Potential for farm-scale conversion of straw to energy

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Biomass as Renewable Energy Feedstock in the PNW

Why go there?

1) **Energy production can provide opportunities for rural communities.**
2) **We can use cellulosic crop and wood residues without impacting the cost of food.**
3) **Because we have to?**

State Renewable Energy Acts

Oregon: Senate Bill 838 - 25% by 2025

Washington Initiative 937 - 15% by 2020

California Senate Bill 1078 - 20% by 2010

Nevada RPS - 20% by 2015 (5% solar)

Table 2. Acceptable Technologies and Resources for State Renewable Energy Requirements as of December 31, 2003

State	Biomass	Biomass Co-firing	Biomass Cogeneration	Geothermal	Conventional Hydroelectric	Landfill Gas	Municipal Solid Waste	Ocean or Tidal	Solar	Wind
Renewable Portfolio Standards										
Arizona	Yes	NS	NS	Yes[a]	No	Yes	NS	No	Yes	Yes
California	Yes	NS	NS	Yes	Small only	Yes	Yes	Yes	Yes	Yes
Connecticut	Yes	NS	NS	No	Small only	Yes	Yes	Yes	Yes	Yes
Maine	Yes	Yes	Yes	Yes	Small only	Yes	Yes	Yes	Yes	Yes
Massachusetts	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes
Nevada	Yes	NS	NS	Yes	Small only	Yes	No	No	Yes	Yes
New Jersey	Yes	Yes	NS	Yes	Small only	Yes	No	Yes	Yes	Yes
New Mexico	Yes	Yes	NS	Yes	Small only	Yes	No	No	Yes	Yes
Wisconsin	Yes	Yes	NS	Yes	Small only	Yes	No	Yes	Yes	Yes
Mandates										
Iowa	Yes	NS	Yes	NS	Small only	Yes	Yes	NS	Yes	Yes
Minnesota	Yes	NS	NS	No	Small only	Yes	Yes	No	Yes	Yes
Texas	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Wisconsin	Yes	Yes	NS	Yes	Small only	Yes	No	Yes	Yes	Yes
Goals										
Hawaii	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Illinois	NS	NS	NS	NS	NS	NS	NS	NS	Yes	Yes
Minnesota[b]	Yes	NS	NS	No	Small only	Yes	Yes	No	Yes	Yes
Pennsylvania	Yes	NS	NS	Yes	No	Yes	No[c]	Yes	Yes	Yes

[a]Accepted by waiver only.
[b]Specific characteristics are being determined. See web site www.puc.state.mn.us, Docket 03-869.
[c]Yes by exception, for General Public Utilities (GPU) only.
NS = not specified in the State requirement.
Source: Energy Information Administration, Office of Integrated Analysis and Forecasting.

Biomass is considered “renewable”.

Predominant sources of biomass in the PNW:

Agricultural residues

Residues from wood products

What is the potential for using biomass as feedstock for power or fuel production?

Straw is an abundant feedstock in the PNW.

- >17 million tons per year
- > 7 million tons available over and above NRCS recommendations for conservation purposes

(Banowetz et al., 2008, Biomass and Bioenergy)

Sufficient to provide 8% of regional power or fuel needs.

