3-25-10 Overview: Biomass Energy in Alaska

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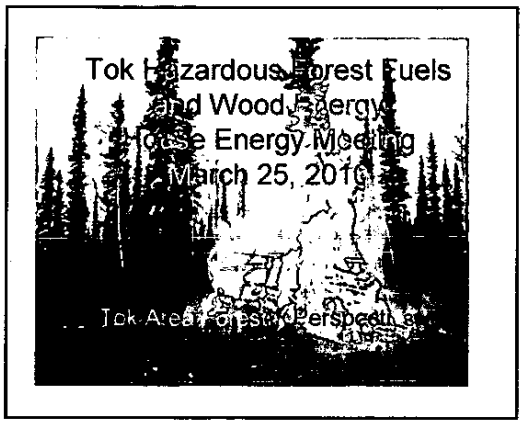
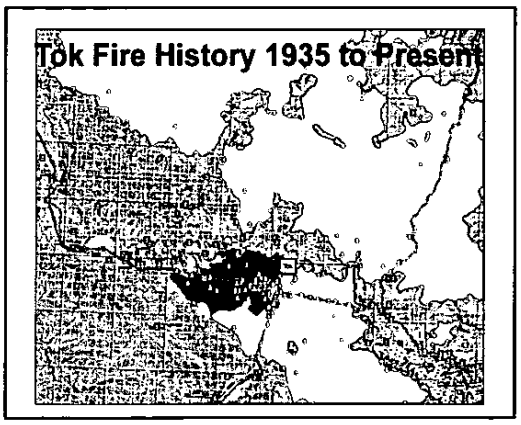
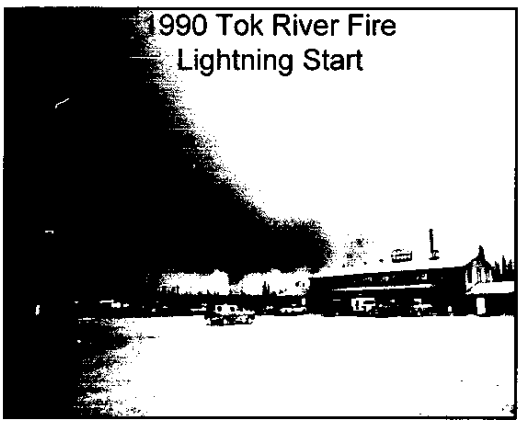
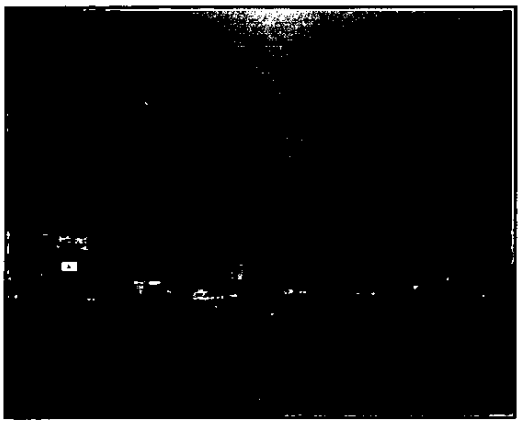

Tok Hazardous Forest Fuels
and Wood Energy
Tok Energy Meeting
March 25, 2010
Tok Area Forest Perspective

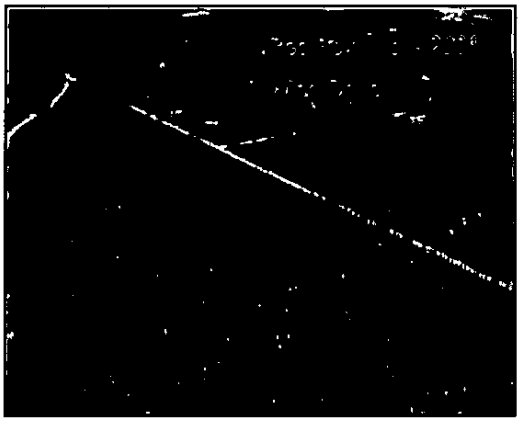

Tok Fire History 1935 to Present

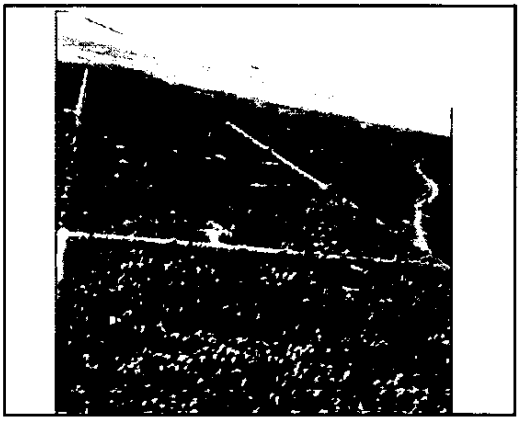

1990 Tok River Fire
Lightning Start

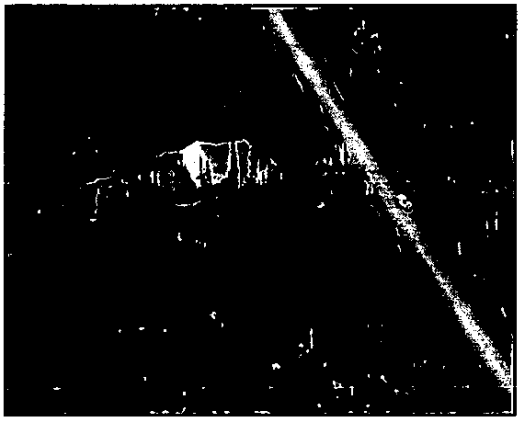

TOK RV

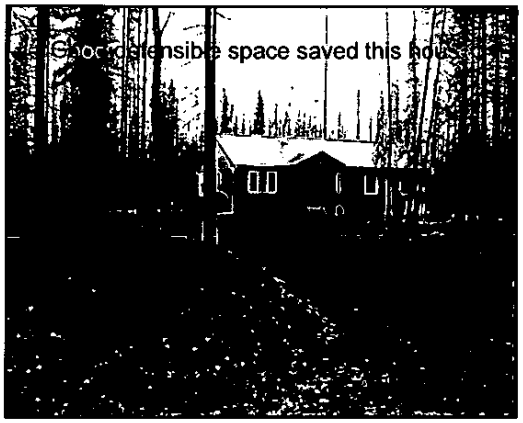



2001 Red Fox Fire
Human Caused



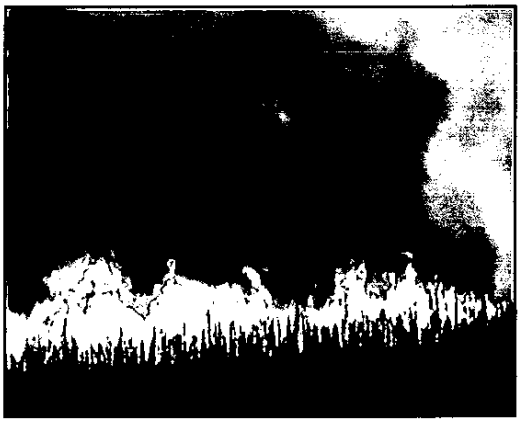






Cost of Fires in the Tok Area

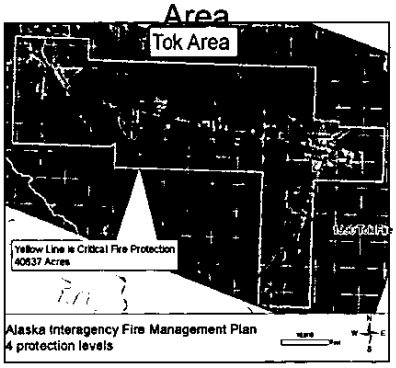
- 50 Million Dollars in State money over the last 25 years!!



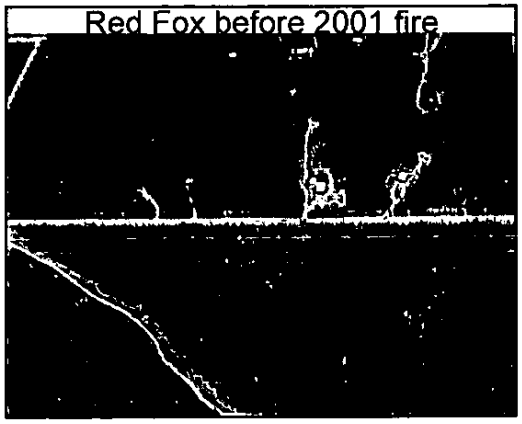
What has changed in 20 years

- We are nearly as dangerous as we were in 1990.
- Contiguous dense high volume hazardous fuels
- No breaks or anchor points except the incomplete Red Fox fuel breaks
- More people living within the Tok Area.
- 20 years of lands sales by the state.

Tok Critical Fire Protection Area

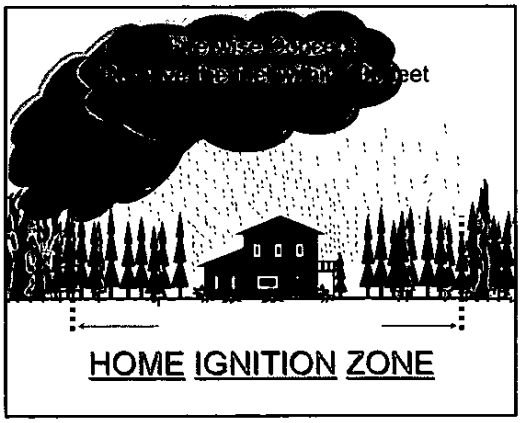


Tok Community Wildfire Protection Plan Meeting (CWPP)

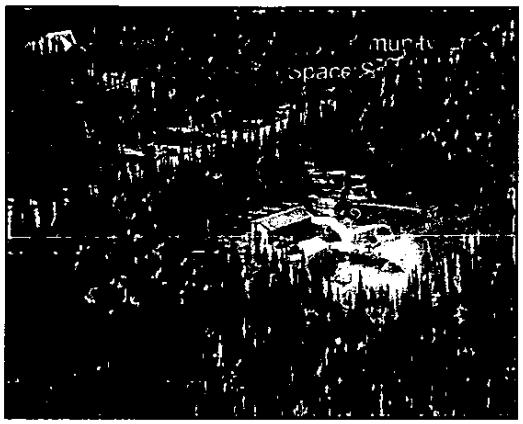


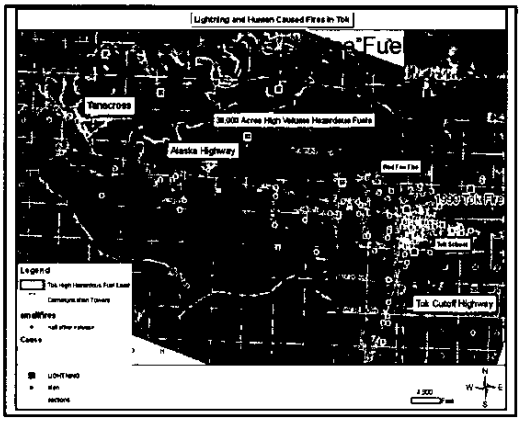
Red Fox before 2001 fire

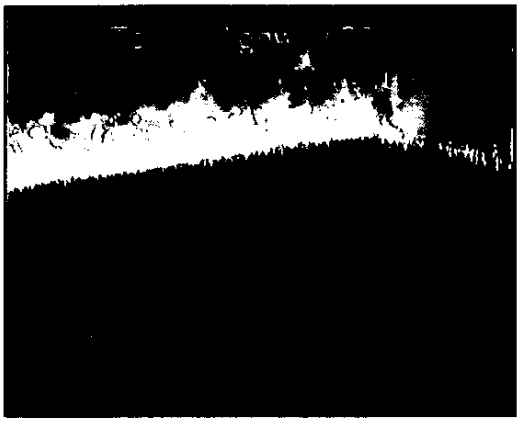
Typical Drive way in Tok



HOME IGNITION ZONE





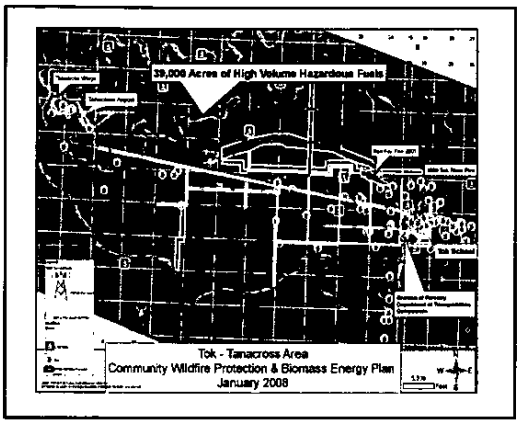


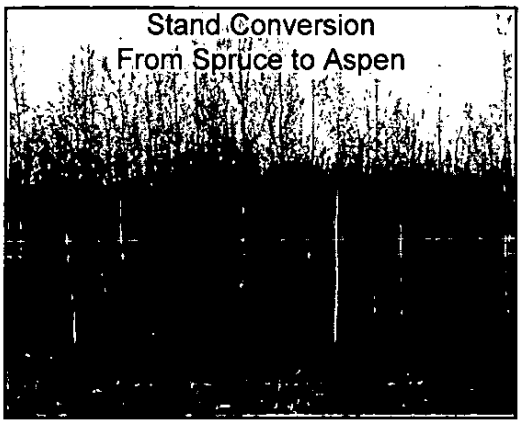
CWPP Principles

- Work from the inside out – remove the fuels closest to the values at risk – Fire wise Basics
- Use Fuel Reduction moneys effectively – treating the most acres.
- Don't be cute
- Use solid science
- Don't pull any punches with the public
- Educate the public on what must be done.
- Create a value for the fuel removed

Failures of Fire wise

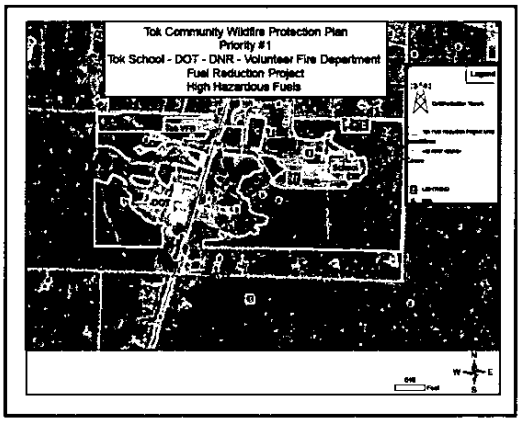
- Why don't people remove the fuels when they know how dangerous it is?
  1. They cannot physically remove the fuels themselves. 2000 to 10000 stems per acre of spruce fuels.
  2. They cannot afford to remove the fuels. From $1500 to $5000 dollars an acre.

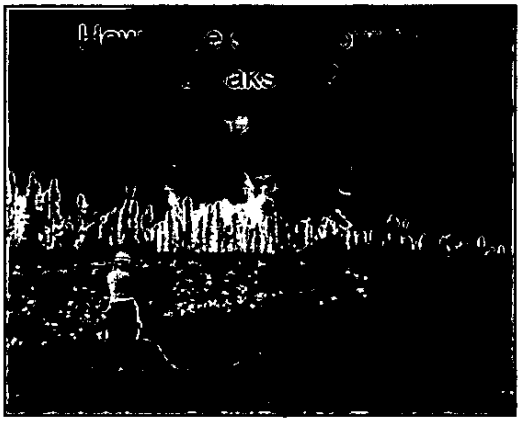




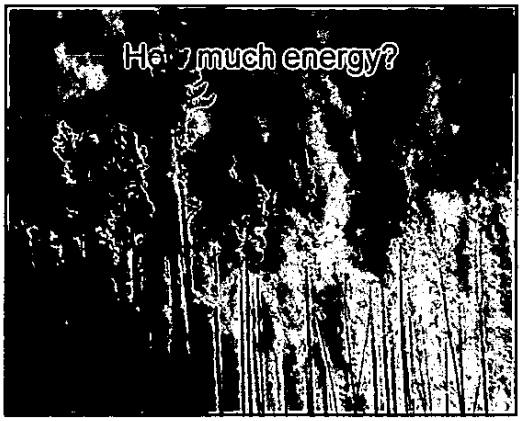
Tok CWPP Priorities

1. Remove fuels from - Tok School - DOT and Forestry / State Communication tower.
2. Safe evacuation routes and road ROWs.
3. Senior Citizens Defensible Space
4. Create effective fuel breaks and anchors for our firefighters.



