a multi-use biomass crop

- Paper
- Cellulosic ethanol
- Biofuel pellets and briquttes
- “Straw bale” Housing

Grass Pellet Burning Stoves

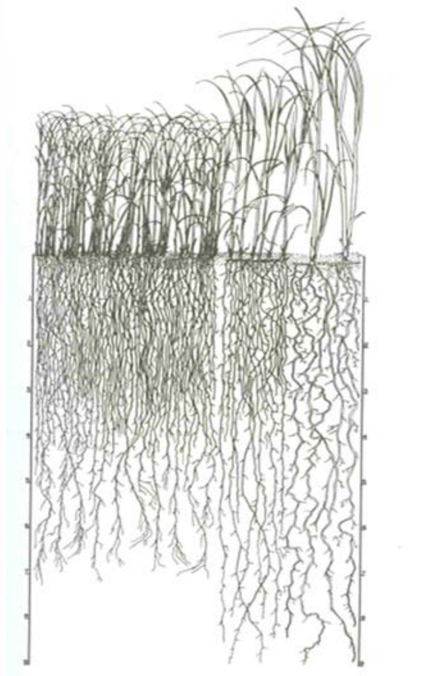
Comparing C3 and C4 plants

Cool season (C3) Plants

- Greater chilling tolerance
- Utilize solar radiation effectively in spring and fall

Warm season (C4) Plants

- Higher water use efficiency (typically 50% higher)
- Can utilize solar radiation 40% more efficiently under optimal conditions
- Improved biomass quality: lower ash and increased holocellulose and energy contents
- Responsive to warming climate



Warm Season Grasses

C4 Grasses such as Switchgrass (*Panicum virgatum*), are ideal bioenergy crops because of their moderate to high productivity, stand longevity, high moisture and nutrient use efficiency, low cost of production and adaptability to most agricultural regions in North America.

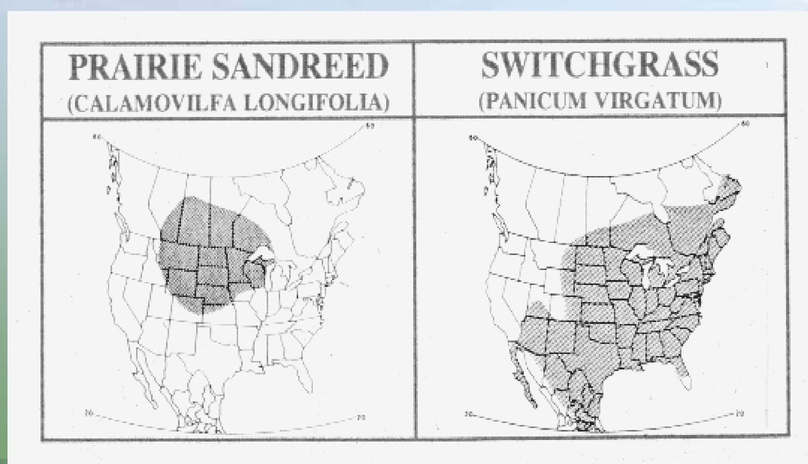
Water as a factor limiting yield

- Ontario and Quebec receive 1000 mm/yr
- Assumption that 40% of water is available for crop growth: 400 mm/yr
- Assume C4 species use 20 mm/tonne

