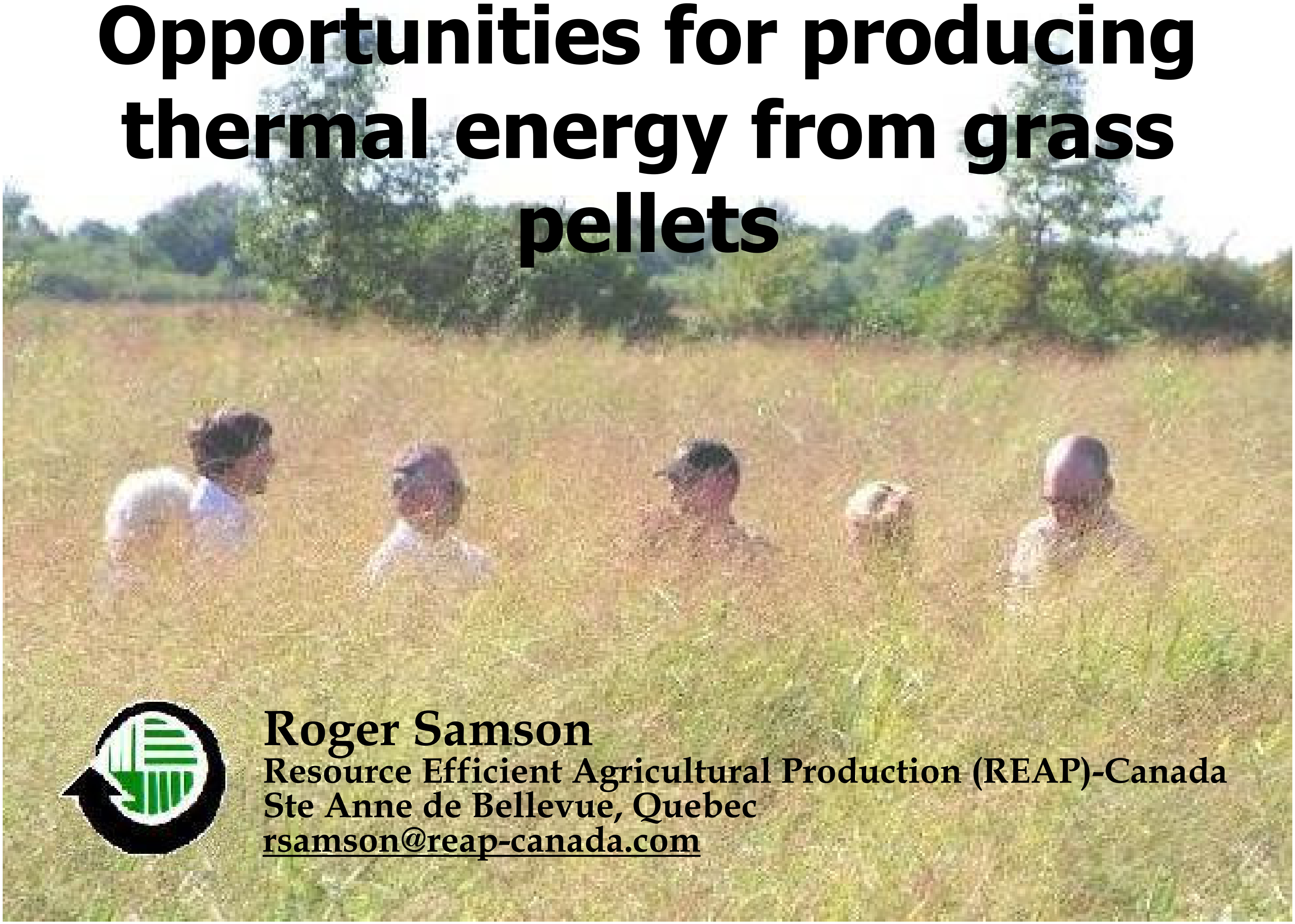
# Opportunities for producing thermal energy from grass pellets



**Roger Samson**
**Resource Efficient Agricultural Production (REAP)-Canada**
**Ste Anne de Bellevue, Quebec**
**rsamson@reap-canada.com**

# REAP-Canada

- Providing leadership in the research and development of sustainable agricultural biofuels and bioenergy conversion systems for greenhouse gas mitigation
- 18 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

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# Bioenergy Follows the Emergence of Food Production Systems

- 10,000 years ago humans learned to grow food from the land as a response to exhaustion of food supplies from hunter gatherer lifestyle
- Today bioenergy is emerging as a response to exhaustion of fossil energy supplies and the climate change problem
- One of the greatest challenges of humanity is to create resource efficient bioenergy systems from our agricultural lands

# Optimizing Bioenergy Development for Energy Security

*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 useful energy forms for energy consumers

