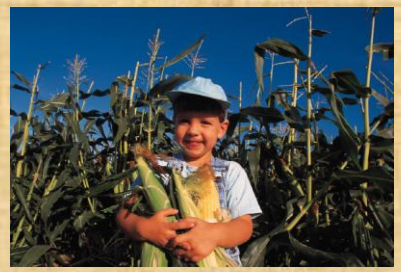
Adding Value to Ethanol Production Byproducts Through Production of Biochar and Bio-oil

Grain

DDGS

Ethanol Plant



Corn stover

Pyrolysis Unit
(portable)

Bio-oil

Biochar

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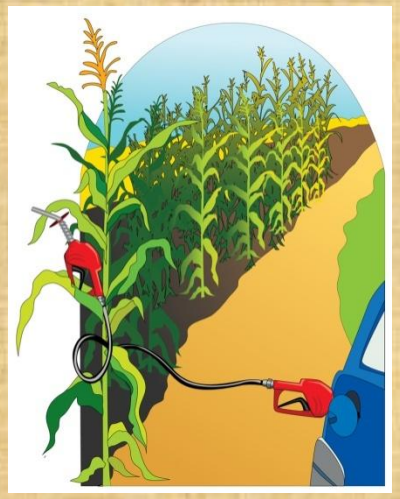


Project Objectives

1. Examine the production of **biochar** and **bio-oil** from distillers grain and corn stover mixtures from **microwave assisted pyrolysis**

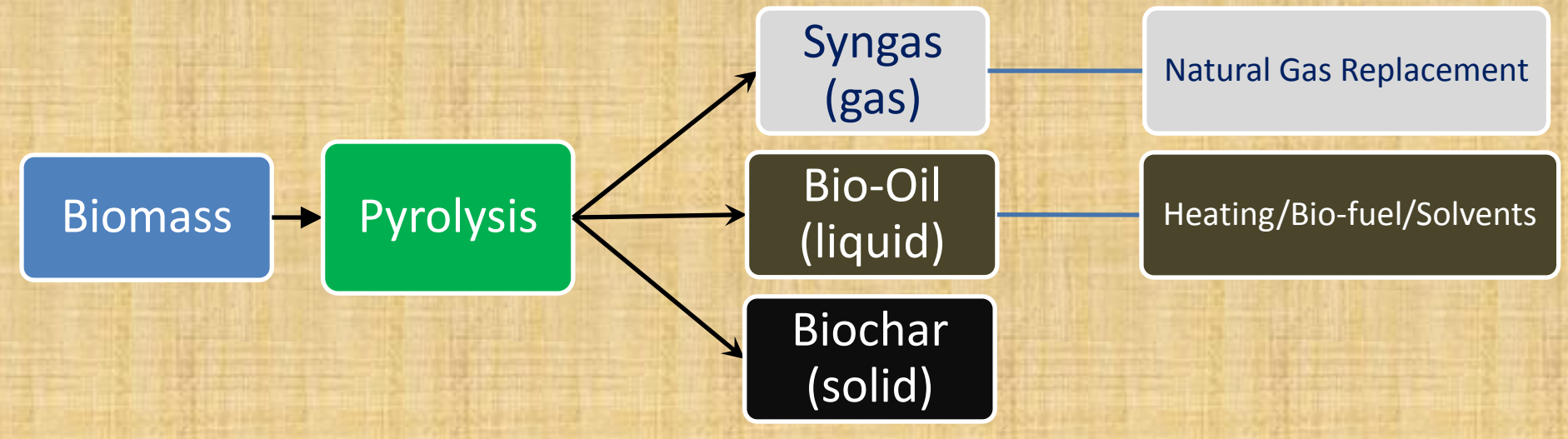
2. Examine the potential role of this biochar in **C sequestration** and improvements in the **sustainability** of corn production

Overview of Pyrolysis

- Pyrolysis
  - Chemical decomposition of an organic substance by heating
    - **Does not involve reactions with oxygen**
    - Pyrolysis is found in everyday activities

Cooking [roasting, baking, frying, grilling]

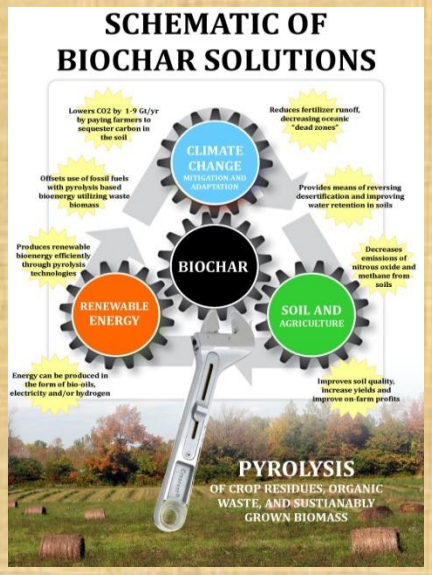
Also occurs in lava flows and forest/prairie fires