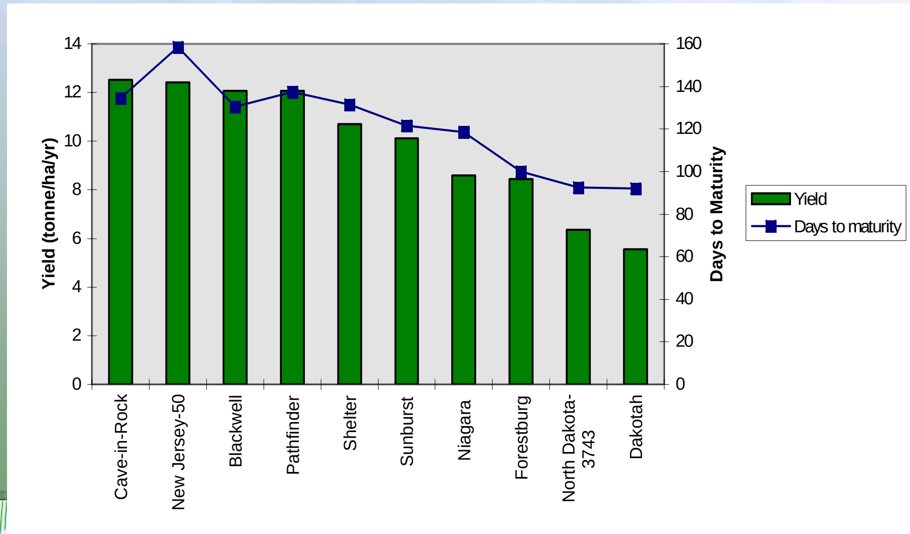
  Assume C3 species use 40 mm/tonne
- Maximum yield C4 species: 400/20 = 20 tonnes

  Maximum yield C3 species: 400/40 = 10 tonnes

Native Range of Promising Warm Season Grass Biomass Feedstocks



Yield of switchgrass cultivars at Ste. Anne de Bellevue, Quebec (1993-1996)



Mean Annual Biomass Production of 7 Grasses in 3 Provinces of Western Canada (3 or 4 yr averages).

	Location					
Species	**Cultivar or line**	**Brandon clay soil**	**Brandon sandy soil**	**Lethbridge**	**Swift Current dryland**	**Swift Current irrigation**
Cool-season grasses	------------------------------------ Mg/ha[a] ------------------------------------					
Thickspike	Critana'	7.2	1.2	6.7	2.7	4.0
wheatgrass	Lodorm'	4.8	1.6	7.5	2.0	5.3
Green needlegrass	ND-691	10.5	2.4	15.8	2.2	6.6
Mammoth wildrye	Rodan'	6.9	2.0	7.7	2.2	5.2
Western wheatgrass	Rosana'	6.0	1.7	8.8	2.5	5.4
Warm-season grasses						
Big bluestem	Bison'	6.2	1.6	5.5	1.1	3.0
Switchgrass	Dacotah'	6.5	1.7	7.0	1.0	4.3
Prairie sandreed	Goshen'	0.0	1.8	9.5	1.1	2.4
	ND-95	0.3	2.2	7.9	1.4	3.1

Jefferson et al. 2002

Farmland in North America and Potential for Biofuel Production

Land use	Millions of Hectares	Area for biofuel production* (million ha)	Potential perennial grass production** (million tonnes)	Solar energy collected (Billions GJ)
Canada	68	10.2	60.2	1.11
U.S.A.	377	56.6	458	8.47

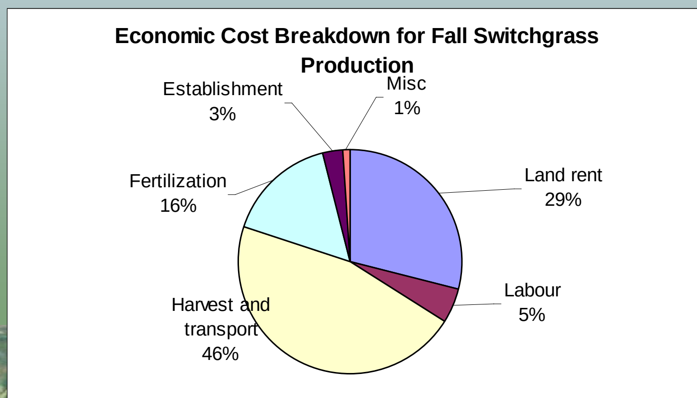
** Estimated 15% land converted to bioenergy grasses*

