Apollo Bioenergy

Energy • Environment • Empowerment

Apollo Bioenergy
Energy • Environment • Empowerment

Value-Added Opportunities in Woody Biomass Utilization

Pinyon-Juniper Restoration and Utilization Summit

December 8, 2010

Las Vegas, Nevada

Lauren Scott
President/CEO
Apollo Bioenergy, Inc.
Reno, Nevada

DISCLAIMER

This presentation may contain copyrighted material, the use of which has not always been specifically authorized by the copyright owner.

This material is being made available in an effort to advance understanding of environmental, political, human rights, economic, democratic, scientific and social justice issues, etc. This constitutes a 'fair use' of any copyrighted material as provided for in section 107 of the US Copyright Law.

In accordance with Title 17 U.S.C. Section 107, the material in this presentation is being distributed without charge to those who have expressed an interest in receiving the included information for educational purposes.

Apollo Bioenergy

Energy • Environment • Empowerment

COPYRIGHT NOTICE

Unless otherwise noted, the contents of this document may not be reproduced, transmitted or stored in a third party retrieval system, in any form, without prior permission of Apollo Bioenergy, Inc.

All trademarks remain the property of their respective owners.

The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

The information contained herein is subject to change without notice.

Copyright (c) 2010 by Apollo Bioenergy, Inc. (USA).

All rights reserved.

MISSION STATEMENT

Our mission is to produce biofuels and other value-added products from sustainable biomass while protecting the natural environment and empowering rural communities in Nevada, Oregon and Northern California.

Photo credit - Wikimedia Commons, public domain

BIOMASS OVERVIEW

- In a broad sense, biomass is organic material derived from plants and animals.
- Examples of biomass include agricultural commodities, plants and trees, algae, crop residue, wood and paper products, animal waste and byproducts, construction waste, and food and yard waste.
- Biomass can be used to produce renewable fuels, chemicals, biodegradable products, heat and electrical power.

Apollo Bioenergy, Inc. (c) 2010

BIOMASS OVERVIEW

- Biomass utilization efforts must carefully consider:
  - Raw material costs
  - Logistics costs
  - Processing technologies
  - Energy requirements
  - Market and product opportunities
  - Capital requirements
  - Operational and labor costs
  - Potential commercial partnerships
- Does this project make good commercial sense?

BIOMASS OVERVIEW

- Success will be measured on a regional, case-by-case basis.
- A project is underway in Lakeview, Oregon to convert wood waste from lumber mills into heat and electricity.
- In the Midwest, several facilities are being planned which would convert waste corncobs and switchgrass into millions of gallons of biofuels and chemicals.
- In Georgia, construction has started on a cellulosic ethanol plant which could annually produce 20 MMGPY from pine tree residue.

BIOMASS OVERVIEW

- In Nevada, the abundance of pinyon pine and juniper trees has created an interest in their use as a potential biomass.
- Tim Minor at the Desert Research Institute has estimated that the inventory of pinyon pine and juniper in Nevada is approximately 90 million tons (DOE/GTI project).
- The areas of Lincoln, Nye and White Pine counties have perhaps the of the highest concentration of pinyon and juniper biomass – with an estimated inventory of 57 million tons.

BIOMASS OVERVIEW

- Currently, thousands of tons of woody biomass are regularly mechanically treated in fuel reduction and thinning operations in Nevada.
- Most of the removed material is masticated in place, mulched, burned or left for the public for firewood collection.
- The raw value of the biomass generally does not cover the cost to transport it to a processing facility.
- Only a small percentage is utilized for the production of renewable energy as part of the ‘Fuels for Schools’ program.

BIOMASS OVERVIEW

- A recent for-profit effort to manufacture wood fuel pellets for home heating use proved unsuccessful.
- The $8.8 million biomass power plant at the Northern Nevada Correctional Center proved uneconomical to operate, has been shut-down and is now for sale.
- With few exceptions, effective utilization of PJ biomass in Nevada has proven elusive.
- The lesson learned – Biomass utilization is a complex subject often not well suited for the faint-hearted capitalist.

BIOMASS CONVERSION

- Pinyon and juniper biomass in its raw form typically has little intrinsic value.
- It is often considered simply a waste product of thinning operations.
- Burning in place is often the only from of “utilization.”

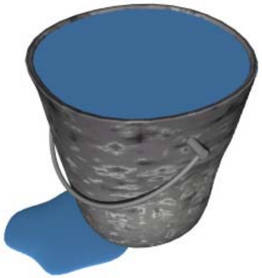
Photo credit - treeworld.info

- New processing technologies may enable the economic conversion of waste materials into high-value products.

BIOMASS CONVERSION

- The two primary conversion technologies showing the most promise are commonly known as pyrolysis and hydrolysis.

Pyrolysis



Hydrolysis

- These two very different technologies are literally allowing laboratory process chemists to literally spin straw into gold.

BIOMASS CONVERSION – PYROLYSIS

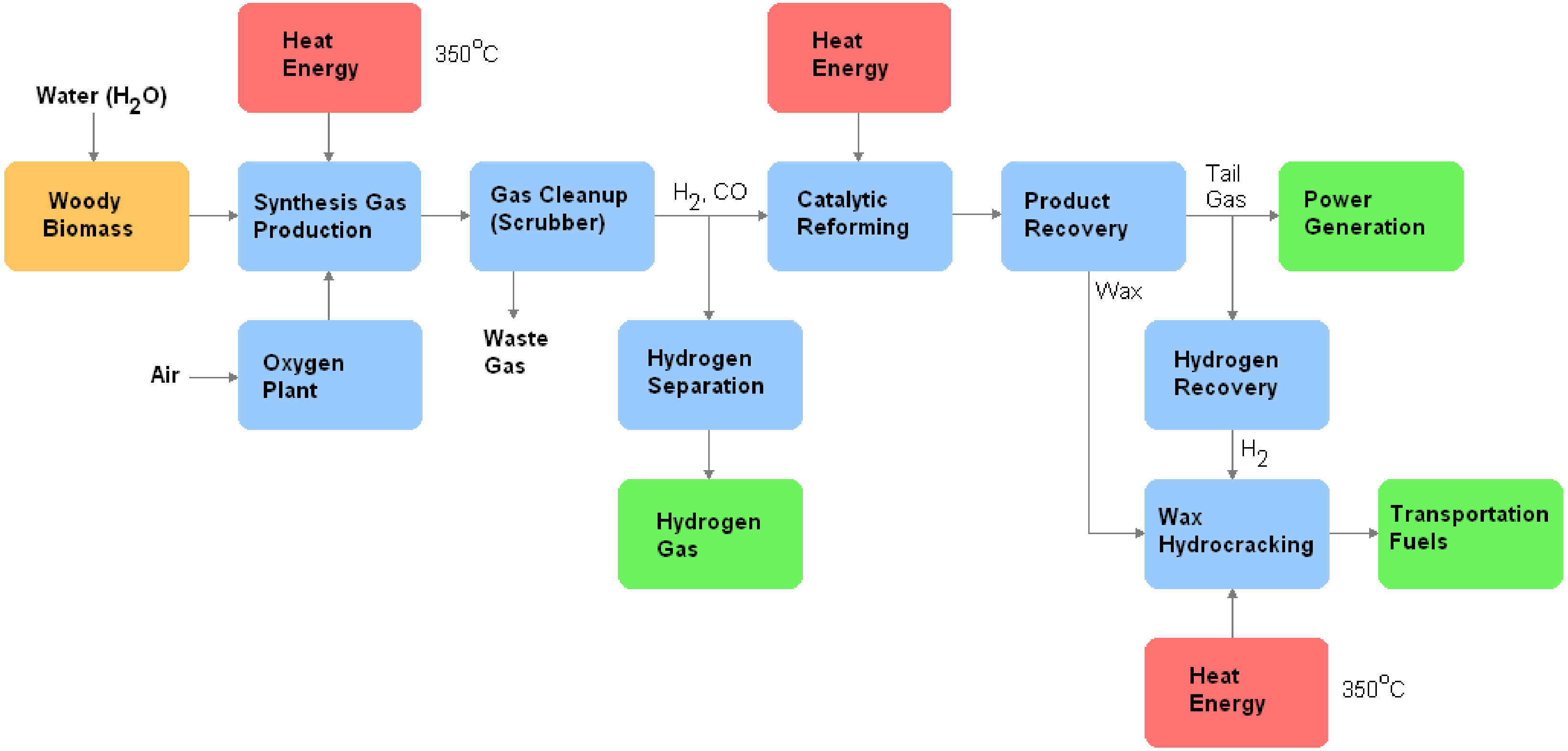
- During pyrolysis, gasification or thermochemical conversion, the biomass is reduced at high temperatures in an oxygen deficient environment.
- Thermochemical conversion can reduce the biomass to:
  - Gaseous products (CO, H_2, H_20).
  - Liquid hydrocarbons (Biocrude)
  - Carbon rich solids (Biochar)