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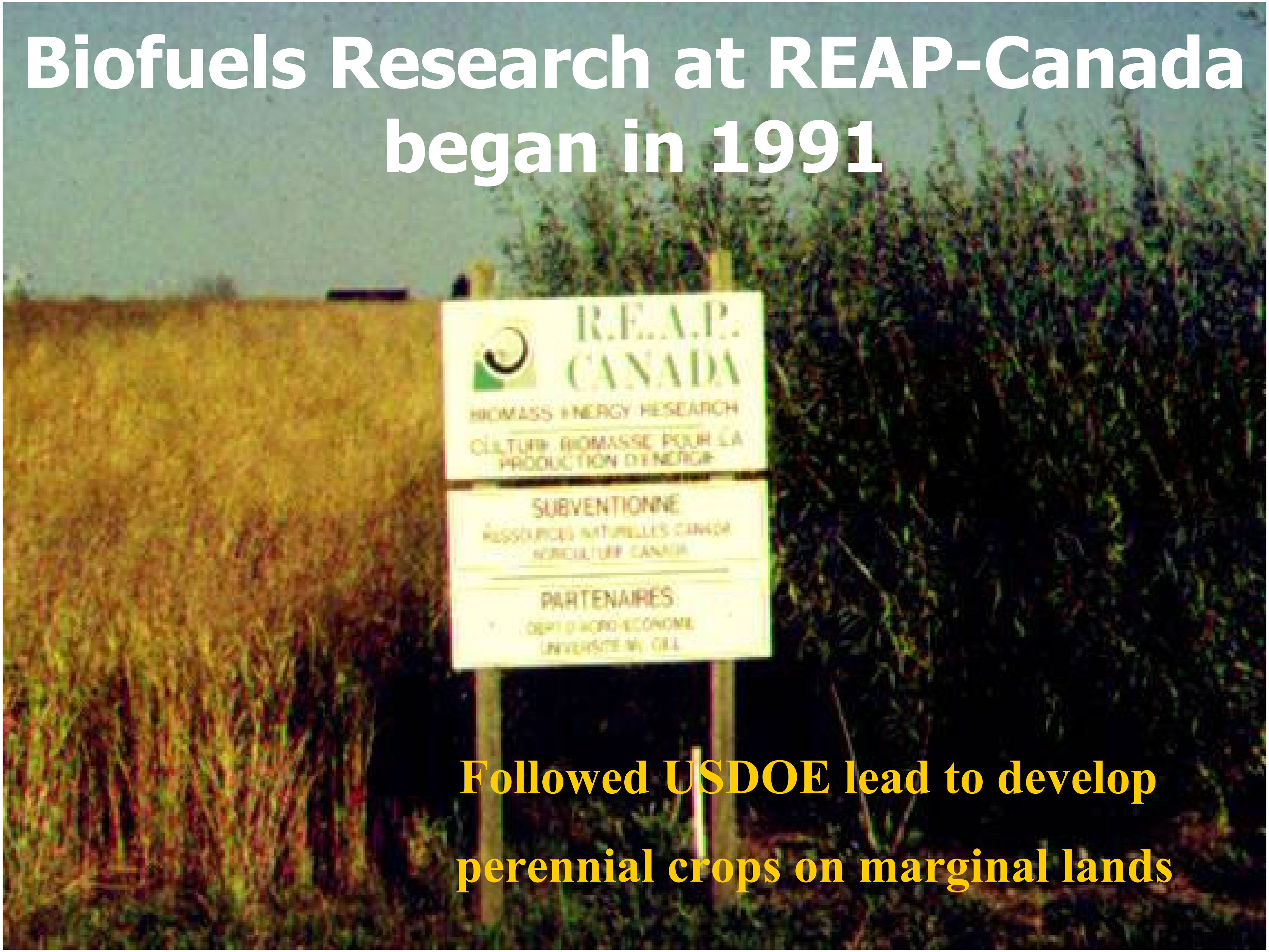
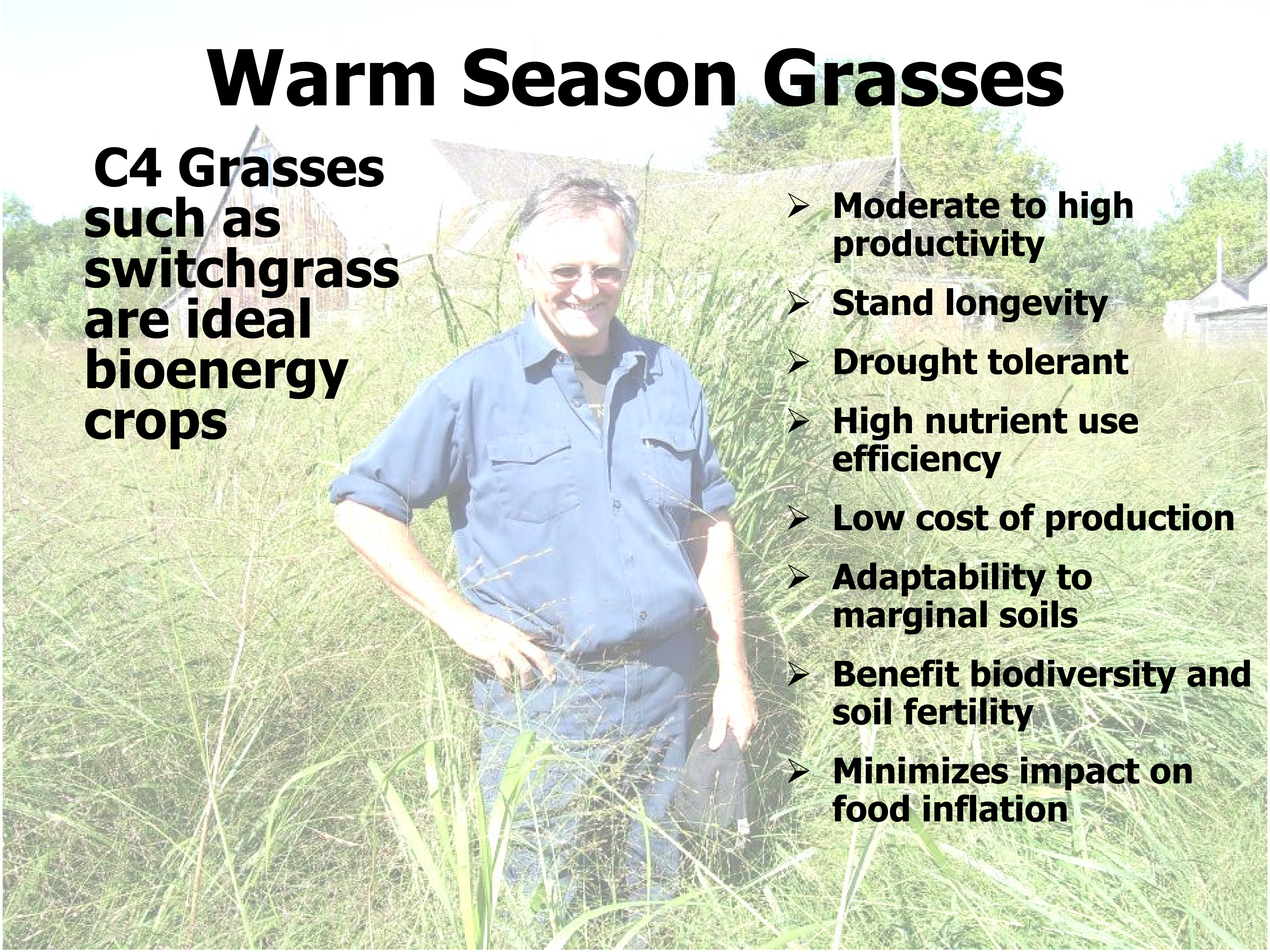
# Biofuels Research at REAP-Canada began in 1991




