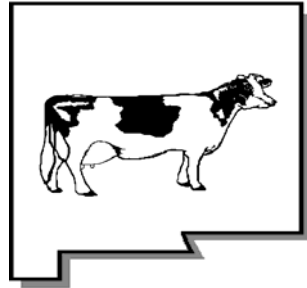
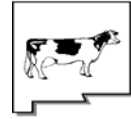


DPNM Biomass Project 2005



Agri-Energy and the Dairy Producers of New Mexico

Developed by: Kyle Hoodenpyle,
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DPNM Biomass Project Final Report

Outline and Contents for Final Report

Forward

DPNM Introduction

DPNM Biomass Project Description

Complete report of all findings, at a minimum, addresses the following:

I. Biomass Resources Assessment

i. A detailed assessment of biomass source, type, and potential amount available within each Region:

1. Roswell,
2. Portales,
3. Clovis,
4. Las Cruces,
5. Hobbs/Lovington,
6. Artesia,
7. South Albuquerque: Belen & Socorro

ii. Specific criteria for and potential participants of a biomass cooperative of all Regions.

II. Bioenergy conversion technology and Biofuels products.

iii. A detailed assessment of available technologies for converting biomass product and a recommended technology most suitable for all Regions.

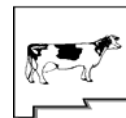
iv. An assessment of the potential viability of developing biomass conversion plants in all Regions.

v. Identification of commercially viable end products from biomass conversion.

III. Collaboration, education and outreach.

vi. Identification of potential resources and collaborative agencies/organizations to assist with development of proposed conversion plants.

IV. Conclusion



V. Appendices (on CD Rom)

DPNM Biomass Final Report

Conversion Technologies

- Anaerobic Digestion
- Biomass Combustion
- Biomass Gasification
- Fast Pyrolysis

Exhibits

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- Exhibit B Bylaws of Biomass Cooperative
- Exhibit C Membership and Marketing Agreement
- Exhibit D Agreement to Form Cooperative
- Exhibit E Potential Participants in the Pecos Valley Region
- Exhibit F Biomass Supply Contract
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- Exhibit J New Mexico Dairy Allied Industries
- Exhibit K Biomass Review Committee
- Exhibit L PVBC Meeting Announcement
- Exhibit M PVBC Biomass Production
- Exhibit N Primenergy gasification system
- Exhibit O Westwood Energy Systems

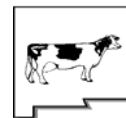
- Spreadsheet 1 NM Biomass Produced
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- DPNM Biomass Project Presentation



Foreword

This has been an exciting project with significant potential, and I wish to express my thanks to Sharon Lombardi, Executive Director of Dairy Producers of New Mexico (DPNM), and all those who helped make this project possible.

This report was funded by a grant from the Thaw Charitable Trust and Maddox Foundation. The opinions expressed are those of the author and do not necessarily represent the position of DPNM or the grantors.

Dairy Producers of New Mexico (DPNM) Introduction

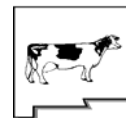
Dairy Producers of New Mexico is a non-profit agricultural organization for grassroots dairy producers. We represent these producers in all levels of government: provide educational services and technical assistance to enhance the existing dairy industry in New Mexico. The dairy industry in New Mexico grew very rapidly in the early 1990's and we are now 7th in the nation in milk production. We have the largest dairy herds (avg. size 1,800) in the nation and our dairies are all family owned and operated. With all of this in mind, it is important for us to be progressive, not only in milk marketing and production but in energy efficiencies and environmental concerns.

DPNM is concerned about rising energy costs and availability, as well as increasing environmental regulations. Therefore, we are seeking ways to improve energy efficiency and stability for our New Mexico dairies. The cost and availability of energy is an important variable in dairy profitability and an upset in supply could be detrimental to the milk supply for our nation.

BioConversion of dairy wastes into value added products such as BioFuels and BioPower offers many advantages. BioFuels in conjunction with BioPower production is an effective method to augment a New Mexico dairy's energy position. Dairies could also combine their resources with their neighbors into a centralized plant. An efficient BioFuels and BioPower production facility offers many benefits to the producers as well as the public.

Not only are we concerned about energy, our producers in New Mexico have an environmental awareness and they recognize that the ever increasing environmental regulations will subsequently increase production cost. Therefore, positive benefits such as BioConversion offers could then be associated with being better "environmental stewards."

With all these variables, it would be beneficial for dairies to pursue BioConversion of dairy wastes for economic stability and environmental stewardship. These technologies have the ability to enhance the dairy industry in New Mexico while benefiting local economic development and the community; such facilities would have positive influences in energy, economic and environmental issues.



DPNM Biomass Project Description

This project grew out of the following initial ideas:

The Best Plan for the Utilization of New Mexico Biomass Resources

In living, like all living entities, man must consume, it is a necessary aspect of life. Food, air, water and energy are required. In our efforts to procure these necessities, man has adversely impacted our only source of supply, the earth. We can effect change to minimize or reverse our impacts on the earth and insure a better place to live. The first step is simply to care.

It is well established that the utilization of Biomass as an energy source has many advantages ranging from rural economic development to the many environmental implications including being a carbon neutral fuel. According to the United States Department of Energy, utilizing Biofuels is a solution to climate change.

The best plan for the utilization of New Mexico Biomass Resources entails two interconnected parts. First is organizing the producers of all biomass resources into a concerted force capable of regular and systematic delivery of biomass product. Second is seeking out, verifying and committing to a Bioenergy conversion technology and its subsequent Biofuels product.

Through the efforts of this project, the Pecos Valley Biomass Cooperative, Inc. was formed. In addition, several other biomass cooperatives are on the verge of forming which will bring New Mexico that much closer to the realization of a biorefinery in the state. The probability of a biorefinery to become a reality in New Mexico depends on many variables.

Some Variables:

- √ Continuation of high energy prices: base price natural gas >\$4.50
- √ Environmental pressures of biomass suppliers: few at present but increasing
- √ Developing a market price for the biomass feedstock: must cover producer costs
- √ Organization of biomass feedstock suppliers: Pecos Valley Biomass Coop & others a must
- √ Financial partners recognition of biomass investment potential: Need complete business plans

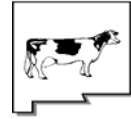
Our biomass project as conducted however beneficial is far from actually developing a biomass facility. More work needs to be done from this INITIAL effort of:

1. Organizing producers
2. Finding technology

A NEXT PHASE of the plan would be expanded to:

3. Analyzing biofuels markets and long term sales contracting
4. Analyzing energy load profiles of our local Allied Industry groups and assessing their potential for participation
5. Securing potential financial partners of interest and developing financial business plans
6. Developing a biomass centralized infrastructure for biomass processing, handling, storage and best site.