BIOMASS CONVERSION – PYROLYSIS FOR LIQUID FUELS

- The evolved carbon and hydrogen rich gases and materials can be reformed into valuable chemicals and biofuels.
- Biomass gasification processes were first developed in the 1920s by Franz Fischer and Hans Tropsch.
- The Fischer-Tropsch process, as it became known, was used in Germany during World War II, when crude oil and gasoline were in short supply.

BIOMASS CONVERSION – PYROLYSIS FOR LIQUID FUELS

Fischer-Tropsch process -



BIOMASS CONVERSION – PYROLYSIS FOR LIQUID FUELS

- After nearly a century, the pyrolytic conversion of biomass to liquid fuels has not yet proven to be economical on a commercial scale.
- Recent advances in catalyst and process technologies are rapidly improving the economics of this technology.
- Through the support of the U.S. Department of Energy and the Gas Technology Institute, researchers at the University of Nevada Reno are exploring ways to make the gasification of biomass for fuel production practical.

BIOMASS CONVERSION – PYROLYSIS FOR LIQUID FUELS

- Sierra Biofuels intends to construct a facility near Reno that could convert 90,000 tons of municipal solid waste (MSW) per year into 10 million gallons of ethanol via plasma gasification and catalytic conversion.
- Other companies such as Envergent Technologies and Coskata are also working to develop commercially viable biomass pyrolysis technologies.
- The rapid conversion rates of pyrolytic conversion make it an attractive process for handling large amounts of biomass.

BIOMASS CONVERSION – PYROLYSIS BARRIERS

- Gasification and liquefaction technologies face many barriers to successful commercialization:
  - Research and development costs
  - Effective gas cleaning technologies
  - Development of selective catalysts
  - Energy inputs required to provide process heat
  - Upgrading of pyrolysis oils to usable products
  - Transportation of pyrolysis oils
  - Marketing pyrolysis gas
  - Tar production

BIOMASS CONVERSION – PYROLYSIS FOR SOLID FUELS

- Biochar production technology is well understood but commercialization faces primarily market barriers.
- Chemical and testing specifications for 'biocoal' are required for industry acceptance of the product

  - BTU value
  - Moisture content
  - Total carbon
  - Total sulfur and nitrogen
  - ASTM standard

Photo credit - University of Florida

BIOMASS CONVERSION – HYDROLYSIS

- A more conventional approach to the production of biofuels from biomass is via hydrolysis and biochemical fermentation.
- During hydrolysis, the bonds that hold the components of biomass together are broken in aqueous solutions.
- Woody biomass is a tough, complex structure comprised of cellulose, hemicellulose and lignin.
- Cellulose contains glucose sugars.

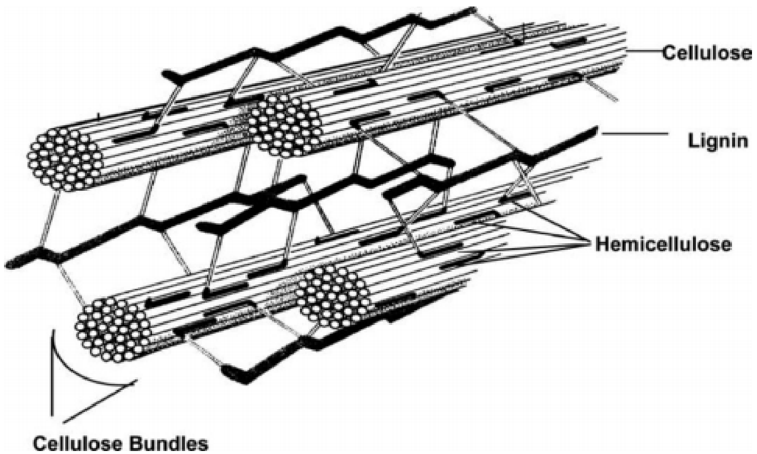
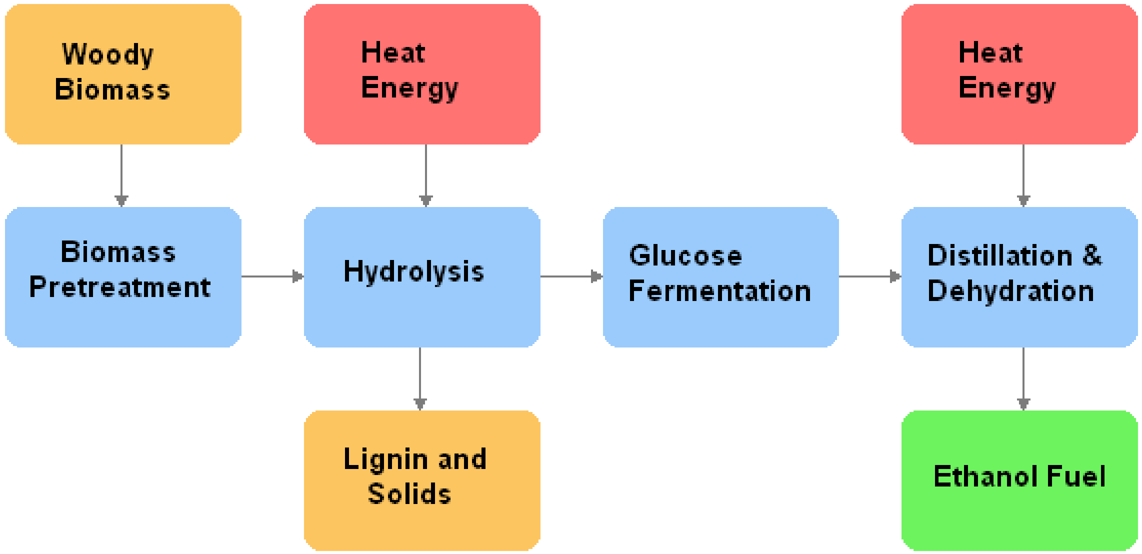