*** Assumed bioenergy hay yields of 5.9 tonne/ha in Canada and 8.1 t/ha in the US and 18.5GJ/tonne of hay*

Switchgrass Harvesting Operations

Economics of Switchgrass Production

- Fall harvesting
  $41-57CDN/tonne
- Spring harvesting
  $46-68CDN/tonne

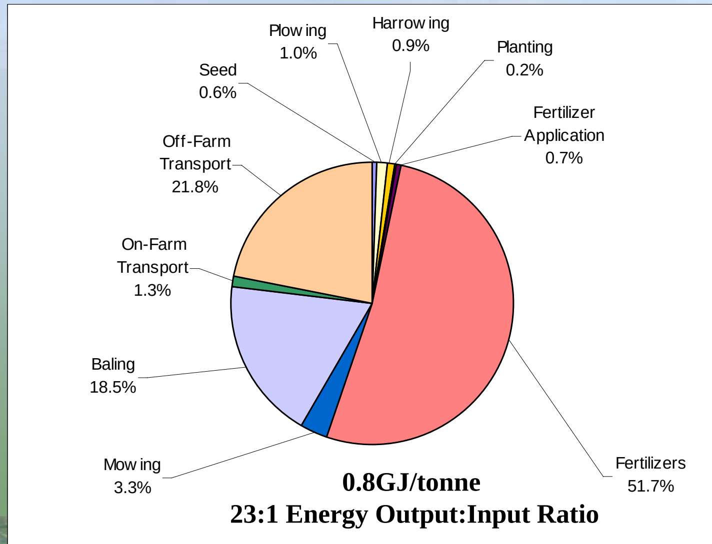


Modernizing the Bioenergy Heat Production Chain

Energy crop	Pellet fuel	Stove Boiler	Heating Cooking

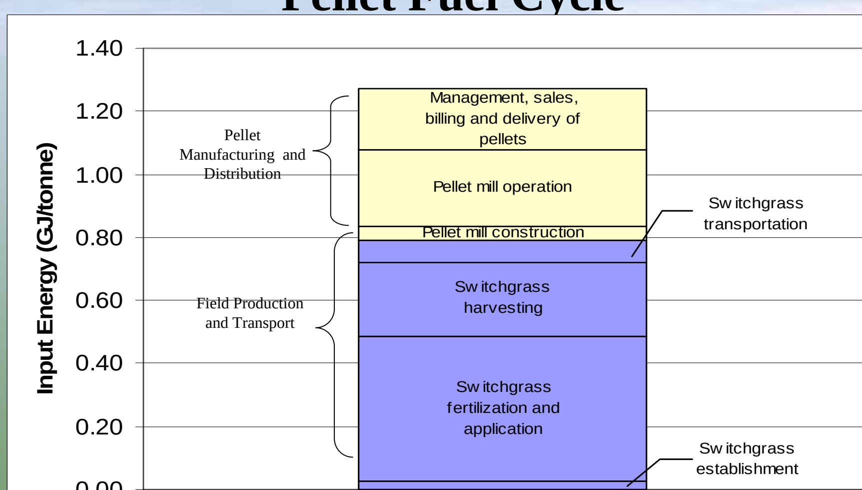



Relative Energy Use in Switchgrass Production



Bale processing at a pellet mill

Energy Associated with Switchgrass Pellet Fuel Cycle



Energy Output:Input Ratio 14:1

Net Energy Gain and Land Use Efficiency

	Switch-grass fuel pellets	Co-firing switch-grass with coal	Switchgrass cellulosic ethanol and electricity	Grain corn ethanol
Biomass yield per hectare (ODT)	10	10	10	6.5
Direct biomass energy yield (GJ/ha)	185	185	185	136.5
Energy yield after conversion (GJ/ha)	175.8	58.3	73.0 (67.2 ethanol + 5.8 electricity)	64.2+ coproducts
Energy consumed in production & conversion (GJ/ha)	12.7	11.1	15.9	42.8+ coproducts credits
Net energy gain (GJ/ha)	**163.1**	**47.2**	**57.1**	**21.4**