Just to name a few; these tasks now fall on the biomass cooperatives.



I. Biomass Resources Assessment

i. A detailed assessment of biomass source, type, and potential amount available within each Region:

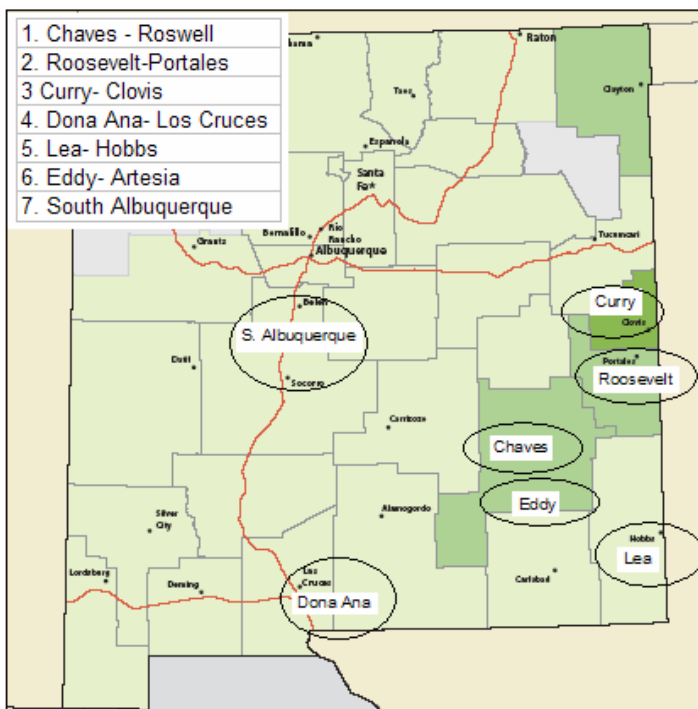
1. Roswell,
2. Portales,
3. Clovis,
4. Las Cruces,
5. Hobbs/Lovington,
6. Artesia,
7. South Albuquerque: Belen & Socorro

The Biomass Supply

Biomass represents one of the largest bases of renewable energy for New Mexico. New Mexico, like many other states, has a broad base of biomass feedstock ranging from potential separated municipal solid wastes to forest residue. However, unique to most states, New Mexico possesses an animal biomass supply through its dairy industry. New Mexico dairies rate as the largest average herd size in the United States.

Dairies are important for New Mexico agriculture as they provide a marketplace for a large percentage of state-grown crops making dairies an ideal source of Biomass supply as all these crops are consolidated. Approximately 1.2 million tons of Biomass is consolidated to less than 170 facilities within the state. (Table 1) Most of this Biomass could further be consolidated to 7 regional biorefineries throughout the state. (Map 1)

Map 1: New Mexico’s predominant Dairy regions.





Dairy Biomass can act as an “**anchor**” feedstock supply for a state-wide biorefinery system which can in turn utilize the state’s other variable and seasonal Biomass supplies (Table 2) which in themselves would not warrant a scale for commercial use.

Table 1: Dry Matter (DM) Biomass (manure) production in New Mexico

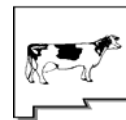
Region	County - City	Dairies	Milk cows	Tons/day DM	Heifers	Tons/day DM	Total/day (tons)	Total/year (tons DM)
1	Chaves - Roswell	39	85,317	640	69,960	262	902	329,313
2	Roosevelt-Portales	44	57,300	430	46,986	176	606	221,171
3	Curry- Clovis	20	53,068	398	43,515	163	561	204,835
4	Dona Ana- Las Cruces	24	47,426	356	38,889	146	502	183,058
5	Lea- Hobbs	16	25,276	190	20,726	78	267	97,562
6	Eddy- Artesia	7	16,138	121	13,233	50	171	62,290
7	South Albuquerque	16	12,574	94	10,310	39	133	48,533
Total		166	297,099	2,228	243,619	914	3,142	1,146,762

This report is limited to the seven regions defined. Sources and feedstocks like forest residue are not addressed because there is no significant production within our regions. Generally it is economically feasible for biomass to be hauled approximately 50 miles.

A detailed breakdown of the feedstocks in Table 2 can be found in the Appendix: Spreadsheet 1; NM Biomass Produced. Since a biorefinery uses biomass on a continuous daily basis, Table 2 estimates the biomass as if it were averaged out over a year’s time and the biomass delivered on a daily basis to a biorefinery.

Table 2. Predominant Variable and Seasonal Biomass Sources & Feedstocks in selected regions of New Mexico (tons/day) compared to dairy biomass.

Region	County - City	Dairy	Cotton residue	Grain residue	Wheat residue	Peanut hulls	MSW	Total	Dairy percent
1	Chaves - Roswell	902.2	2.3	1.7	5.0		39.3	950.6	95%
2	Roosevelt - Portales	605.9	8.5	46.7	79.0	6.0	11.6	757.7	80%
3	Curry - Clovis	561.2	6.8	212.0	165.0	0.5	29.1	974.6	58%
4	Dona Ana - Las Cruces	501.5	5.8		6.0		118.6	631.9	79%
5	Lea - Hobbs	267.3	16.2		11.0	4.0	35.8	334.3	80%
6	Eddy - Artesia	170.7	7.3	0.3			33.0	211.2	81%
7	South Albuquerque	133.0					-	133.0	100%
Total		3,142	47	261	266	11	267	3,993	



Dairy Biomass Supply

Dairymen have options in dealing with manure. Dairies are faced with new challenges and opportunities in dealing with manure these days. Challenges dealing with manure arise from higher handling costs to increasing environmental regulations on both the air and water side as well as public and neighbor relations.

Opportunities dealing with manure arise in the form of manure biomass as an energy source. With increased energy prices and increased government support in renewable energy, biomass becomes more valuable. It is estimated that dairy manure biomass (dry matter) basis is worth over \$100 per ton on today's retail energy basis.

Dairymen have several options:

1. Continue as before, primarily land application of manure.
2. Give away manure to others who intend on its conversion to energy products.
3. Sell manure directly to others who intend on its conversion to energy products.
4. Organize to form a biomass supply "group" who sells biomass for conversion.
 - a. This "group" could be a partnership, Limited Liability Corporation (LLC) or Cooperative.
 - b. The supply "group" could also own all or part of a conversion plant much like they do in milk or cheese cooperatives.

Dairy Manure Management

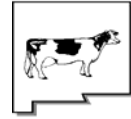
Dairy manure management includes: collection, transport, storage, treatment, disposal, and utilization. New collection methods are being utilized on dairies which include mechanical and vacuum assisted loader units as well as efficient solids separation systems on flush dairies. Collection and/or separation of manure solids and conversion to bio-products can fit into existing management practices of dairies and eliminates their concerns of environmental problems. Land application of manure can be substantially decreased or eliminated.