**Followed USDOE lead to develop perennial crops on marginal lands**

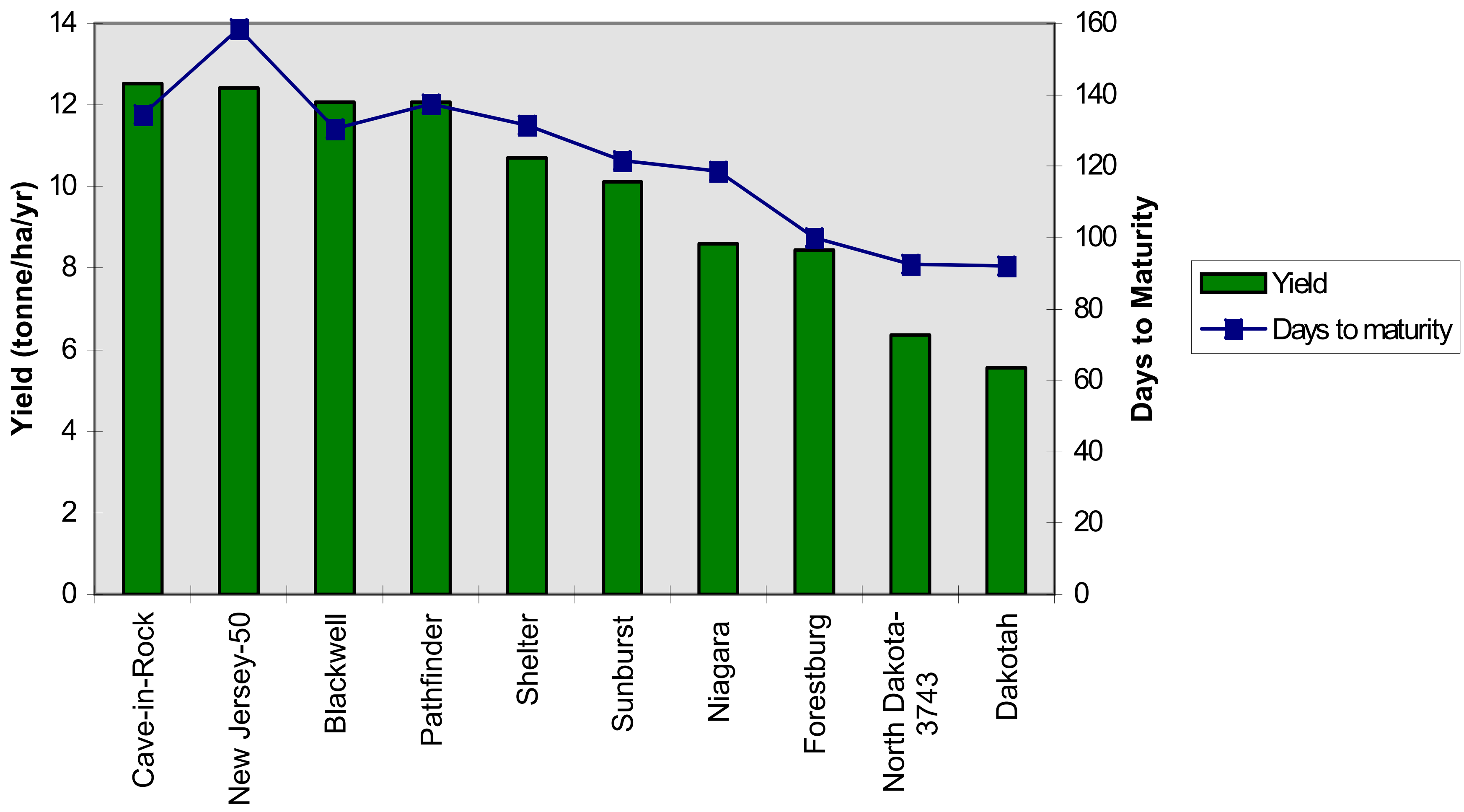
# Warm Season Grasses



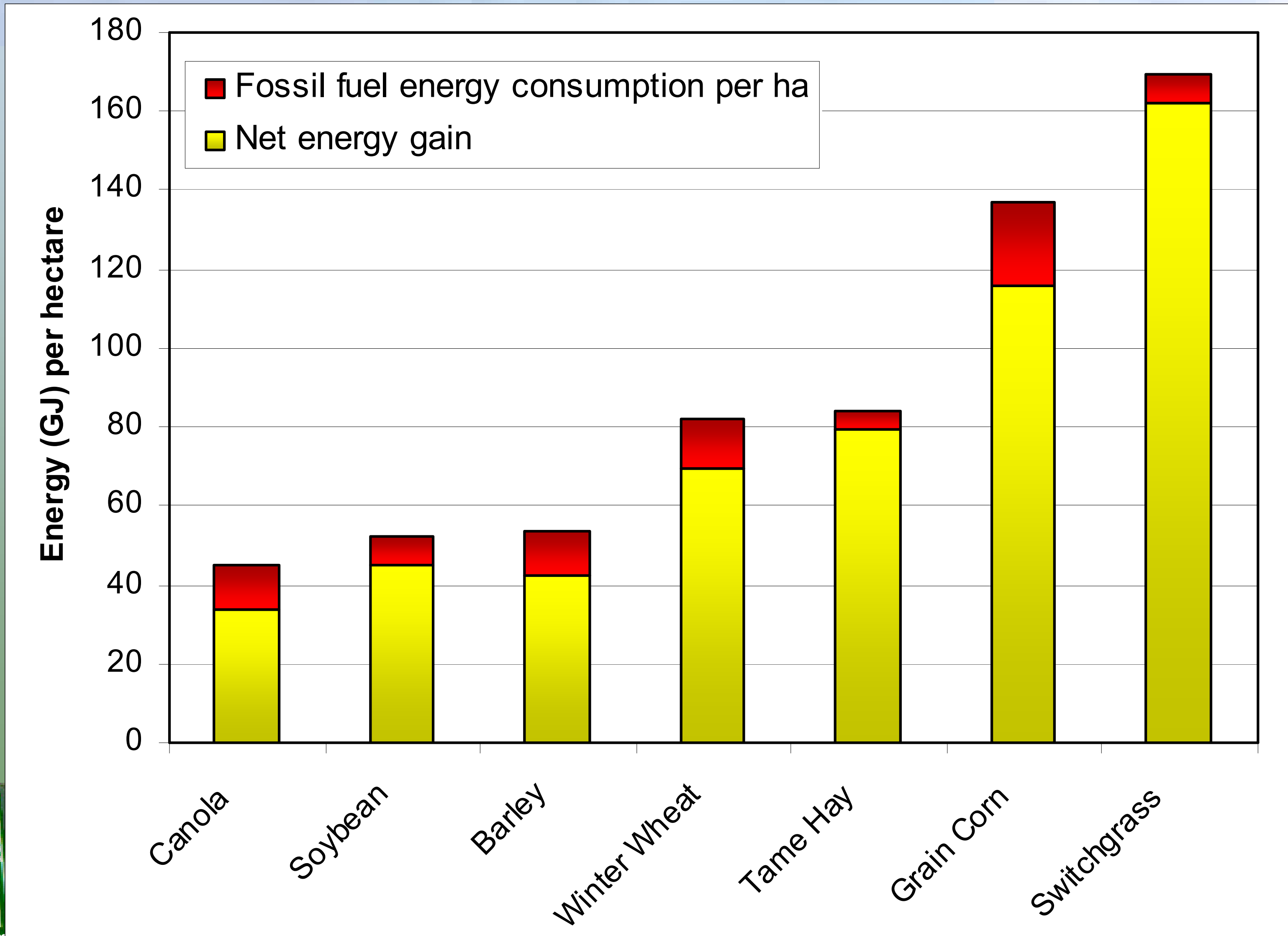
**C4 Grasses such as switchgrass are ideal bioenergy crops**

- Moderate to high productivity
- Stand longevity
- Drought tolerant
- High nutrient use efficiency
- Low cost of production
- Adaptability to marginal soils
- Benefit biodiversity and soil fertility
- Minimizes impact on food inflation

# Fall Yield of Switchgrass Cultivars at Ste. Anne de Bellevue, Quebec (1993-1996)



# Solar Energy Capture and Net Energy Gain of Ontario Field Crops (Samson et al., 2008)

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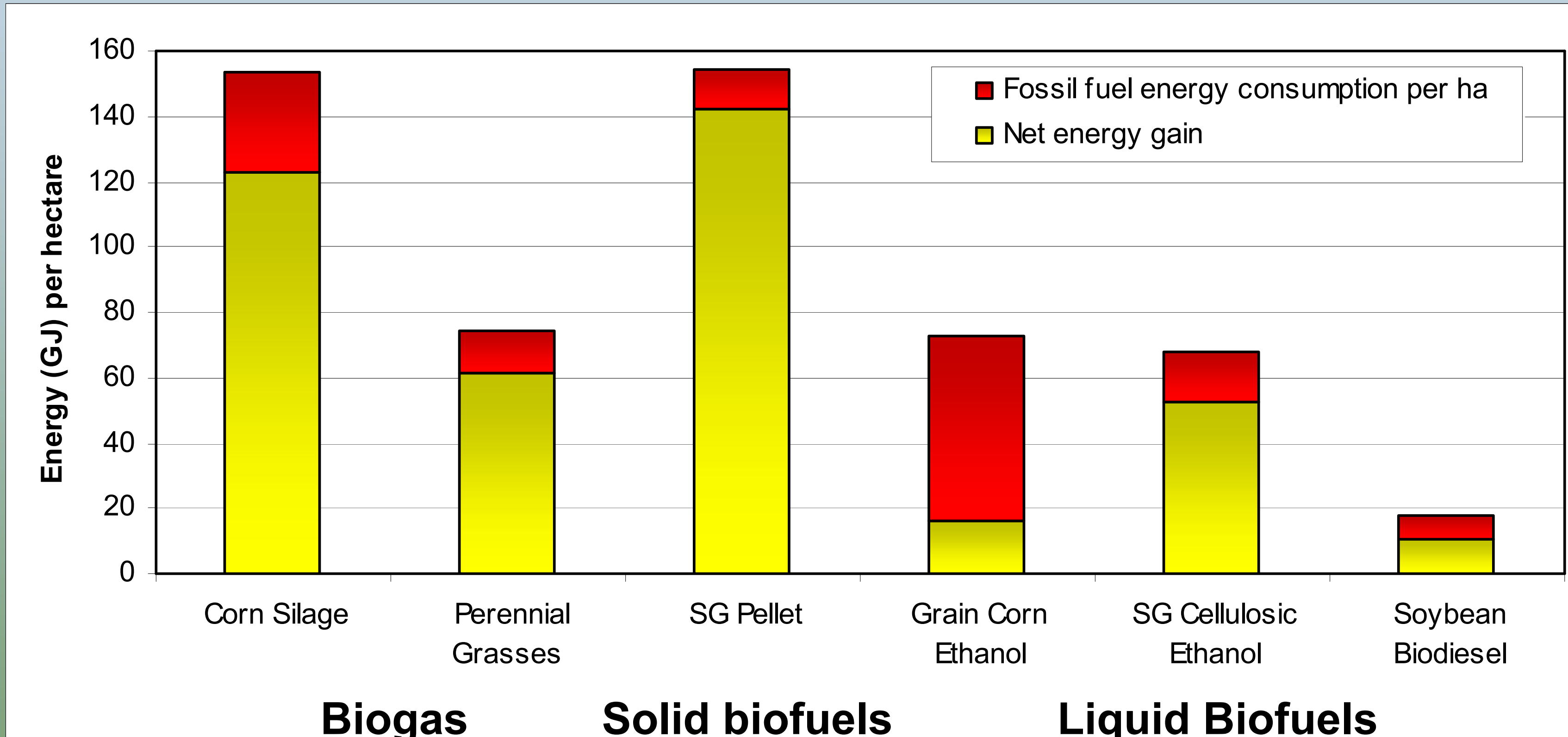
# Assessment of Net Energy Gain from Ontario Farmland using various Biomass and Bioconversion Options (Samson et al., 2008)