Photo credit – Curtin University of Technology

BIOMASS CONVERSION – HYDROLYSIS

- After hydrolysis, released sugars can easily be fermented into ethanol by commercially available yeasts



BIOMASS CONVERSION – HYDROLYSIS

- Several different hydrolysis process technologies are currently being pursued at various demonstration-scale facilities:
  - Concentrated acid hydrolysis (using sulfuric acid)
  - Dilute acid hydrolysis
  - Steam hydrolysis
  - Subcritical water hydrolysis
  - Enzymatic hydrolysis
  - Mechanical shear
  - Black rot fungi based biochemical processes
  - Genetically engineered microbes
  - Multi-stage processes

Apollo Bioenergy, Inc. (c) 2010

BIOMASS CONVERSION – HYDROLYSIS

- In 2002, NREL demonstrated a steam hydrolysis pretreatment process and was awarded two patents
- The work done by Nick Nagle of NREL showed that hydrolysis was “well suited to the sugar platform biorefinery concept of producing a suite of different products from lignocellulosic material once it is broken down into component sugars.”
- The processes achieved “excellent yields” but appeared “to be difficult to scale up to industrial levels and the projected economics were disappointing, in large part because of the large volumes of high-temperature steam needed.”

BIOMASS CONVERSION – HYDROLYSIS

- Today, enzymatic hydrolysis is the leading pretreatment process, employing expensive and proprietary enzymes, such as those produced by Genencor and Novozymes.
- Enzymes costs have come down to the point of being an economical means of pretreatment at commercial scale.
- There are numerous demonstration-scale cellulosic ethanol facilities operating using hydrolysis and fermentation in the United States and Europe.
- Hydrolysis pretreatment and biochemical conversion are currently the leading technologies for cellulosic ethanol production.

BIOMASS CONVERSION – HYDROLYSIS

- The EPA expects only four companies to produce cellulosic biofuels next year, each using hydrolysis and fermentation – DuPont Danisco, Fiberight, KL Energy and Range Fuels.
- On November 29, 2010 the EPA reduced the requirement for cellulosic biofuel production in 2011 to only 6.6 million gallons.
- The final 2011 cellulosic biofuel volume is drastically less than the original goal of 250 million gallons.
- The EPA "remains optimistic" and is currently tracking more than 20 facilities representing more than 300 million gallons of production scheduled to come online in 2012.

** December 2010 edition of Ethanol Producer Magazine.*

BIOMASS CONVERSION – HYDROLYSIS BARRIERS

- Biological fermentation is slow and typically requires 18 to 36 hours to yield a solution of up to 20 percent ethanol.
- Traditional distillation is used to concentrate the ethanol.
- Distillation is energy intensive and produces greenhouse gas emissions, as natural gas is used for process heat.
- The remaining hemicellulose, lignin and xylose sugars, are a waste product using traditional ethanol fermentation processes.
- With further processing, these waste materials could be used as raw materials to produce a variety of value-added products.

BIOMASS UTILIZATION - BARRIERS

- The most significant barrier to biomass utilization is –

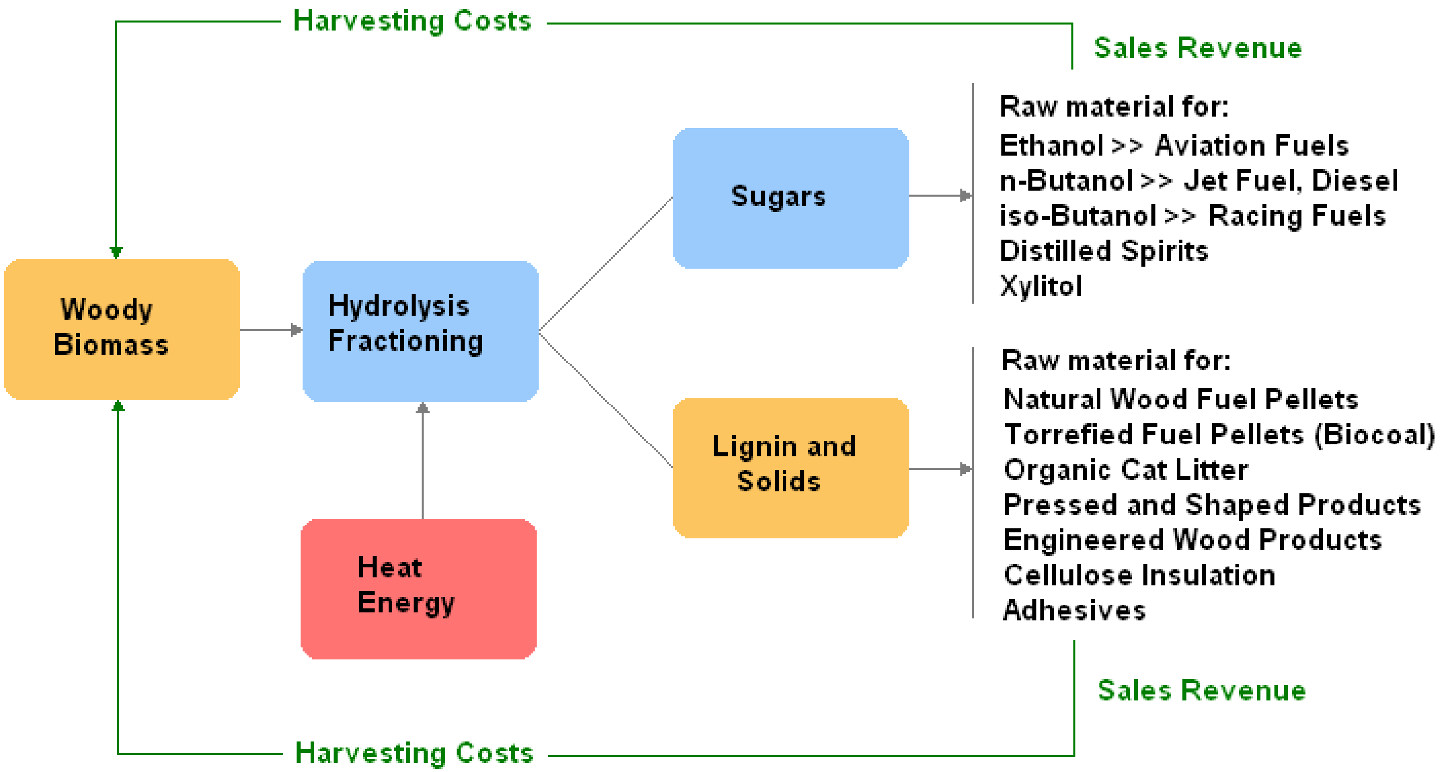
ECONOMICS

BIOMASS UTILIZATION - BARRIERS

- The economic barriers to biomass utilization include –
  - Biomass costs
  - Harvesting costs
  - Transportation costs
  - Equipment financing costs
  - Operational costs
  - Processing costs
  - Enzyme costs
  - Energy costs
  - Marketing and packaging costs
  - Workforce education costs
  - Market value of end products

BIOMASS CONVERSION – ADDING VALUE

- A hydrolysis-based facility yields two product paths:



ADDING VALUE – LIGNIN AND SOLIDS UTILIZATION

- Waste lignin and other solid residues can be used to manufacture extruded wood pellet stove fuels

  - Simple mechanical processing
  - Established market
  - Replaces oil and gas heat
  - Renewable fuel
  - Modest heat value
  - Some residual moisture
  - Retail market value:
    $0.08 to $0.15 /lb

Photo credit - Maughan Energy & Environmental Consultants

ADDING VALUE – LIGNIN AND SOLIDS UTILIZATION

- Waste lignin and other solid residues can be used to manufacture extruded organic cat litter
  - Simple mechanical processing
  - Growing competitive market
  - Replaces clay and silica litter
  - Garden and compost friendly
  - Retail market value:
    $0.25 to $0.50 /lb

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.
Photo credit - Nature's Earth Products, Inc.