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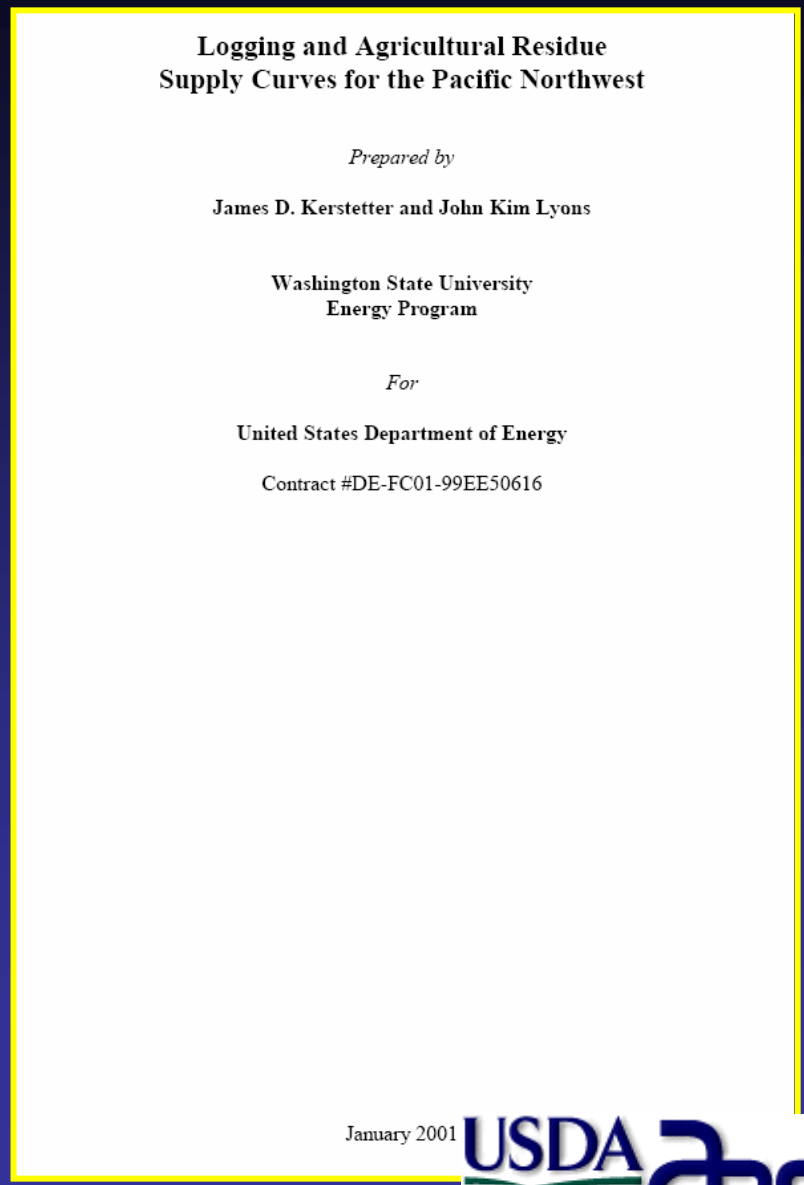
So:

- We’ve go lots of straw;
- We need more power and transportation fuels;
- Energy prices are increasing;

What are we waiting for?

Previous efforts to convert straw to energy concluded:

- Collection/transportation costs were excessive
- Chemical constituents (Si, K, Cl) of straw were incompatible with thermochemical conversion technologies



Logging and Agricultural Residue Supply Curves for the Pacific Northwest

Prepared by

James D. Kerstetter and John Kim Lyons

Washington State University
Energy Program

For

United States Department of Energy

Contract #DE-FC01-99EE50616

January 2001

- **The costs of collecting and transporting biomass to conversion facilities is, in many cases, the major factor limiting energy production from biomass.**

  National and regional projections that biomass feedstock would have to be provided to the conversion facility for $8 – $10 per ton to make conventional, large scale model economic.

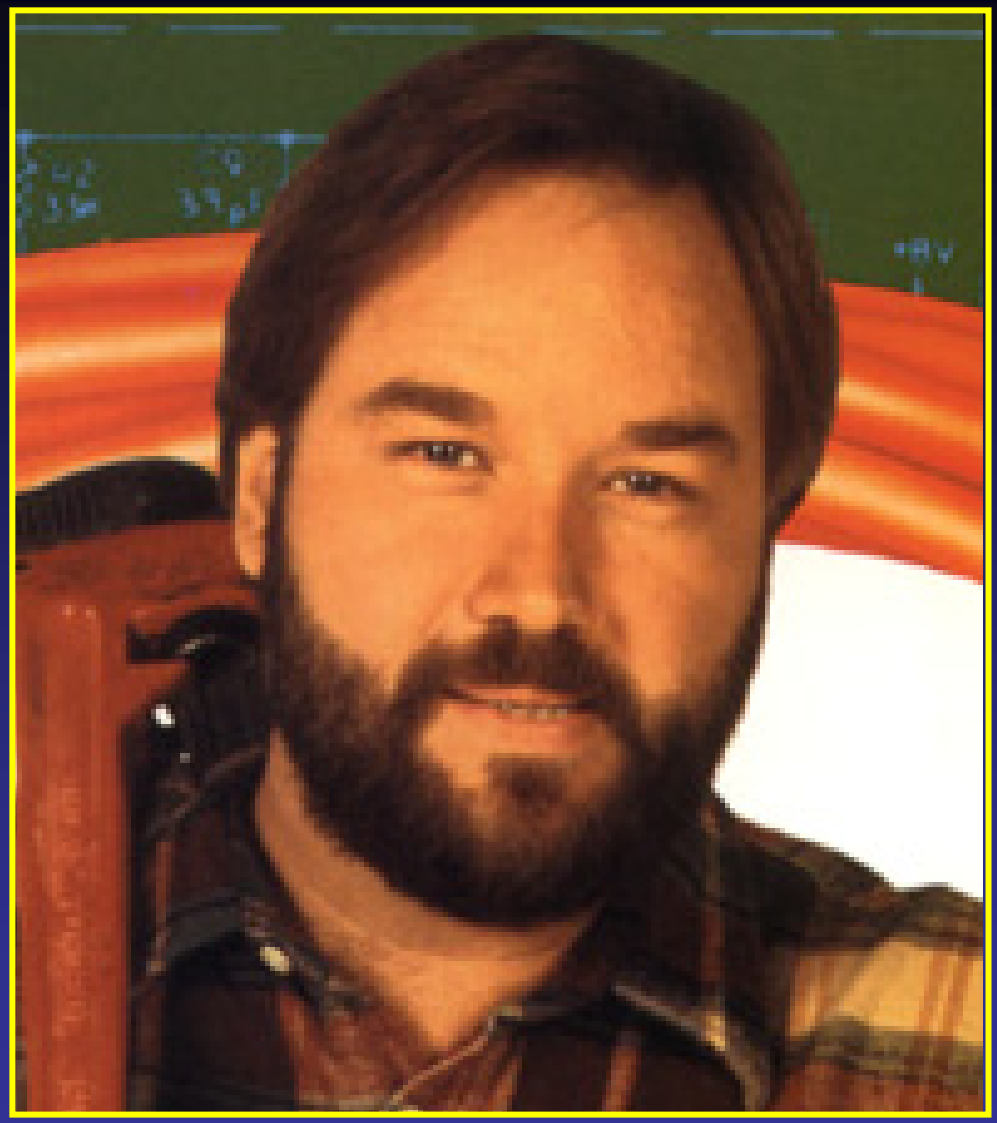
Cost to bale and load straw ranges from $25 - 45 per ton.

