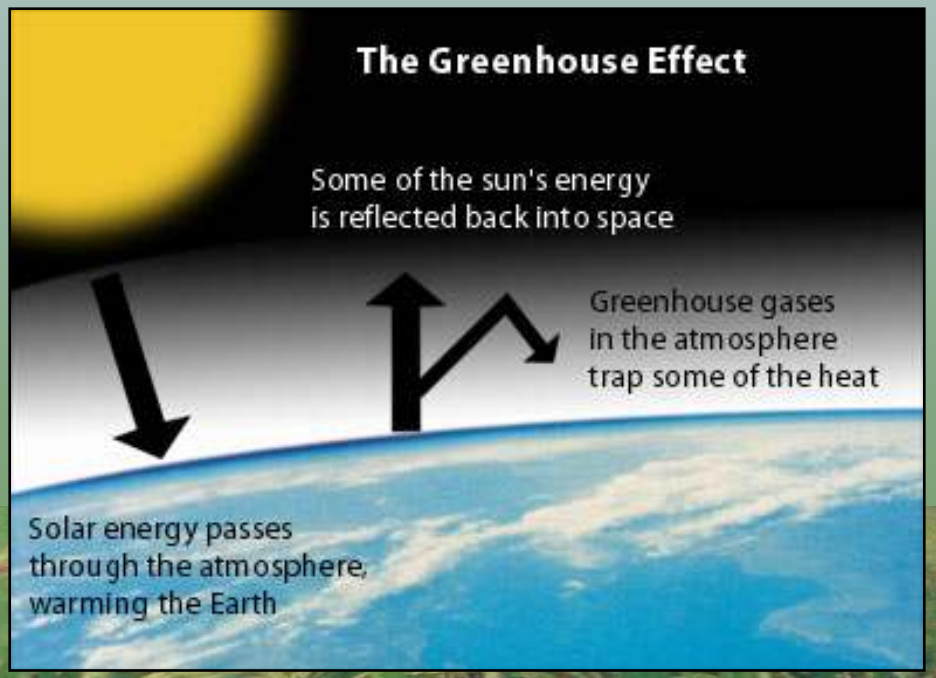
GHG Mitigation Potential of Biofuels in Canada

Stephanie Bailey Stamler
Resource Efficient Agricultural Production (REAP)-Canada
Toronto, Ontario
sbailey@reap-canada.com

GHG's-Why They're Important

- Include water vapour, ozone, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).
- Occur naturally in the atmosphere and trap energy from the sun.
- Without them, Earth's temperature would be 33°C lower.
- Human activities are increasing GHG's.



What is a GHG Offset?

- A reduction or avoidance in GHG emissions in one place in order to "offset" emissions somewhere else.
- GHG's differ in their "global warming potential"- their ability to absorb heat in the atmosphere.

Greenhouse Gas	100 yr-GWP
Carbon Dioxide-CO_2	1
Methane-CH_4	23
Nitrous Oxide-N_2O	296

Expressed in CO_2 equivalents

Biofuel GHG Offsets Basics

GHG offsets are a function of 2 main factors:

The total amount of renewable energy (GJ) produced/ha
(solar energy collected in the field less energy lost going through the biofuel conversion process)

The amount of fossil energy (GJ) used in the production of the feedstock/ha

The amount of fossil energy used to convert the raw feedstock to a processed biofuel form

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Comparing Biofuels as Offset Strategies

Factors to Consider:

- Net GHG savings by replacing a fossil fuel with a a biofuel option (kg CO_2e/GJ).
- Efficiency of the offset (%).
- The cost of incentives or subsidies for each unit energy produced ($/GJ).
- Cost required to offset 1 tonne of CO_2e ($/tonne).

N_2O Emissions Problem

- Canadian models estimating GHG for biofuels from agriculture crops do not include N_2O emissions.
- Annual crops take up less than 50% of applied nitrogen (N) fertilizer.
- Remaining N results in nitrate losses to water or gaseous N to the atmosphere.
- Need to examine N_2O emissions from annual grains and oilseeds used for biofuels.