Example: Biomass Production, Collection and Delivery (Exhibit M)

Dairies in the Pecos Valley region can supply biomass (manure) to a centralized biorefinery located in the geographic center of the primary dairy population. The daily biomass production rate of approximately 46 dairies in the region is over 1,073 tons per day (Dry Matter [DM] basis) and it is estimated that 50-60% of this quantity (550-650 tons per day) could be delivered to a biorefinery on a regular basis. The majority of these dairy facilities lie within an 11 mile radius. Crop residues and other biomass feedstocks (10-20 tons/day) in the area can also be utilized in the biorefinery.

We must qualify our terminology of biomass moisture content. Throughout this paper and spreadsheets, I will use biomass as dry matter DM only; however, this is never the case in reality. Manure is deposited as 85% moisture, typically is 40-70% moisture in static piles and can be dried to 20% moisture in compost lines. Only through thermal drying can manure biomass reach < 5% moisture levels. Keep in mind, it takes about 1,000 btu/lb to vaporize water, an expensive proposition with these quantities.

Quality of the biomass is of the utmost importance and the energy content in biomass manure degrades quickly as the Volatile Solids (VS) decay. Energy values DM basis will be in the 6,000-



7,500 Btu/lb range of well managed biomass. Collecting biomass (manure) quickly and frequently not only assures that the biorefinery maintains a quality feedstock; it also helps the dairies minimize odors and gaseous emissions.

Dairies in the Pecos Valley are primarily dry lot dairies. Only a few of the dairies have feed alley flush systems. All have separator-lagoon systems for their parlor effluent. Biomass Manure feedstock will be a compilation of all the manure collected in different ways on the dairy. The 50-60% biomass manure collection estimate is based on many variables.

Dairy manure is typically deposited in three locations on the dairy depending on the amount of time the cows spend in each location; 15% in the milking barn, 35% in corrals and 50% on feed alleys is a typical estimate. The manure may be mixed together or collected separately, depending on facility design and management style. Because of the collection inefficiencies associated with each of these particular areas, only a percentage of the deposited manure can be collected.

Manure washed out of the milk barn is sent to a separator screen where approximately 25% is separated from the effluent. The remainder in solution is sent to the lagoon.

Approximately 75% of the manure from the corrals is collectible because much is spread around by the animals and some material is needed to maintain a “manure pack” above the soil.

Approximately 95% of the feedstock deposited in the concrete feed alleys is collectible if removed directly instead of dragging it into the corrals.

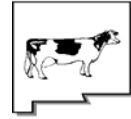
And lastly, not all dairy facilities in the region will participate in the program. Participation of at least 75% of the dairies would be required to meet the economies of scale for a cost-effective biorefinery. Approximately 613 tons/day DM could be delivered from 75% of the dairies in the region.

The biorefinery system is intended to improve environmental stewardship in the area. It will be one of the first of its kind and will be highly scrutinized. Due to zoning restrictions, permitting, public perception and future litigation concerns; outside processing of manure should not take place at the biorefinery. Any outside processing required should take place separate from the biorefinery.

Region	% Dairies	Parlor	Corral	Alley	Parlor	Corral	Alley	Total MC	Heifer	Total	%
	participating	deposited	deposited	deposited	Collection	Collection	Collection	Collection	Collection	Collected	
	75%	15%	35%	50%	25%	75%	95%	58%	55%	Tons/day	
1	479.91	71.99	167.97	239.95	18.00	125.98	227.96	371.93	144.29	516.22	57
6	90.78	13.62	31.77	45.39	3.40	23.83	43.12	70.35	27.29	97.64	57
Total 1 & 6	570.68	85.60	199.74	285.34	21.40	149.80	271.08	442.28	171.59	613.87	

Biomass Collection/Harvesting Efficiency

The most popular method of handling corral manure is scraping with a tractor and box blade. This system is a very time consuming and inefficient method of moving manure. If manure is scraped into piles it requires multiple passes; as many as 30-40 are required for cleaning. The piles must then be loaded onto trucks by front-end wheel loaders.



There is a need for improved biomass/manure harvesting system for dry lot confined animal (beef and dairy) operations. A prototype manure loader truck has been built and in operation for over two years collecting manure from the concrete feed aprons of confined animal operations.

A similar truck needs to be engineered and constructed for operation in the dry lot corrals. The majority of large confined animal operations in the US are dry lot facilities, yet most of the attention has been given to the conversion of animal wastes into energy products, primarily by anaerobic digestion and its production of biogas from manure slurries of large dairy facilities.



Little attention has been given to the energy production potential of biomass from dry lot beef and dairy operations for three reasons. These include:

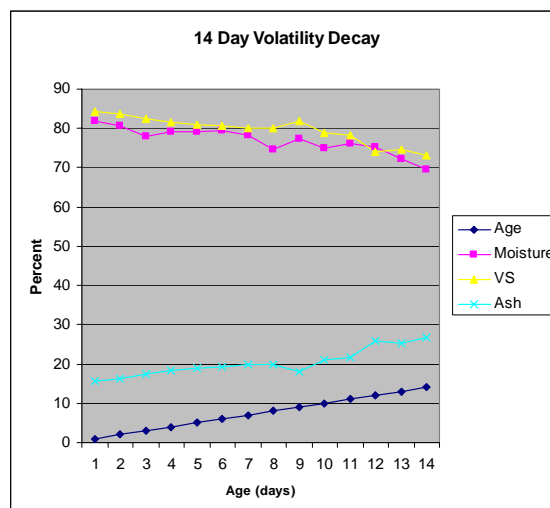
1. Energy Value - Manure decomposition in dry lot operations leaves a biomass product high in ash, debris and low in energy value.
2. Handling - Inefficient collection mechanisms; manure is simply scraped up into piles and stockpiled for months allowed to decompose and then removed with front-end wheel loaders.
3. Biomass to energy conversion mechanism – Equipment for the conversion of dry biomass such as gasifiers has only recently become commercially available.

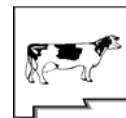
Biomass Energy Value Lost

The energy content in manure on dry lots decreases significantly before collection. Manure wastes contain fats, carbohydrates and proteins called "volatile solids." From the moment manure is deposited it begins decaying by aerobic or anaerobic processes where a portion of the waste is converted into gasses losing energy in the uncontrolled environment.

The quality of the feedstock in terms of its energy yield will partly depend on its freshness: the fresher it is, the higher the energy yield will be. A study conducted by DPNM and NMSU with dairy feed lane manure over a two-week period of time showed a 15% decrease in VS.

Chart 1: Volatile Solids Decay of Dairy Manure on Dry Lot corrals.





