Viability of Corn Cobs as a Bioenergy Feedstock

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Energy in the U.S.

- Energy production is vital modern standards of living
- Annually U.S. uses approximately 100 quadrillion BTUs (100,000,000,000,000,000 BTUs) (EIA-DOE)
- Sources of U.S. produced energy
  - Petroleum - 39.3%
  - Natural gas – 23.3%
  - Coal – 22.5%
  - Nuclear power – 8.3%
  - Renewable energy – 6.7%

    Source: EIA-DOE

Biomass and Bioenergy

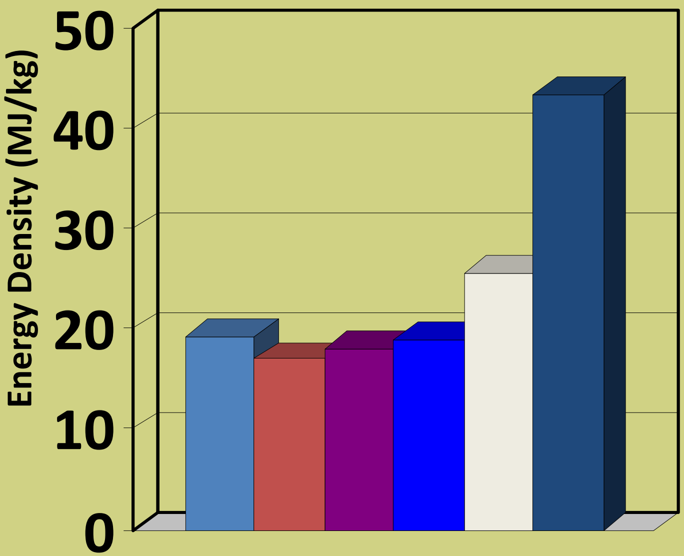
- Biomass - renewable plant derived organic matter
  - Can use as energy feedstock
- Bioenergy uses renewable biomass for energy production
- Forestry, waste, and agricultural industries are biomass sources
  - Annually produce 172 million dry metric ton (Perlack, R.D.et al.)
  - Underutilized

Corn Cobs: A Biomass Feedstock

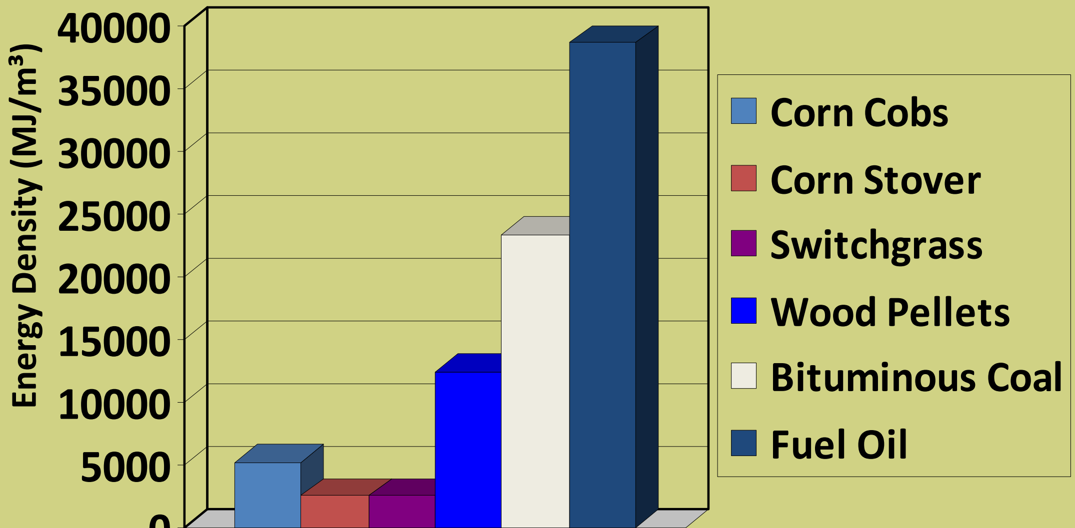
- Corn - U.S.'s largest crop
  - Returned to ground
  - Potential biomass feedstock
  - Complete stover collection not sustainable
- Corn cobs for bioenergy addresses:
  - Volumetric energy density
    - Logistical issues
  - Sustainable production
    - Soil organic matter
    - Nutrients
    - Soil erosion