Biochar Properties

- Properties of Biochar
  - Stable (resident times 100 to 10,000 yrs)
  - High carbon content
  - Mechanism to “lock” atmospheric carbon in soil
  - Already accounts for up to 35% of C in prairie soil

- Gaining Significant Attention



→Carbon Storage (Climate Change)

Biochar can store atmospheric carbon, potentially providing a mechanism for reduction in atmospheric CO_2 levels

→Soil Improvements

Improves water quality
Improves soil fertility
Reduces Greenhouse Gas emissions (N_2O, CH_4)

→Bio-Energy Source & Renewable Energy Source

Traditional vs. Microwave Assisted Pyrolysis

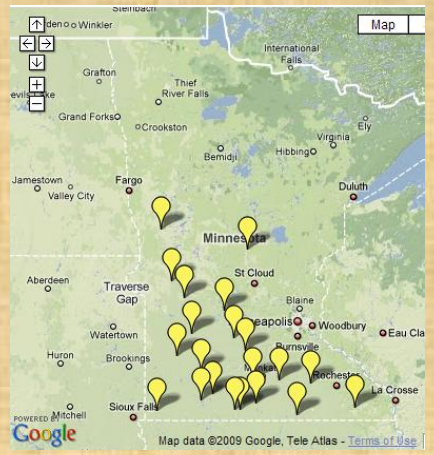
- Traditional Pyrolysis (Fast/Slow/Gasification)

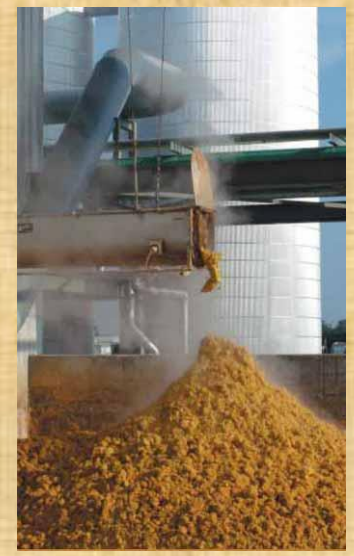
  - High capital costs
    - Large scale needed for economics
  - Strict feedstock parameters
    - e.g. moisture, particle size
  - Fluidized bed requires carrier gas in the process (dilutes Syn-gas)

- Microwave Assisted Pyrolysis

  - Capital costs significantly lower /highly scalable
    - << ½ of traditional systems
  - Less complexity → lower maintenance costs
  - Allows smaller size systems to be economical: further reduces costs
  - No fluidized carrier gas → Syn-gas is not diluted.
  - Better process control

Why Distillers Grain?





- ~20% of US ethanol plants are in MN
- Emerging issues related to distillers grain as livestock feed:
  - **Food security**
    - Pharmaceutical residues (antibiotics)
    - Mycotoxins (e.g. vomitoxin)
    - Other pathogens (*E. Coli*)
- **Distillers grain is an important income source for ethanol plants**
  - Need to keep and enhance economic value of distillers grain co-product

Current Ethanol Production

25% in MN

Future?