SG=Switchgrass

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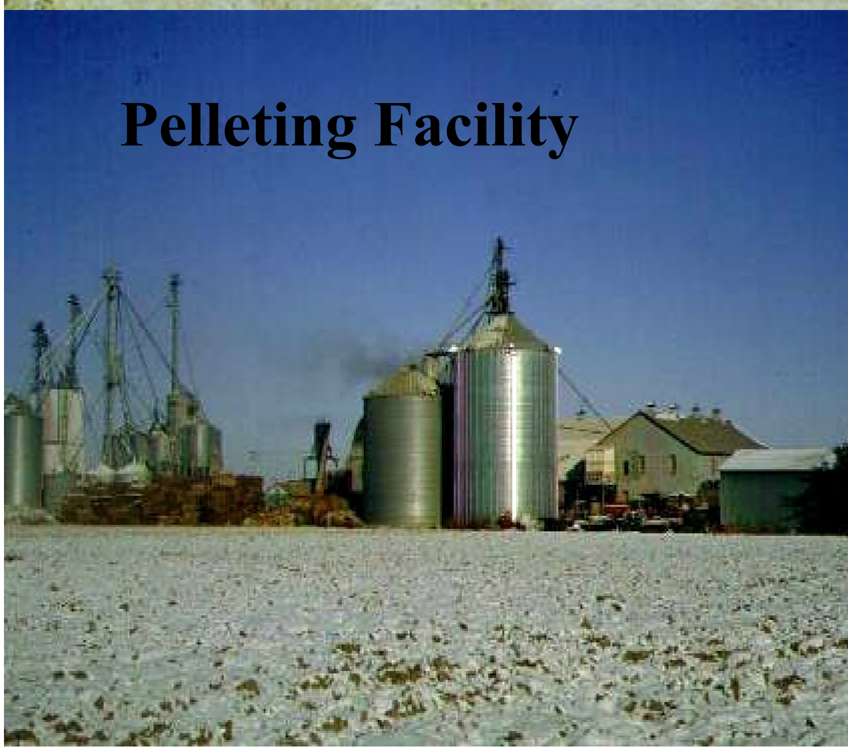
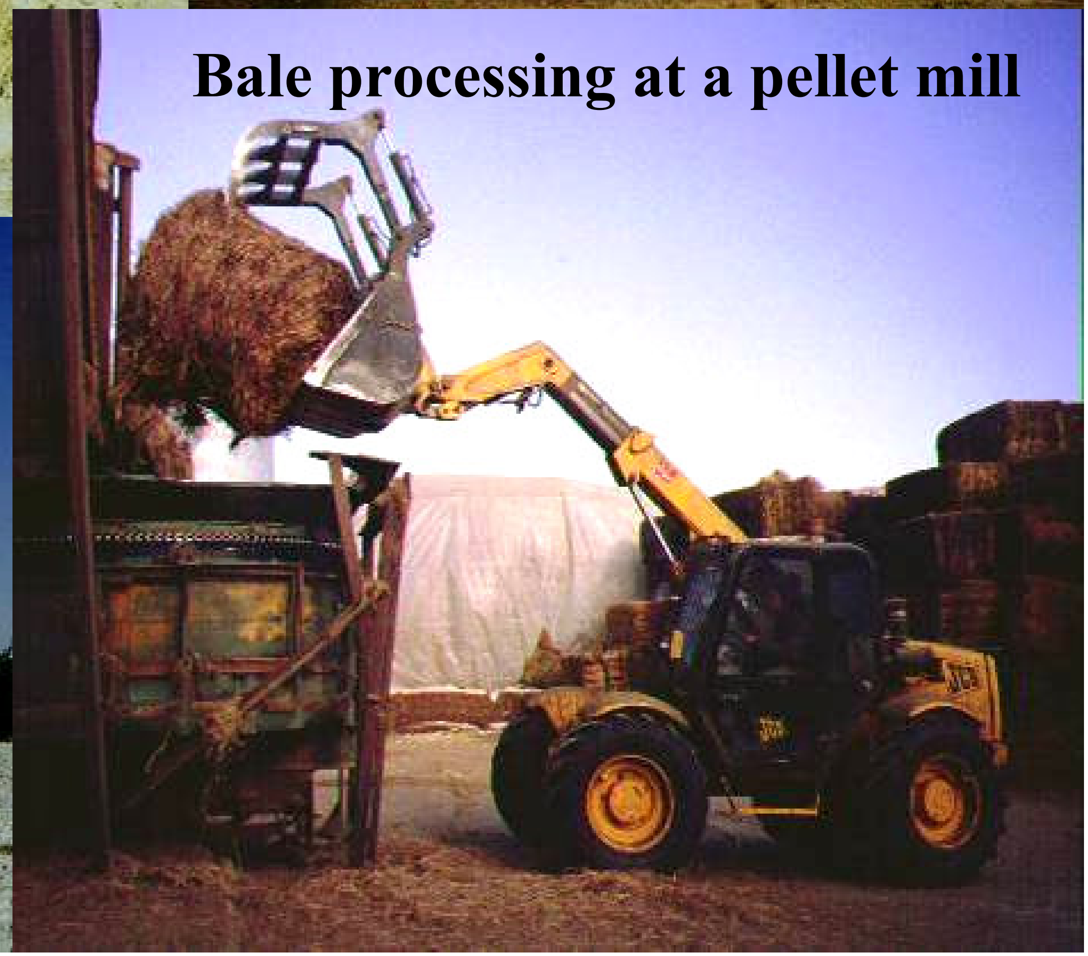
Switchgrass Harvesting
Operations


Bale Transport


Pelleting Facility


Bale processing at a pellet mill

# Reasons to Densify Herbaceous Biomass

- Convenient for handling and storage
- Increased energy density (smaller storage and combustion systems)
- Reduces fire risks
- More control over combustion
  - Higher efficiency
  - Lower particulate load

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# Bioenergy Capital Costs Investment Requirements