Cost to bale and load straw range from $25 - 45 per ton.

Quiz question:

If the cost of collection is $25-45 per ton, will farmers and others sign long-term contracts to deliver straw to conversion plants for $10 per ton?

(answer on next slide)



I don’t think so, Tim.

Since transporting biomass to a central conversion facility is expensive in terms of $ and energy input, can we develop technology to do conversion on-site, or near-site?

Two general approaches:

Biological (fermentation)

Thermochemical

(gasification, combustion, pyrolysis)

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Thermochemical approach (gasification)

WHAT IS THERMOCHEMICAL?

- An alternative to biochemical conversion for producing power and fuels from a wide variety of biomass feedstocks.
- Can convert all components of whole biomass, including lignin (a residue of fermentation processes) to clean intermediates which can be transformed into power and fuels

.

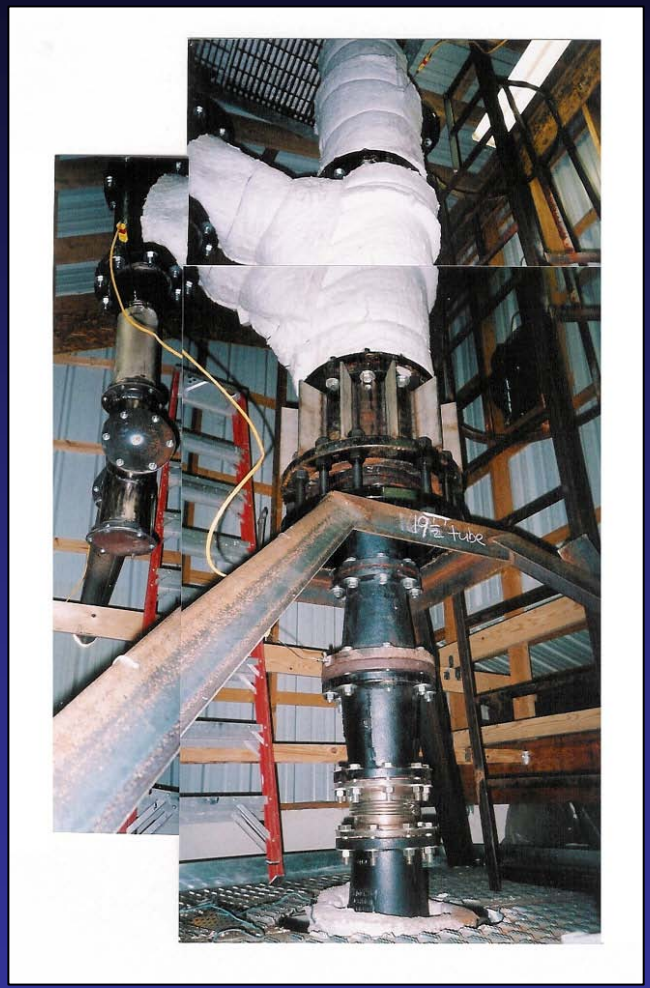
We decided thermochemical conversion was most appropriate for small scale because:

- Doesn’t require water;
- Doesn’t generate a liquid waste stream;
- Uses a variety of cellulosic feedstocks
- Can be sized to fit application and location – amenable to distributed production
- Underlying technologies already exist at commercial scale for coal

Can we make a system that could be marketed for approximate cost of a high end combine?