A range of energy values can be expected from biomass. Table 3 is a proximate analysis of two typical dairy manure samples. Table 4 is a typical dairy manure production calculation yielding a dry matter daily production of 15.6 pounds DM per cow.

Table 3: Dairy Manure Sample Proximate Analysis & Energy Values

Proximate Analysis, Weight Percent		
	SAMPLE 1	
	Wet Basis	Dry Basis
Moisture	24.99	0
Ash	17.19	22.92
Volatile	48.21	64.27
Fixed C	9.61	12.81
Total	100	100

Ultimate Analysis, Weight Percent		
Moisture	24.99	0
Carbon	30.94	41.24
Hydrogen	3.15	4.2
Nitrogen	1.89	2.52
Sulfur	0.5	0.67
Ash	17.19	22.92
Oxygen	21.34	28.45
Total	100	100
Chlorine	0.1	0.13

Higher Heat Value, Btu/lb	
Wet Basis	5,024
Dry Basis	6,697
Dry Ash free	8,087

Elemental Analysis of Ash, Weight Percent	
SiO ₂	27.97
Al ₂ O ₃	4.85
TiO ₂	0.24
Fe ₂ O ₃	1.66
CaO	18.8
MgO	6.34
Na ₂ O	3.82
K ₂ O	19
P ₂ O ₅	5.2
SO ₃	4.39
Cl	0.05
CO ₂	1.3
Total	94.07

SAMPLE 2	
Wet Basis	Dry Basis
18	0
31.1	41.6
38.8	47.3
12.1	11.1
100	100
18	0
27	33
4	4.9
0.57	0.69
0.64	0.78
31.1	41.6
14.3	17.5
95.61	98.47
1.32	1.61
5,330	
6,350	
9,216	
59.5	
9.8	
0.4	
1.3	
7.2	
2.3	
1.4	
4.2	
4.7	
3.7	
3.6	
0.9	
99	

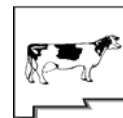
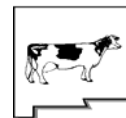


Table 4: Dairy Manure Production Estimates

Yearly averages	Example	Units
Herd Information:		
Average number milking cows/d (d = day)	1800	milk cows
Average DMI/d (DMI = dry matter Intake)	52	lb/d DMI
Average diet CP % (DM basis) (CP = crude protein)	17	% CP
Average diet N % - CP % x .16 =	2.72	% N
Average diet P % (DM basis)	0.5	% P
Average diet K % (DM basis)	1	% K
Milk yield/d (milking cows)	60	lb/d
Milk protein percentage	3.2	%
Milk N % = protein % x .155 =	0.496	% N
Milk phosphorus (P) %	0.1	% P
Milk potassium (K) %	0.15	% K
Average net body weight gain/day	0.2	Lb/d
Average N % Of weight gain	1.2	% N
Average P % of weight gain	0.7	% P
Average K % of weight gain	0.2	% K
Average diet DM digestibility %	70	%
Dry Matter production		
Input: lb DMI	52	lb/day DMI
Output (feces) = lb DMI- (dig. x DMI) =	15.6	lb DM
Output (urine): = .05 x DMI	2.6	lb DM
Total DM output/d = feces + urine =	18.2	lb DM
Manure DM output, % of input =	0.35	%
Manure DM/yr = cows x output DM/d x 365d =	5,979	tons/yr/herd
Manure organic matter/yr = DM/yr x .83 =	2	tons/yr
Wet manure/yr @ 14% DM = DM/yr / .14 =	21	tons/yr
% manure collected (% of time in area)	100	%
Per Milk Cow Output (feces) DM/year	5,694	lb DM/yr/cow
Herd output (feces) DM/year	5,125	ton DM/yr/herd
Herd output (feces) DM/day	14.04	ton DM/day/herd



ii. Specific criteria for and potential participants of a biomass cooperative of all Regions.

In order to commercially develop Biomass into Bioenergy, the Biomass supply (producers) and a Bioenergy Processor must be brought together. Processors hesitate to commit to a product that is not readily available and producers hesitate to commit to supplying product with no assurance of demand. A **Biomass Cooperative** can address the many challenges of bringing this new supply to an energy market. Dairy Producers of New Mexico, in their efforts to access the feasibility of a Biomass Project, has made tremendous progress in laying the foundation for a Biomass Cooperative enterprise.

Before a market commits to regular use of Biomass, several things need to happen. Mechanisms need to be put in place to maintain adequate production/collection of Biomass. Mutually satisfying fuel supply contracts must be developed. Mechanisms for processing, quality control and on-time delivery to the market must be developed. Biomass may need to compete with other renewable energies that may be available at lower cost. Higher value markets in the area might also compete for the Biomass supply.

The Bioenergy Processor will prefer to contract with one entity. They will not be inclined to develop separate contracts with individual producers for biomass supply. This single point of contact could be a cooperative or a private biomass broker. Initial estimates of the costs of production and the estimated price for delivered biomass indicate a narrow margin of profit. A biomass broker acting as a middleman between producers and the energy market would cut into the profits that would otherwise go to producers. The cooperative business structure provides an opportunity to distribute dividends to all producers while delivering biomass supplies to Bioenergy Processors at a price they are willing to pay. This can be accomplished by a cooperative through reductions in production costs and the costs of other services required for marketing and delivering biomass, and by increasing the value of the product.

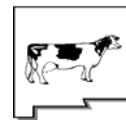
Specific criteria of a biomass cooperative are laid out in the following four legal documents. By way of example, these documents for the Pecos Valley Biomass Cooperative, Inc. are included as Exhibits A-D in the Appendices.

BIOMASS COOPERATIVE, INC

1. Agreement to Form Cooperative and to handle biomass collectively – Exhibit “D”
2. Articles of Incorporation of Biomass Cooperative, Inc. – Exhibit “A”
3. Bylaws of Biomass Cooperative, Inc. – Exhibit “B”
4. Membership and Marketing Agreement – Exhibit “C”

Potential participants of a biomass cooperative within each region consist of all biomass producers in the region including dairy farms, farmers growing crops as outlined in the feedstock sources section, city or county waste facilities. The entire list is too extensive to list; however as an example, Exhibit “E” lists the potential participants in the Pecos Valley Biomass Cooperative, Inc. region.

5. Potential Participants in the Pecos Valley Biomass Cooperative, Inc. region. Exhibit “E”



II. Bioenergy conversion technology and Biofuels products.

- iii. A detailed assessment of **available technologies** for converting biomass product and a recommended technology most suitable for all Regions.

Included in the Appendix is a section on Biomass Conversion Technologies examined in the project.

1. Anaerobic Digestion
2. Biomass Gasification
3. Biomass Combustion
4. Fast Pyrolysis

It would be extremely difficult and incomplete to attempt to give a detailed assessment within this report of available technologies for converting biomass. The federal government and many state governments have done an excellent job at this task. An extensive internet search was conducted for the best information on these topics. Below are links for two of the best resources on this topic.