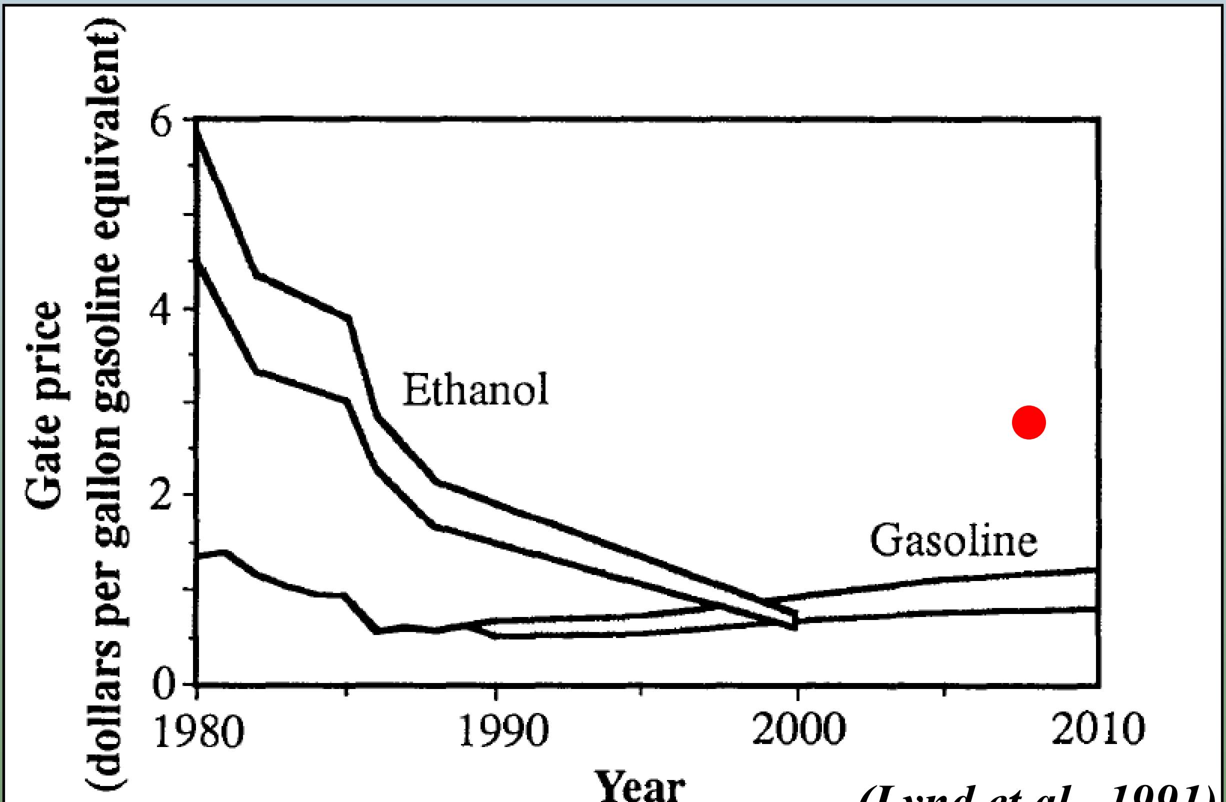
($ per GJ Output Energy plant)

**Grass Pellet**
$5/GJ
→ **$6 million USD capital investment, producing 60,000 tonnes/yr**

**Corn ethanol**
$24/GJ
→ **$102 million USD capital investment, producing 200 million L/yr**

**Cellulosic ethanol**
$263/GJ
→ **$500 million USD capital investment, producing 90 million L/yr (globe and mail, march15, 2008)**

# Cellulosic ethanol not acheiving projected cost reductions




*(Lynd et al., 1991)*

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- **Gate or Rack price of gasoline in June 2008: $3.00/Gallon**

# Effect of fall vs spring mow on yield and quality

**Fall Mow, Spring Bale:**

- *Fall mow took place on November 25th, 2006*
  - 12’ disc mower conditioner, cut height of 10.1 cm
- *Spring baling operations took place on May 3, 2007*
  - Raking was performed prior to baling

**Spring Mow, Spring Bale:**

- *Spring mowing and baling operations took place on May 3rd and 4th, 2007*
  - No raking necessary

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FALL

WINTER

SPRING

# Machine Harvested Recovered Yields

| Treatment | Yield (ODT/ha) | Moisture Content (%) |
|---|---|---|
| Fall mow & spring bale | 6.574* | 6.0 |
| Spring mow & bale | 5.443 | 7.8 |

*Significantly different ($p<0.05$)

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# Biomass Quality of Switchgrass vs. Wood Pellets and Wheat Straw

| Unit | Wood pellets | Wheat straw | Switchgrass | |
|---|---|---|---|---|
| | | | Fall harvest | Overwintered Spring harvest |
| **Energy (GJ/t)** | 20.3 | 18.6-18.8 | 18.2-18.8 | 19.1 |
| **Ash (%)** | 0.6 | 4.5 | 4.5-5.2 | 2.7-3.2 |
| **N (%)** | 0.30 | 0.70 | 0.46 | 0.33 |
| **K (%)** | **0.05** | 1.00 | 0.38-0.95 | **0.06** |
| **Cl (%)** | 0.01 | 0.19-0.51 | n/a | n/a |

**Source: Samson *et al.*, 2005**

# Creating clean combustion with very low particulates

- Pelleted fuel is better than bulk fuel
- Low content of K, Cl and S essential to reduce aerosol (fine particulate) formation
- Advanced Combustion technology (lamda control, condensing boiler)
- Use cyclone on combustion appliance to capture particulates

***Overall, particulate load as low as heating oil is achievable***

**Ontario greenhouse with multi-fuel coal/pellet boilers (3 x 800 kw)**

# Biofuel GHG Offsets Basics

*GHG offsets are a function of several 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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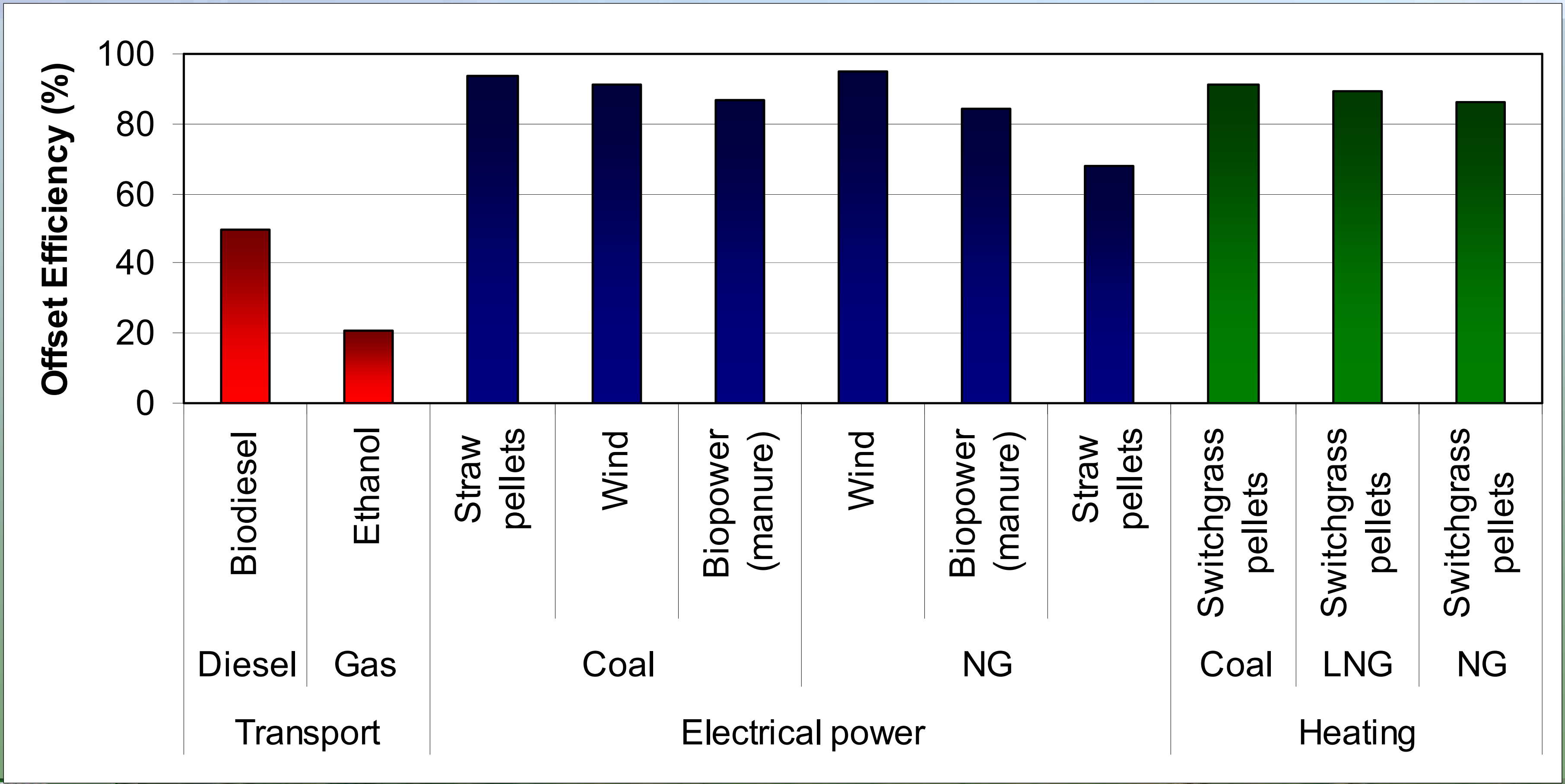
# Offset Efficiency of Biofuel Options




