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Biomass-Fired District Energy: A Source of Economic Development and Energy Security

FINAL REPORT

Prepared for:
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Beyond reducing our dependence on fossil fuels,
aside from the fact that it continuously renews itself,
biomass resources are stewarded by members
of the rural communities that once were the
heart of America.

The growth of oil and gas gave rise to a new kind of economy, in which a few companies provided for the energy needs of many users. As we transition to solar, wind, and biomass energy, we must honor those who spend their lives in close contact with these resources.

Taking a community-based approach to renewable energy means more than just creating jobs in rural areas.
It means helping communities get more of their energy from local, independent producers, thereby ensuring that they once again have a personal stake in their energy future.

We must acknowledge that a sustainable economy based on renewable energy will be very different from our fossil-fueled economy. Like the resources that will power it, it will be more localized, with a more equitable distribution of wealth. It will inspire us to once again focus on caring for the needs of our community.

Our work at Local Energy is dedicated to ushering in this new era of energy self-reliance.

PETROLEUM = GLOBAL DEPENDENCY
BIOMASS = COMMUNITY SELF-RELIANCE

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EXECUTIVE SUMMARY

A three-year study was carried out to design an energy project for Santa Fe, New Mexico in such a way that the local economic benefits created by the system are maximized. The project is to be a biomass-fired district energy system capable of heating the core of downtown Santa Fe with locally sourced biomass. Components of the project are:

- Technical – Design of the System
- Financial – Costs, Revenues, and Payback
- Environmental – Emissions Reductions and their Value
- Fuel – Quantity, Quality, and Cost
- Economics – Income and Energy Trends, Benefits of Localization
- Education – Papers, Articles, Lectures, and Curriculum
- Social – Ownership and Governance Structure of the Project

The technical study characterized the heat load of downtown Santa Fe by performing energy audits in 106 buildings downtown, including 10 residences, 18 commercial spaces, 15 hotels, 2 churches, and 8 schools. Based on the calculated load and load-density, two sites were selected as possible sites for the heating plant: the old Waste Transfer Station and the site of the old Coal-Fired Power Plant. Network lengths were calculated at 18.5 and 13.6 miles, respectively. Heating plants of two kinds were designed for each location: heat only, and combined heat-and-power (CHP). The heating plants have approximately 44-million BTU per hour of biomass-heating capacity, and nearly twice that capacity in gas-fired capacity. Even so, biomass provides about 95 percent of the annual heat load. The CHP plants have 1.1 megawatt-capacity, and generate electricity using an organic Rankine cycle process that uses silicon oil as the working fluid. Such systems are very low maintenance and have a proven track record of more than 6 years with biomass.

The financial analysis shows costs of the four system options (two configurations at two locations) ranging from $21.6 to $27.1 million. Heat is expected to be sold from the system at the current prevailing rate for gas heat, which is about $14.07 per MMBTU. Annual revenues from heat sales at this price are about $2.2 million. There is potential for an additional $50,000 in annual revenues from the sale of emissions credits, which could rise considerably in the future. None of the four design options show a positive financial performance in the conventional sense, with a dynamic payback of less than fifteen years, unless subsidies are provided. With a $12.8 million subsidy, the "heat-only" configuration at the Waste Transfer Station has a 15-year dynamic payback. The financial performance of all systems improves dramatically if the heat price is escalated. Adjusted for inflation, the cost of gas-fired heat in Santa Fe has been escalating 6.7 percent per year on average over the last 10 years, and 21.1 percent per year over the last three years.

Emissions from the system are compared to baseline emissions using both macro and micro-analyses, and show significant reductions in carbon dioxide and hydrocarbons. Particulate emissions rise (there are no particulates in gas), but the level remains low due to high efficiency and aggressive after-treatment of the flue gases. Nitrogen emissions also rise slightly, but remain low compared to vehicle emissions.