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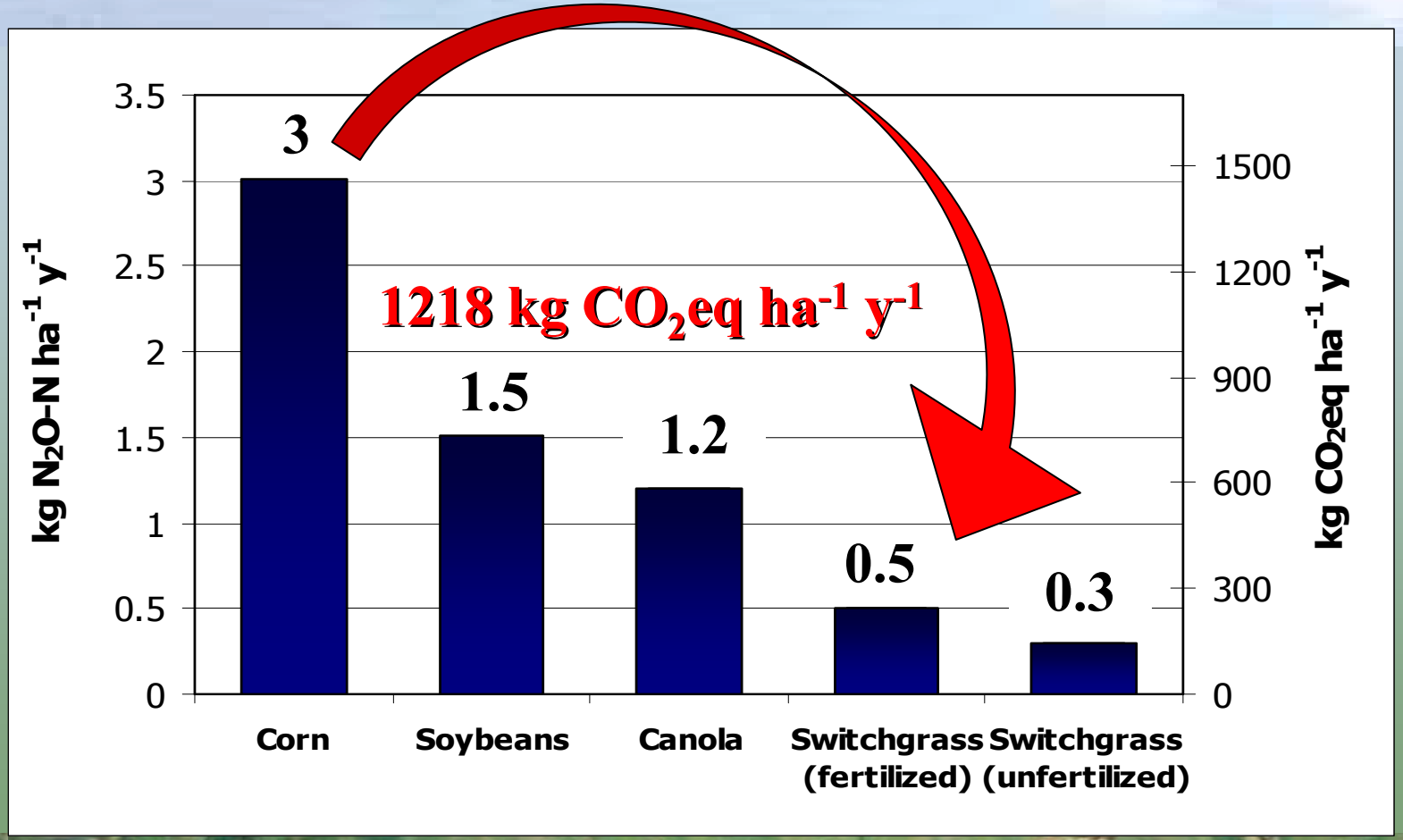
N_2O Emissions from Crop Production in Canada



e.g. Corn: 3 kg N_2O-N x 44/28 x 310 (CO_2 forcing value for N_2O) = 1461 kg CO2eq/ha

Samson et al 2007

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Biofuel Options Examined

Sector	Traditional Fuel		Alternative Fuel
Transportation	Gasoline	→	Ethanol
	Diesel	→	Biodiesel
Electrical Power	Coal Natural gas	→	Wind energy Straw pellets Biogas
Heating	Coal Natural gas LNG	→	Switchgrass/Wood pellets