**NG-natural gas; LNG-liquefied natural gas**

**Samson et al. 2008**

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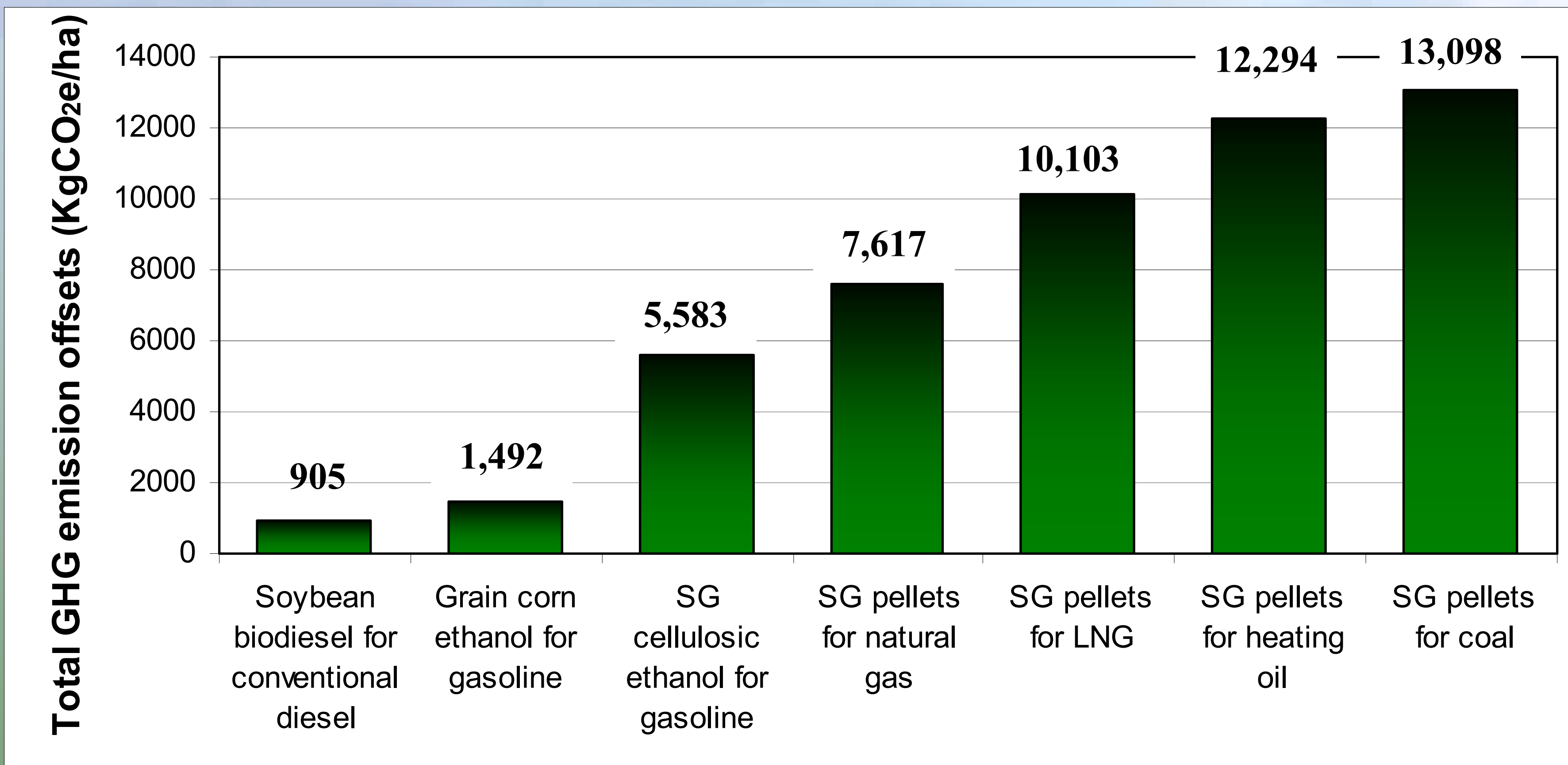
# GHG Offsets From Ontario Farmland Using Biofuels (Samson et al 2008)




**SG=Switchgrass; LNG=Liquefied Natural Gas**

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# Renewable Energy Incentives in $/GJ in Ontario, Canada (Samson et al.2008)