U.S. Department of Energy; Energy Efficiency and Renewable Energy; Biomass Program

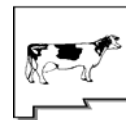
<http://www.eere.energy.gov/biomass/>

I have included a synopsis of the program:

Biomass use for food, clothing, shelter, and fuel of course dates to man's earliest years. Intensive fossil fuel use greatly expanded man's use of energy, fostering the Industrial Revolution and much of modern technology and lifestyle. But the finite supply of fossil is rapidly diminishing and its use carries a price in economic and security concerns, pollution, and global warming. [Biomass technology today](#) already serves many markets that were developed with fossil fuels and modestly reduces their use. These uses include [industrial process heat and steam](#), [electrical power generation](#), transportation fuels such as [ethanol](#) and [biodiesel](#), and valuable [chemicals and products](#) that would otherwise likely be made from oil or gas.

The primary focus of the Biomass Program and this Web site is to dramatically expand the use of biomass by developing advanced technologies such as making ethanol and valuable chemicals from [cellulosic biomass](#) instead of grains and [gasifying or liquefying biomass](#) for more efficient power production or for [catalytic conversion](#) to valuable products. The program foresees a future in which [biorefineries](#) would convert biomass into a variety of fuels, chemicals, materials and power, much as petrochemical refineries do with oil and gas. To foster that future, the Biomass Program focuses on two "platform technologies" by which biomass would be converted to base platform chemicals from which this variety of products could be made.

[Sugar platform](#) technology breaks cellulose and hemicellulose (the bulk of most plant material) down into their component sugars so that those sugars can be fermented or otherwise converted to valuable fuels and chemicals. [Thermochemical platform](#) technology transforms solid biomass to gas or liquid by heating it with limited oxygen. The intermediate synthesis gas or pyrolysis oil can then be more efficiently and cleanly combusted or converted to valuable chemicals or materials.



The Biomass Program looks to industry to apply a wide range of technologies to develop products from sugars, lignin, synthesis gas, pyrolysis oils, and other intermediate chemicals developed with these platform technologies. While the program is focusing on these two most promising technology areas, there are also a variety of other platforms with potential for supporting large-scale biomass technology development.

Several very useful resources are available to you to help find documents of interest relating to biomass.

- The Biomass Document Database is a comprehensive collection of technical and outreach documents produced by the Biomass Program and predecessor Biofuels Program.

<http://www.eere.energy.gov/biomass/publications.html#feed>

iii. A detailed assessment of **available technologies** for converting biomass product and **a recommended technology most suitable for all Regions.**

Start out defining the **biomass characteristics** we have for our Anchor Feedstock:
New Mexico Dairies

Location (is critical to economies of hauling biomass)
Six separate areas of dairy concentration

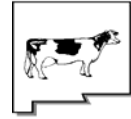
Physical properties of the majority of our biomass
Moisture (85% collected dry)
Ash (higher than wood)
Odor
Potential pathogens
High lignin content

Narrow the field of conversion technologies based on our **biomass characteristics**

Eliminate what is less likely to work based on our biomass characteristics

Anaerobic Digestion – Gas – Elec.
Wet process
Concentrates N in solution (we are permitted on N)
Small conversion of solids to energy
Hard to “base load”
Cannot store end product (elec or gas)
Hard to sell end product (no utility interest – opposition)
No – Net metering
Difficult interconnect agreement
Multiple meters on each facility
Standby charges

Combustion steam driven electric turbine
Requires very large plant size (Utility project, PNM)
Lower value end product (wholesale elec.)
means lower biomass commodity price to producers
Electric Renewable Portfolio Standard filled with wind power



Long hauling distances for large biomass demand

Densification for thermal use (pellets, logs)

High ash content

Odor

Potential pathogens

Hydrolysis

Small conversion of solids (low lignin conversion)

Wet process

Focus on technologies that fit our biomass characteristics

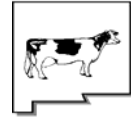
Gasification

Pyrolysis

Hydrothermal Liquefaction (entrained moisture returned)

Gasification is the recommended technology most suitable for all regions based on our biomass characteristics and its potential for integrating with and supplying power to local energy markets within our allied industry group. There are many gasification companies which have prototype systems or beta test units; however, two companies in particular stand out in the field of gasification primarily because of their proven commercial installations. These are Primenergy LLC of Tulsa Oklahoma (Exhibit N) and Westwood Energy Systems of Kamloops, BC (Exhibit O).

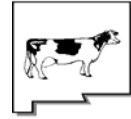
The Pecos Valley Biomass Cooperative, Inc. is currently analyzing potential systems with both Primenergy LLC and Westwood Energy Systems.



U.1 . An assessment of the potential viability of developing biomass conversion plants in all Regions.

The potential viability of several different type of biorefineries are outlined in the Appendix: Spreadsheet 2, Dairy biomass delivered to plant; for ethanol production and electrical production. The estimate for steam production by gasification and delivered to a local allied industry is copied below. The estimate yields a simple payback of 1.5 years.

Allied Industry Cogeneration	INPUTS RED	
Steam Loads		
Current load	80,000.00	lbs/hr
Percent supply goal	75%	
"Base Loaded " Steam Load	60,000.00	lbs/hr
Steam Pressure	150	psi
Enthalpy	1194	Btu/lb
Ideal energy required	71640000	Btu/hr
Ideal energy required	71.64	MMBtu/hr
BHP conversion	34.5	lbs/BHP
Boler Horse Power equivalent	1,739.13	BHP
System efficiency (boiler & gasifier)	80%	
Energy required	89.55	MMBtu/hr
Energy required	2,149.20	MMBtu/day
Biomass		
Biomass energy as Recd	6,500.00	Btu/lb
	13,000,000.00	Btu/ton
	13.00	MMBtu/ton
ash	26.64%	% ash
moisture	20.32%	% M
Biomass required as Recd	6.89	Ton/hr
Operational hours	23	hours
	158.43	Tons/day
Trucking Requirements		
Truck quantity	24	Tons/truck
Truck per day required biomass	6.60	Truck/day Biomass
Ash generated	42.21	Tons/day ash
Trucks per day ash	1.76	Truck/day Ash
Total truck per day operating	8.36	Trucks/day
Truck per operating year	2,758.82	Trucks/year



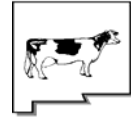
Yearly gas sales	\$ 3,093,923.84
Yearly trucking	\$ 137,941.10
Biomass drying costs	\$ 522,834.23
Biomass processing	\$ 660,775.33
Net sales	\$ 2,433,148.52
Net biomass per ton	\$ 46.54
\$/1000 lbs steam delivered	\$ 5.10