ADDING VALUE – LIGNIN AND SOLIDS UTILIZATION

- Waste lignin and other solid residues can be used to manufacture cellulose building insulation

  - No VOCs
  - No glass-reinforced plastics
  - Slightly better R-values
  - Improved sealing and packing
  - Proven 20-30% better performance
  - Class 1 fire safety rating
  - Increasing market demand
  - Environmentally friendly
  - Ease of installation
  - Lower cost of ownership

Photo credit – mdinsulation.net

ADDING VALUE – LIGNIN AND SOLIDS UTILIZATION

- Waste lignin and other solid residues can be used to manufacture molded pulp packaging
  - Simple mechanical processing
  - Replaces expanded polystyrene
  - Increasing market demand
  - Garden and compost friendly
  - Diverse utilization market - Egg cartons, printer cartridges

Photo credit - Shanghai Huoer

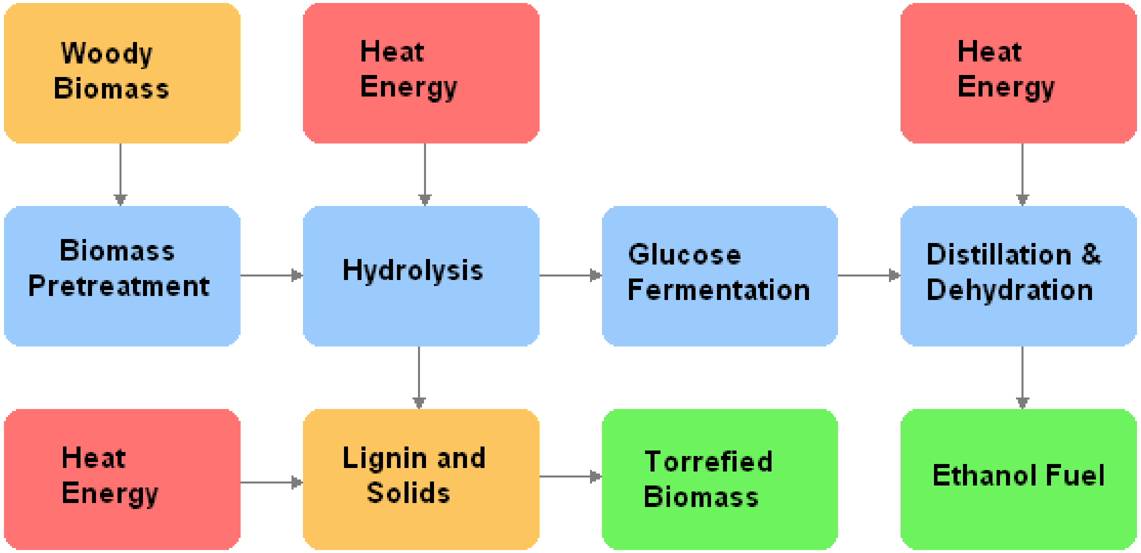
ADDING VALUE – LIGNIN AND SOLIDS UTILIZATION

- Waste lignin and other solid residues can be used to manufacture engineered wood products
  - Uses wood pulp and recycled plastics
  - Weather and wear resistant
  - Available in popular shapes
  - Increasing popularity
  - Easy installation
  - TREX plant in Fernley, NV

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.
Photo credit – TREX Company, Inc.

ADDING VALUE – TORREFACTION

- Waste lignin and other solid residues can be torrified to yield a high energy solid fuel - biochar



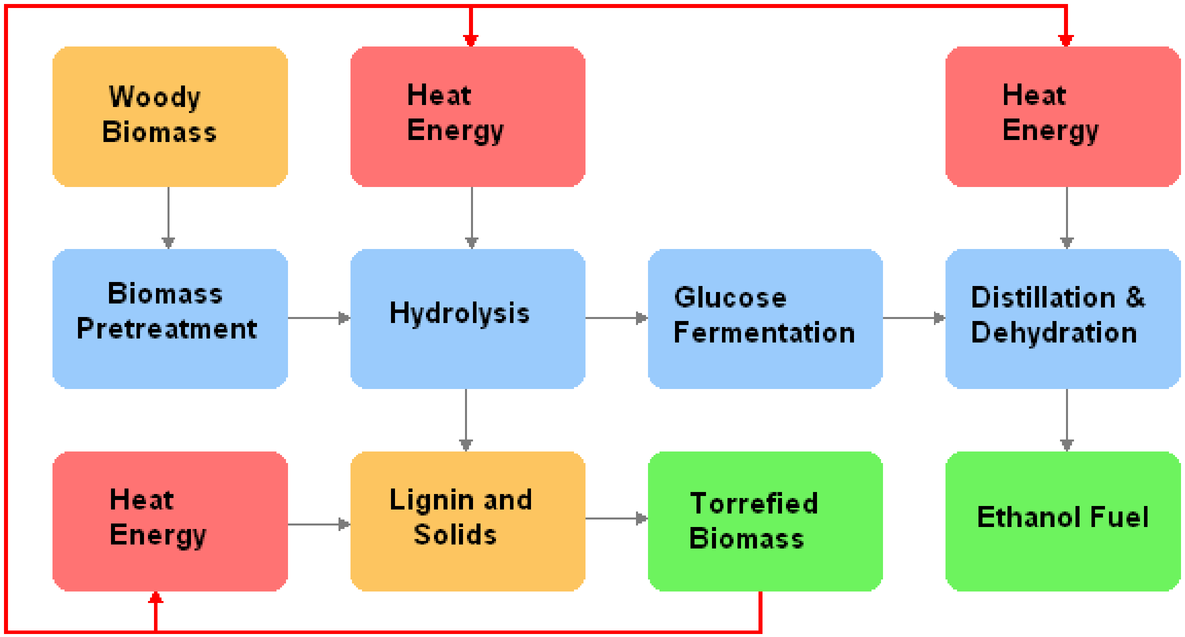
ADDING VALUE – TORREFACTION

- Torrefaction of biomass is a mild form of pyrolysis which occurs at temperatures of 200-320°C.
- During torrefaction the biomass properties are changed to obtain a much better fuel quality for combustion.