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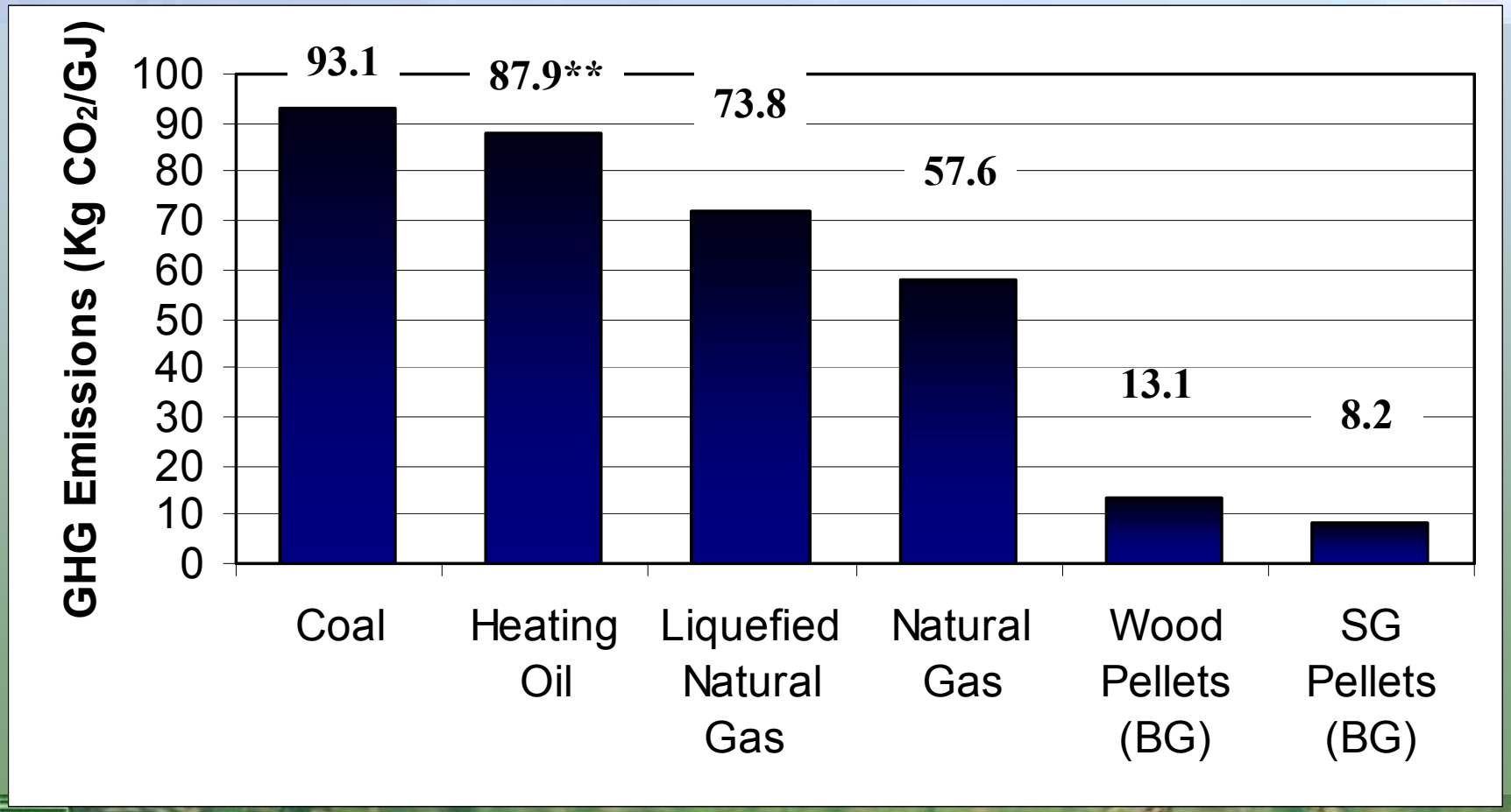
LNG-liquefied natural gas

Relative Carbon Intensity of Various Fuel Sources



*Based on GHGenius 3.9xls Natural Resources Canada, Samson et al., 2007
**Based on typical Canadian oil mix of 48% domestic and 52% international

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Transportation Sector-GHG Offsets

Fossil Fuel		Renewable Fuel		Net offset (%)
	kg CO_2e/GJ		kg CO_2e/GJ	
Gasoline	99.6	Corn ethanol	62.0	21
		Cellulosic ethanol	23.4*	76
Diesel	95.5	Soybean biodiesel	36.4	50
		Canola biodiesel	28.8	58

* Does not include GHG emissions associated with N_2O from cultivation

Electrical Power-GHG Offsets

Fossil Fuel		Renewable Fuel		Net offset (%)
	kg CO_2e/GJ		kg CO_2e/GJ	
Coal	298.9	Wind	5.6	98
		Straw Pellets	18.9	94
		Biopower (manure)*	39.4	87
Natural gas	121.7	Wind	5.6	95
		Straw Pellets	18.9	84
		Biopower (manure)*	39.4	68