Biomass Samples	Btu/lb
Sample 1	4652
Sample 2	5500
Sample 3	6500

Capital plant costs	Estimates
Unloading & storage	\$ 500,000.00
6-10 Ton/hr Gasifier module	\$ 2,500,000.00
Ash handling & storage	\$ 200,000.00
Area works	\$ 250,000.00
Misc	\$ 400,000.00
Total capital equip	\$ 3,850,000.00

Gas Pricing		
5 Yr Industrial gas avg.	5.69	
Discount	20%	
Gas discount	1.138	
Gas discount price	\$ 4.55	\$/MMBtu
Hourly gas sales	\$ 407.63	\$/hour
Daily gas sales	\$ 9,375.53	\$/day
Operational days	330	days/year
Yearly gas sales	\$3,093,923.84	
Yearly biomass	52,283.42	tons/year biomass
Biomass value before costs	\$ 59.18	\$/ton

Avg. Trucking cost	\$ 50.00	\$/load
Daily trucking	\$ 418.00	\$/day trucking
Yearly trucking	\$ 137,941.10	\$/year trucking
Biomass trucking costs	\$ 2.64	\$/ton



Remote Drying		
Biomass drying costs	\$ 10.00	\$/dry ton
	\$ 1,584.35	\$/day drying
	\$ 522,834.23	\$/year drying

Goal: 3 yr simple payback capital equipment		
Plant capital costs	\$3,850,000.00	
Years simple payback	1.58	
Actual finance 7-10 years		

Regarding the potential viability and probability of one or more biomass conversion facilities.

PROBABILITY: 99%, what does that number mean? The 1% uncertainty is simply because of the difficulty of organizing all the participants.

Within one year and under current energy market conditions; new energy bill provisions; according to the level of interest by biomass suppliers; technology providers and potential financial participants; the probability of at least one of the following biomass conversion facilities is 99%.

Gasification to Syngas

- Syngas to ethanol
- Syngas to fire boiler
- Syngas to electricity

Digester to biogas

- Biogas to pipeline methane
- Biogas to fire existing local boiler
- Biogas to electricity

Biomass combustion

- Combustion fired boiler for steam
- Combustion steam electrical generation

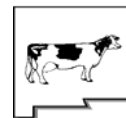
Pyrolysis to biocrude oil

- Biocrude oil to diesel
- Biocrude oil to electrical

The probability of a biomass conversion facility to become a reality in New Mexico depends on many variables.

Biomass as a commodity

The system of commodity production and commodity trading is the backbone of the U.S. agriculture and energy system.



Biomass will become a regularly traded cash commodity, graded and paid for by its quality ranking much like other commodities like oil, hay, grains, etc.

A Biomass Program will establish biomass as a new cash commodity stimulating new economic growth and development, providing a new source of revenue to rural and urban producers.

Biomass to Biofuels

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels—biofuels—for our transportation needs (cars, trucks, buses, airplanes, and trains). The most common types of biofuels are *ethanol, biodiesel FTdiesel, refined bio-oil, and methanol*.

Processors will capitalize on the unique attributes of biomass (as compared to the other renewable energy sources) as being able to be converted to biofuels.

Biofuels impact on reducing oil imports

New locally produced synthetic biofuels has the greatest potential impact on reducing U.S. dependence on imported oil and thereby increasing national energy security.

Biofuels flexibility

Biofuels are storable and dispatch-able unlike other renewable energy alternatives. Biofuels can be co-utilized with existing coal and natural gas systems.

Biomass feedstock supply

The commodity biomass will be collected, consolidated and processed at key locations across the state.

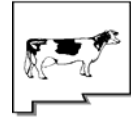
Biomass Dual Environmental benefits

Dual Environmental benefits as clean energy fuel and utilization mechanism for waste streams.

Biomass program will convert existing low value waste streams into a high value high demand product.

Biomass a part of the Renewable Energy Mix

RE utilization reaps the greatest benefits when geared around the unique attributes of the energy source in relation to its potential energy output. We should not view biomass utilization as an isolated event.



	Renewable						Non-renewable	
	Location Specific						Natural Gas	Coal
	Highly			Low				
	Geothermal	Hydro	Biomass	Wind	Solar	Conc solar		
Low Thermal	X		X		X		X	X
Electrical	X	X	X	X	X	X	X	X
High Thermal			X			X	X	X
Liq Fuels			X				X	X

Biomass Focus

Focus on strategies that will make a difference to our primary objective.

Biomass utilization primary Objective Set

Decrease our dependence on imported petroleum and increase U.S. energy security. Our latest U.S. concerns are not just a reduction of fossil fuels but the reduction of imported petroleum.

Unlike the other renewable energy sources of wind, solar, geothermal and hydro, biomass can be converted to liquid fuels and have a direct impact on imported petroleum.

Biomass has many participants in rural New Mexico, keeping the money at home and spreading the wealth locally.

Environmentally biomass utilization has a dual benefit of being a clean fuel alternative and waste stream utilization.

Incentives needed for Biomass to biofuels

U.S. tax credits to match ethanol and biodiesel. Biofuels like FT Diesel produced from 100% renewables should receive comparable tax credits.

State biomass haulers incentive (similar to Texas program for hauling dairy biomass for composting) pays per ton hauled.

Financing

Development and organizational funds

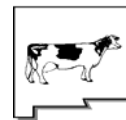
City initiative to separate bio-wastes

Biofuels advantages over other RE utilization

Electrical – no interconnection, net metering hassles

No variable loads, can be base loaded to specs fulltime

Fewer sites, easier to manage emissions



v. Identification of commercially viable end products from biomass conversion.

Syngas

Biomass gasification is a high-temperature process (600 to 1000C) to decompose the complex hydrocarbons of biomass into simpler gaseous molecules, primarily hydrogen, carbon monoxide, and carbon dioxide. Some char, mineral ash, and tars are also formed, along with methane, ethane, water, and other constituents. The product gas must be cleaned of solids, tars, and other contaminants sufficient for the intended use.

The mixture of raw product gases varies according to the feedstock and gasification approach.

A typical composition of a medium energy biobased syngas from biomass gasification is as follows: hydrogen (H₂) 22.0 percent, carbon monoxide (CO) 44.4 percent, carbon dioxide (CO₂) 12.2 percent, methane (CH₄) 15.6 percent, ethylene (C₂H₄) 5.1 percent, and ethane (C₂H₆) 0.7 percent, with a heating value of (about 465 Btu/scf).

Systems producing either fuel gas or syngas must deal with the cleanup of five primary contaminants including particulates (mineral ash and char), alkali compounds, tars, nitrogen-containing components, and sulfur. Methane, ethane, and other hydrocarbons are acceptable if the products gases are to be combusted.