Market Vehicles for capitalizing on the value of the roughly 13,000 tons of reduced carbon emissions are investigated. These are worth about $4 per ton in U.S. markets, and several times that if they could be sold abroad. As an alternative, there may be more value in green-credits generated by the system, as some trial markets of thermal green-energy credits are being tested.

We looked at forest-thinning projects, municipal landfills, and commercial sawmills within a 50-mile radius of Santa Fe, and identified more than 30,000 tons of biomass fuel available on a sustainable basis. This is about 150 percent of the fuel requirement for the system. Far more supply exists, especially in planned forest-thinning projects (which were not counted—we only considered projects that had both environmental approvals and funding). About 24,000 of the 30,000 tons available were from the 10 sawmills we visited or spoke with.

Our economics study shows a significant and growing energy burden on Santa Fe County residents. Incomes over the past 12 years have grown just 5 percent faster than inflation, and the cost of home heating has risen 65 percent over the same period. The effect is regressive for a number of reasons, but primarily because low-income households already spend a disproportionate share of their income on energy, so increases in energy bills hit hard. The increased retention of energy dollars in the local community generates between $79 million and $8.9 billion in economic benefits over the 50-year life of the system, depending on how fast gas costs rise. If the benefits are discounted to consider the real cost of money, which is arguably—but not necessarily—valid, the discounts reduce to between $27 million and $1.1 billion – still quite significant. These numbers are deemed highly conservative, as they rely on gas-price escalation rates that are significantly lower than what we have experienced locally. The model furthermore did not account for the increased fraction of utility bill payments that leave the community when the hike in bills is due to an increase in the cost-of-gas portion of the bill, which is entirely non-local.

For our education effort, we publicly screened our documentary video five times, showing it to more than 400 people, and distributed 100 copies locally, nationally, and internationally. We developed and taught a course in biomass at the Santa Fe Community College, and gave interviews on three radio stations. We also gave more than 40 lectures and presentations about the project and the principles behind it. We are featured in the current issue of Santa Fe Trend, with a full-page photo and interview.

We studied four possible models for ownership of the system that seemed most appropriate for carrying out the social and economic goals: municipal ownership, community trust, cooperative ownership, and community corporation, which has residency requirements attached to the voting stock.

The biomass system for Santa Fe is technically feasible, economically beneficial, and environmentally important. More than that, given the increasingly serious situation with natural gas, it is absolutely necessary. Sitting idly by while Santa Feans shell out more money each year, deepening their dependence on a depleting resource, would be unconscionable.

INTRODUCTION

The idea of building a biomass-fired district energy system in Santa Fe originated neither out of a fascination with combustion technology nor a desire to improve forest health and management. In fact, the origins of the project had nothing to do with biomass at all.

This project originated after many months of study on the degradation of the North American natural-gas supply. Having just come off more than a year of study on oil depletion, we were less than prepared to learn of an even worse problem on another front. More and more wells were being drilled every year, and yet gas supplies were falling. In March of 2001, the nation's stores of natural gas dropped to record low levels, and fears of losing pressure in the pipelines sent prices to the moon.

A few mild winters later, most of us have completely lost sight of this event and its implications. But its return is guaranteed by the physical laws that govern us. The energy resources on which we presently rely are finite, and we'd better use what's left of them to build systems that run on renewable fuels. But renewable fuels aren't like fossil fuels—not physically, not economically, and not socially. The new systems that we build should also be different—physically, economically, and socially.

The goal of this project was not to solve Santa Fe's heating-fuel problem, it was to advance the understanding of how energy projects can be developed such that they help communities address fundamental issues of energy security, economic well-being, and social equity. For example, a non-local heating fuel, sold to the community by an investor-owned monopoly, is becoming more scarce and expensive, draining more and more money from the community and driving low-income households into bankruptcy. Should the community switch to a local fuel that is piling up at the local dump?