- Does not include GHG emission reductions from manure through biogas treatment

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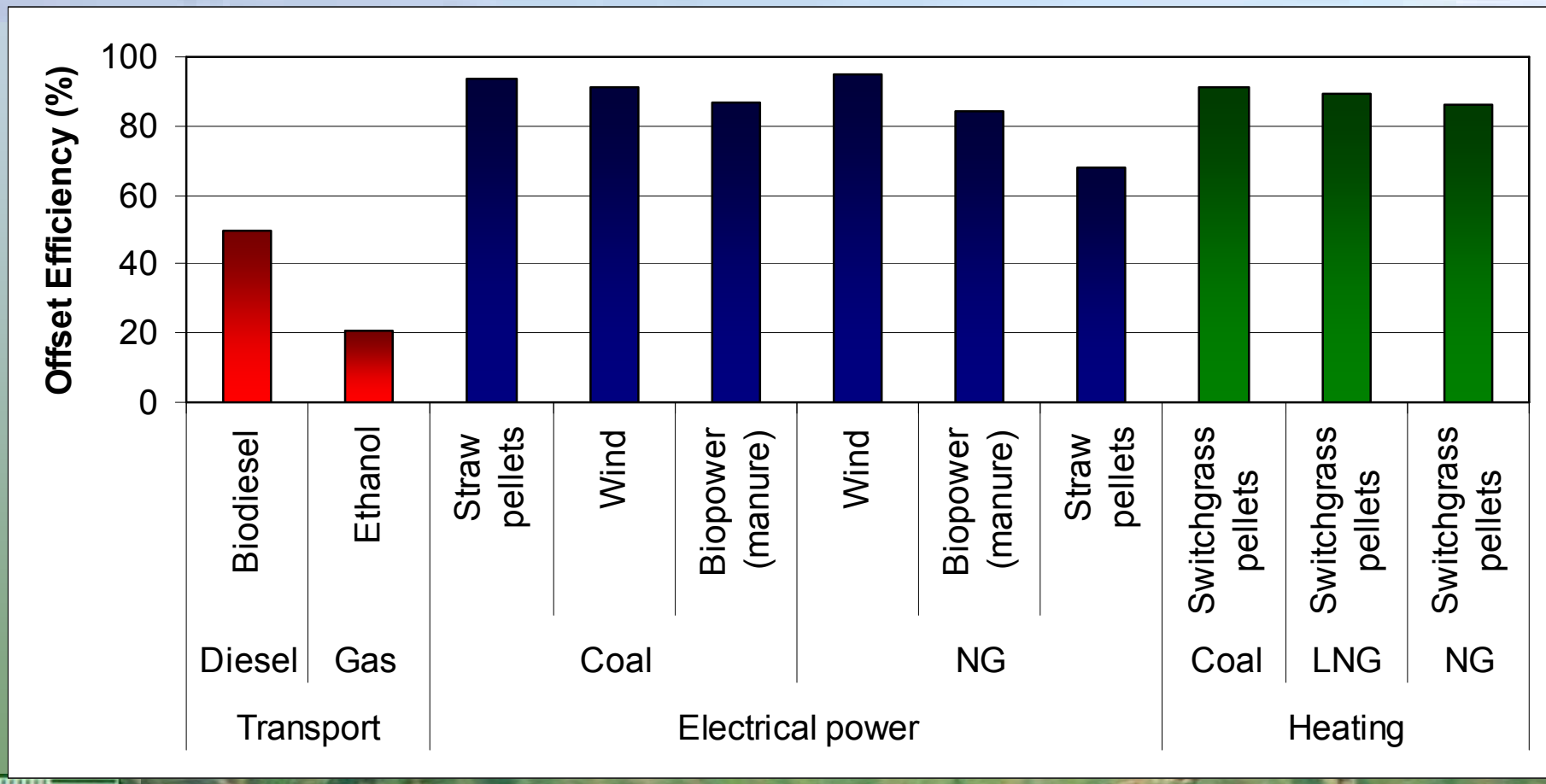
Samson et al., 2007

Heat Generation-GHG Offsets

Fossil Fuel		Renewable Fuel		Net offset (%)
	kg CO_2e/GJ		kg CO_2e/GJ	
Coal	93.1	Switchgrass pellets	8.2	91
LNG	87.9	Switchgrass pellets	8.2	89
Natural gas	57.6	Switchgrass pellets	8.2	86