Biogas

Biogas is the major product of anaerobic digestion. It is 60-80 percent methane, with carbon dioxide and trace gases comprising the balance. Biogas can be fired like most natural gas streams, although most applications require that the gas be cleaned to remove corrosive trace elements.

Biogas replaces natural gas (\$5.582/MMBtu¹, although this fluctuates throughout the year), but biogas must be cleaned before use, reducing its effective price.

Ethanol

Ethanol, or ethyl alcohol, is a clear liquid used primarily as a fuel additive – specifically, an oxygenate blended with gasoline to reduce net carbon monoxide emissions. The use of ethanol in gasoline is legislatively mandated, which ensures an ongoing market for the fuel. Ethanol sells for \$1.28–\$1.40/gallon, depending on corn prices and delivery charges, there is a tax credit available to the fuel blender.

Typical production: Fermentation of 6-carbon sugars and starches, fermentation of lignocellulosic biomass, wet mill corn processing, dry mill corn processing.

BioCrude (Pyrolysis Oil)

BioCrude is a free-flowing, dark brown liquid that can be stored and transported, allowing decoupling of feedstock, process, and use.

Prior to removing extractives for secondary products, “whole” bio-oil has a higher heating value of approximately 7500 Btu/lb, and a lower heating value of 6850 Btu/lb. After extracting value added chemicals, the residual bio-oil heating values are reported to be approximately the same or slightly higher. For improved economics, the manufacturer recommends extracting higher value secondary products such as resins and food additives prior to using the residual as fuel.



A complex, combustible mixture of oxygenated hydrocarbons, with a low pH in the range of 2.5, a specific gravity of 1.2 (about 40 percent greater than fuel oil), and a moisture content of 15 percent to 30 percent.

III. Collaboration, education and outreach.

i. identification of potential resources and collaborative agencies/organizations to assist with development of proposed conversion plants.

To accomplish collaboration, education and outreach for the project we identified three groups.

Group One: DPNM members; power point presentations (Exhibit L) were given in each of DPNM's six district meetings and at the DPNM annual meeting.

Group Two: A Biomass Review Committee was formed. The following letter was sent out: Expertise for the committee was sought in these areas: Banking and Finance; Accounting; City Municipal; Permitting; Government; University. A power point presentation was given to the committee and the tasks outlined below were discussed. A complete list of the Biomass Review Committee is provided in (Exhibit K).

Group Three: New Mexico Dairy Allied Industries for Dairy Biomass Energy Utilization (Exhibit J)

Dairy Biomass Energy Cooperatives should seek out strategic alliances with NM Dairy Allied Industries. Rising energy costs for these industries ultimately affect individual dairies and the dairy industry. Dairy biomass can provide a large percentage of electrical and thermal energy for these industries. A complete list of the following is provided in Exhibit J.

Roswell Area

1. Leprino Foods Company
2. Select Milk Producers, Inc.
3. Hi-Pro Feeds

Clovis/Portales Area

4. Southwest Cheese Company L.L.C.
5. Garvey Processing Inc., Portales
6. Dairy Farmers of America (DFA) (DairiConcepts) Portales
7. Gore Brothers Inc., Clovis
8. Abengoa Bioenergy

Hobbs/Lovington Area

9. DFA Processing Plant, Lovington, NM

Las Cruces Area

10. F & A Dairy Products Inc.



December 6, 2004 – Letter

Dairy Producers of New Mexico has received a grant to study the sources, conversion and possible end products for biomass within six specific dairy regions in New Mexico. We are very excited about this study recognizing that it could bring another value to our biomass resources (i.e. manure, crop residues, MSW etc.).

We would like to develop a Review Committee to assist us in the direction of this study. This Review Committee would meet at least once a month to review the project as it is developed.

We should have the study completed by the end of May, 2005. I'm anticipating a great deal could even be done by email, since I'll be in the middle of our legislation session most of that time.

I would like to invite you to sit on this Biomass Review Committee. If you are interested, please email me, or call me, and I will forward you a copy of our proposal and timetable.

Thank you for your consideration in this matter.

Sincerely,

Sharon L. Lombardi
Executive Director

Tasks for the Review Committee; hash out the preliminaries of dairy biomass potential.

Dairy Producers of New Mexico believing strongly that they support Biomass developed the following position statement for their association at the September 16, 2004, Board of Directors meeting:

“DPNM supports the promotion of dairies as biomass fuel suppliers for renewable energy. Biomass is a fuel and or a fertilizer, and like other commodities like coal or natural gas it should have an associated value.”

DPNM supports renewable energy systems for dairy in order to promote better dairy environmental stewardship.

Environmental

- Public Image
- Odors
- Gas emissions
- Herd health
- Potential water contamination
- Potential pathogens

Value

The conversion into renewable energy is a value added product.

Today's dairies are in the public eye.

The biorefinery plant itself has to be a positive image for biomass to renewable energy conversion.



Products of a dairy farm: Milk, Renewable Energy.

Feedstock system should be a benefit to dairies and conversion facility.

Incentive-ize feedstock handling.

Conversion facilities need a consistent, storable, low ash, high VS, low moisture, clean and uniform product delivered at the best price.

REVIEW COMMITTEE CONSIDERATIONS

A look at the big picture to formulate a plan of action.

Why a biomass project, what direction to take?

Type of project

Individual on-site dairy conversions

Best suited where an individual facility is not in close proximity to a central processing site.

Centralized Multiple Dairy project

Economies of scale

Shared process equipment

Process off site, away from dairy

Basic Questions first? To get answers we have to ask questions?

Why is DPNM involved with renewable energy?

What can conversion of dairy manure to renewable energy do for dairy environmental concerns?

How much biomass does a cow make?

How much biomass can we collect?

Where is all this biomass located?

How much energy value and other stuff is in our biomass?

What can we make from our biomass?

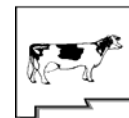
What equipment is available to convert biomass to useful stuff? What works, what doesn't?

How is our biomass different from other kinds of biomass?

The public and environmental groups seem to care a lot about what we do these days: Will this help?

Do other groups organize for biomass supply?

How do we organize ourselves to move ahead?



Environmental Benefits to Dairies

Frequent collection of manure is one of the most effective ways to reduce emissions.

Decreases gaseous emissions including ammonia, hydrogen sulfide, methane, carbon dioxide and volatile organic compounds, which contribute to odors.

Reduction of particulate matter (fine dust) which also emanates from corrals. Maintaining a uniform “manure pack” on top of the soil helps reduce particulate emissions.

Frequent collection disrupts the fly larvae cycle reducing fly propagation.

Regulations for air emissions from EPA Region 6 NPDES CAFO permits are increasing.