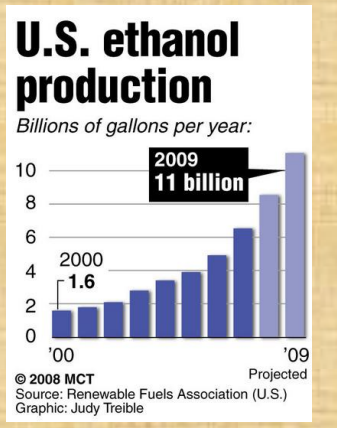
1.1 Billion gal

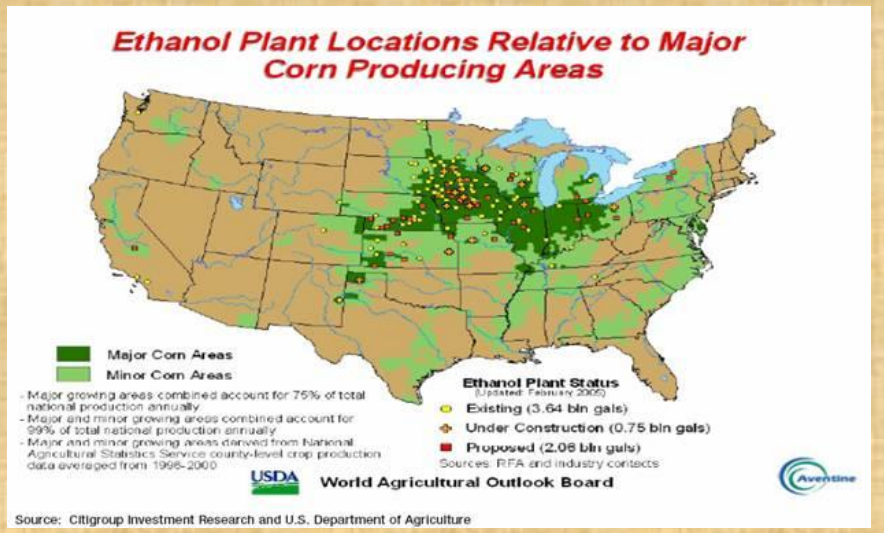
wet cake separated

Ethanol → market

DDGS → market

Syrup/thin silage → market





Proposed Enhanced Cycle for Ethanol Production

Syn-gas – Reduce natural gas use

DDGS/Wet cake

Heating Oil

Ethanol Production

Microwave Pyrolysis

Bio-oil

Ethanol → market (unaffected)

(reduced quantities)
DDGS → market
Syrup/thin silage → market

Corn Production

Biochar

Soil Applied Biochar

Potential Improvements
- Improved sustainability
- Improved nutrient utilization
- Decreased nitrate leaching
- Reduced fertilization requirements
- Reduced N_2O production

Increased soil quality and fertility

Proposed Research

- Ruan's Laboratory (UMN) (Objective 1)
  - Experts in microwave pyrolysis
  - Why microwave pyrolysis ?
    - Wet material can be used
    - No preprocessing requirements (e.g. grinding)
    - Eliminate drying costs
    - Source of 3 products: Syn-gas, Bio-oil and Bio-char
    - Lower capital costs vs. traditional pyrolysis

  - Demonstrate feasibility and optimization of Syn-gas, Bio-oil and Bio-char production from DDGS/corn stover mixtures using MAP

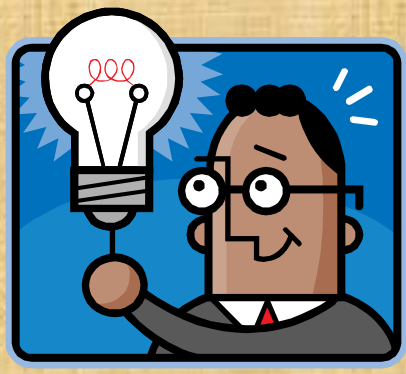
Proposed Research (continued)

- Spokas (USDA-ARS) (Objective 2)
  - Biochar research will be focused on determining major mechanisms behind benefits observed with bio-char additions

  - Research will focus on answering some of these unknowns with detailed laboratory incubations examining:
    - ❑ Carbon sequestration potential
    - ❑ Greenhouse gas production potentials
    - ❑ Nitrate leaching potentials
    - ❑ Potential nitrification inhibitor

- Morrison (UMN) – Initial economic modeling

Potential Benefits of Proposed Research



- **Improved and alternative uses of co-products**
  - Potential use of prior classified "*contaminated*" grain
  - New potential markets for co-products → Bio-oil & Syngas
  - Not only DDGS/wet cake, other co-products
    - e.g. corn syrup, rejected grain, excess biomass, etc.

- **Additional bio-energy sources**
  - Expanded end-uses of DDGS/wet cake
    - Bio-oil source: Heating oil replacement (boilers)
    - Syn-gas: Replacement for natural gas use
    - Biochar : Soil amendment

- **Improving sustainability of corn production through biochar applications**
  - Improve soil quality
  - Reducing soil greenhouse gas emissions (N_2O)
  - Reduced nitrate leaching (decreased nitrate formation)
  - Potential carbon sequestration credit

Research Questions

- What is the optimum mixture of ethanol co-products for the production of bio-oil and biochar by microwave pyrolysis?
- Will the biochar that is returned to the soil improve sustainability of corn production?
- What are the potential:
  - Soil fertility benefits?
  - Carbon sequestration benefits?
  - Fertilization benefits?
  - Economic implications?
  - Implications on nutrient cycling?

Proposal Summary

- This proposal will examine a potential mechanism to improve the sustainability of corn production by returning carbon (bio-char) to the soil derived from ethanol production co-products through MAP (microwave assisted pyrolysis)

  - Indications are that this action will improve soil quality, fertility and potentially have other positive soil impacts (e.g. GHG reductions, lower fertilizer use requirements)

Thank-you for your time and consideration

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