While some of the recommendations given in this report may seem rather obvious, others are more subtle. We carried out engineering and financial analysis in exhaustive detail, but in a larger context, the project is the beginning of an inquiry into the relationship of energy to the economy. The structure of energy systems, beginning with the selection of technology and ending with the ownership and finance structures, determine in large part how economic benefits are distributed within a community. From this perspective, the correct starting point for remodeling a community's energy infrastructure might be to ask how equitable a social structure is desired.

Moving this project forward in Santa Fe will require courage and foresight on the part of community leaders, the outspoken support of well-informed community members, and a great deal of patience and understanding for all involved with it. After three years of study, we are well aware of the complexity. Never have we suggested that switching from gas to biomass will be easy, nor have we strayed from our contention that it is absolutely essential that we do so.

- Mark Sardella
  December, 2006

SECTION 1: TECHNICAL DESIGN OF THE SYSTEM

The technical scope of the project included a determination of the technical feasibility and projected cost to install a system that could utilize locally sourced biomass to heat all of the buildings in downtown Santa Fe. The steps used to design the system and characterize its technical performance are outlined in this section. The remainder of the technical work is given by the financial projections (Section 2), the emissions estimation and valuation (Section 3), and the fuel study (Section 4).

Following the determination of technical feasibility and cost, we were then to follow through with detailed engineering sufficient to construct the system. Although the system was shown to be technically feasible, we elected not to proceed with detailed engineering for a couple of reasons. First, our initial calculations showed that the cost of biomass energy would be significantly higher than the current cost of heating with natural gas. (Gas-heating costs have risen by 34 percent since that time.) Second, the cost of the detailed engineering for a system this size is significant—so significant that it is typically not carried out until customers representing 70 percent of the target heat load have signed binding commitments to purchase heat from the system. With our biomass industry still in its infancy, natural gas still relatively inexpensive, and the gas-supply problem still largely unrecognized, we knew that it would be difficult to obtain such a commitment within the 3-year timeframe of our study.

With the approval of our Program Officer in Washington D.C., we decided instead to study several smaller biomass projects, called micro-grids. A success with a smaller project, we reasoned, would go a long way toward building the support needed to carry out the downtown project.[1] The micro-grid studies are presented in detail in our *Final Feasibility Report*. See Reference 4.

The technical analysis summarized below is presented in greater detail in Reference 2 and Reference 4.

Heat Demand Inquiry

Characterizing the heat demand is the first and most fundamental step in determining the feasibility and cost-effectiveness of district heating. In addition to determining how much heat is currently being consumed in the target area, the heat-demand inquiry also determines when the heat is used and how much of it could be served with district heating. The resulting data also show the typical heat demand for various types of buildings, and the process of gathering the data is useful for informing the potential customers of the system about the advantages of having a heat supply based on a local fuel.

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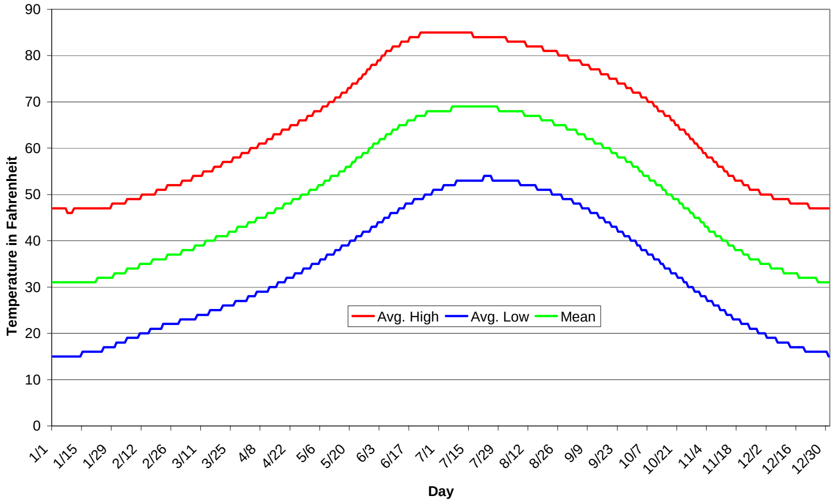
[1] Micro-grid studies were done at the South Capitol Complex, Los Arroyos Condominiums, the Santa Fe Railyard, and the Santa Fe Community College. Happily, the College supported moving a project forward, and together we designed an automated system capable of heating the campus. The system will be operational in 2007.