Samson et al., 2007

Offset Efficiency of Biofuel Options



NG-natural gas; LNG-liquefied natural gas

Samson et al. 2007

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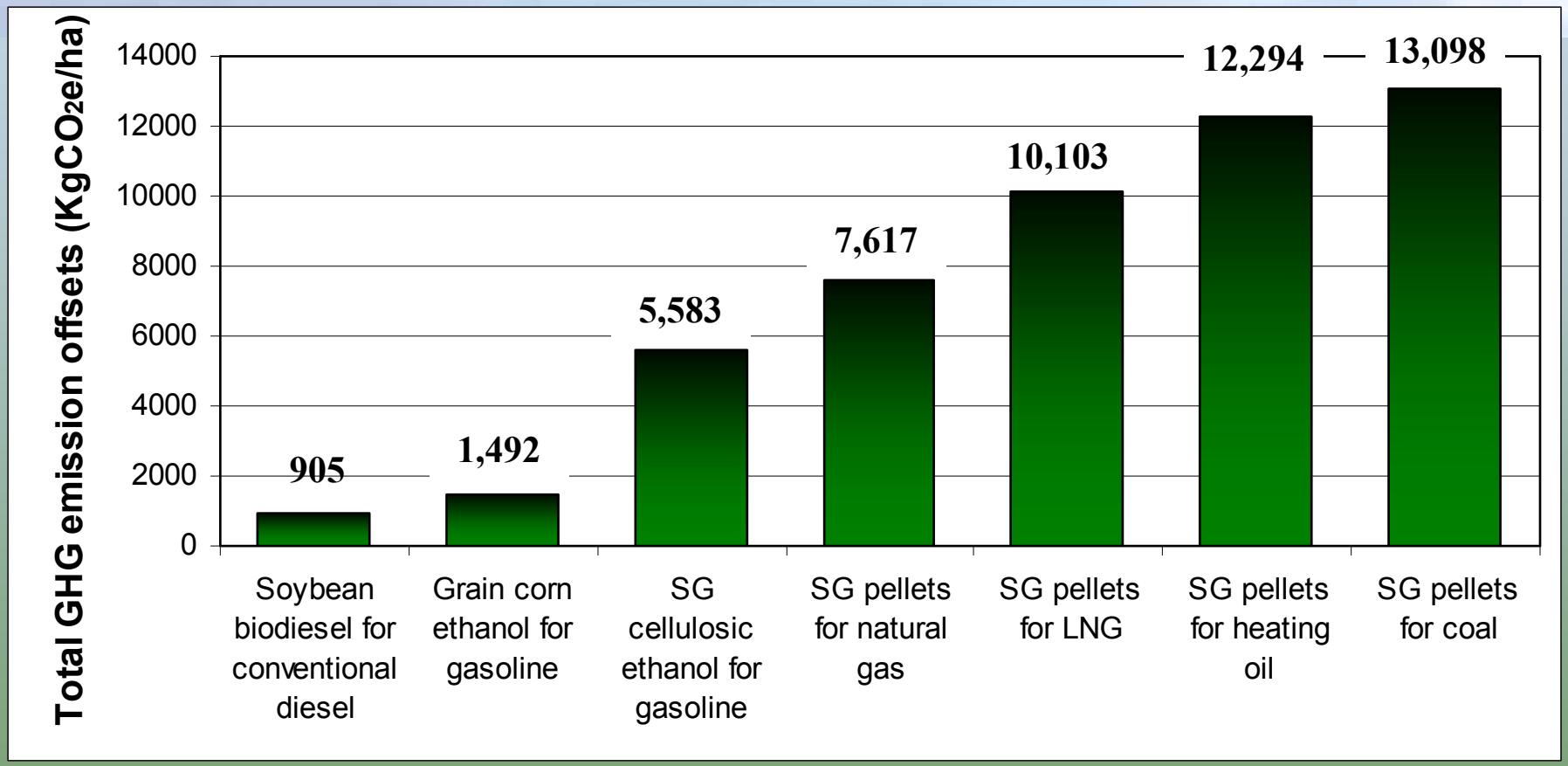
GHG Offsets From Ontario Farmland Using Biofuels



SG=Switchgrass; LNG=Liquefied Natural Gas

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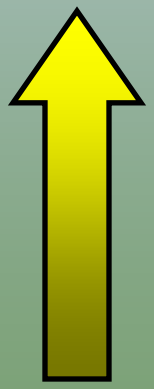
Summary

- Biofuel GHG offsets are directly linked to
  - Offset efficiency of the biofuel (GJ)
  - Energy produced (GJ) per ha of biofuel crop

Biofuel Option	Offset efficiency	Output (GJ/ha)	Overall efficiency
Switchgrass pellets	High	High	
Switchgrass ethanol	Moderate to high	Moderate	
Corn ethanol	Low	Moderate	
Soybean biodiesel	Moderate	Low	

Thank You!

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