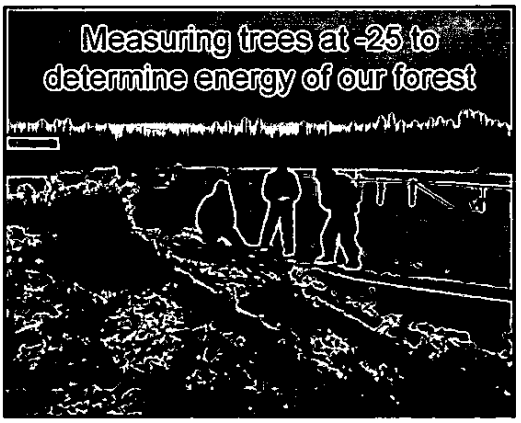


How Dangerous is Tok?
How much energy is there?



How Much Biomass is there per acre?

Biomass Inventory Work At -28 below zero!!



Chipping the Trees

Weighing each tree on Digital Scales

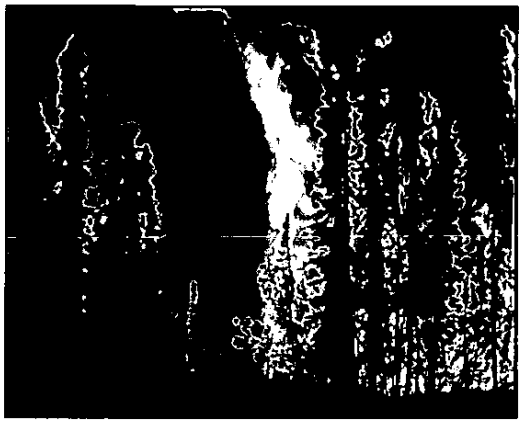
Forest Techs on Summer Plots

What did we find out?

- There was far more energy per acres than we had previously thought.
- 100th acre plots with up to 64 trees representing 6400 per acre
- From 33 to 187 Tons per acre

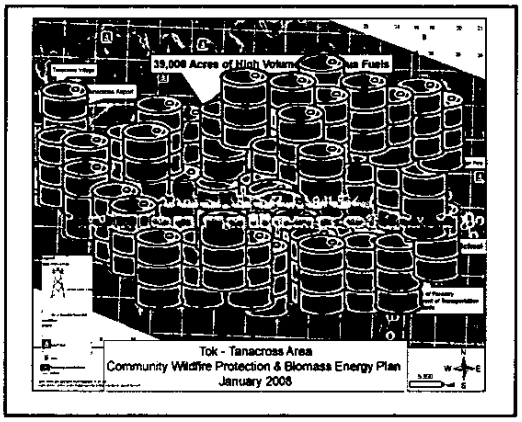
Computed Energy - BTU totals

- 60 tons x 2000 lbs x 4,572 BTUs per lb = 548,640,000 BTU per acre of green 50% moisture Hazardous Fuels
- 548,640,000 BTU per acre x 39,000 acres of highly volatile hazardous spruce fuel =
- 21,396,960,000,000 BTU
- That is a lot of energy!!



Fuel Oil Equivalent

- 1gallon of fuel oil has 139,000 BTU
- 1 acre of hazardous fuel / Biomass 548,640,000 BTU / divided by 139,000 BTU per gallon of fuel oil = 3947 gallons of fuel oil per acre
- 39,000 acres x 3947 gallons per acre = 153,934,964 million gallons
- 153,934,964 Gallons / 3,665,118 barrels of fuel oil (BTU equivalent of the hazardous fuels biomass equivalent) that we are surrounded by.



Dollar value of forest fuels

153,934,964 gallons of fuel oil @ $2.00 per gallon = $307,869,928
Fuel oil BTU value equivalent

39,000 acres x 60 tons per acre x $60 per ton = $140,400,000
Value of hazardous Fuels / energy

How many acres of hazardous fuels need to be removed right now?

- 500 acres – private property (defensible space) current estimate
- 39,000 acres – total # of acres of hazardous fuels
- 2,800 acres – transportation routes, state facilities and fuel breaks
- 3,300 acres total requiring removal out of 39,000 acres equals only 8% of the total fuel load.

What Does Hazardous Fuel Removal Cost?

- Past manual projects (by hand with chainsaw) have cost from $3,500 to $5,500 per acre.
- Past mechanized projects (with feller buncher and skidder) have cost $1,100 to $2,000 per acre.

Cost to remove current identified hazardous fuel priorities

- 500 acres on private property x $3,000 per acre = $1,500,000 (combination of mostly manual removal with some mechanized)
- 2800 acres on state lands x $1,500 per acre = $4,200,000 (combination of mostly mechanized removal with some manual)
- **Total $5,700,000 million dollars**

Funding received since the 1990 Tok River Fire

- Tok has received $320,000 federal funding for fuel reduction from the US Fish and Wildlife.
- The State of Alaska has not funded *any* fuel reduction in the entire state.
- The outlook for fuel reduction funding is not bright. Alaska does not do well competing with California for these federal funds.

We want to harvest 50 acres of forest around the Tok School!

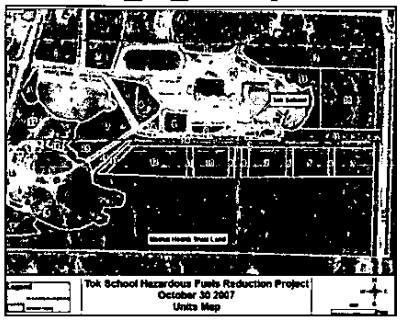
- Presented the concern expressed through the Community Wildfire Protection Plan to the School Principle, Superintendant, School Board and Tok Public

One of several Field Trips

Getting the Funding Fuel Reduction Project

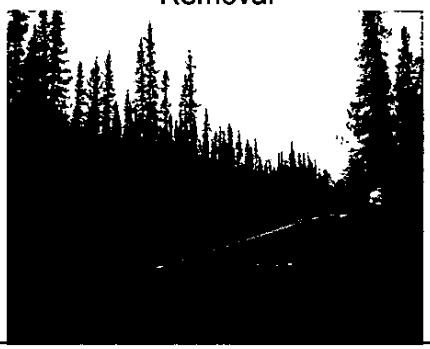
- $50,000 Dollars from the USF&W for Hazardous Fuels Reduction
- Agreement – Remove 50 Acres of Fuel
- Safely Harvest while kids attending school.
- Meet the Schools criteria for land use and aesthetics
- Have useable bio-fuels decked ready for processing.

Tok School Hazardous Fuels Project 50 acres – 1200 Tons



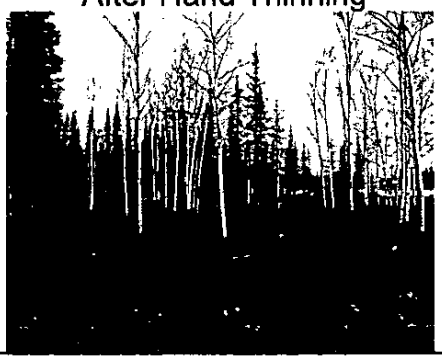
Red Fox Fire Field Trip

Road into School Before Fuel Removal

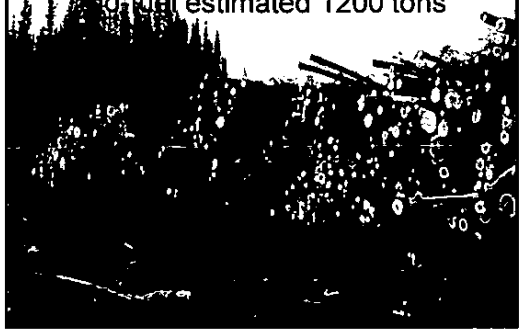


Conventional Timber Harvest Equipment

After Hand Thinning



Hazardous Fuels ready for Processing into Wood Energy / Bio fuel estimated 1200 tons



Contractor directional tree length hand felled – skid with grapple log skidder

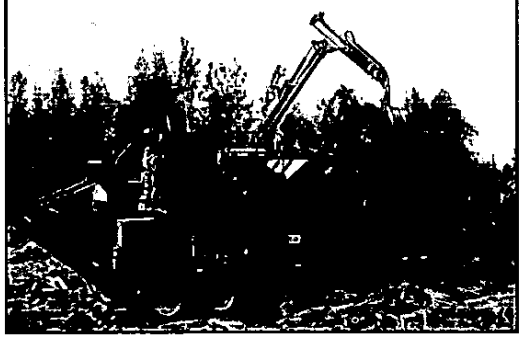
Public Approval

- We did not receive a single phone call complaining about the harvest activities.
- We did get many phones asking if they could cut firewood out the decks.
- We did get many compliments.

Where will the money come from to remove the hazardous fuel?

- What if we could create a value for the hazardous fuel that needs to be removed?
- If instead of being only a liability to the community it became an asset.

Wood Energy - Bio-fuel

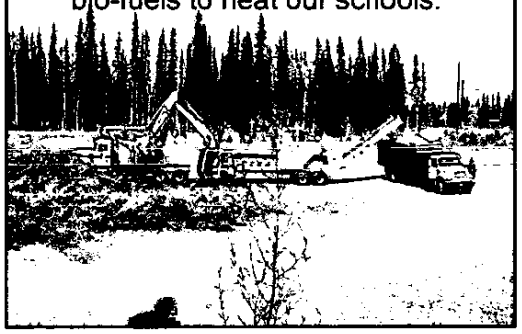


What we have done with the Hazardous fuels in past projects

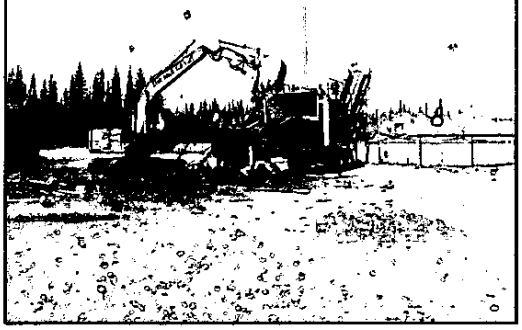
What is the difference between hazardous fuels and bio-fuels?

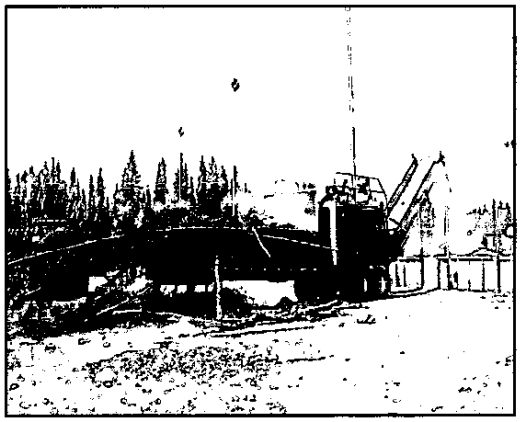
- Absolutely nothing
- Hazardous fuel is the material before it is processed into bio-fuels.
- We can cut the hazardous fuels, grind it into a usable form of bio-fuel, transport it to a school and burn it in a high efficient boiler to generate heat.
- This is a better alternative to cutting hazardous fuel and setting a match to it –

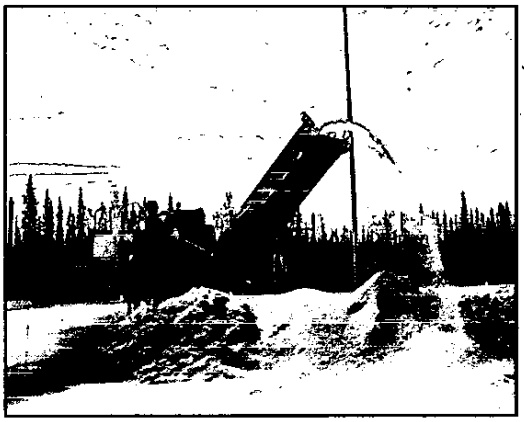
What we plan to do with all future hazardous fuel – process it into bio-fuels to heat our schools.



Tok Community Received a $500,000 state CIP To purchase the equipment to process Hazardous fuels into bio- fuels







What's the difference?

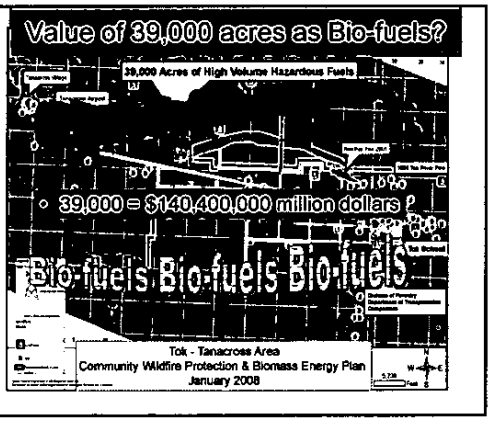
- Remember?
- 2800 acres on state property x $1,500 per acre = $4,200,000 (combination of mostly mechanized removal with some manual)
- 500 acres on private property x $3,000 per acre = $1,500,000 (combination of mostly manual removal with some mechanized)
- **Total $5,700,000 million dollars**

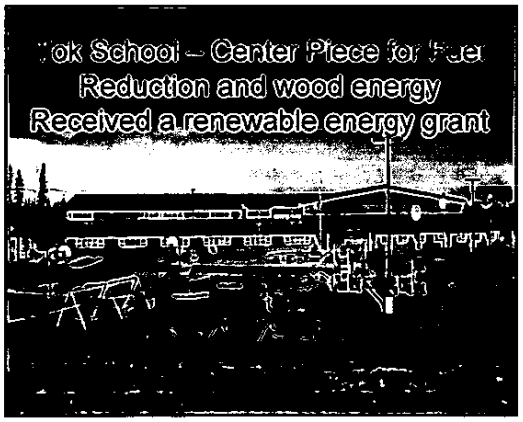
Hazardous Fuel processed into biofuels has real value

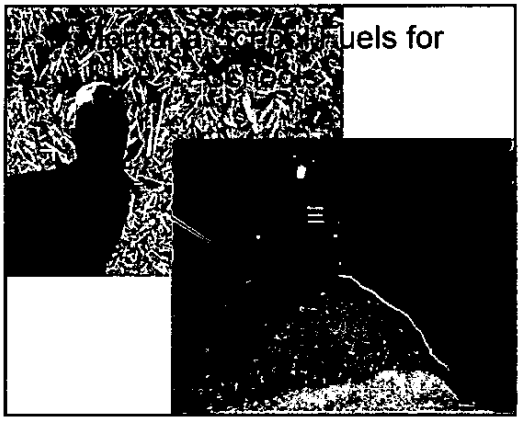
- Biomass delivered to the School will have a value up to $60 a ton or more.
- Our 3,300 acres of hazardous fuels have an estimated average of 60 tons per acre.
- That is 30 - 90 years of fuel for the Tok School.
- 3,300 acres x 60 tons per acre x $60 per ton of biomass = **$11,880,000**

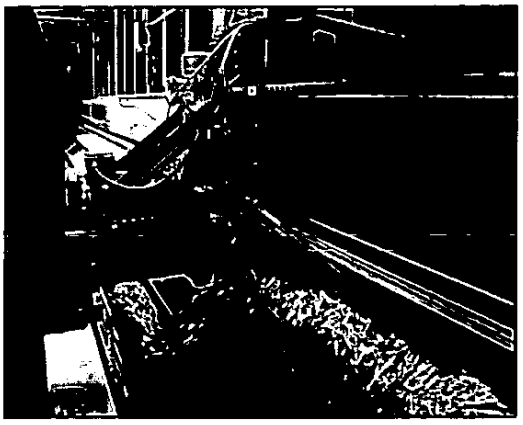
What's the difference?