Evaluation of Weather Data for Santa Fe

The single greatest driver of heat demand is, of course, the weather. The average daily temperature in Santa Fe for each day of the year is shown in Figure 1. Daily average highs range from 85ºF in summer to 47ºF in winter, while average lows range from 54ºF in summer to 15ºF.

Figure 1: Daily Average Temperatures in Santa Fe



Using daily average temperature data, the need for heat on any particular day is calculated in terms of "heating degrees". The number of daily heating degrees for any particular day is defined as the difference between the mean temperature for that day and 65ºF. Adding together the daily heating degrees for every day of the year gives a single figure called the annual heating-degree-days, which represents how cold the climate is in a particular area. Santa Fe averages 5920 HDD per year, whereas Albuquerque averages only 4281 and Denver averages 6128 HDD per year. See Figure 2 and Figure 3.

Figure 2: Daily Average Heating Degrees for Santa Fe

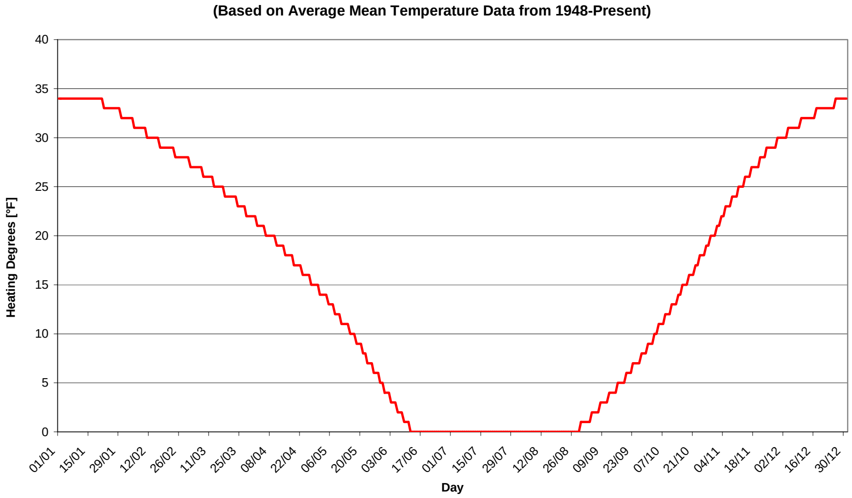
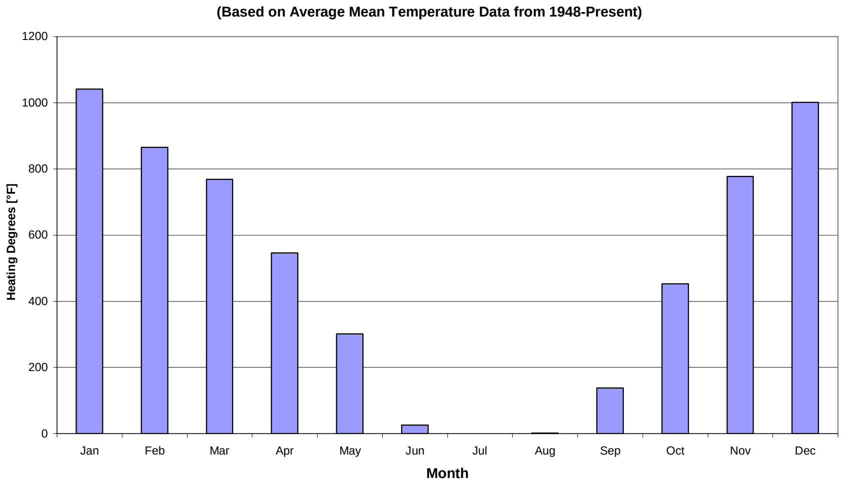