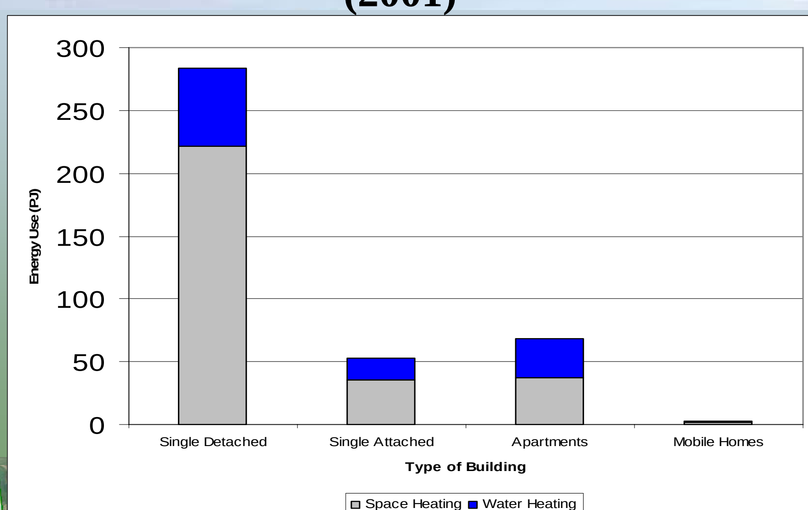
BIOHEAT : is the best way to use farmland to reduce GHG's

- In Ontario Bioheat from grasses is 7 times more efficient than using land to produce corn for ethanol
- Switchgrass Cellulosic ethanol is 2.7 times more effective than corn ethanol
- Corn ethanol is a subsidy to US corn farmers as Canada is a net corn importer
- Corn ethanol is weak GHG and rural development policy

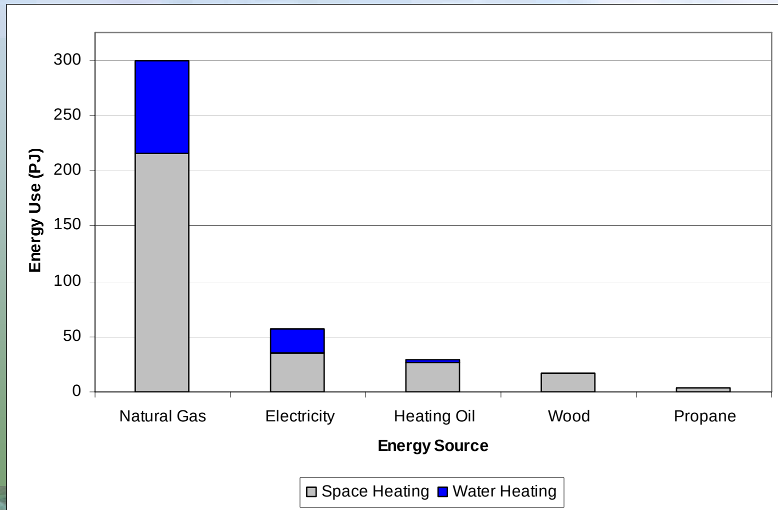
New Advances in Pellet Combustion Technologies

- Gasifier Pellet stove and boilers can have 85% efficiency and can burn densified switchgrass fuels

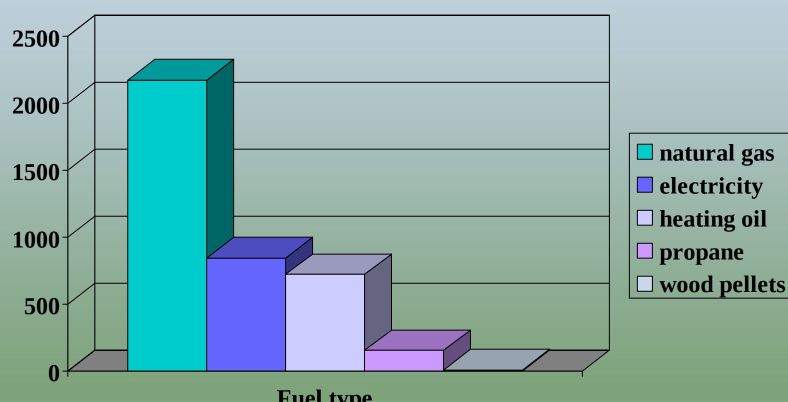
Space and Water Heating in the Residential Sector by Type of Building in Ontario (2001)