Some states have proposed regulations to reduce emissions. California Air Quality Management District (AQMD) proposed rule: AQMD Rule 1127 – Emission reductions from Livestock Waste, would require dairies to clear manure from corrals more frequently and send the manure to an emissions-controlled composting facility, an anaerobic digester (power conversion site). The rule also contains other provisions to minimize dust.

Clean environment advantages

- Breeding – Dairy personnel will do a better job breeding in a cleaner environment.
- Herd Health – Cows will be healthier in a cleaner environment. Fewer hoof problems. Less Mastitis.
- Flies – There will be fewer flies in a cleaner environment.
- Visual and aesthetic – Dairy will be cleaner, look cleaner.

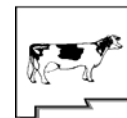
Cleaner dairies mean
Cleaner cows,
Fewer flies,
Happier employees,
Happy neighbors.

Clean Corrals



Clean Lanes





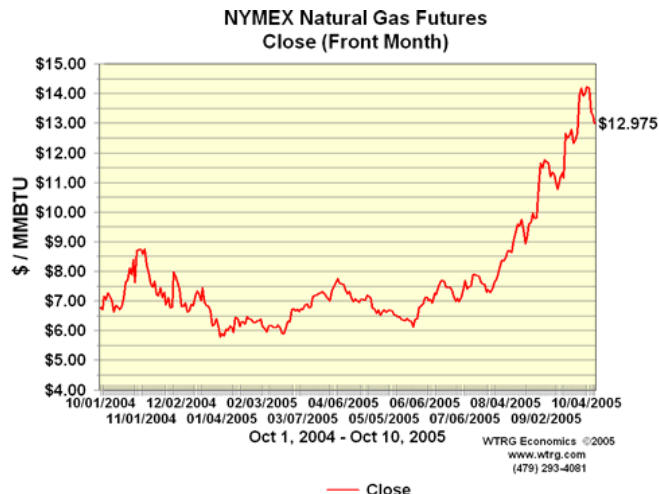
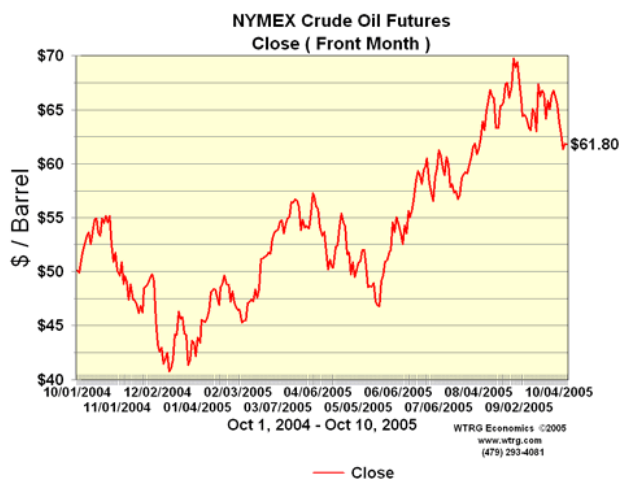
Conclusion

One would think with all the activities going on there would be more interest and more efforts in developing renewable energy. And here are just a few:

- Record Energy Prices
- NM Governor's Clean Energy Executive Order and Task Forces
- New Mexico Governor Bill Richardson signs Executive Order to fight climate change
- EPA Confined Animal Feeding Operation regulations
- What is next?

Record Energy Prices

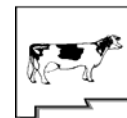
At the time of this writing, oil and gas prices are at an all time record high. Crude Oil \$61.80 per Barrel and Natural Gas \$12.97 per MMBtu. Biomass at 6,500 Btu/lb = 13 MMBtu/ton = \$168.61/ton. Biomass manure delivered to a local boiler would cost < \$10/ton. Now is the time to utilize biomass energy.



NM Governor's Clean Energy Executive Order and Task Forces

Clean Energy Development Council – Established pursuant to Executive Order 2004-019 declaring New Mexico the “Clean Energy State” and establishing an internal Clean Energy Development Council (CEDC) consisting of relevant cabinet secretaries. All task forces are charged with developing policy and legislative recommendations. The CEDC initially established six task forces one of which is biomass.

- **Biomass** – The mission of the Biomass Task Force is to develop recommendations for increasing the development and use of New Mexico's biomass resources, including:
 - Identify barriers (technical, economic, financing, regulatory, etc.) impeding the more widespread adoption of biomass technologies in various diverse applications throughout the state.



- Examine other states' biomass laws/regulations, policies and initiatives.
- Formulate and analyze promising solutions for overcoming identified barriers.
- Determine what policies and programs could be implemented by the Richardson Administration to accomplish the Task Force mission.
- Develop legislative proposals that would stimulate the biomass market in New Mexico; prioritize all proposals; provide justification/documentation of anticipated benefits.

New Mexico Governor Bill Richardson signs Executive Order to fight climate change

SANTA FE, NM (06/14/05) – Governor Bill Richardson has signed an Executive Order that mandates a thorough evaluation of ways to significantly reduce greenhouse gas emissions, sets aggressive reduction goals, and creates the New Mexico Climate Change Advisory Group (NMCCAG) with broad industry and environmental representation.

"A group of national science academies from various nations including Brazil, China, India, Japan, Russia, and the United States has confirmed the science of global warming and climate change," said Governor Richardson. "Those groups agree that we must work together to reduce greenhouse gas emissions, and if we don't act soon, the potential consequences could be devastating - from sea level change, to drought, to weather disasters. Without action at the federal level, states like New Mexico have a responsibility to address this important issue."

The Governor's Executive Order directs the New Mexico Climate Change Advisory Group (NMCCAG) to find ways to reduce New Mexico's total greenhouse gas emissions to 2000 levels by 2012, 10% below those levels by 2020, and 75% below 2000 levels by 2050. These goals are among the most aggressive in the nation.

"Addressing climate change not only protects future generations, it also strengthens our economy," said Governor Richardson. "The corporate world knows that actions to reduce greenhouse gas emissions on a national level are coming. Companies that are out ahead of this curve will be the ones to benefit in this future economy. GE knows this and so does PNM. Together, we can continue to move New Mexico forward, in ways that are environmentally and economically sustainable."

EPA Confined Animal Feeding Operation regulations

EPA's CAFO regulations are the new minimum standards for all livestock operations that meet EPA's definition of a CAFO. The schedules for compliance vary among existing facilities designated as CAFOs. Many of the regulations must be met by December, 2006.

That doesn't mean they're the ultimate regulations. States can always choose to pass more rigorous standards and to enforce them. In many states, this is the case for certain types of livestock operations and especially for producers of certain species of livestock. When state or local laws and regulations exceed the minimum requirements for federal standards, then those are the rules in force. When state standards are less restrictive, the EPA standards are the rules in force. New Mexico will fall under EPA Region 6 permit, however dairy producers also fall under the New Mexico Environment Department ground water permits as well.



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