**Corn Ethanol**

**$8.00/GJ**

**Wind Power Incentives**

**$15.28/GJ**

**Bioheat Pellets**

**$2-4/GJ**

***Incentive Assumptions:***

**Corn Ethanol** (0.021GJ/L @ $0.168/L) based on $0.10 federal + $0.068 Ontario Ethanol Fund

**Wind Power** (0.0036GJ/kwh @ $0.055/kWh) based on $0.01 federal + $0.045 province of Ontario

**BioHeat Pellets** (18.5 GJ/tonne @ $37-$74/t) currently no policy incentives are in place

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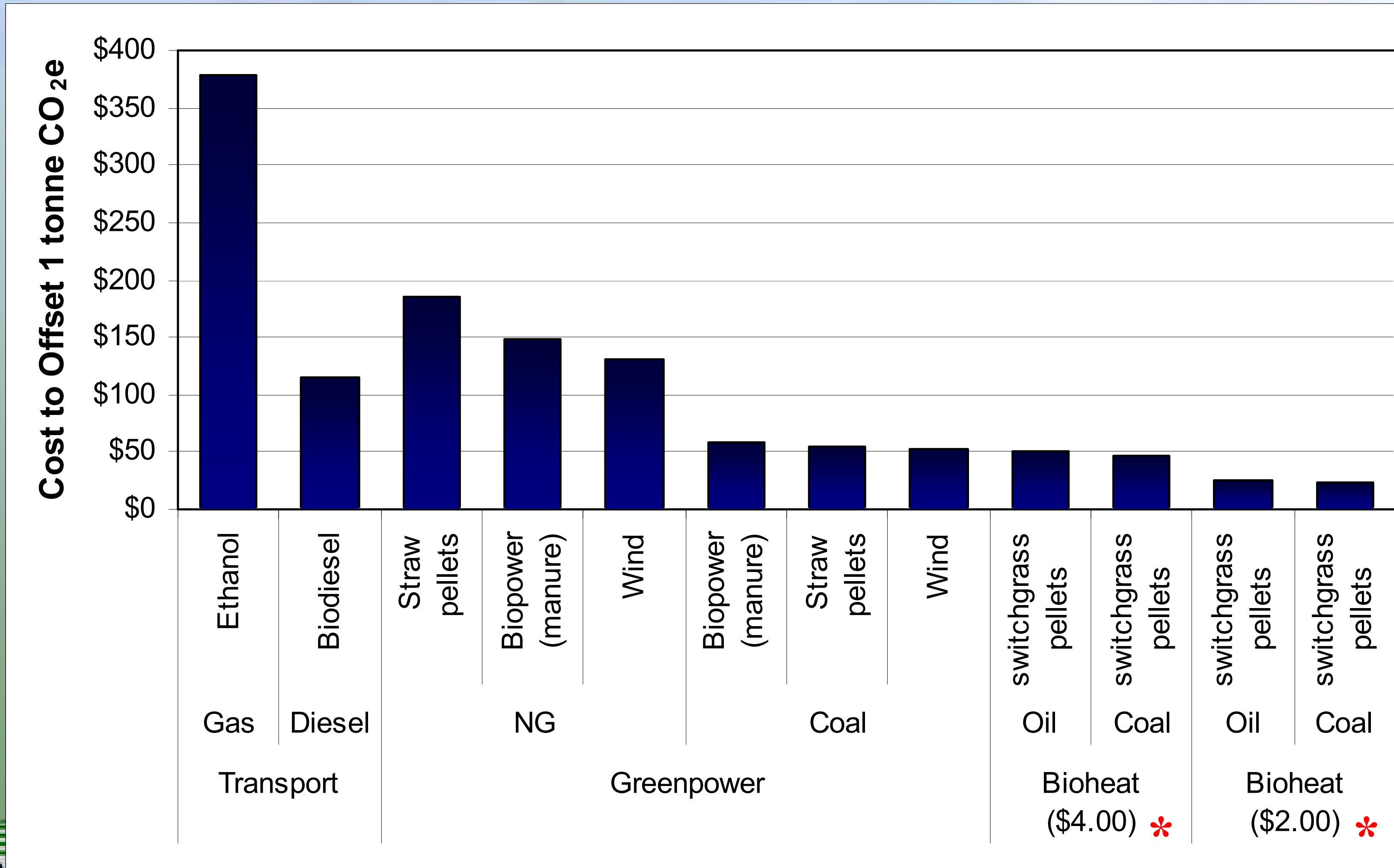
# Costs required to offset 1 tonne $CO_2e$ with current Ont. & Federal Incentives

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*Suggested incentive

Samson et al. 2008

# Provinces need more progressive RET and climate change policy leadership from the federal government

- Need greater parity in the application of federal incentives (eg wind power \$2.78/GJ and \$5.00GJ ethanol and \$5.68GJ/biodiesel and nothing for biogas or bioheat)

- If CO2 is the main policy rationale, we should use results based management approaches and reward technologies that appreciably reduce CO2

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# Best Policy Instrument Options:

**I. Modest carbon tax of $25/tonne $CO_{2eq}$**

**II. Federal 1-2-3-4-5 Renewable energy and climate change program**

1. One national renewable energy incentive program
2. $2/GJ Green heat
3. $3/GJ Biogas
4. $4/GJ Liquid biofuels and green power
5. 50% reduction in GHG required to qualify for incentives

# Thank You!

**REAP-Canada's Biomass Energy Program Sponsored by**

Natural Resources Canada

Canadian Farm Business Management Council

Ontario Ministry of Agriculture, Food and Rural Affairs

Alberta Agriculture and Food

Alberta Research Council

ERNST Conservation Seeds

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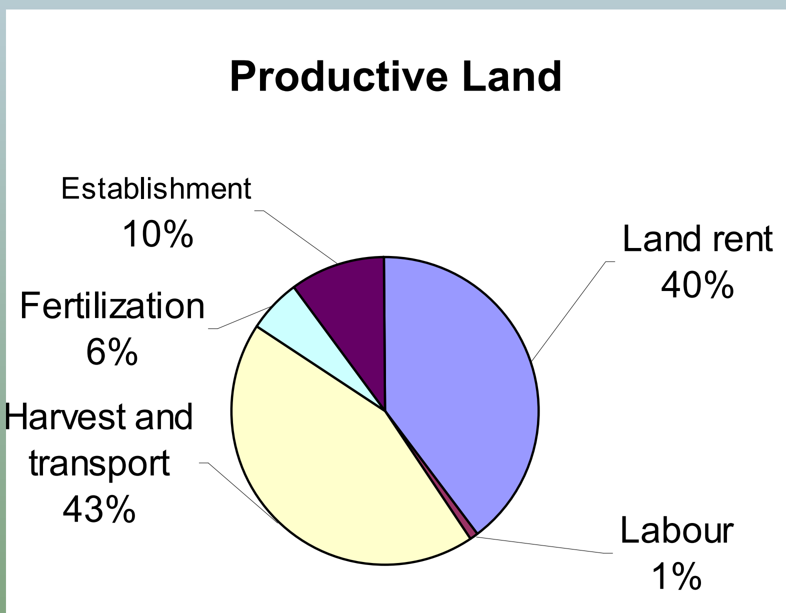
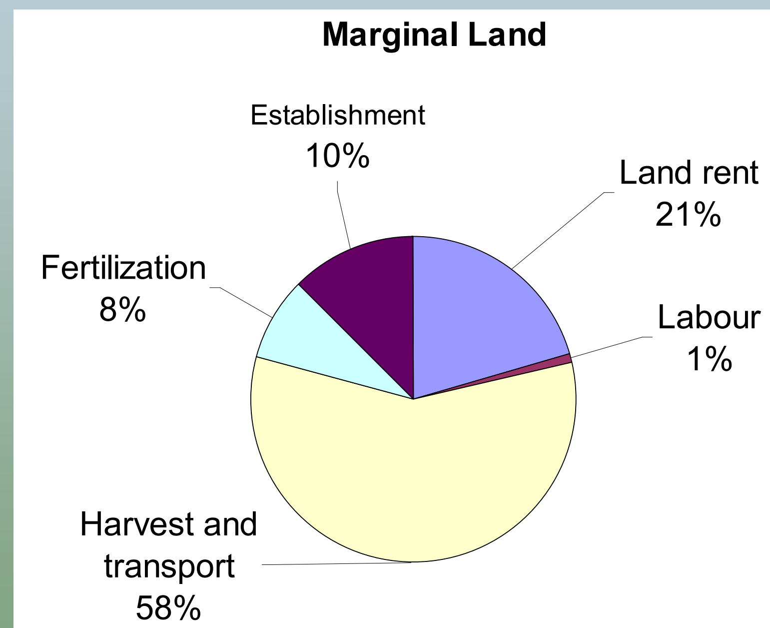
# Economics of Switchgrass Production in Eastern Canada