Energy Content

Mass Energy Density



Volumetric Energy Density



Sources: Foley, K.M., Clark, T.F., Powder and Bulk, EIA-DOE

- Mass energy density = 18.25 - 19.18 MJ/kg (7845 - 8245 btu/lb)
- Volumetric energy density = 4960 - 5210 MJ/m³ (133,000 - 140,000 btu/ft³)
- High volumetric energy density
  - No densification

Production Estimate

- Estimates to understand potential
- Figures used for estimation:
  - Annual corn grain harvest volume (Perlack, R.D. et al.)
  - Stover to grain ratio (1:1) (Graham, R.L., et al.)
  - Stover composition (% of stover that is cob) (Myers, D.K.) (Hanway, J.J.)
- 223 million metric ton corn produced (dry basis)
- 223 million metric ton stover (15-20% corn cobs)
- 33.5 - 44.6 million metric ton of cobs
  - Sustainability not considered

Harvest

- Single-pass harvest of grain and cobs
  - Harvest rate not significantly reduced
  - Reduces time, equipment, and labor
  - Reduced compaction
  - Cobs clean feedstock
- Collection possible with modern combine and attachments

Harvest

Cob Caddy™- Self contained sort and collection wagon pulled behind combine

Iowa State University experimental cob collection attachment. Sorts cobs and blows them into wagon pulled behind

Ceres Residue System™- Attachment sorts stover at back of combine and collects cobs in hopper on top of combine

Storage

- Temporary field storage possible
  - Reduce harvest transportation
  - Transport to central distributor or energy plant
  - Piles removed before spring
- Outdoor cob storage practical
  - Large storage volumes
  - Building storage expensive
- Moisture management is storage concern
  - High moisture encourages microbial activity and cob decay
    - Reduces cob energy content

Moisture Content

- Corn cob moisture 20-50% at harvest
  - Varies with:
    - weather conditions, harvest date, and cultivar
- High moisture concern in storage and energy production
  - 10-30% ideal for energy production
    - High moisture reduces net heating value
  - ≤ 20% ideal for storage (Foley, K.)
- Delayed harvest reduces cob moisture
  - Not desirable for grain harvest
- Ventilation reduces cob pile spoilage (Smith, R.D.)

Sustainability

- 15-20% of residue removed with corn cob harvest
  - Residue for ground cover and reincorporated
  - Reduce soil erosion
  - Reduce depletion of soil organic carbon
- Cobs have low nutrient value
  - Reduce depletion of nutrients
  - Minimal nutrient replacement necessary
- Research necessary to determine sustainable removal

Cost of Nutrient Replacement

Cost of Nutrient Replacement Associated with Harvest:

	Nitrogen Replacement Cost ($/acre)	P2O5 Replacement Cost ($/acre)	K2O Replacement Cost ($/acre)	Total Nutrient Replacement Cost ($/acre)	Total Nutrient Replacement Cost ($/ton)
Grain Harvest	54.21	56.74	24.58	135.53	35.29
Cob Harvest	2.10	1.39	4.80	8.29	13.70
Stover Harvest	31.83	26.55	68.74	127.12	30.07

Source: Iowa State University Research

- Cob collection removes less nutrients
  - Costs less to replace expensive nutrients
  - Profit potential

Conclusion

The use of corn cobs as bioenergy feedstock is viable because:

- Cobs are desirable energy feedstock
  - Higher volumetric energy density
  - Easier handling
  - Low nutrient content
  - Clean feedstock
- Currently produced
- One-pass grain and cob harvest
- Outdoor storage with minimal spoilage
- Sustainability
  - Reduced impact on soil
  - Reduced cost

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