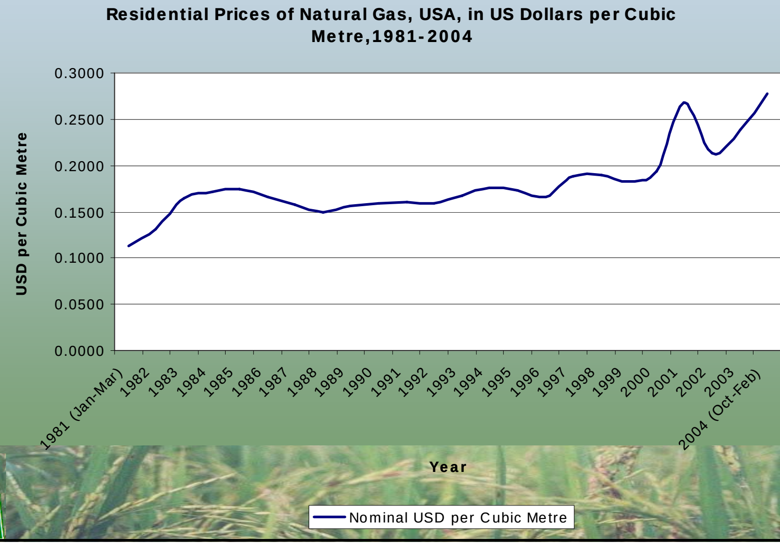
Residential Space and Water Heating Energy Use in Ontario (2001)



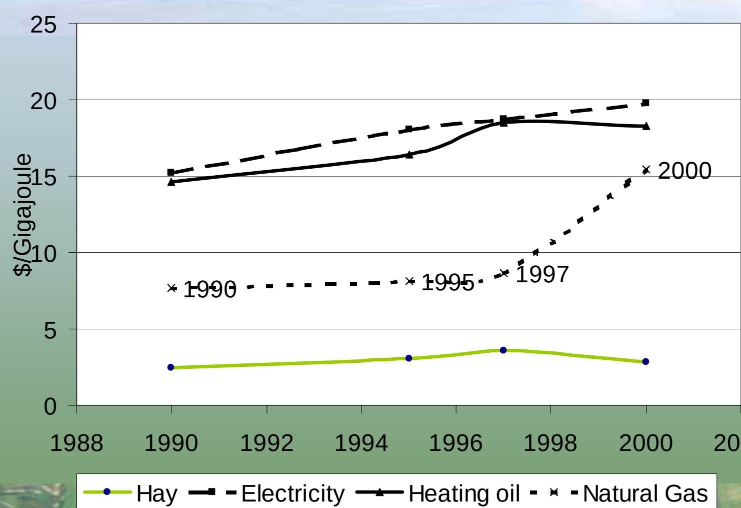
Average Annual Energy Expenditures (millions$) for Domestic Space Heating in Ontario (Jannasch et al 2001)



The Main Fuel in Use is Natural Gas, but where are Natural Gas Prices Headed in North America?