- Low moisture and high energy content; 8,000 to 10,000 BTU/lb is typical
- Market value as a coal replacement: $0.08/lb, up to $150/ton
- Large, well-established market for coal

ADDING VALUE – TORREFACTION

- Biochar can provide process heat and reduce operating costs



ADDING VALUE – TORREFACTION

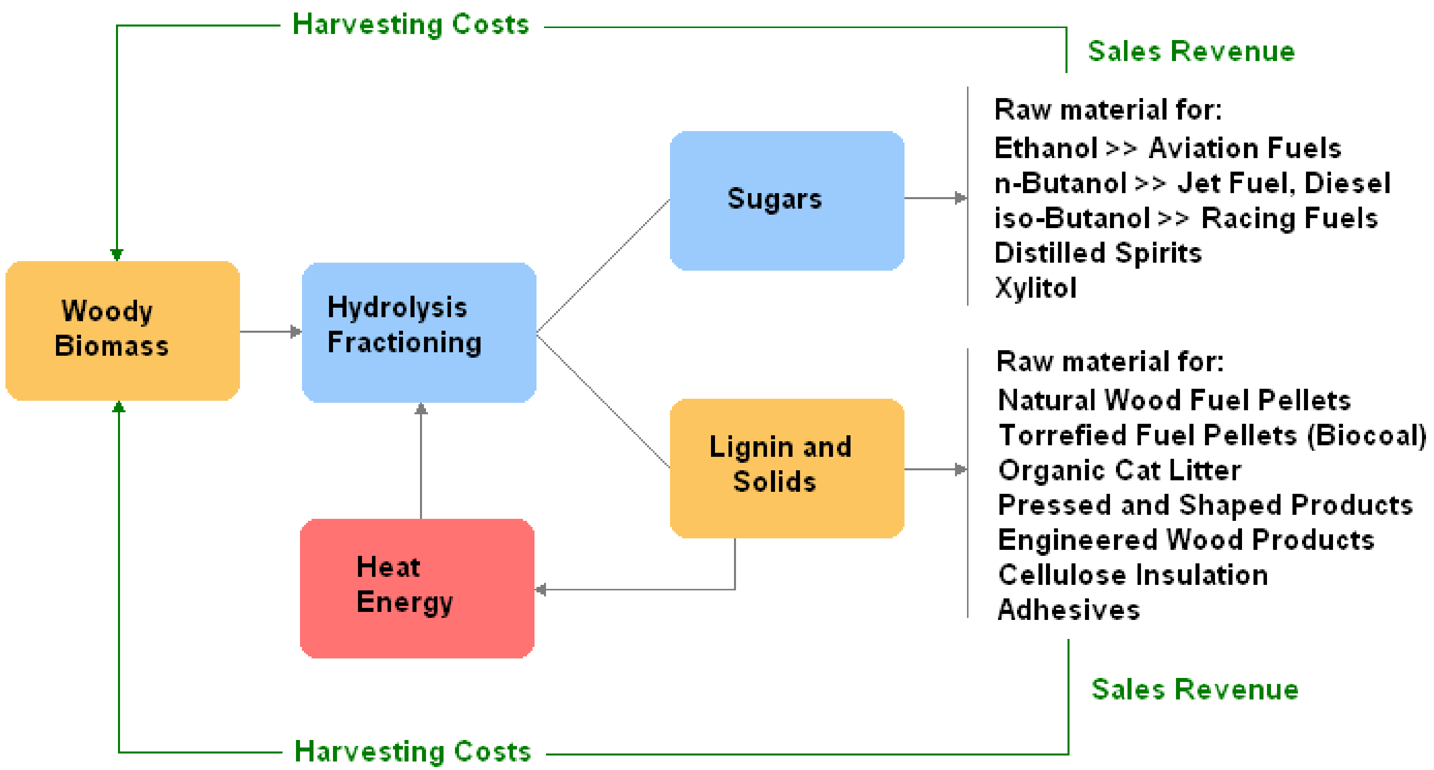
- Growing market interest in direct torrefaction processors and several companies are pursuing various platforms
  - Renewable Fuel Technologies
  - Sea 2 Sky
  - AgriTech Producers
  - Integro earthfuels
  - Topell Energy

Torbed® reactor system

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

BIOMASS CONVERSION – SUGAR UTILIZATION

- A hydrolysis-based facility yields two product paths:



ADDING VALUE – SUGAR UTILIZATION

- Extractable sugars (glucose, xylose, mannose, pentose) can compose up to 40 percent of the biomass
- Through the fermentation of these sugars and the distillation of the products, liquid biofuels and other products can be produced, such as:

  - isoButanol
  - nButanol
  - Acetone
  - Ethanol
  - Distilled spirits

ADDING VALUE – SUGAR UTILIZATION

- iso-Butanol can be produced from the fermentation of sugars
- Gevo and Butamax are both working to develop an economical processes to produce iso-butanol
- iso-Butanol is a high-octane, high BTU content motor fuel and is DOT and EPA approved for blending with unleaded gasoline up to 16 percent as a motor fuel
- The American Le Mans Racing Series approved an iso-butanol blend as an approved fuel in 2010

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

ADDING VALUE – SUGAR UTILIZATION

- n-Butanol can be produced from the fermentation of sugars
- Cobalt Technologies is focused developing an economical process to produce n-Butanol, with acetone as a co-product
- n-Butanol and acetone are commonly used as a raw material for paints and other industrial products
- n-Butanol is also approved to be blended with unleaded gasoline as an oxygenation additive to 16 percent
- Cobalt Technologies has the rights to develop a process licensed from the US Navy to convert n-Butanol to renewable diesel fuels and jet fuels

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

ADDING VALUE – SUGAR UTILIZATION

- Ethanol can also be produced from the fermentation of sugars
- Unleaded gasoline is seasonally oxygenated with corn-based ethanol to 10 percent (E10)
- The DOT, EPA and the USDA are considering allowing gasoline to be blended with ethanol to 15 percent (E15)
- Flexible fuel vehicles (FFVs) can operate on unleaded gasoline blended with ethanol to 85 percent (E85)
- The current consumption of anhydrous fuel ethanol in Nevada is approximately 90 MMGPY – valued at $135 million
- Washoe county alone consumes over 10 MMGPY

ADDING VALUE – SUGAR UTILIZATION

- SWIFT Enterprises is has developed a process to convert ethanol into a 100 octane, low-lead piston engine aircraft fuel
- High-octane ethanol-blends have been approved by NASCAR as a racing fuel
- Distilled spirits, such as Vodka and Gin, could be produced from the fermentation of pine and juniper sugars

Photo credit - Jamie Squire/Getty Images

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

ADDING VALUE – SUGAR UTILIZATION

- Sugar-based products market values
  - Anhydrous ethanol (for E10, E85 blends) – $1.50/gal
  - n-Butanol (chemicals market) – $3.75/gal
  - iso-Butanol (high octane fuel additive) – $4.00/gal
  - General aviation fuel (100LL replacement) – $4.50/gal
  - Jet A (DOD and commercial aviation) – $4.75/gal
  - High octane racing fuels (iso-Butanol blends) – $12.00/gal
  - Distilled spirits (40 percent ethanol) – $25.00/gal
- Market entry barriers and economics need to be considered

ADDING VALUE – SUGAR UTILIZATION BARRIERS

- Ethanol fermentation normally requires 18 to 36 hours
- Traditional processes utilize only glucose (C6) sugars
- New yeasts, cyanobacteria and GMOs can utilize glucose (C6) and xylose (C5) sugars and/or ferment at higher temperatures and accelerated rates

  - Cobalt Technologies (*Clostridium*)
  - Mascoma (*Clostridium*)
  - Qteros (*Clostridium*)
  - Gevo (*E. coli*)
  - TMO Renewables (*Geobacillus*)

- Biologic fermentation rates soon may be less than two hours

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

ADDING VALUE – SUGAR UTILIZATION BARRIERS

- Solid catalysts can allow conversion in less than 30 minutes
- Yields solutions greater than 20 percent ethanol
- Reduces distillation energy requirements
- Immune to antimicrobials in biomass (pine and juniper oils)
- Commercial scale technology available in about one year
  - Carter Technologies Corporation
  - Georgia Alternative Fuels
  - Ceramatec
  - Catilin

All trademarks remain the property of their respective owners.
The appearance of a product or company does not necessarily imply an endorsement by Apollo Bioenergy, Inc.