Local-scale Straw-to-Energy Conversion

Value-added opportunities for farmers and rural communities



Pilot gasification reactor
Western Research Institute
Laramie, WY

Approach:

- We formed a partnership with Farm Power, Inc. (a nonprofit), Inland Power and Light, and concerned citizens to develop a viable alternative to grass straw burning in eastern Washington. BPA contributed a generator and collaborated with Inland to permit purchase of power from project.

- The synthesis gas (syngas) produced from gasification can be cleaned and then used to power a generator, or with different technology, liquid transportation fuels.

- Senator Patty Murray (WA) obtained $736,000 for Farm Power, a non-profit, to work with us.

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Local-scale Straw-to-Energy Conversion

Value-added opportunities for farmers and rural communities

Ignited synthesis gas generated from straw

Progress:

- Two-phase gasifier that works with Kentucky bluegrass straw was built and tested in Laramie, WY. (Boateng et al, 2007, Biomass and Bioenergy)
- A new gasifier based on that design has been constructed in a new facility built by Farm Power. Grid connection provided by Inland Power and Light, generator provided by BPA. Anticipate completion spring 2008.
- Phase 1: convert syngas to electricity.
- Phase 2: convert syngas to liquid fuels.

Potential Impact to the Pacific Northwest: Sufficient available straw to provide 420 million gallons of liquid fuel, approximately 8% of the region's transportation fuel usage, approximate same potential for electricity.

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Data will we collect:

- Economic feasibility
- Practical feasibility
- Quality and quantity of syngas
- Energy and carbon budget
- Optimal operating conditions
- Effect of straw removal on soil carbon, P and K

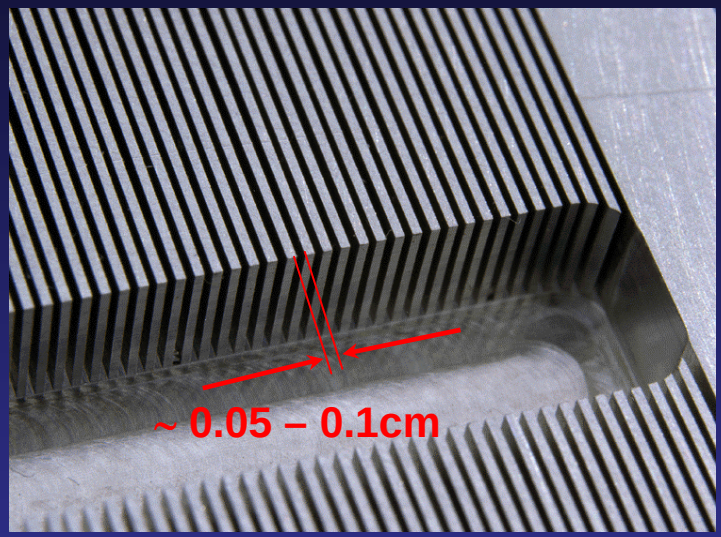
How much P, K and C are we removing with the straw?

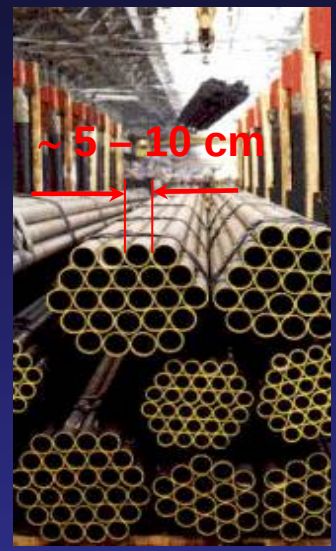
Species	P	K	C
	(pounds per ton of straw)		
Tall fescue	1.3	41.5	858
Kentucky bluegrass	1.9	36.3	872
Orchardgrass	3.3	57.7	864
Perennial ryegrass	2.8	34.5	802
Native grasses	(9 species, four locations in western U.S.)		
Switchgrass	(5 ecotypes, 6 locations in midwestern U.S.)		

Where are the opportunities?

- On-farm where straw is produced
- Mill sites where mill wastes are produced
- Central sites where lawn wastes are collected (i.e., Corvallis Recycling Center)

Microchannel reactors offer great potential for fuel production





- A potentially cost-competitive solution at the scale relevant to biomass
- Allows integration of unit operations in-field
- Preliminary experimentation completed for biomass-derived syngas converted to a light diesel fuel. Catalyst performance verified & initial reactor design completed.
- This work was done by Batelle labs in Richland, WA

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In summary:

- Gasifier testing should begin early summer, utilizing straw, an abundant source of PNW biomass;
- Wood products will be tested next;
- Economics of a distributed system will have to be determined;

"The future ain't what it used to be."