Comparative Costs of Hay Prices vs. Residential Heating Costs in Manitoba



On-Farm Energy in the Prairies at $5.50/GJ

- Energy grasses grown for $55/tonne or $3/GJ
- Densification at $45/tonne or $2.50/GJ
- On-farm fuel at $100/tonne or $5.50/GJ
- Cheap rural energy will stimulate the entire rural economy

PFI Pellet Fuel Quality Standards

- Premium (<1% ash) vs. Standard (3% ash)
- Density: 40 pounds per cubic ft.
- Dimensions: Maximum 1.5 inches in length
  Diameter ¼ or 5/16 in.
- Fines: Maximum 0.5% by weight
- Chlorides: Maximum 300 ppm

Biomass quality of switchgrass as a combustible biofuel

The formation of clinker is a concern when combusting herbaceous feedstocks such as switchgrass pellets. Late fall harvesting and overwintering warm season grasses reduces the potassium and chlorine content which improves overall biomass quality to enable combustion in commercial boilers.

Spring harvested switchgrass:	**2.8-3.2% ash and 19.1GJ/tonne**
Fall harvested switchgrass:	**4.5-5.2% ash and 18.5 GJ/tonne**
Western wheat straw:	**7-11% ash and 17.5-18 GJ/tonne**
Wood residues	**.5-3% ash and ~19.5 GJ/tonne**

Also Crop Milling Residues

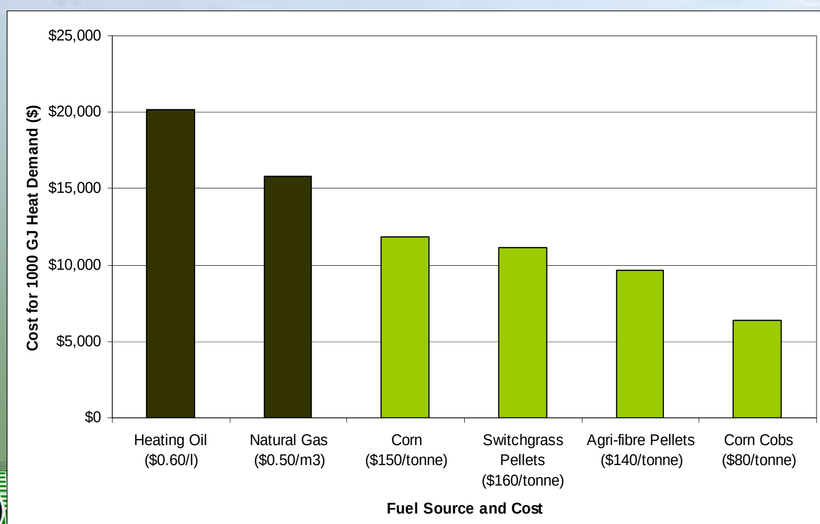
- Oat hulls, pin oats, wheat midds, flax shives, sunflower hulls are all excellent low cost fuels for pellets/cubes
- These fuels will create the market for energy grasses to follow
- These fuels can be developed in 2006 at <$100/tonne and are the low hanging fruit for developing the emerging bioheat industry
- The main reason field crop residues will be slower to develop are the high ash, chlorine and potassium content

Main Market Opportunities for energy grasses and crop milling residue fuels

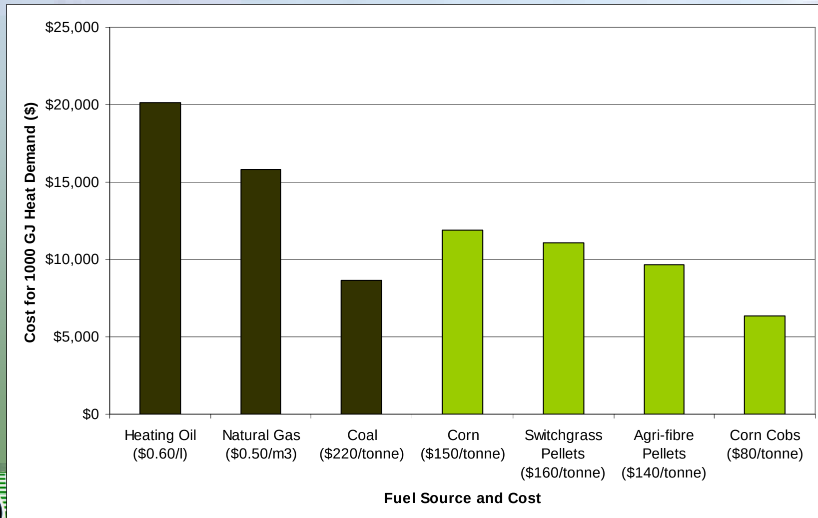
- Residential stoves and boilers 9-25 kw (though not quite as fuel friendly as bigger units)
- Small commercial boilers 100-300kw (few combustion limitations, most units now with ability to burn most higher ash fuels due to advancing technology)
- Industrial boiler biofuel markets, few technical problems but will greatly benefit from carbon credits especially in western Canada