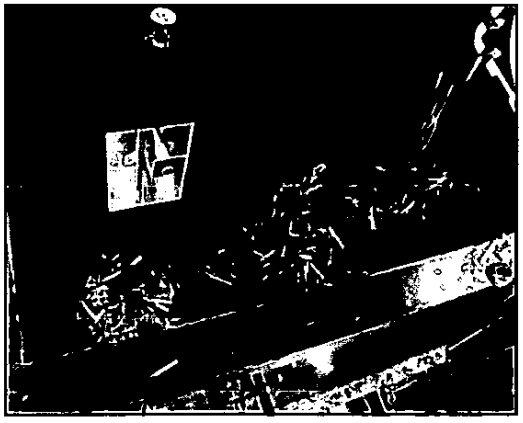
- How about going from spending $5,700,000 to remove the hazardous fuels to a potential positive value of $11,880,000 as delivered biofuels.
- **That is $17,580,000 difference.**

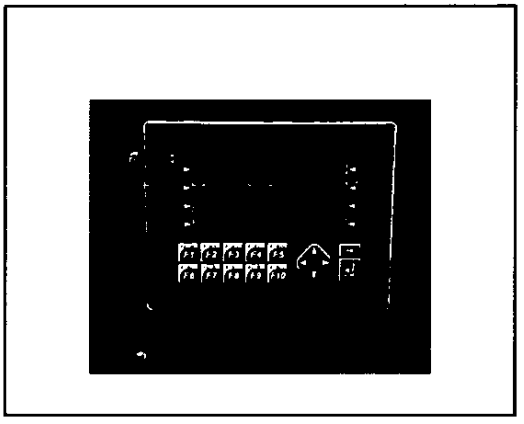


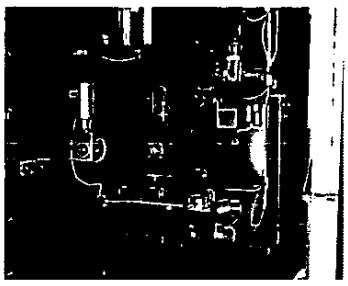


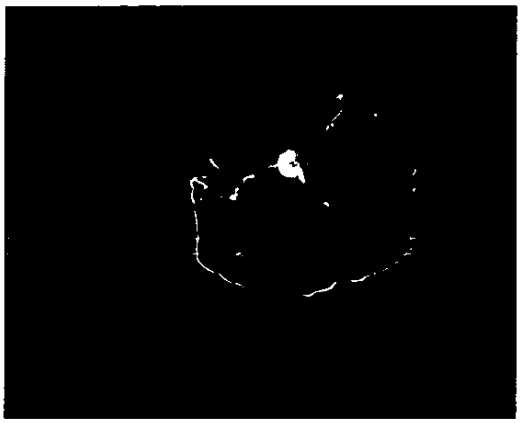


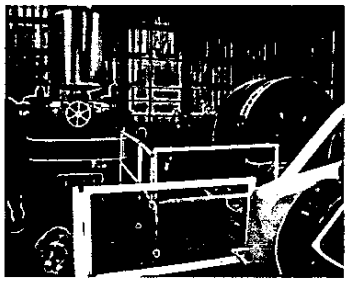


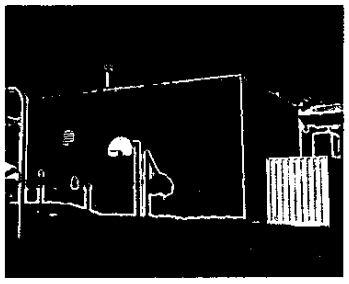












What is the value in savings to the School?

- $100,000 annual savings in heating cost
- $160,000 additional savings in electricity
- $2,600,000 in ten year savings
- $7,800,000 in thirty years

Value of Tok School – Project

- The Tok School will require 1200 tons of wood energy a year.
- At $60 per ton - $72,000 annually
- That is 30 acres of hazardous fuel removed annually.
- That is 900 acres over 30 year life of project.
- At $1200 per acre for fuel reduction this worth $36,000 annually.
- $1,080,000 over 30 year life of project!!

Direct Cost of Urban Interface Fires

- The cost of an urban interface fire is at least $10,000 per acre.
- This is 3 to 10 times the cost of fuel reduction and or harvest of wood energy per acre.
- This is 2 to 10 times the cost of land DNR Lands is selling in Tok.

Conclusion

- We need the State of Alaska to declare that fuel reduction is in the best interest of the state.
- We need annual state funding for fuel reduction work.
- We need develop wood energy projects to use the hazardous forest fuels.
- We need the state committed to using renewable wood energy in state facilities to help create the stable market demand.

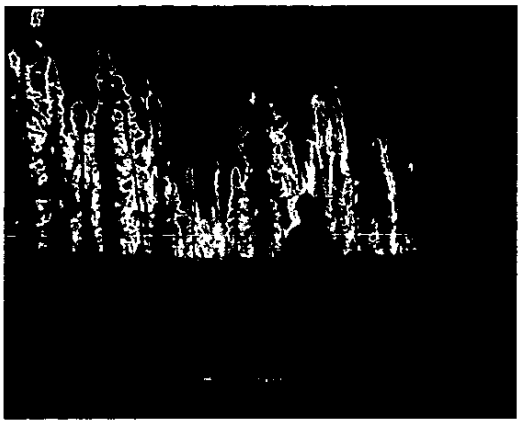
- We need a detailed statewide inventory of our forest resources.
- We need 25 year detailed forest harvest plans to show where the harvest would occur and develop the cost for harvesting.
- We need to commit to long term contracts for supply of forest fuels.
- We need trained people to plan and do the field work to implement these projects.
- Educate the public about the incredible energy in our forest.
- Educate the public on the benefits of renewable wood energy products and

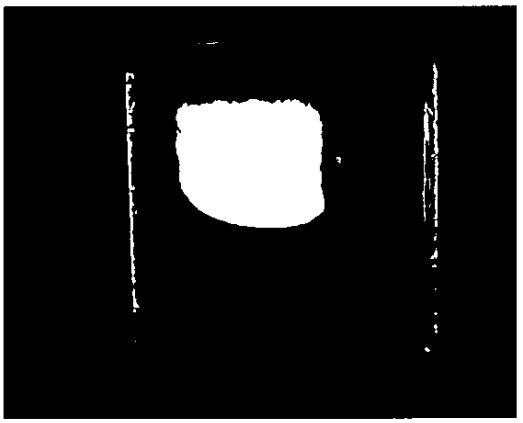
Has that crazy Tok Area Forester gone positively Mad?

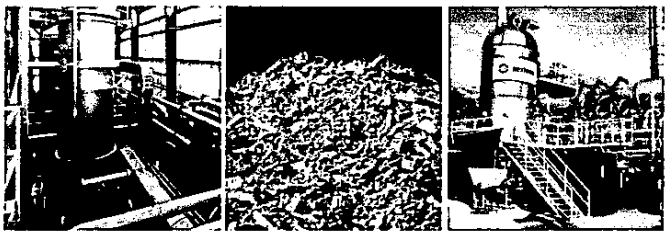
NO

We not going to clear-cut Tok and grind all the trees into bio-fuels.

We just want people to start looking at our dangerous situation and our incredible renewable forest resources with a new perspective!!







TOK Advanced Power Biomass Gasification Project

Project Update - 1 March 2010

Alaska Power & Telephone (AP&T), in collaboration with Nexterra and GE Energy, the communities of Tok, Tetlin, Tanacross and Dot Lake, and with assistance from Dalson Energy, propose to deploy a "State of the Technology" community-scale 2MW Biomass CHP (combined heat and power) system to offset diesel power generation. The system will use locally-sourced woody biomass as fuel.

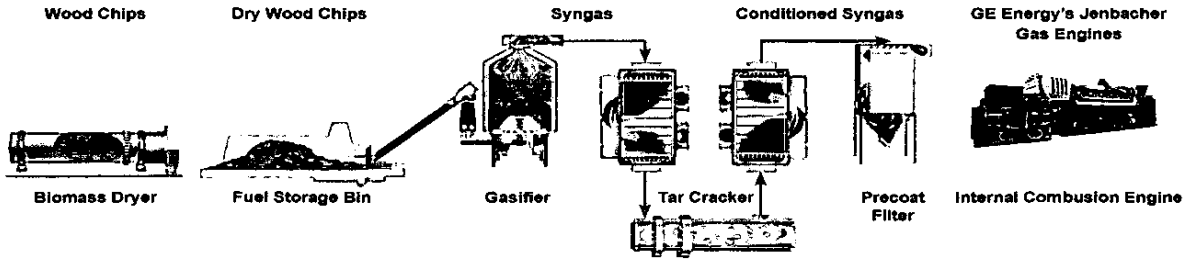
This biomass gasification system has the highest conversion efficiency of viable renewable energy systems, provides demand power, and is a new standard for renewable community-scale (2-10MWe) heat and power generation in rural communities, and in industrial and institutional facilities, while demonstrating sustainable forest practices using small volumes of local woody biomass as fuel.

The thermal output (heat) will be available for a community district heat loop, and could integrate with the (pending) Tok school biomass heat project. Heat can also be sold to the proposed biomass pellet and briquette manufacturing facility.

Benefits include:

- ⇒ *Local fuel source alternative to imported diesel*
- ⇒ *Carbon emission reductions using carbon-neutral woody biomass*
- ⇒ *Improved local air quality using clean gasification technology*
- ⇒ *Creating valuable use for overstocked local scrub-Spruce forests*
- ⇒ *Reducing wildfire risks around communities*
- ⇒ *Creating local jobs for harvesting and processing of feedstock*

□ BIOMASS-TO-POWER SOLUTION



Fuel Supply

The Project Coordinator is continuing negotiations with Alaska State Department of Natural Resources, Department of Forestry (DNR) on a 25-year sustained yield biomass fuel harvest contract. A draft contract has been created by DNR, and input was gathered from local forest contractors and other to respond.

The harvest contract, when fully developed and executed, may serve as a model for biomass fuel contracts in Alaska. Historically, harvest contracts have been focused on merchantable sawlogs for lumber mills.

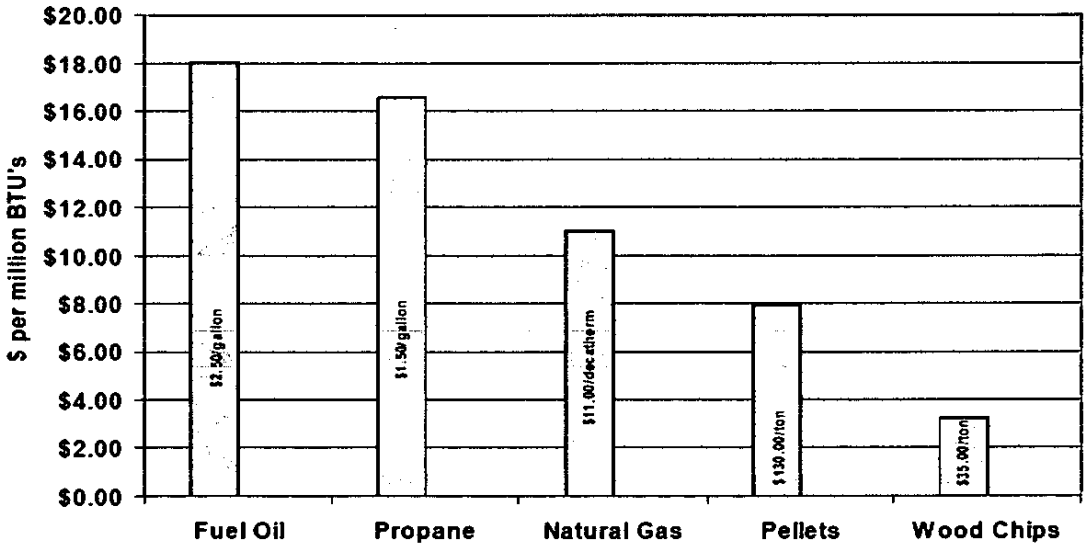
The decline in milling operations has resulted in DNR not meeting its own "allowable cut" goals for several years. The wildfire risk is high in the areas identified for harvest around communities, especially Tok. There is much more available acreage than is necessary to meet this scale of biomass energy system feedstock requirements.

Harvest for biomass fuel will serve several purposes: reduce wildfire risk, create local jobs, enhance wildlife habitat, especially Moose who prefer new growth, and create a valuable use for this otherwise unusable fuel source.

The diesel fuel cost for the existing generators was over $4M in 2008, most of which will be offset by less expensive local biomass fuel. The O&M costs for the biomass system are projected to be comparable to the existing diesel generators.

The benefit of keeping most of the fuel money in the local economy will be very significant. Additionally, industrial capacity will be enhanced by availability of heat from the plant, especially in the summer when it is not needed for district heat.

DNR estimates that over 90% of the forest in the Tok area designated for wildfire risk reduction is non-merchantable trees. They estimate that resource inventory will take several months of DNR staff time. DNR has indicated that they are willing to allocate their staff resources to this task when the CHP Project is funded.



Support for Project

The ongoing delay in decision announcement by DOE NETL has resulted in some general erosion in awareness and confidence. All will be forgiven upon positive announcement.

Local Support
The Tok Umbrella Corporation (TCUC), Tok Chamber of Commerce and many area community members have all expressed support for the project. No opposition has been identified.

From the TCUC support letter:

"The project will help to accomplish several goals of the Tok Community: Electric generation is currently dependent on expensive diesel fuel. Switching to local wood biomass will reduce electrical costs for all of us; reduce carbon emissions by using a carbon-neutral fuel; and improve local air quality during temperature inversions.

Money spent for fuel will remain in the community rather than going out to multinational oil companies, and several additional jobs will be created, to the benefit of the local economy. We'd have a safer community and a healthier local economy"

Funding
The Department of Energy National Energy technology Lab Grant request for $10M is still pending. DOE NETL recently issued a revised estimate of announcement by end of Q1, 2010. Another funding option, in case of failure by NETL, is to seek funding through the pending 2010 Biomass Energy programs at DOE.

State Support
Alaska Energy Authority has expressed support for the project, and will likely provide match funding after DOE funding is committed. State legislators and the Alaska Governor's office have also expressed interest and support. We have done no lobbying for the project to date, simply made them aware of it.

Federal Support
Senior researchers at NREL and DOE have been monitoring Nexterra for several years. Dr, Richard Bain, NREL and John Scahill, DOE, long-time bio-energy researchers, have both expressed knowledgeable confidence in the Nexterra/GE Jenbacher system.

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Dalson Energy

Office of the Commissioner and Division of Forestry

Alaska Department of NATURAL RESOURCES

BRIEFING PAPER

Alaska Wood Energy Development Task Group

May 20, 2008

ISSUE

With national heating and electricity costs increasing yearly, Alaskan communities are experiencing drastic fiscal impacts. In some communities, utilization of excess woody biomass from Alaska's forests has risen from being a prominent issue to a necessity for survival. Economic and environmental stressors promote developing markets for alternative biomass energy. In both the short and long term, alternative energy will save money; however, the fiscal resources required to cover the up front costs for transitioning from fossil fuels to wood/ wood-chip/wood-pellet burning appliances and support infrastructure are limited. The Alaska Wood Energy Development Task Group was formed in 2004 to provide funding and expertise for selected projects that promote the use of biomass over fossil fuels.

BACKGROUND

Biomass comes from two primary activities: treatments to reduce hazardous fuels, and forest management to accomplish other objectives. Alaska woody biomass sources include:

- Trees thinned from the wildland urban interface (WUI) to reduce risk to communities from wildland fires
- Trees from hazard fuel clearings in fire-prone, spruce bark beetle-killed forests
- Logging and sawmilling by-products (including woodchips, sawdust and planer shavings from sawmill operations)
- Low quality sawlogs and smaller diameter trees in commercial stands that currently have low or no market value and thus are under-utilized

Alaska's forests provide an abundance of locally-grown, sustainable wood products. Broader utilization of forest resources creates economic opportunity, beyond traditional sawmill uses, through a wood-based bioenergy industry. Renewable wood energy products are also considered "carbon neutral" from a climate change perspective. Additional benefits from a more wholistic forest resource usage include: habitat improvements for a wide range of wildlife that depend on a mosaic of forest age classes, and fuels management in the wildland urban interface from a wildland fire risk management perspective.

ALASKA WOOD ENERGY DEVELOPMENT TASK GROUP (AWEDTG)

The Alaska Wood Energy Development Task Group is a coalition that is exploring opportunities to increase the use of wood for energy in Alaska. From 2005 to present, the task group has solicited statements of interest for thermal wood heat projects in Alaska. From 2005 to present, the task group has received and reviewed 79 statements of interest; selected 42 projects for further study; completed 34 site inspections and field reports; completed 21 feasibility assessments; 2 projects are in the design stage; and 3 projects are installed and operational.

The USDA Forest Service and Alaska Energy Authority have been the lead agencies, providing expertise and the bulk of the funding. Juneau Economic Development Council provides the primary "point of contact," resource information, technical assistance, site reconnaissance, and pre-feasibility assessments.