ADDING VALUE – SUGAR UTILIZATION BARRIERS

- The energy requirement for distillation has a significant impact on the economics of ethanol production
- Using natural gas fired heating systems consume fossil fuels and releases CO_2 (one of the many anti-ethanol arguments)
- Studies have shown that a 10 MMGPY corn-based ethanol plant could use direct-use geothermal, realizing a savings of nearly $2 million per year in operational costs but*...
  - There's not much geothermal heat in Iowa
  - There's not much corn in Nevada
  - There is biomass and geothermal heat in Nevada

** Geo-Heat Center, Oregon Institute of Technology, January 2007*

The Apollo Project

A Pinyon-Juniper Biomass Utilization Case Study

THE APOLLO PROJECT

Develop a demonstration-scale pinyon-juniper biomass utilization model that considers –

- Options available in conversion technologies
- Energy inputs
- Existing import and export markets
- Level of risk
- Return-on-investment
- Impact on regional macroeconomic activity

THE APOLLO PROJECT

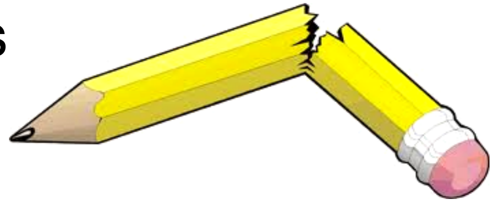
The parameters used for this demonstration-scale pinyon-juniper biomass utilization model are –

- Harvest 300,000 acres in both Pioche and Ely areas consisting of pinyon-juniper in phase II and phase III
- Harvest no more than 15,000 acres per year in each area
- Yield of a minimum of 6 tons/acre (90,000 tons/yr/area)
- Harvesting reimbursement must be at least $50/ton
- Length of project is 20 years
- Positive impact on regional macroeconomic activity

THE APOLLO PROJECT

Option 1 – Burn the P-J in a new biomass power plant

- The economics of constructing and operating a biomass-fired electrical generating station have been consistently poor.
- The $8.8 million biomass power plant at the Northern Nevada Correctional Center proved uneconomical to operate, has been shut-down and is now for sale.
- Improved thermal processing technologies have improved the economics slightly



- In most cases, it just doesn't pencil.
- Little environmental benefit and the only macroeconomic impact is the harvesting costs paid to BLM contractors

THE APOLLO PROJECT

Option 2 – Convert all of the biomass to torrified pellets and burn the material in an existing coal-fired power plant

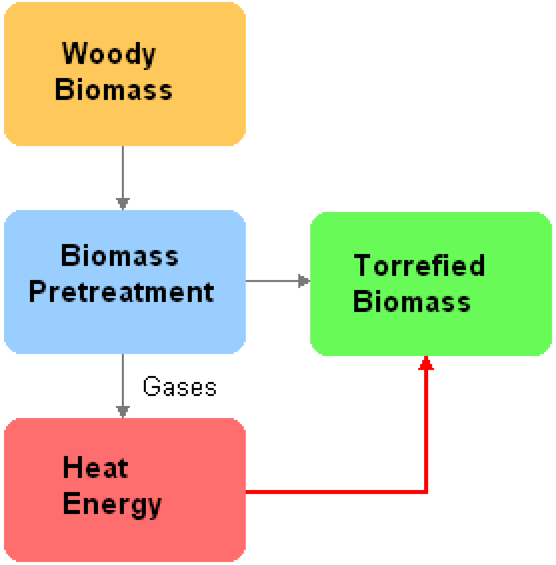


Photo credit – AgriTech Producers

THE APOLLO PROJECT

Option 2 – Convert all of the biomass to torrified pellets and burn the material in an existing coal-fired power plant

Project scale	600,000	acres
Harvesting	30,000	acres/yr
Harvesting yield	180,000	tons/yr
Biochar market price	$100	ton (bulk)
Revenue (before costs)	$18,000,000	annually
Biomass harvesting rate	$50	ton
Biomass cost (w/o BCAP)	($9,000,000)	yr
	==========	
Net revenue (before costs)	$9,000,000	yr

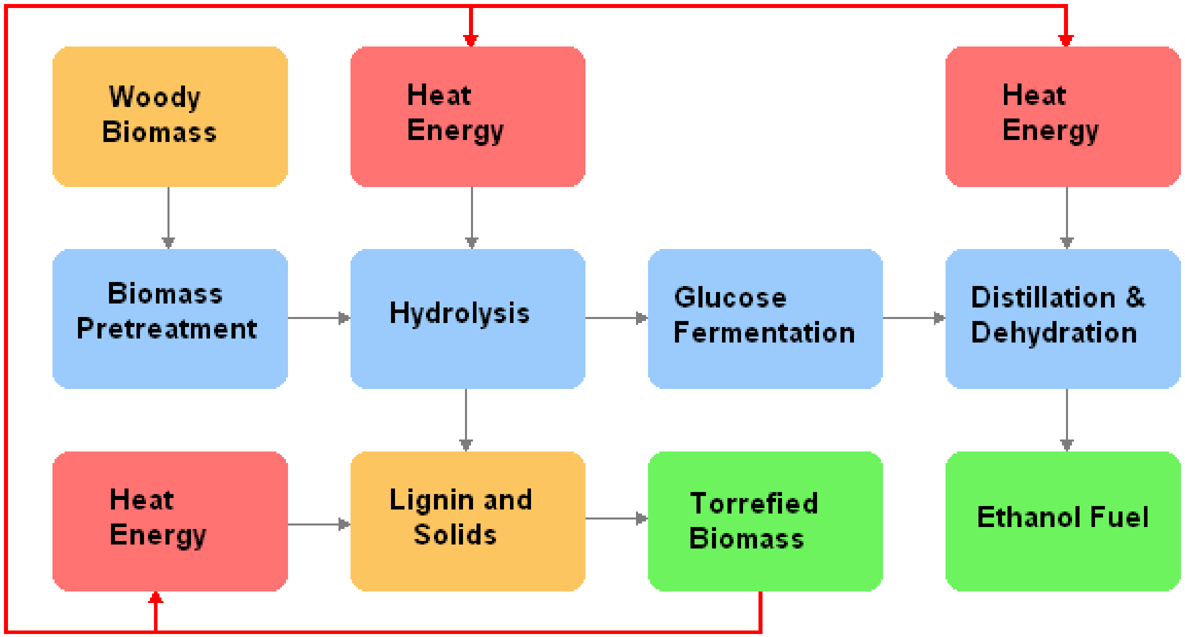
THE APOLLO PROJECT

Option 2 – Convert all of the biomass to torrified pellets and burn the material in an existing coal-fired power plant

- No need to permit or construct a permanent power station
- Transportable torrefaction machines could be utilized on-site
- Torrefaction heat would be provided by gasified products
- Fundamental economics appear favorable
- Positive macroeconomic and environmental impact
- Nevada could reduce imports of coal by 180,000 tons annually, keeping $18,000,000 in the state economy, while reducing coal-fired power plant emissions

THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets



THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets

- Market situation in Nevada:
  - Ethanol could be blended locally into the existing Nevada motor fuels markets (estimated to be 90 MMGPY)
  - Torrified pellets could be burned in an existing coal-fired power plant (demand is in excess of potential biochar supply)

THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets

Project scale	600,000	acres
Harvesting	30,000	acres/yr
Harvesting yield	180,000	tons/yr
Ethanol yield	70	gal/ton
Ethanol production	12,600,000	gals/yr
Market price	$1.50	gal
Revenue (before costs)	$18,900,000	annually
Lignin yield (biochar)	70,000	tons/yr
Market price	$100	ton
Revenue (before costs)	$7,000,000	annually

THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets

Ethanol revenue (before costs)	$18,900,000 annually
Biochar revenue (before costs)	$7,000,000 annually
	===========
Net (before costs)	$25,900,000 yr
Biomass cost (w/o BCAP)	($9,000,000) yr
	===========
Net (before costs)	$16,900,000 yr

THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets

- Larger, more complex permanent facility
- Complicated permitting and licensing (TTB, bonding)
- Production economics similar to corn ethanol plants
  - Energy requirements can be offset by burning biochar product
  - Reduced revenues from consumption of biochar product
  - Air quality restrictions
- Increased logistics costs and taxes
- Fundamental economics appear more favorable

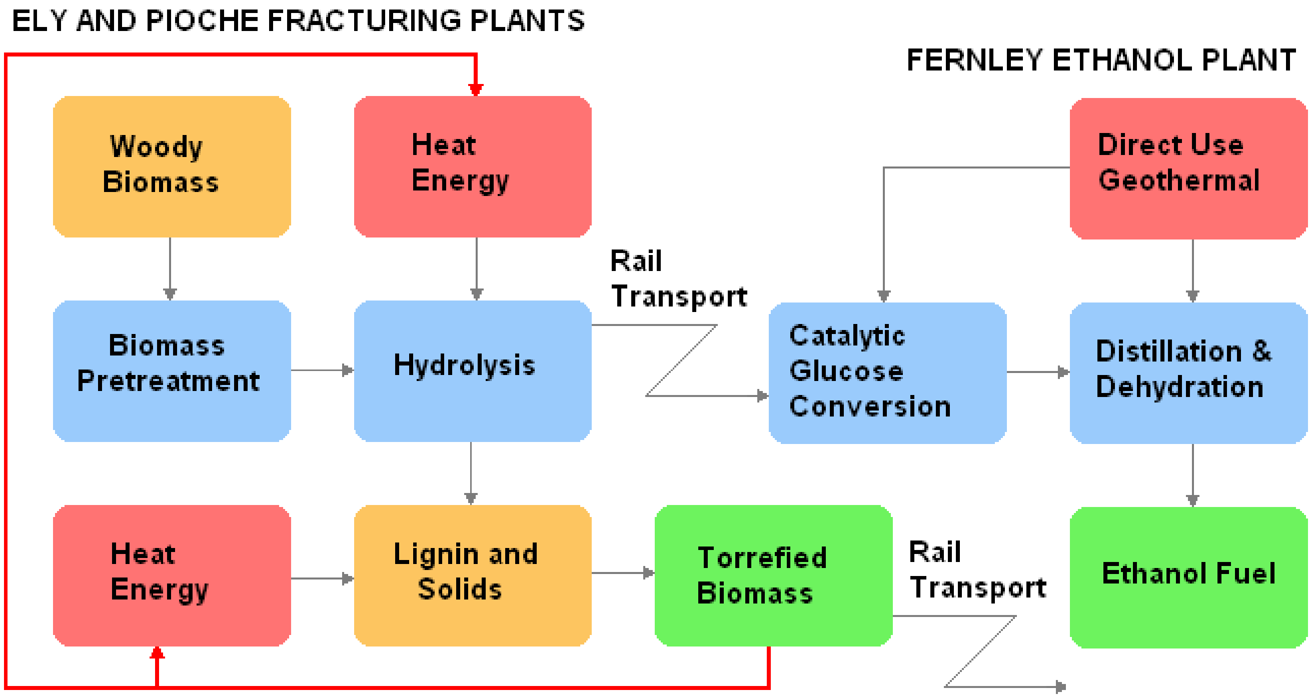
THE APOLLO PROJECT

Option 3 – Produce ethanol fuel and torrified pellets

- Positive macroeconomic and environmental impact
- Nevada could reduce imports of coal by 70,000 tons annually, keeping $7,000,000 in the state economy, while reducing coal-fired power plant emissions
- Nevada could reduce imports of ethanol by 12.6 MMGY, keeping an additional $18,900,000 in the state economy
- Total impact statewide –
  $25,000,000 reduction in imported products

THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal



THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

- The use of geothermal heat would lower operating costs and greenhouse gas emissions
- First use of geothermal energy in an ethanol plant
- One of the first cellulosic ethanol plants using woody biomass
- The production scale of 12.6 MMGY would be nearly double the EPA mandate for all cellulosic ethanol production in 2011

Apollo Bioenergy, Inc. (c) 2010

THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

- Use of catalytic conversion of glucose and xylose to ethanol is required, due to antibiotic nature of pinyon and juniper oils
- Catalytic conversion reduces plant size and improves throughput
- Low-cost geothermal heat improve economics of catalytic conversion
- First use of catalytic conversion of glucose-to-ethanol at commercial scale

THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

Project scale	600,000	acres
Harvesting	30,000	acres/yr
Harvesting yield	180,000	tons/yr
Ethanol yield	70	gal/ton
Ethanol production	12,600,000	gals/yr
Market price	$1.50	gal
Revenue (before costs)	$18,900,000	annually
Lignin yield (biochar)	85,000	tons/yr
Market price	$100	ton
Revenue (before costs)	$8,500,000	annually

THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

Ethanol revenue (before costs)	$18,900,000 annually
Biochar revenue (before costs)	$8,500,000 annually
	===========
Net (before costs)	$27,400,000 yr
Biomass cost (w/o BCAP)	($9,000,000) yr
	===========
Net (before costs)	$18,400,000 yr

THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

- Distributed, task specific facilities
- Greatly reduced energy requirements
- Use of geothermal increases revenues and reduces greenhouse gas emissions
- Use of catalytic conversion would reduce plant size and improve throughput
- Modest logistics costs (based on rail transport)
- Fundamental economics appear very favorable