(Kyoto should become a favourite word of farmers!)

Estimated Cost of Heating in Ontario (2006)



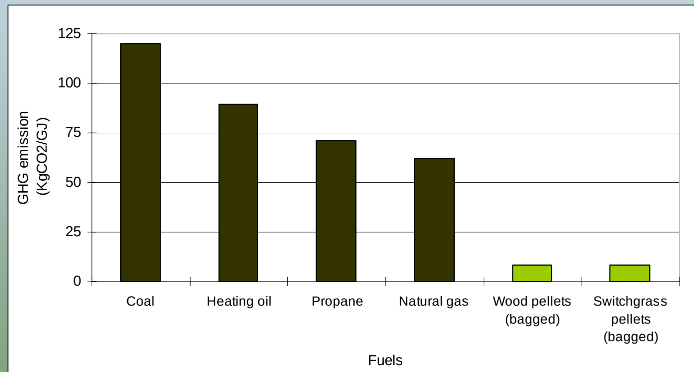
Estimated Cost of Heating in Ontario with coal (2006)



Estimated Cost of Heating in Ontario (2006)

Conventional Fuel	Cost per Unit	Unit	Energy Content	Cost per GJ	Efficiency	Cost per GJ	Cost for 1000 GJ
Heating Oil	$0.60	Litre	0.039	$16.12	80%	$20.15	$20,145
Natural Gas	$0.50	m^3	0.037	$13.43	85%	$15.80	$15,800
Coal	$220	tonne	31.8	$6.92	80%	$8.65	$8,648
Grain Corn	$150	tonne	15.8	$9.49	80%	$11.87	$11,867
Switchgrass Pellets	$160	tonne	18	$8.89	80%	$11.11	$11,111
Agri-fibre Pellets	$140	tonne	18.1	$7.73	80%	$9.67	$9,668
Corn Cobs	$80	tonne	18	$4.44	70%	$6.35	$6,349

GHG Emissions for Major Fuel Types



Carbon credits for biomass can make it cheaper than coal

- Since burning 1 tonne of biomass displaces emissions of ~1.2, 1.5 and 2 tonne from combustion of natural gas, oil, and coal
- Carbon credits of ~10/tonne CO2 avoided could be worth up to $20/tonne of biomass
- Carbon trading system could reduce users cost of biomass by ~10-15%

Summary

- Direct Combustion of densified fuels represents the best biofuel cycle in terms of energy, land use and economics
- Could provide a substantial new GHG friendly energy resource for North America to displace declining fossil fuel reserves
- Emission reductions in Canada could be ~100 million tonnes

Summary, (continued)

- Perennial grasses hold the potential to become Canada’s largest new renewable energy source
- The federal government should encourage the development of 10-15 million ha of perennial forages for biofuel applications
- The farmers in Canada and the US could produce more than 500 million tonnes of energy crops annually
- Energy equivalent is ~1.5 billion barrels of oil equivalent or 4 million barrels/day

Time to get the message out!

- Bioheat is a “made in Canada” GHG solution that greatly benefits rural Canada
- Energy crop farming will absorb the surplus production capacity of the farm sector and cause an across the board rise in commodity prices
- North American farmers can out produce the Tarsands within the next 25 years
- We need to sow the seeds of a GREEN PROSPERITY movement to keep our economy and biosphere healthy