AWEDTG Members

- Alaska Energy Authority
- Alaska Village Initiatives
- Alaska DNR Division of Forestry
- Denali Commission
- Juneau Economic Development Council
- USDA Farm Services Agency
- USDA Forest Service Alaska Region
- USDA Natural Resources Conservation Service
- USDA Pacific Northwest Research Station
- USDA Rural Development
- USDI Bureau of Indian Affairs
- USDI Bureau of Land Management Alaska Office
- USDOE National Renewable Energy Lab
- UAF Cooperative Extension Service

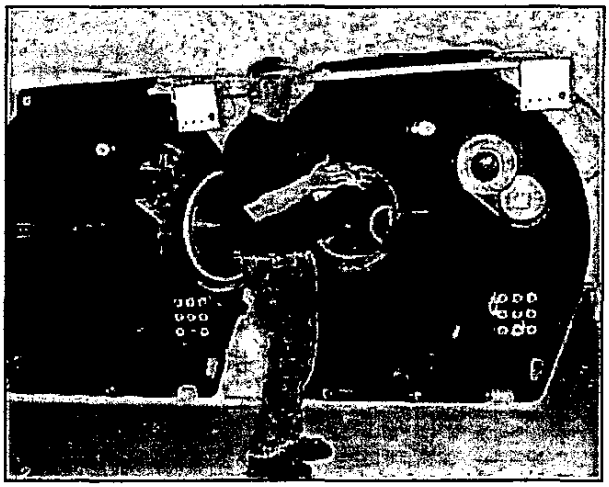
Alaska Department of NATURAL RESOURCES

PROJECTS THAT ARE NOW OPERATIONAL

o **Craig** - The boiler was operational at the beginning of May. The City of Craig constructed a wood-fired boiler heating system to supplement propane and oil heating systems for the municipal pool water, pool building, and elementary and middle school buildings. The new facility uses wood shavings, chips, and dried planer shavings, collectively known as hog fuel, from local mills as fuel. The system is maintained by the Craig City School District. Installation of this system will result in cost savings of $40,000 - $60,000 per year between the municipal pool and the school buildings. The project will also reduce the reliance on fossil fuels for heating and will also help local mill owners by purchasing and utilizing wood waste generated by their manufacturing process. Funding was provided by the USDA Forest Service, USDA National Resource Conservation Service, Alaska Energy Authority, the Denali Commission, and the City of Craig.

o **Kasilof** - A community of about 10 families in Kasilof has installed two GARN wood-fired boilers, located in an outbuilding, to supplement masonry heaters used to heat their community center. The GARN units provide roughly one-third of the community center's heat. Hot water provides warmth through radiant tubing in the floor and wall baseboard heaters. The boilers also provide all of the hot water that is used for the village's community kitchen and hand laundry. Their wood source comes from beetle-killed spruce found on their 200 acres of land off of North Cohoe Loop Road. The community already has plans to install another GARN unit in their barn, which stores crops. Funding for the project came from the Alaska Department of Health and Human Services, and the USDA Forest Service Jump-Start Wood Energy Program grant through the Division of Forestry and managed by the Juneau Economic Development Council (JEDC).

o **Tanana** - Two GARN Boilers are in place in the community of Tanana and are used to heat a washeteria and city water system. Not only do the boilers cost less than importing fuel oil, they create jobs within the community as the source of fuel is driftwood harvested from the Yukon River. The boilers were transferred from the city to the nonprofit water and sewer utility Too'gha Inc. Funding for the project came from the USDA Forest Service Jump-Start Wood Energy Program grant through the Division of Forestry (managed by JEDC), the Alaska Department of Commerce Community and Economic Development, and Too'gha Inc.



Above Left: *Dave Frederick of Alaskan Heat Technologies explains the operation of GARN wood-fired boilers in Tanana, AK. Photo by Daniel Parrent*

Above Right: *Ted Eller loads wood into a Garn wood-fired boiler at the Ionia community in Kasilof. The boiler is heating a large community center and much of the hot water the group consumes. Photo by M. Scott Moon*

INFORMATION SOURCES

- City of Craig Website: http://www.craigak.com/index_files/wood.htm
- Peninsula Clarion Article: "Ionia Revisits Wood as Fuel" by Phil Hermanek, 3/20/08
- Daily News-Miner Article: "Building a Better Wood Stove in Tanana" by Stefan Milkowski, 11/14/07
- AWEDTG Wood Energy Conference Materials: http://www.tananachiefs.org/natural/AWEC2007.shtml

CONTACT

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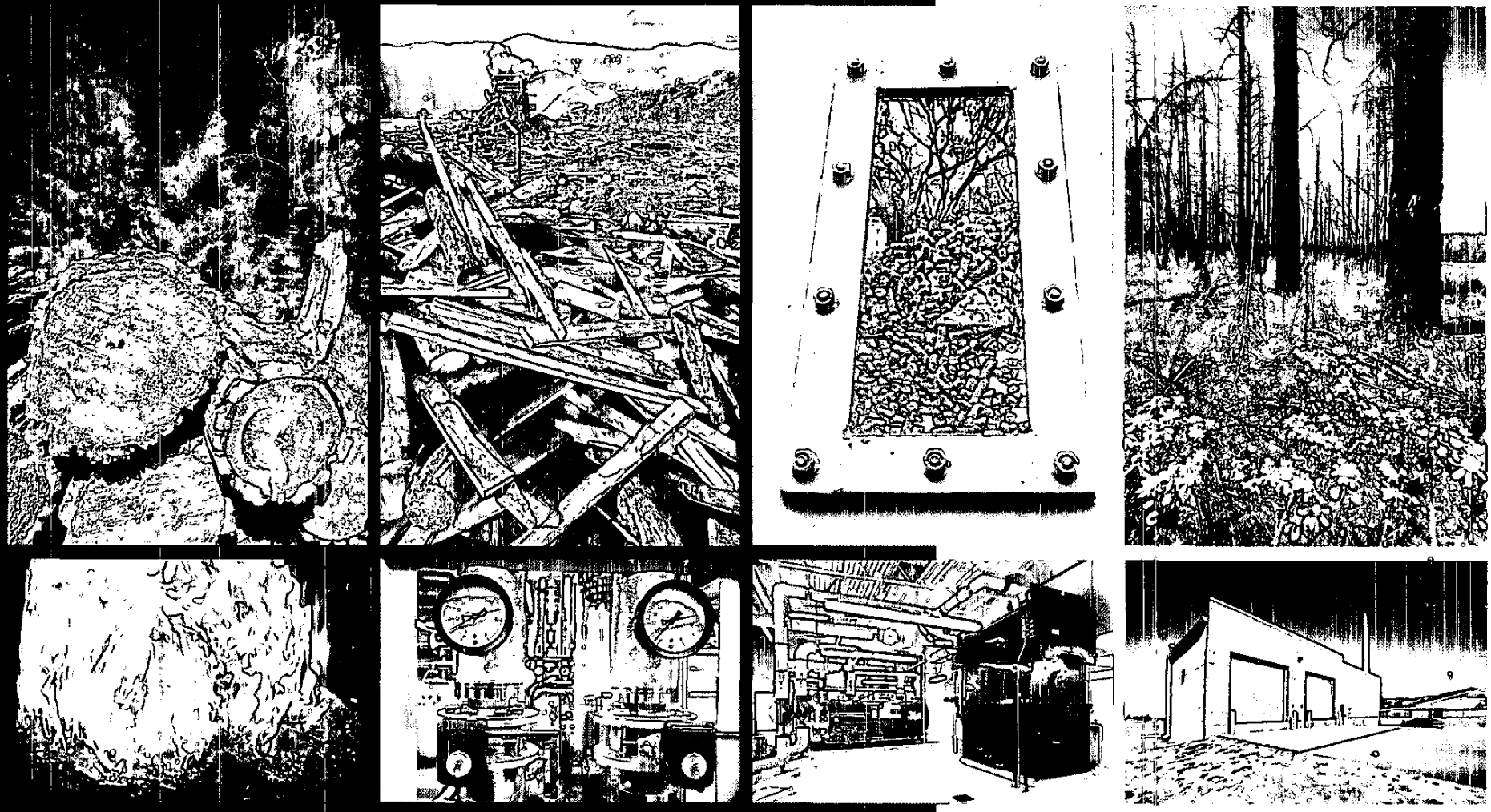


Where Wood Works

Strategies for Heating with Woody Biomass

Welcome

National Leadership

"We are on the brink of a new healthy forest economy that will sustain large-scale forest restoration in the long run. The rapid growth of a young bioenergy industry holds the promise of a reliable and expanding market to use the small trees supplied by forest restoration projects for cleaner and cheaper energy sources."

Rick Cables
Rocky Mountain Regional Forester
Forest Service, USDA

"Technology is taking wood use to new levels. BLM is committed to providing biomass to help meet future needs for energy and value-added products, while reducing the risk of catastrophic wildfire."

Gregg Nelson
National Biomass Coordinator
Bureau of Land Management

"Matching the bioenergy technology to the available forest resource is extremely important. Sometimes, smaller scale applications such as heating a community building makes the most sense."

Marcia Patton-Mallory, PhD
Biomass and Bioenergy Coordinator
Office of the Chief
Forest Service, USDA

Colorado Leadership

"Renewable energy resources such as biomass are key components of the New Energy Economy. Through effective use of biomass resources we can reduce our dependence on fossil fuels, improve forest health, protect our environment and stimulate local economies."

Tom Plant
Director,
Colorado Governor's Energy Office

"Wood is the environmentally friendly fuel source of the future because it is carbon neutral and renewable. When we begin actively including wood in the energy equation we also contribute to improved forest health, safer watersheds, and reduced fire risks."

Jeff Jahnke
Colorado State Forester

"To create a truly environmental and sustainable energy source we must look to biomass utilization as our answer for the future."

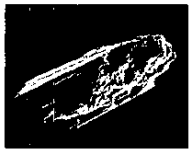
Jeff Kitchens
Colorado Forest Program
BLM

2095

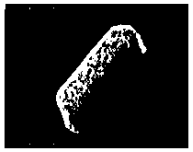
Wood Can Work for Your Community

If your community is looking for ways to reduce heating bills and you are near a forest, you have probably considered using wood for heat. Yes, it can work! It can reduce your heating bills, address regional forest health issues, and help keep more of your energy dollar in your community. But it could also be a disaster. The wrong technology for the wrong application with wrong expectations is a recipe for getting burnt on wood. This article shines light on the pitfalls and potential of wood-fuel applications.

The Basic Technologies



CHIP SYSTEMS are well-suited for large buildings and campuses. Successful projects get their chips locally, usually within 30 miles or so. Chip-handling systems are complex and expensive to build and operate. This is offset by the low cost of the fuel itself.



PELLET SYSTEMS work very well at the residential scale and are beginning to be used in commercial buildings. In Europe, pellets are delivered in bulk to heat entire towns and they are even used as a zero-carbon substitute for coal in large electric power plants.

CORDWOOD SYSTEMS heat large mountain homes, winter lodges and camps, and even swimming pools. In the right location, the fuel (basically firewood) is free or nearly so. These systems must be manually loaded once or twice a day with up to 100 pounds of wood. Great exercise!

COMBINED HEAT AND POWER (CHP or cogeneration)—the production of heat and electricity from wood—is very promising. Today, it works very well in large lumber mills, paper mills, and furniture factories. In the future, it may even work for smaller applications.

EMERGING TECHNOLOGIES are being developed by governments and industries looking for low-carbon, low-cost energy sources. Wood can be ***gasified.*** The gas can be used to fire a boiler, drive an engine or turbine, and even run a fuel cell. Wood can be ***liquefied*** into liquid biofuels for transportation. These technologies are being prototyped today and should be commercially viable within the next decade.

THE BOTTOM LINE
Is your building...

More than 100,000 square feet?

If you have more than 100,000 square feet to heat in a moderately cold climate and you're located near a stable supply of wood chips, you may have a winner. If the building is a hospital, prison, or dormitory, even smaller buildings might make sense since these buildings use lots of hot water year round.

Less than 10,000 square feet?

If you have a building less than 10,000 square feet to heat and you live in a moderately cold climate, a wood pellet solution might work for you even if you're far from the nearest tree. And if you don't have access to natural gas, things look even better.

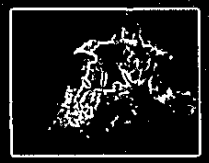
The Messy Middle!

Buildings in the 10,000–100,000 square feet range are the most likely building you'll be planning and, unfortunately the least likely for a simple off-the-shelf wood-fueled solution. But, please read on. There are some very exciting systems heading your way—and you really should consider designing your building to take advantage of them when they arrive. Flexible Energy Communities Initiative can help!

Some Key Opportunities and Issues...

AIR QUALITY should always be a concern. Wood-fueled systems can be made to meet any air quality standard, but there are cost trade-offs. The good news is that burning wood in a properly designed and maintained system is ***much*** cleaner than burning it in a slash pile or wildfire. In some situations, a wood-fueled system can actually improve local air quality.

WILDFIRE MITIGATION



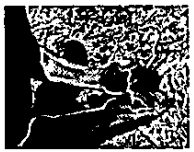
ALTERNATIVE TO SLASH PILE BURNS

ALTERNATIVE TO PRESCRIBED BURNS

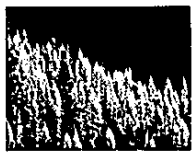
Fuel-reduction and restoration activities are key components of forest management policies.

- ◇ *Land treatment projects are expensive and funds are not always available.*
- ◇ *Slash burning and prescribed burns can adversely impact local air quality.*
- ◇ *In situations where outdoor burning is prohibited, local landfills are often the only alternative.*

Developing local wood-fuel markets can help offset treatment and disposal costs. This also creates local jobs, which keeps more money in your community.

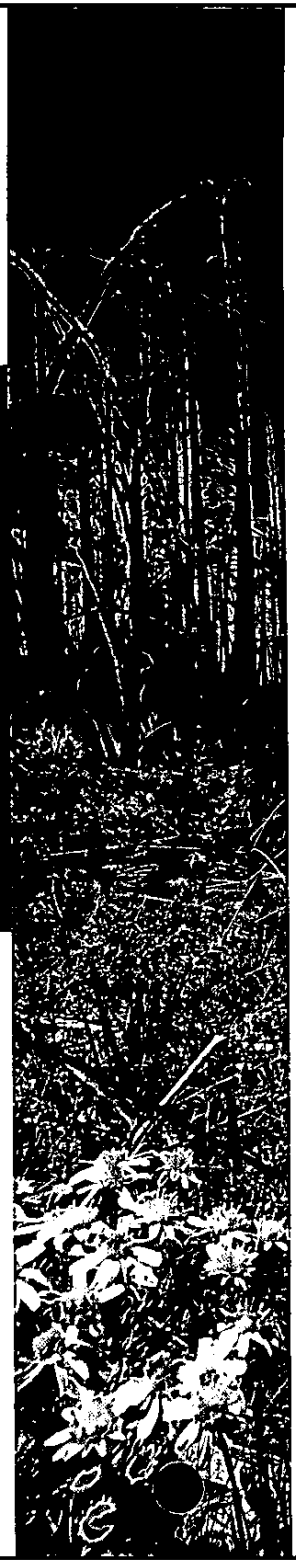


SUPPLY QUALITY. If you use wood pellets, the quality is very high and very uniform. However, wood-chip quality varies a great deal, depending on how the material is handled. "Treat it like fuel and it is fuel; treat it like trash and it is trash." Training, awareness, and long-term business relationships are the keys to success for a dependable, quality wood chip supply.



SUPPLY AVAILABILITY. For wood-fuel systems to work, you will need a reliable, long-term supply. The weight and bulk of wood-fuel will keep your supply geographically nearby. A forest might burn, or environmental regulations may reduce access to some areas, forcing you to travel further for your wood supply. This could incur significant transportation costs—making wood the high-priced fuel.

CARBON-NEUTRAL. Wood-fuel is considered carbon-neutral. While carbon dioxide is emitted when wood is burned, the very same amount of carbon dioxide is absorbed when the tree grows. When wood-fuel is used to offset fossil fuels such as propane and natural gas, the net effect is lower carbon emissions, allowing carbon credits to be sold.



Wood is Working for Other Communities

Wood as fuel is making a comeback around the country as the cost of other energy sources continues to rise. In many areas, forest management activities produce potential fuel. Clean wood technology is becoming available and affordable—and the word is getting out. Wood works, and your community can learn from communities where it does!

Successful Projects Almost Always Have...

1. A GOOD LOCAL WOOD SOURCE. You won't find many wood-fueled systems too far from a forest. Wood is bulky and often full of moisture, two things that make transporting this fuel long distances impractical. However, wood pellets are routinely shipped from Canada to higher-priced markets in Europe.

2. THE RIGHT TEAM—THE RIGHT TECHNOLOGY. To make wood-fueled systems work for your community, you need to choose the right technology that matches your building's needs. The best way is to take advantage of the experience of others, especially at the early design stages. Fortunately there are people to help!

3. POLITICAL WILL AND LONG-TERM COMMITMENT. The economics and logistics of wood-fuel systems can work, but it is seldom a slam-dunk. Wood systems typically cost two to three times more than conventional systems and can take 10 years for the lower cost of wood-fuel to pay back the investment.

4. A CHAMPION. The daily and yearly operations, maintenance, and fuel supply management are not for everyone. The most successful projects have one person who is committed to making things work and to figuring things out when they don't. Don't have a champion? Don't expect success.

5. A HIGH ENERGY BILL. The potential savings wood-fueled systems promise can only be met if your need for energy is significant. Facilities with year-round need for heat like swimming pools, health facilities, and prisons are ideal!

FLEXIBLE ENERGY Communities

A community that prepares their new and existing buildings for an uncertain energy future by:

- ◇ *Planning and designing so that new energy systems can be easily added when those systems become economically attractive.*
- ◇ *Purchasing and installing new energy equipment when the time is right for your community.*
- ◇ *Minimizing energy use while maximizing comfort and utility.*

The Flexible Energy Communities Initiative (FLECI) is a design-assistance program sponsored by the U.S. Forest Service, the Bureau of Land Management (BLM), and the Colorado Wood Utilization and Marketing Program (CO-Wood) to help your community prepare for emerging new energy technologies including wood-fuel, solar energy, geoexchange (geothermal), biogas, and fuel cells.