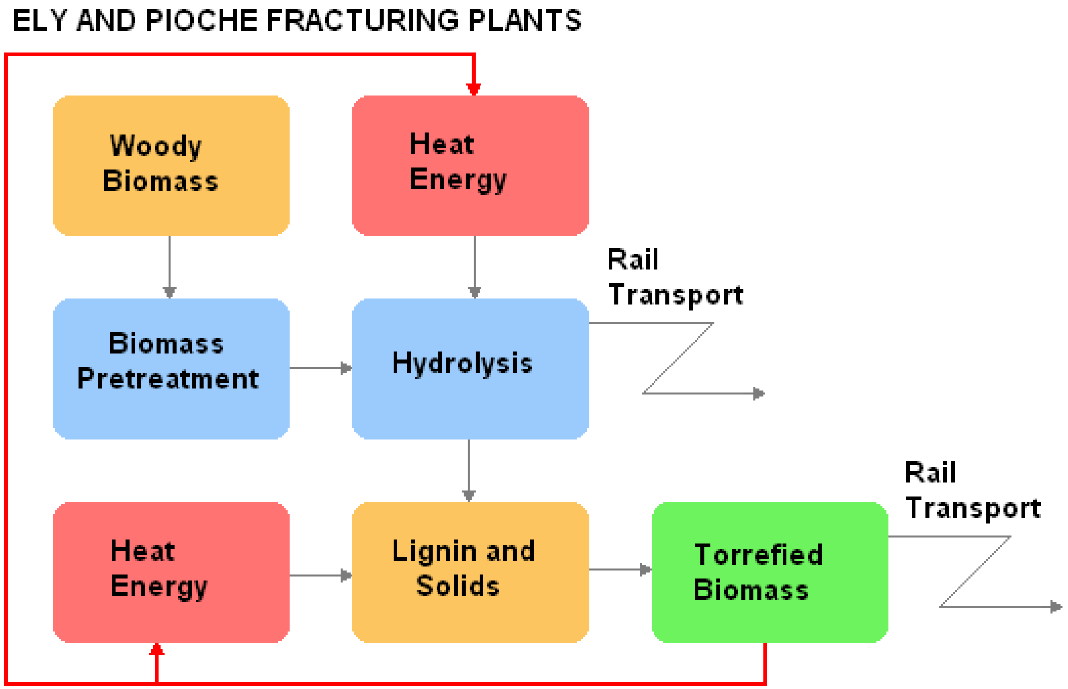
THE APOLLO PROJECT

Option 4 – Ethanol fuel and torrified pellets with geothermal

- Positive macroeconomic and environmental impact
- Nevada could reduce imports of coal by 85,000 tons annually, keeping $8,500,000 in the state economy, while reducing coal-fired power plant emissions
- Nevada could reduce imports of ethanol by 12.6 MMGY, keeping an additional $18,900,000 in the state economy
- Total impact statewide –
  $27,400,000 reduction in imported products

THE APOLLO PROJECT

Option 4 – Fractioning facility specifications



THE APOLLO PROJECT

Option 4 – Fractioning facility specifications

- Estimated cost of fractioning facilities - $20 million each
- Each facility would fraction 90,000 tons/yr of chipped pinyon-juniper biomass, paying $50/ton
- BCAP availability and logistics costs will increase/decrease biomass payment per ton
- Design would be a combination of steam hydrolysis and torrefaction (pyrolysis) processes
- Rural facility would be powered entirely by biochar CHP

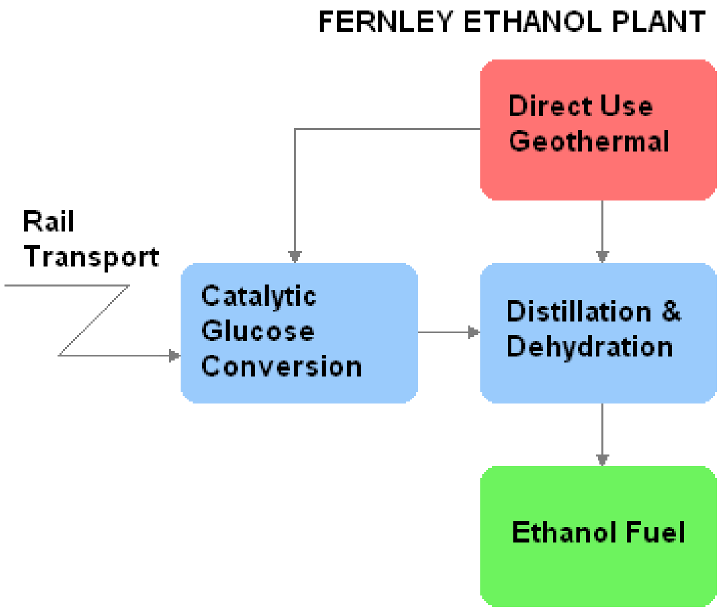
THE APOLLO PROJECT

Option 4 – Fractioning facility specifications

- Facilities would be located in Ely and Pioche, Nevada
- Ely facility would produce biochar for Newmont or Valmy and sugar syrup for Fernley ethanol plant
- Pioche facility would produce biochar for Reid-Gardner and sugar syrup for Fernley ethanol plant
- Additional products, such as pellet stove fuel and cat litter could also be produced at these facilities
- Once operational, each facility would create 25 full-time jobs

THE APOLLO PROJECT

Option 4 – Ethanol production facility specifications



THE APOLLO PROJECT

Option 4 – Ethanol production facility specifications

- 12.5 MMGPY scale would meet Washoe county requirements
- Estimated cost of ethanol production facility - $25 million
- Design could begin in with off-the-shelf ‘corn-based’ plans
  - Distillation would be converted from natural gas to geothermal
  - Fermentation would be converted to catalytic conversion
- Facility would be located in industrial development with geothermal direct-use and rail access near Fernley, Nevada

THE APOLLO PROJECT

Option 4 – Ethanol production facility specifications

- Site preparation could begin as early as 2011
- Start-up could commence immediately with commercially available sugar molasses via 33,000 gallon tank car
- With support of the USDA and the BLM, the plant could be operational within two years of funding availability
- Once operational, about 35 full-time jobs would created
- Facility would be used to validate additional product pathways to butanol, aviation fuel, diesel and jet fuel
- Partnerships would be established with local academic and technical training institutions (UNR, DRI, TMCC)

Apollo Bioenergy, Inc. (c) 2010

THE APOLLO PROJECT

- Logistics map

THE APOLLO PROJECT

Option 4 – Project summary

- Total cost of three facilities: $65 million
- Economic impact: $27.4 million annually
- Full-time jobs created: 85 (plus BLM harvesting contractors)
- Reduction of coal imports by 85,000 tons annually
- Reduction of ethanol imports by 12.6 MMGY
- Reduction of coal-fired power plant emissions
- Ethanol plant design will utilize cutting-edge renewable energy technologies and will be a flag-ship for advanced biofuels production in the West

THE APOLLO PROJECT

Option 4 – Future model expansion capabilities

- Additional biomass fractioning facilities could be deployed in densely forested regions of the west
- Distillation facility in Fernley could accept fractioned sugars from biomass in Northern California and Oregon
- Additional ethanol distillation facilities could be constructed in areas with geothermal and rail facilities (Gerlach, Beowawe)
- An additional 10 to 20 MMGPY of capacity could be brought on-line on an annual basis, as biomass harvesting capabilities became available

THE APOLLO PROJECT

Option 4 – Future model expansion capabilities

- Current pinyon-juniper inventory in Nevada could support the annual production of -

  100 MMGPY ethanol ($150 million market value)
  1 million tons of biochar ($100 million market value)

- Limiting factor is primarily the scaling of harvesting capabilities
- Flexible hydrolysis chemistry would allow the future processing of energy crops, such as switchgrass and Miscanthus
- Provides a path for Nevada farmers to enter the biofuels market with reduced risk and investment

Apollo Bioenergy

Energy • Environment • Empowerment

QUESTIONS

Lauren Scott
President/CEO
Apollo Bioenergy, Inc.

775.622.9900 x114
lauren.scott@apollobioenergy.com

www.apollobioenergy.com