Spring harvesting $61-81CDN/tonne




**Establishment Costs $212.93/ac (not including land rent)**

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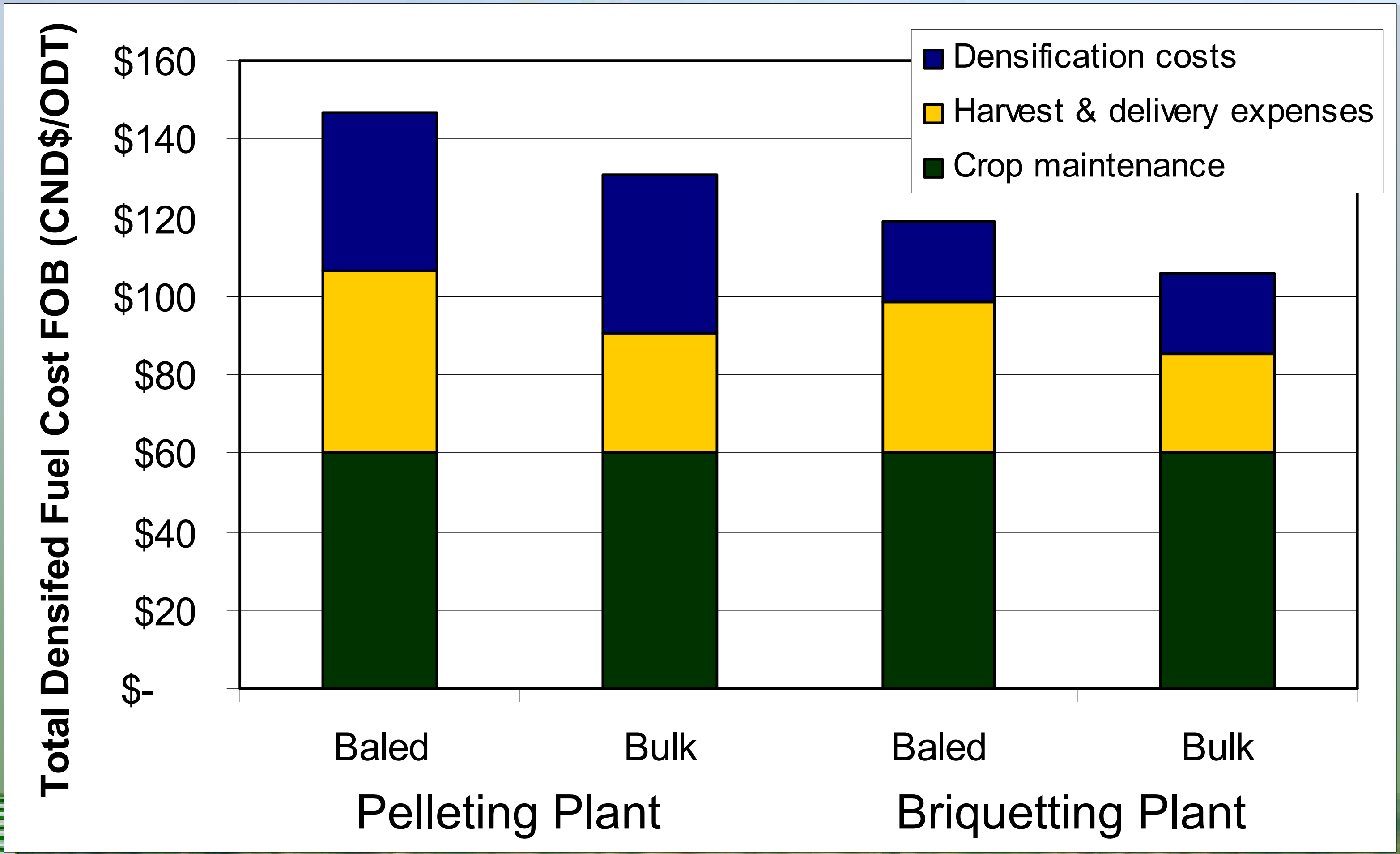
# Estimated Densified Fuel Costs in Ontario




Samson et al., 2008

# Harvest Period and Biomass Composition Changes

| Biological Component | Fall m.c. (%) | Composition | |
|---|---|---|---|
| | | Fall 2006 | Spring 2007 |
| Head | 4 | 12.5 % | 5.2% |
| Leaf | 15 | 25 % | 13.2% |
| Sheath | 13 | 14.8 % | 17.9% |
| Stem | 25 | 47.7 % | 63.7% |

- Whole plant moisture contents was reduced to ~7% at baling in the spring

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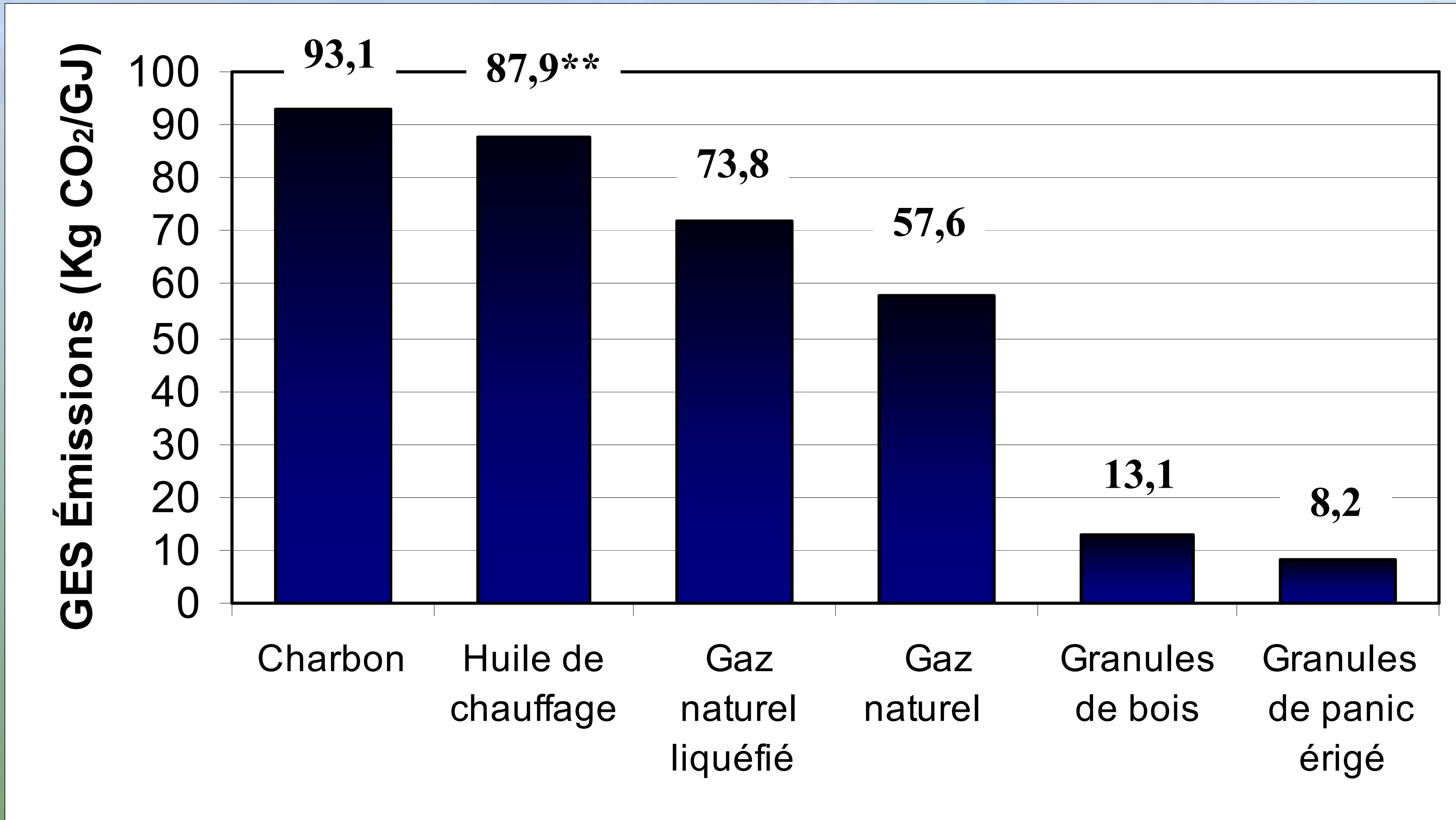
# Émissions de GES des énergies fossiles *




*Basé sur GHGenius 3.9xls, Ressources Naturelle Canada, Samson *et al,* 2008

**Basé sur un mélange d'huile typique Canadien à 48 % de provenance domestique à 52 % de provenance internationale

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