This funded design-assistance program can help you make your building "woody biomass ready", often at no increase to your construction costs!

visit: www.fleci.org

Wood Chips

Ed Hoffman describes the Chadron wood-chip boiler, which consumes approximately 7,000 tons each year, equivalent to one 20-ton truck delivery just about every day of the year.

Chadron State College, Nebraska

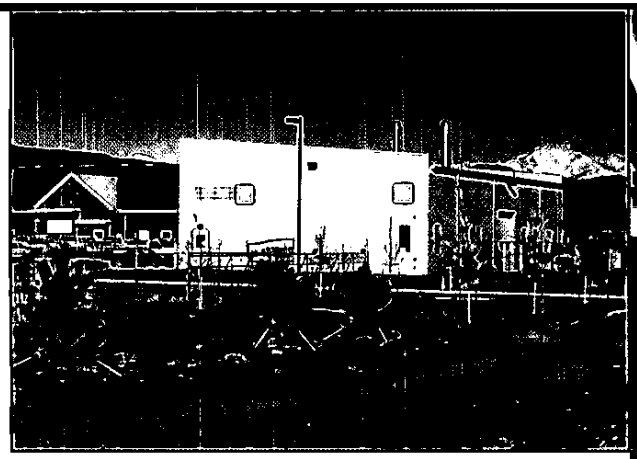
For more than 15 years, Chadron State College in Nebraska has been heating its campus of 2,800 students with wood chips from local forests. Keys to success include: a solid design, proven technology, reliable local supply of wood chips, and the personal commitment of Ed Hoffman, now a vice chancellor for the Nebraska State College System.

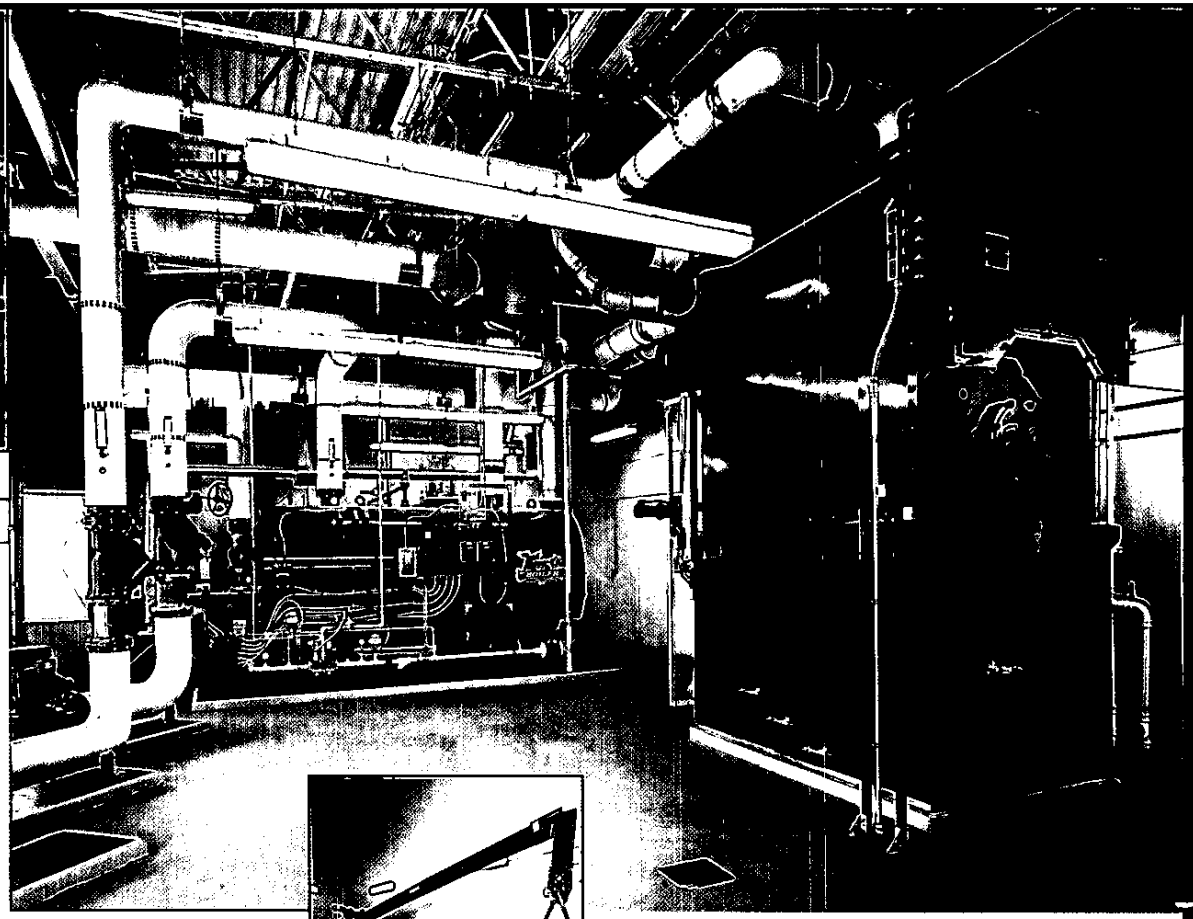
A local, family-run business supplies chips for the campus, and their kids now attend the very college they help heat. The moisture content of the chips varies over the year, so the contract is based on the energy content, not weight.

Ed says it took about four years before the operation ran smoothly. Now, it works so well that they recently added an absorption chiller to cool their buildings in the summer using the steam from the wood-chip boilers. The more they run the boiler, the more money they save, and the less carbon they emit.

The Numbers

- *24 buildings*
- *1,100,000 square feet*
- *9-MMBTU/hr wood-chip boiler system.*
- *Including operations and maintenance, estimated savings are more than 30% over natural gas at $10/MMBTU.*





Boulder County, Colorado

Boulder County's new 120,000-square-foot Parks and Open Space complex in Longmont, Colorado, is an excellent example of where wood really works. All the right conditions for success existed:

- ◇ The county manages more than 18,000 acres of forested land. Their ongoing fuel-reduction and restoration efforts are capable of easily meeting their fuel needs.
- ◇ They designed from the ground up.
- ◇ The county and community strongly value environmental stewardship and appreciate the zero-carbon impact of wood-fuel.
- ◇ A project champion (or two, or three) who wanted to make it happen.
- ◇ The team started the design just as natural gas prices began rising.

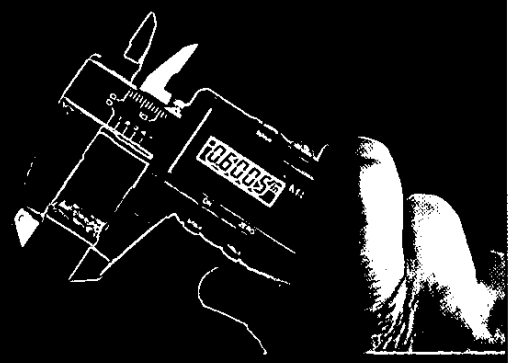
Starting with a blank slate, the design team chose to implement a centralized district energy system using hot water distribution. This gives the site the most flexibility to adapt to a changing energy future. All the changes can be done in one location, taking advantage of scale for both equipment costs and operation and maintenance.

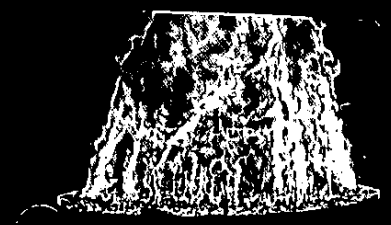
Depending on natural gas prices and the variable costs of chips, the project is estimated to have a simple payback of less than 10 years.

The Numbers

- ◇ *Six buildings*
- ◇ *120,000 square feet*
- ◇ *3.3 million BTU/hr wood-chip boiler*
- ◇ *650 tons/year of dry chips (20% moisture equivalent)*
- ◇ *Depending on natural gas prices, a simple payback of 8 to 20 years is expected*
- ◇ *Video and brochure can be found at Colorado Governor's Energy Office: www.colorado.gov/energy/renewables/Biomass.asp*

Using Wood Pellets





Our Friend the Wood Pellet

Wood pellets are the ideal fuel for small to medium applications—the most promising wood-fuel for buildings in the "messy middle."

Pellets are sometimes referred to as a ***refined wood-fuel***—much as gasoline is a refined fuel from crude oil. Size, shape, moisture, and ash content are very consistent between vendors and bags (and, increasingly, truck loads). This uniformity allows reliable, affordable automatic fuel handling from an outdoor bin or silo to the indoor boiler or furnace.

This uniformity also allows combustion systems to be highly tuned, making pellet systems very clean and efficient.

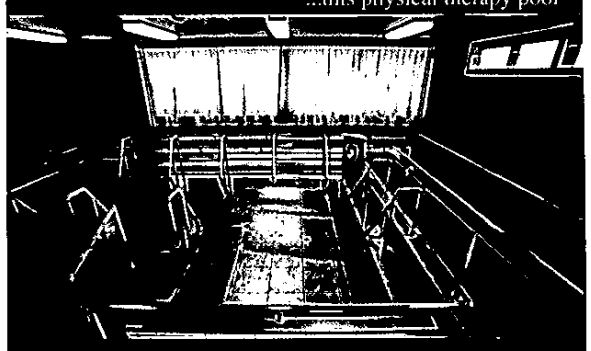
Wood pellets are also known as a ***densified biomass***, where most of the water and air have been squeezed out, leaving just wood energy. Pellets have nearly twice the energy per pound as typical cordwood, and occupy only about one-third the volume. This makes long-distance transportation affordable. In fact, North American pellets are routinely shipped to Europe.

While manufactured wood pellets can be used in simpler systems, this naturally comes at a cost. Wood pellets cost about twice as much as wood chips for the same amount of energy. For medium and small systems, this is a good trade-off.

Wood pellet manufacturing plants are a significant investment. An entry-level factory costs approximately $3 million, and upwards of $10 million is not unusual.

This pellet boiler heats...

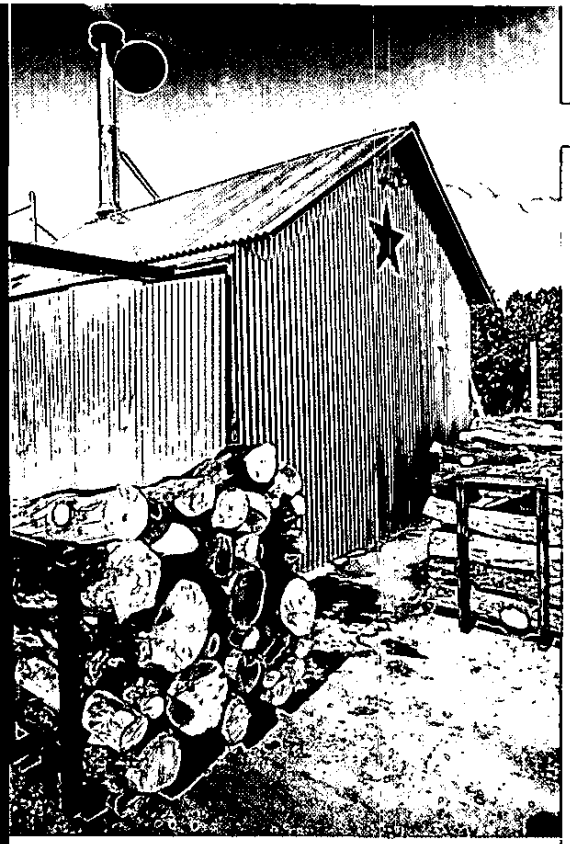
...this physical therapy pool



U.S. Representative John Salazar opens the first bag of 100% Colorado wood pellets in October 2006.

2100

Cordwood Boilers



The Numbers

- *Cost: $20K to $60K*
- *Heat output: 100,000 to 900,000 BTU/hr*
- *Fueling cycle: Stoke one to three times a day*
- *Payback: 3-5 years against propane and heating oil*
- *Air quality: very clean to very dirty.*

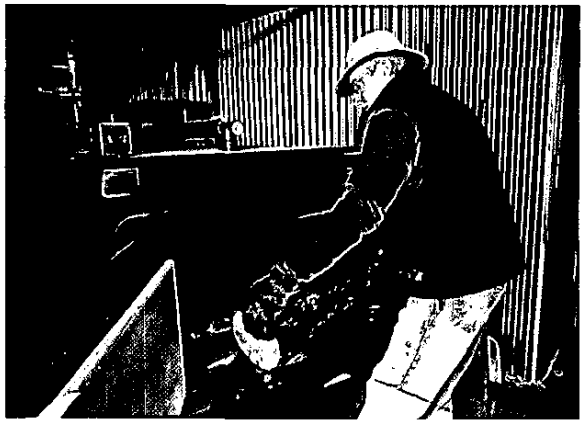
Cordwood

Simplicity and great economics make cordwood boilers increasingly popular around the country. Cordwood—firewood size or a bit bigger—from on-site or local forest management projects is often free!

If you have a home or small building to heat and live near a forest that needs thinning, these systems have very good economics. If you have a hot water (hydronic) heating system, the economics are even better.

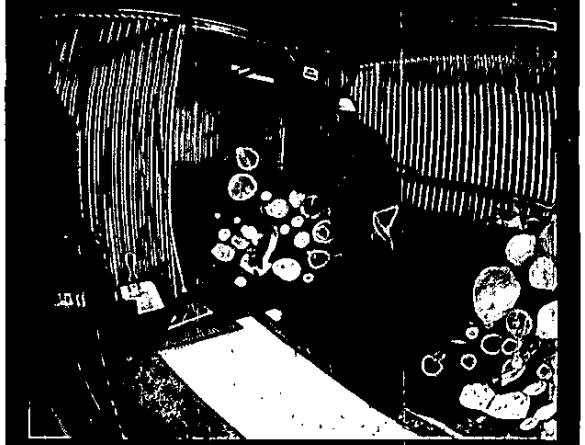
Buyer beware! There is a huge difference between clean units and dirty units. The EPA has recently released voluntary guidelines, but they have a ways to go.

If you follow the manufacturer's recommendation, these units can be very low emitters of smoke—much cleaner than the cleanest of fireplaces. But, if they are mishandled, these units can be very dirty. Some irresponsible owners have used their boilers as an incinerator, burning household garbage, and even tires!

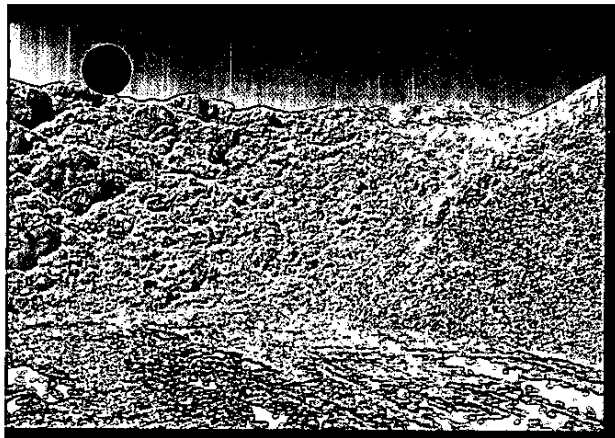


Wood-heating pioneer Dick Cook designed and built the boiler shed and very convenient wood handling system for his 300,000 BTU/hr boiler. Dick has been testing a variety of wood drynesses and species.

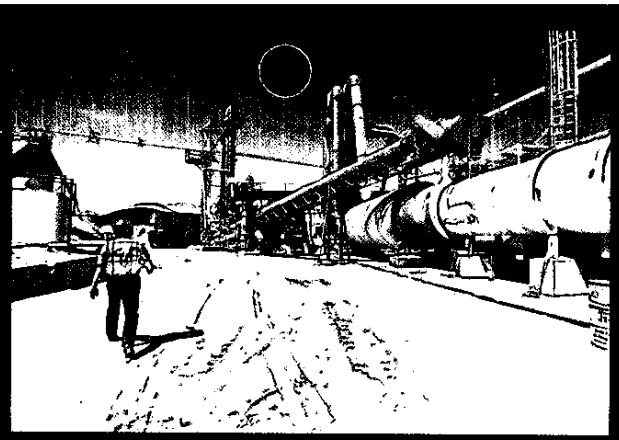
The smoke coming out of the chimney is from excessively dry wood not recommended by the manufacturer (or Dick). But even with the wrong wood, the system is virtually smokeless after the initial 5-15 minute start-up cycle.



Making Wood Pellets



Wood chips await drying

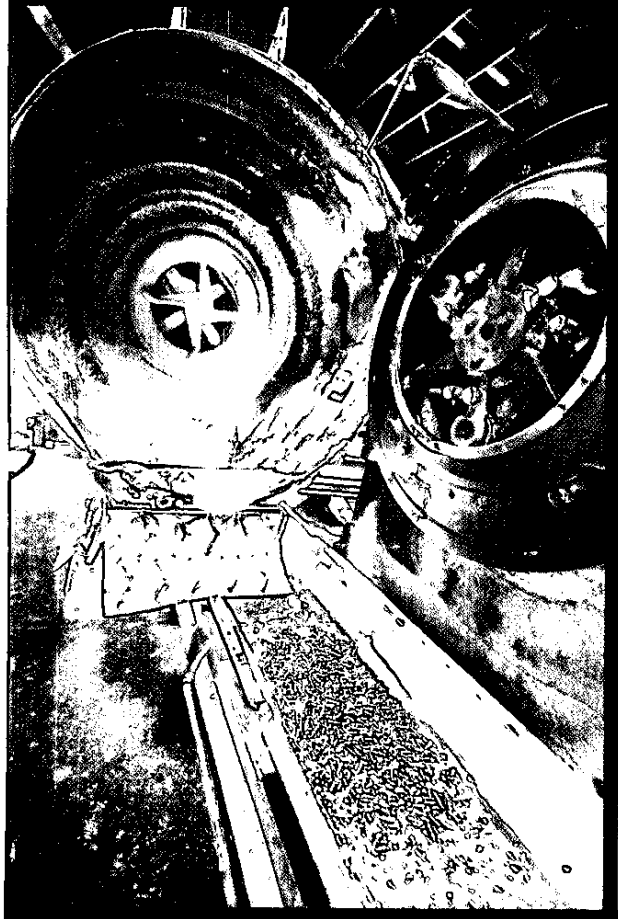


Dryer is fueled with scraps and defective pellets

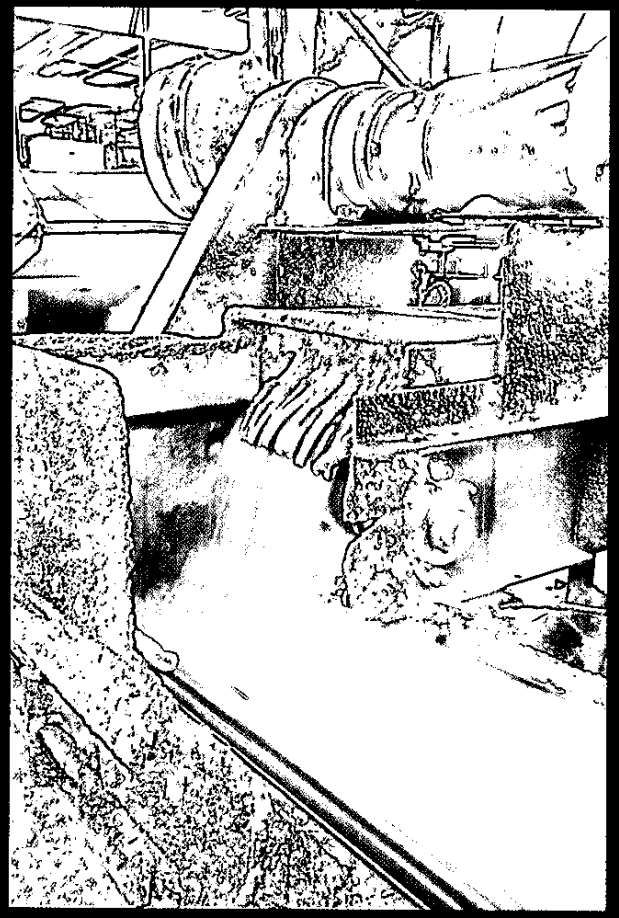
Key Points

- *Uniform size, moisture, ash content, and energy content*
- *Simplified fuel handling*
- *Tuned for clean combustion*
- *About twice the cost of wood chips*
- *Small pellet mills make 4 tons per hour and cost several million dollars.*

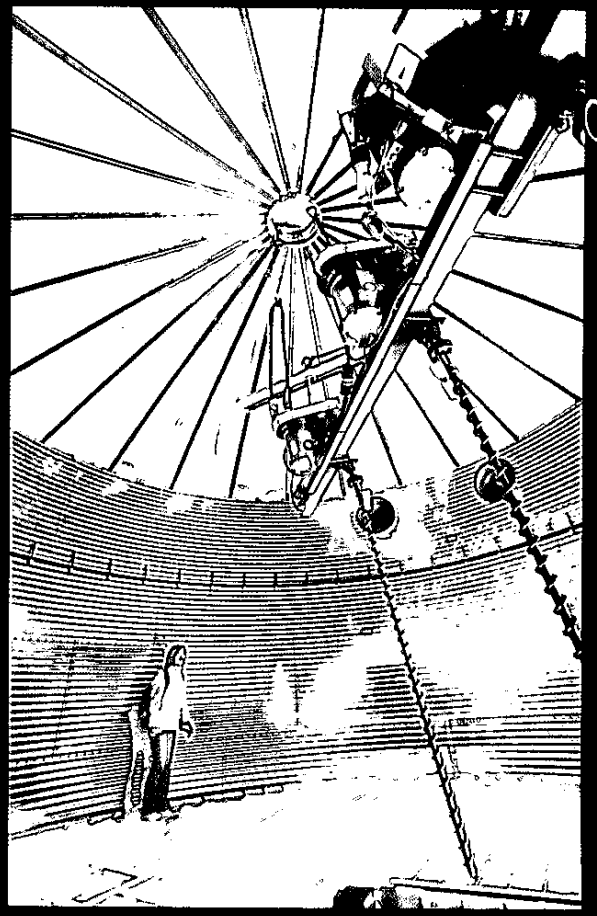
Pellet mill open for cleaning



Pellet mill open for business at 4 tons per hour



Grain silo ready for first batch of wood pellets



Colorado Wood Utilization & Marketing Program

Governor's Energy Office

NREL National Renewable Energy Laboratory

Innovation for Our Future

Produced by Carla Harper, West 65 Inc.
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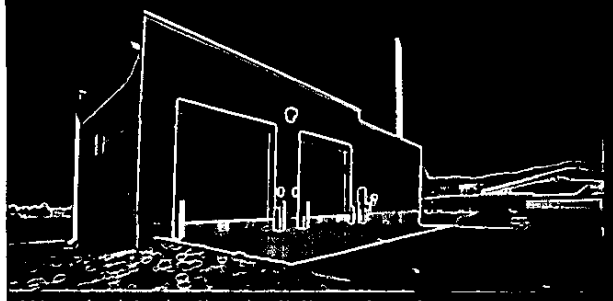


Wood-chip boiler building that heats the Darby School, the first Fuels for Schools project in Montana.

Rick Scheele – Darby Mayor, School Maintenance Supervisor, and local biomass "champion" – inspects a bad load of wood chips and explains how to avoid this problem.

The Team...

It's not what you know, but who you know...

There is no need to travel this road alone. Many communities have successfully installed wood-fueled systems and are willing to share what they have learned. But, perhaps the most important thing they will tell you is, *get yourself an experienced guide.*

COLORADO GOVERNOR'S ENERGY OFFICE, GEO, through its Woody Biomass Program and coordination of the Colorado Biomass Working Group, can assist with facility heating projects throughout the state. GEO staff and Working Group partners can help with overall project design, supply issues and possible funding mechanisms.

www.colorado.gov/energy

BIOMASS ENERGY RESOURCE CENTER has been on the team of nearly every public wood-fueled heating project in the country. You can immediately tap into their expertise through their publications and Web site. And when your team is ready for the heavy lifting, they can provide first-rate and affordable consultation.

www.biomasscenter.org

FUELS FOR SCHOOLS concept is simple: reduce heating bills at schools by utilizing low- or no-value forest waste. Their mission: help make your wood-fueled project a success. Their experience, candor, and successful examples will help guide your first wood-fuel project. As of October 2006, six wood-fueled systems have been installed, with 11 more on the way!

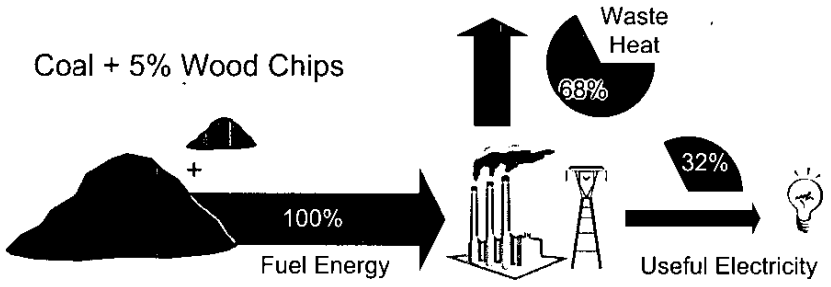
And, they are not just for schools anymore. They have expanded their program to include all public buildings that can benefit by using wood-fuels. Check out their Web site, then give them a call.

www.fuelsforschools.org

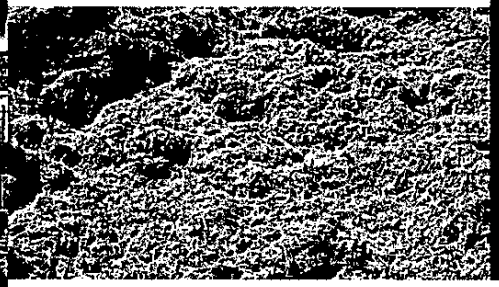
Co-firing with wood chips...

Co-firing usually means mixing a small percentage of wood chips with coal. Technically, this is typically straightforward, but the wood must be very cheap. Why?

- ◊ Coal is generally the cheapest fuel available.
- ◊ Coal supply contracts routinely exceed 15 years. This is difficult for wood to compete with.
- ◊ For a given mine, coal is very uniform in energy and chemistry. Wood is not.



Co-fired, coal-fired 38.5 MW power plant in Cañon City, Colorado. This is the first in the country to qualify the biomass for Renewable Energy Credits (RECs).



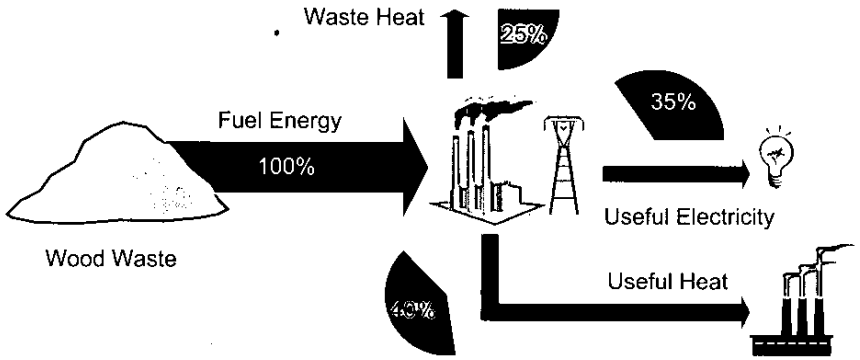
Large-scale, wood-waste-fired cogeneration mill on the Olympic Peninsula, Washington.

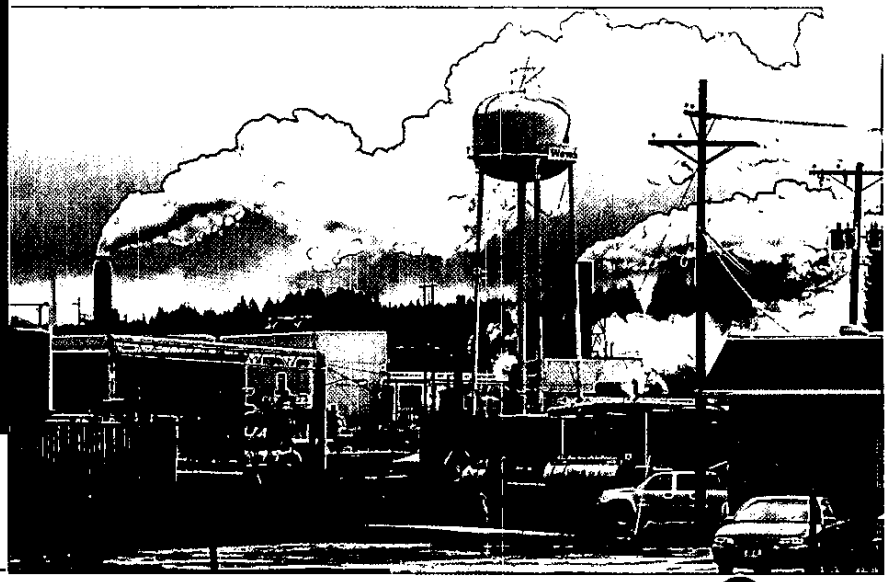
Cogenerating with wood chips...

Cogeneration, cogen, or Combined Heat and Power (CHP), means using the energy released from burning the fuel to simultaneously generate electricity ***and*** heat. While conventional coal plants only utilize a third of the fuel's energy, CHP systems can easily exceed 70%. To make these systems work economically, you generally need:

- ◊ A large heat load (industrial customer or district heating)
- ◊ Very cheap fuel (waste material on-site)

Paper mills are excellent examples of cogeneration, meeting both of these conditions.





If you are buying wood for its energy content, you will want to know the equivalent bone-dry weight. In fact, many good supply contracts are written in terms of the amount of energy, not the physical weight or volume. However, if you're hauling freshly cut wood out of the forest, your costs will be determined by the actual, or green tonnage weight.

Finally, when burning green wood, much of the wood's energy will be used for evaporating the moisture. Most systems cannot recover this heat; it just goes up the chimney as steam.

Electrical energy is measured in kilowatt-hours (kWh). One kWh is the amount of energy a 100-watt light bulb uses every 10 hours a or 1,500-watt blow-dryer uses in 40 minutes. A typical house uses around 700 kWh in a month. A 1-megawatt (MW) power plant can power about 1000 homes.

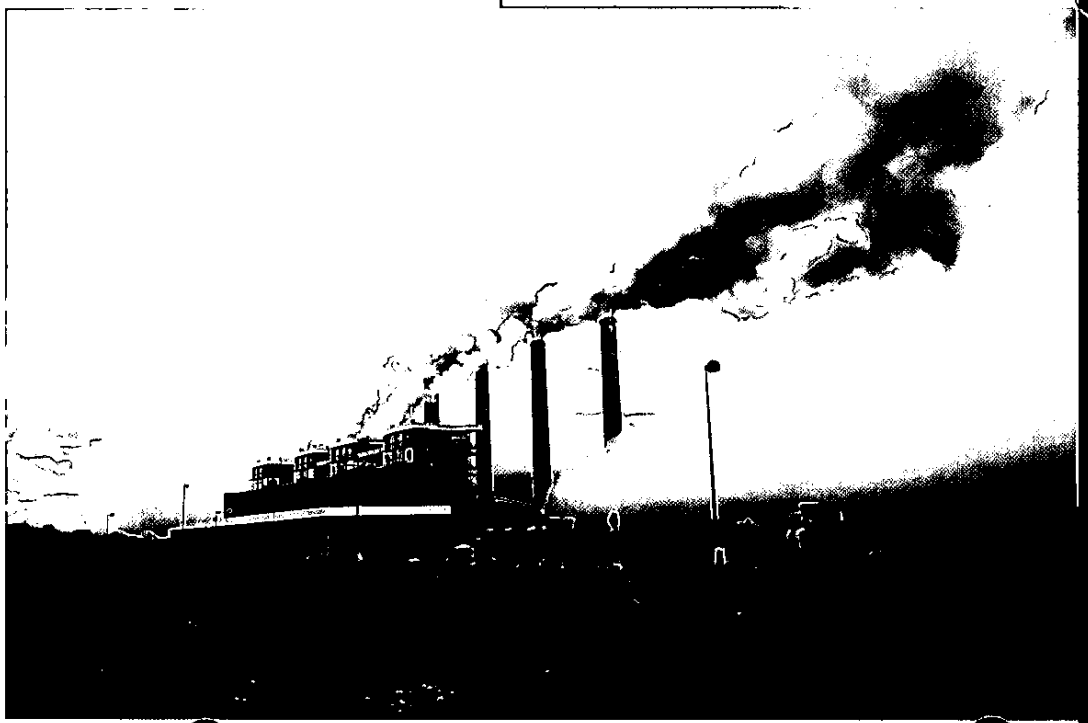
You can mathematically convert between heat energy and electrical energy. One kWh is about the same amount of energy as 1/2 pound of bone-dry wood. However, the most common technology used to convert heat energy to electrical energy—the steam turbine—is only about 35% efficient. So, to get 1 kWh worth of electricity, you need about 1 1/2 pounds of wood!

There are several key issues that often make it difficult for wood to be used as the primary fuel for electrical generation.

- ◊ **Scale.** Most power plants in the U.S. are between 100 MW and 2,500 MW. This is mostly because the cost of operating a power plant doesn't change very much between a small plant and a large plant. You still need a 24 X 7 trained/ skilled workforce.
- ◊ **Fuel costs.** About 50% of U.S. power plants use coal. Low cost, long-term contracts at about $1.20/MMBTU are not uncommon. This is equivalent to wood at $20 per bone-dry ton delivered and guaranteed for many years.
- ◊ **Fuel uniformity.** Coal plants are typically designed to be maximally efficient when using coal from a particular mine. The properties of the coal are very consistent. Wood, on the other hand...

How Much Can a Forest Sustainably Yield?

There is no single answer to this question. You will need to contact your local forest experts. However, as a rough estimate, forest restoration projects in the Intermountain West use 10 bone-dry tons per acre as a rule-of-thumb. In an area where ongoing management is planned, a 20-year re-entry cycle of vegetation treatment is common. Therefore, on average, one-half of a bone-dry ton per acre can be sustainably removed from the forest.



A 2,100 MW coal-fired (not co-fired) power plant in Sweetwater, Wyoming, generates enough energy for about 2,000,000 homes!

Let the Burner Beware...

$30 per ton? Is that a green ton, a bone-dry ton, or something in between?

30% moisture content? Is that dry basis or wet basis?

Moisture Content Formulas (important!)

Wood from a freshly cut live tree is "green wood." Its energy content varies dramatically. Wood that has been placed in an oven until all the moisture is removed is called "bone-dry" or "oven-dry" wood. Its energy content is very consistent.

$$\text{Dry Basis Moisture Content} = \frac{\text{Initial Weight} - \text{"Bone-Dry" Weight}}{\text{"Bone-Dry" Weight}} \times 100\%$$

$$\text{Wet Basis Moisture Content} = \frac{\text{Initial Weight} - \text{"Bone-Dry" Weight}}{\text{Initial Weight}} \times 100\%$$

The word "energy" in normal conversation is used fairly loosely with a variety of meanings. But in engineering and science, energy has a very precise, specific meaning: "the capability of doing work; different forms of energy can be converted to other forms, but the total amount of energy remains the same."

In the case of wood, that work could be warming your home or boiling water to make steam that spins a turbine that, in turn, runs a generator that produces electricity. These two forms of energy—heat energy to warm your home and electrical energy to light a light bulb—can be numerically measured and compared.

In the United States, heat energy is typically measured in BTUs, or British Thermal Units (today, the British use the metric counterpart, the Joule). One BTU is defined as the amount of heat energy needed to raise 1 pound of water 1 degree Fahrenheit. One BTU is about the amount of energy released by a single kitchen match, so it takes a lot of BTUs to do anything useful. Heating your home takes about 1 million BTUs each day in winter in many parts of the country.

How much energy is in a ton of wood?

It depends. Wood with all water removed (called "bone-dry" or "oven-dry") contains about 8,000 BTUs per pound—or 16 MMBTUs (MMBTU means 1 million BTUs) per bone-dry ton. This is nearly the same for all wood species. Wood, however, usually contains water, often a lot of it. And how much water the wood contains is referred to as its moisture content. Moisture content is very important in determining the amount of energy and economic value in a ton of raw material.

The moisture content depends on many things: the tree species; the length of time since the tree was felled, and the humidity of the climate where the wood is stored. Moisture content is measured in percentage (%), but there are two very different definitions—dry basis and wet basis (see calculations on sidebar). Dry basis is the most common method, but this needs to be clearly stated.

When felled, more than half the weight of the green wood can be water. Using the common dry-basis definition, the moisture content can actually be higher than 100%.

Energy Content of Some Common Fuels

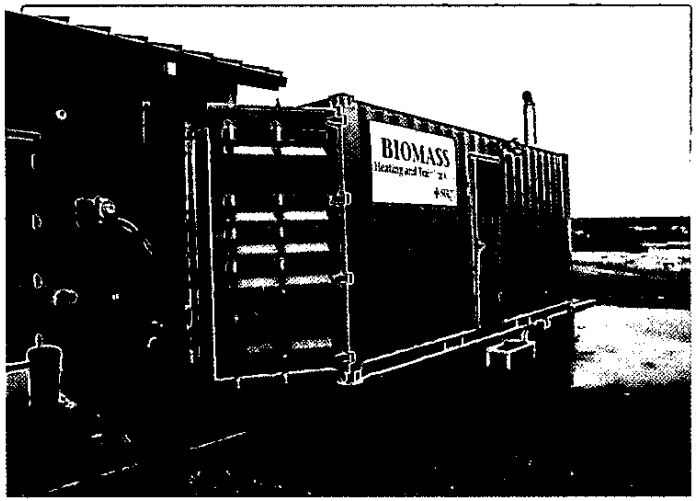
Fuel	Energy Content		Cost per Unit		Cost per MMBTU
Wood Chips	about 8,000 BTU	per bone-dry pound	$0 to $100	per bone-dry ton	$0 to $6.40
Wood Pellets	8,000 BTU	per pound	$140 to $250	per ton	$8 to $15
Electricity	3,413 BTU	per kWh	$0.05 to $0.15	per kWh	$14 to $44
Natural Gas	1,000,000 BTU	per MMBTU	$5 to $15	per MMBTU	$5 to $15
Heating Oil	139,000 BTU	per gallon	$2.00 to 2.60	per gallon	$14 to $19
Propane	91,000 BTU	per gallon	$2.00 to $2.90	per gallon	$22 to $32
Coal	8,800 - 13,000 BTU	per pound	$12.00 to $70.00	per delivered ton	$0.70 to $2.40

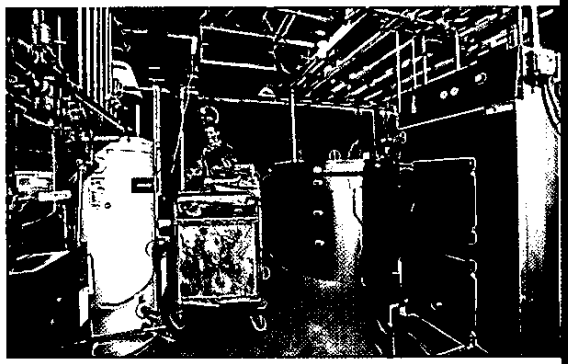
These numbers are derived from U.S. Department of Energy statistics for 2005-2006, your mileage may vary.
MMBTU = 1 million BTUs.

Cordwood Boilers

As part of their hands-on Sustainable Energy Certificate program and the college's efforts to manage rising energy costs, Santa Fe Community College installed this 300,000 BTU/hr boiler and housed it in a shipping container.

The boiler features an integrated 1,500 gallon water jacket to store heat. This allows the wood to be burned rapidly and cleanly at an optimum rate, independent of how much heat is needed. Need more heat? Load the fire box more frequently. Less heat? Less often. No smoldering fires here!

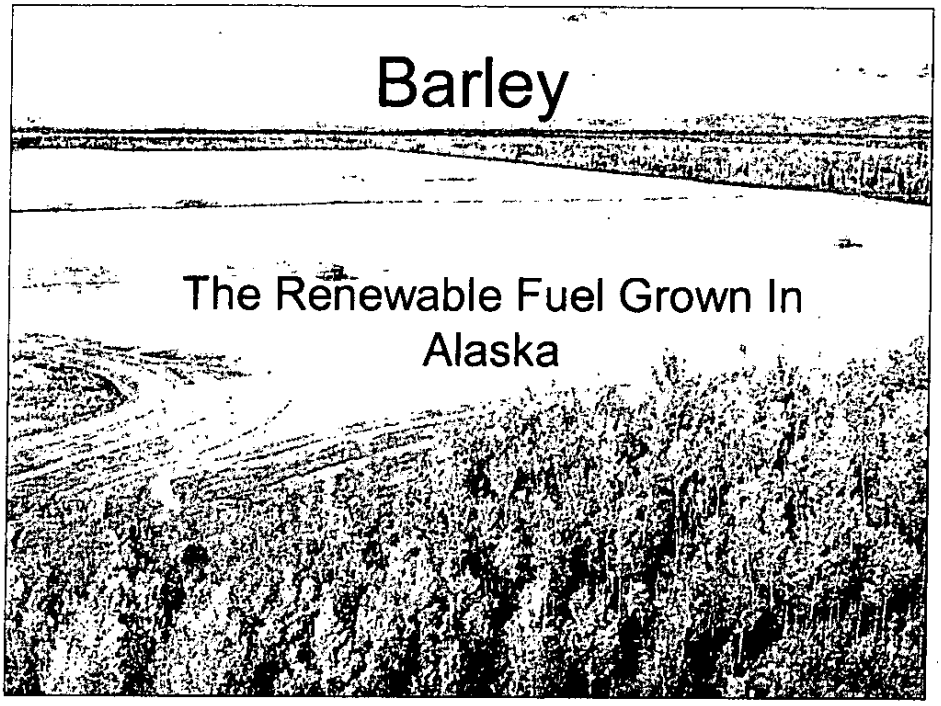




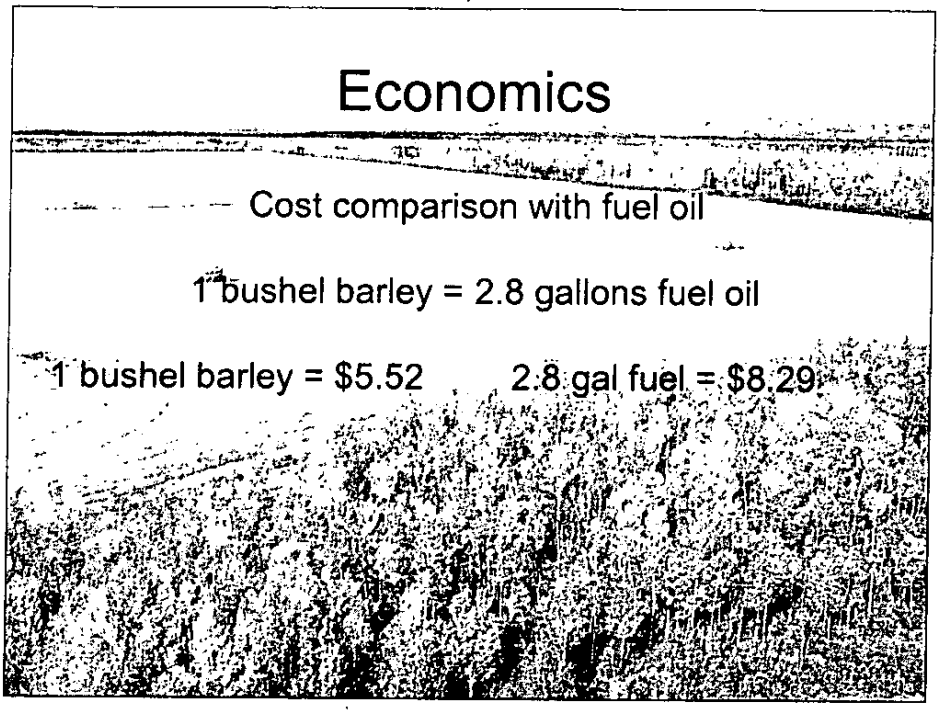
While the larger units really need their own shed or outbuilding, smaller European boilers, like this 130,000 BTU/hr unit, can fit nicely in your basement. Of course, not all basements are set up to haul in firewood.

A 650 gallon hot water tank (silver tank) is the recommended way to store several days' worth of energy.

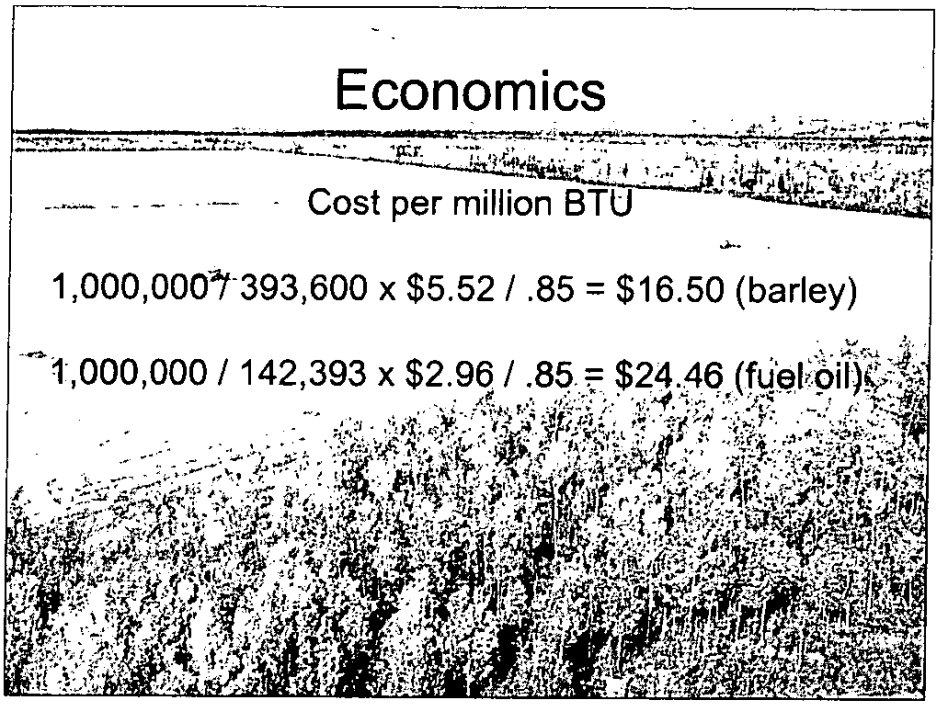
Dave Followill can fire his boiler once a week in the summer to provide his home with domestic hot water.



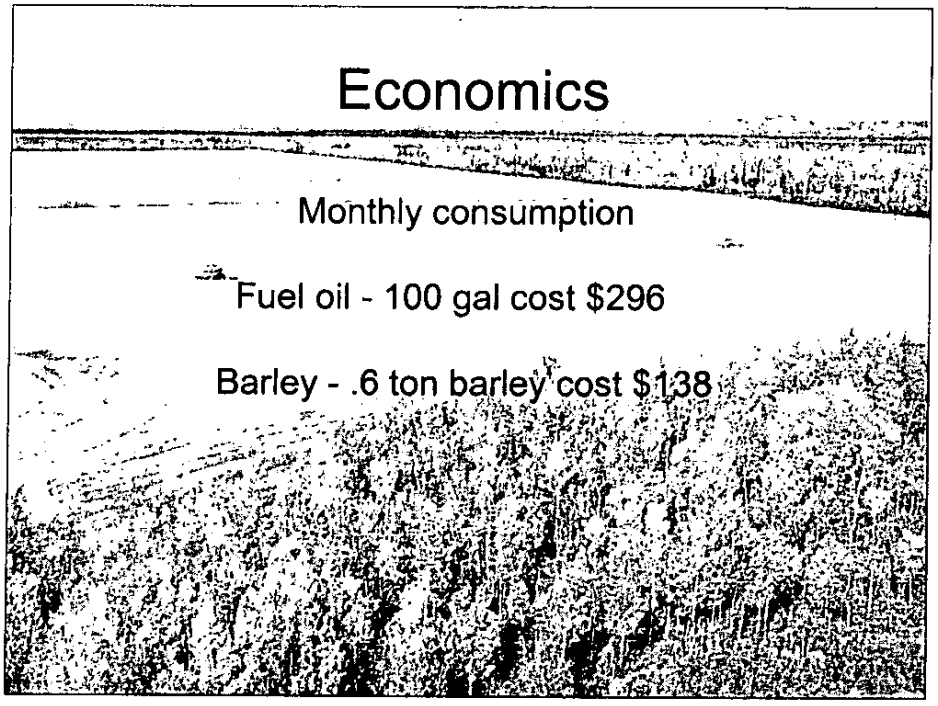
Burning grain for heat is relatively new in the United States. In Europe however, it has been going on for many years. Resource scarcity there has encouraged innovation in renewable resources that we are just beginning to consider here. In spite of our abundant resources, it is incumbent for us as responsible stewards of the land to learn from others so that we do not waste time reinventing the wheel. Barley is a resource easily grown in Alaska. Developing its use as a fuel enables us to utilize other resources the state has – its agricultural land and its citizens.



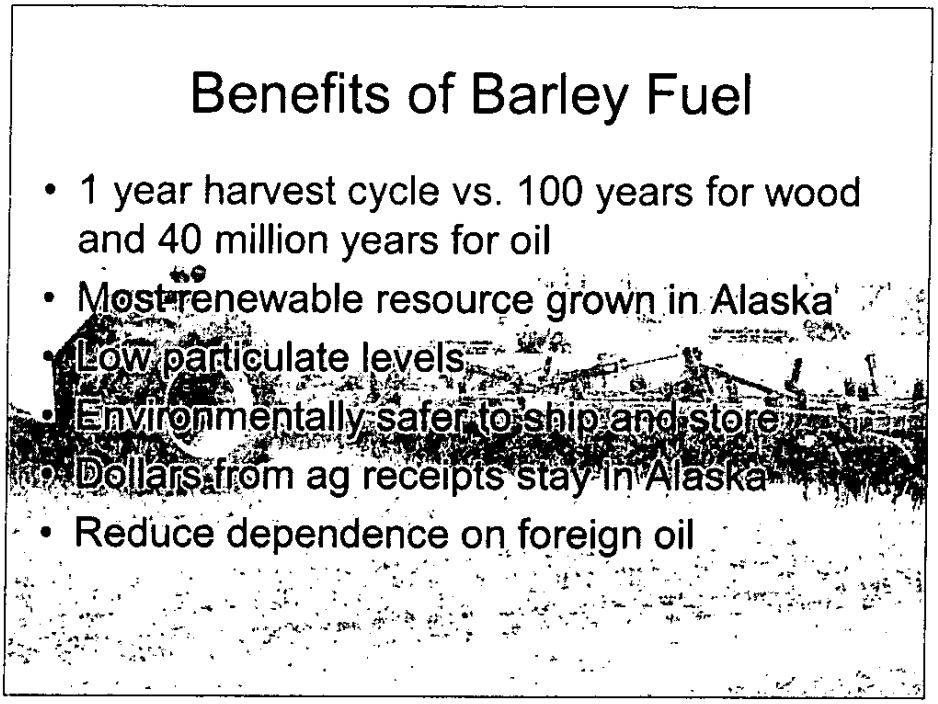
A bushel of barley has the equivalent BTU output as 2.8 gallons of fuel oil. It is challenging to determine what prices to use in order to make a comparison for heating costs. For this presentation, I am using a barley cost of $5.52 per bushel in 50# bags, which is the most expensive packaging. For fuel oil I am using $2.96, the cost I paid for fuel oil this winter in Delta. Right now fuel is less expensive, but the trend is higher again, a trend which is expected to continue.



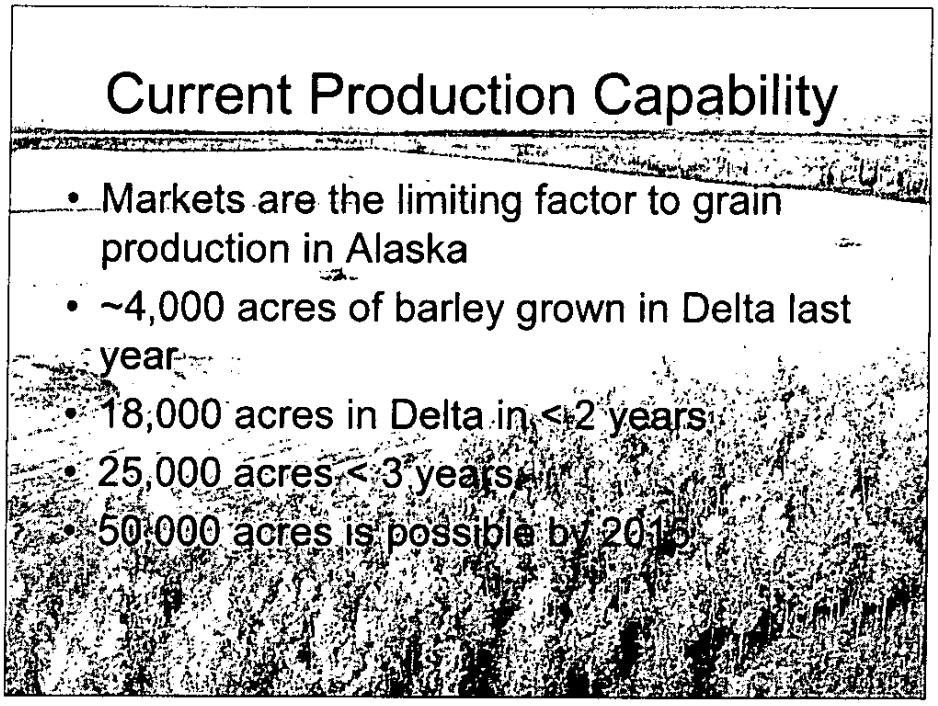
By converting BTU output to cost per million units, it is easy to make a comparison between barley and fuel oil. There are 393,600 BTU's per bushel of barley and 142,000 BTU's per gallon of fuel oil. An 85% efficiency rating was assumed for both furnaces, a reasonable rating for most home heating units.



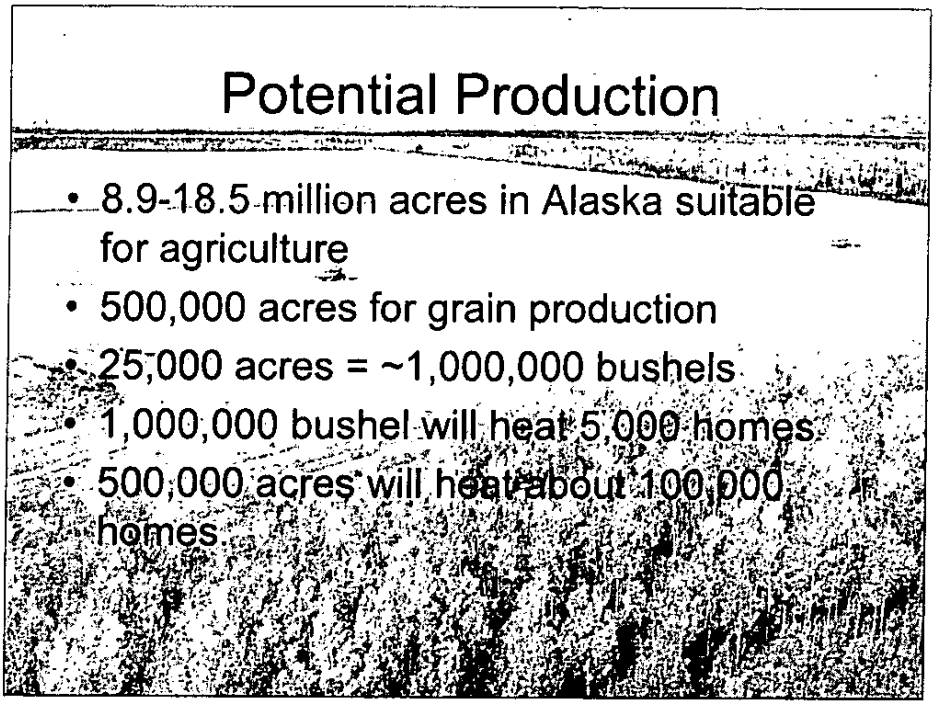
Another way to examine the direct effect on a family's pocketbook is to look at the monthly cost of heating their home. Assuming it takes 100 gallons of fuel oil to heat a 1500 sq ft home for one month, it will cost the family about $300 a month. It takes about 40# of barley per day to heat the same home, or just over a half ton per month. The cost of heating with barley would be about $138 per month.



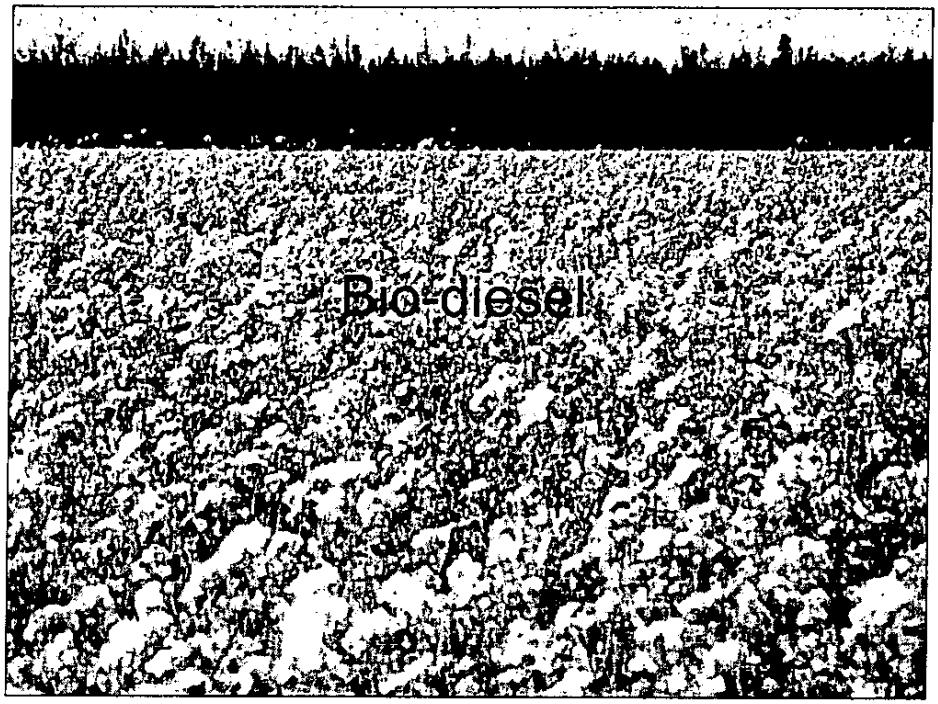
With a carbon cycle of one year, barley is the most renewable resource that can be grown for heat in Alaska. Wood, which is the most common form of alternative energy, has a carbon cycle of 100 years for interior forests. Barley has much lower particulate levels than wood. High particulate levels from outdoor wood burning boilers has caused concern in cities where EPA particulate thresholds are often exceeded in cold weather. Barley is not a hazardous material so it can be shipped as a commodity to villages, making it cheaper and safer than shipping fuel oil. Another advantages to using agricultural products is that typically, ag receipts turn over again and again in the community, up to 7 times. Oil purchases on the other hand turn over twice before finding their way Outside. This is known as the multiplier effect in economics.



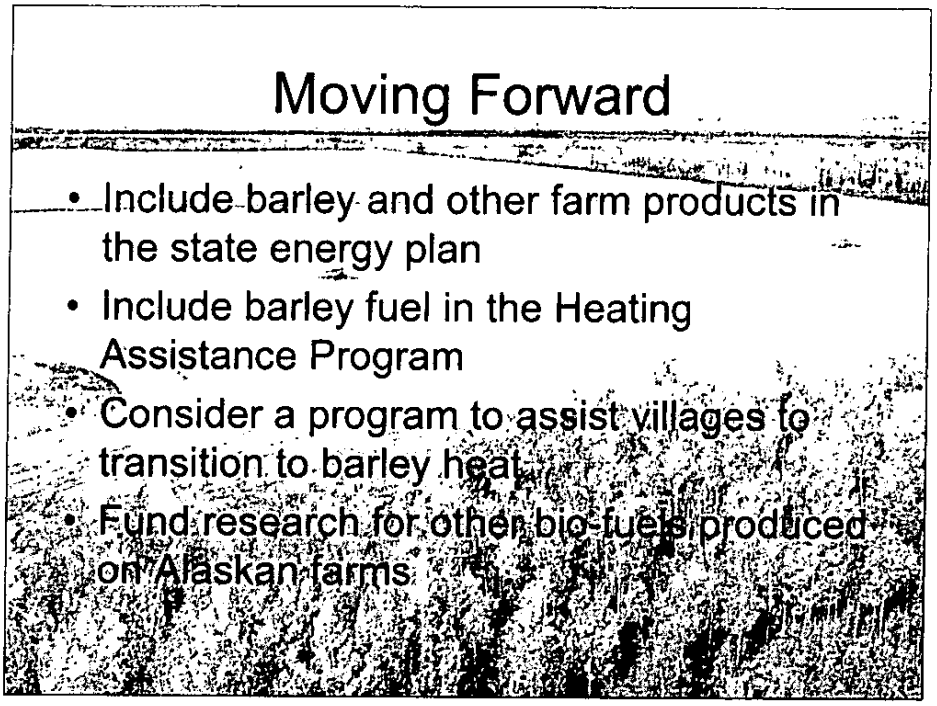
Markets have always been the limiting factor for production. Over the years farmers have adjusted production to the available market. Last year about 4,000 acres of barley were grown. Because barley is such an easy crop to raise, the Delta area alone could have around 18,000 acres in production within 2 years and within 3 years, there could be 25,000 acres in barley if markets justified the extra acreage. By 2015, another 25,000 acres coming out of CRP could potentially be put into production; again, if the market justified the extra production.



2,000,000 acres of farmland is lost each year to urban encroachment in the United States. No where else in the country is there such potential for bringing new ground into production as in Alaska. Depending which survey you choose to accept, between 8.9 million and 18.5 million acres have been identified with potential for agricultural production in Alaska. When the first large scale agriculture area went in, the state's agricultural plan called for 500,000 acres to be in production by the early 1990's. The failure to reach that goal was not because crops could not be grown here. It was primarily because markets did not develop as quickly as production did. As far as potential for grain production and its use for fuel, each acre will produce about 1 ton or 40 bushels. Therefore, 25,000 acres will grow enough barley to heat about 5,000 homes.

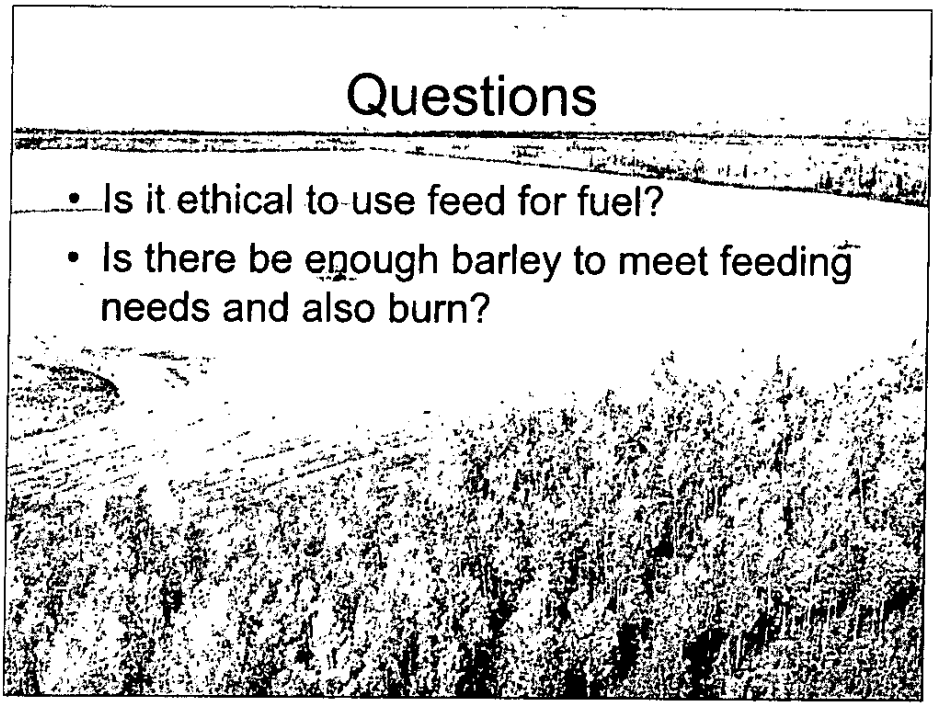


Canola production is gaining interest. New short season varieties show promise for bio-diesel production and biodegradable hydraulic oil. In fact, last summer canola oil was used to run farm equipment on one farm in Delta. The potential for thousands of acres exists if a processing facility can be built. Planning for a small processing facility is already underway in Delta. In the meantime, we have discovered that with the right variety, we can grow canola that meets the requirements for food grade canola oil.



Alaskan farmers have been working for years to create a sustainable agriculture industry. The original goals of the agriculture project remain as important today as they were in the mid 70's. In one generation Alaskan agriculture has accomplished what took 150 years Outside.

Alaskan farmers are stepping up to the plate to help feed and fuel the state. State government can help us do that by including barley and other farm derived products in the state energy plan. Barley should be included in the Heating Assistance Program. State officials could consider a program to help residents transition from polluting, inefficient wood stoves to more efficient stoves designed to burn barley. In an effort to reach the goal of 50% renewable fuel by 2025, research funding should be targeted to producing heat and power from other bio-fuels including straw, canola, and grass.



1- Ethical – barley is a renewable resource, which should be used in the most beneficial manner possible. The in-state demand for livestock feed is currently met with production from about 3,000 acres. It is seldom economically viable to ship grain out because of the cost of shipping. Any increase in production therefore, becomes surplus and too much surplus discourages future production. Additional markets are needed to promote more cultivation, which in turn stabilizes supply for increased livestock production. Asking if burning barley is ethical is like asking if we should burn firewood when there is a demand for lumber.

2- Is there enough barley to burn and feed? Yes, there is at current production and current demand. The goal is to increase demand for barley by expanding markets and at the same time expand production to keep up with the increased demand. A more appropriate question is whether there will be enough to feed if we do not develop additional markets. It requires a certain level of production over demand (>15%) to assure potential livestock owners that their feed needs can be met before they invest in livestock enterprises. The more markets that can be developed for a commodity the more security there is for grain growers to increase production.