Figure 3: Monthly Average Heating Degrees for Santa Fe

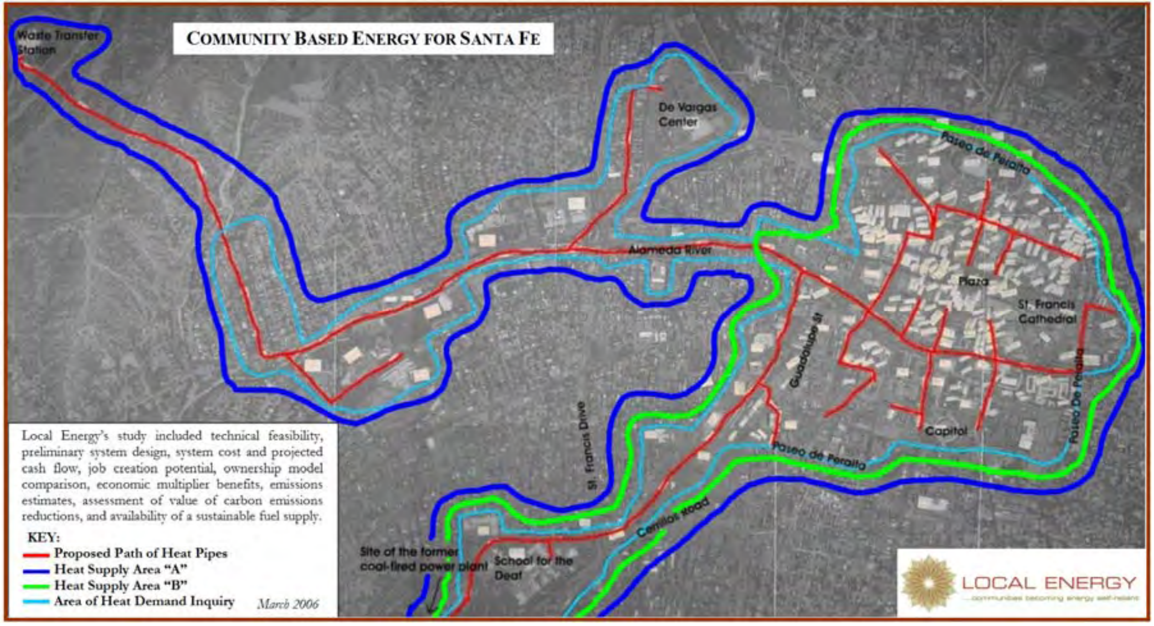


Determination of the Heat Supply Target Area

The initial determination of which areas should be investigated for a possible district heating system is made by simply looking for the largest heat consumers as well as the highest density of heat consumers. Hotels, shopping centers, office buildings, and apartment complexes tend to have high density. Possible locations for the heating plant are also considered.

Our area of initial focus is bounded by the green line in Figure 4 below. The dark blue line was added later, after consideration of the Waste Transfer Station as the most likely site for the heating plant. The red line, showing the probable path of the pipe network, was added much later, after analyzing the heating data.

Figure 4: Target Area of the Heat Demand Inquiry



Local Energy's study included technical feasibility, preliminary system design, system cost and projected cash flow, job creation potential, ownership model comparison, economic multiplier benefits, emissions estimates, assessment of value of carbon emissions reductions, and availability of a sustainable fuel supply.

Notes: The green boundary is the initial target area, and the blue boundary is the revised area after selecting the Waste Transfer Station as a possible heating plant. The red line shows the initial layout of the heat transmission network.

Energy Audits of Buildings

Between February and May of 2004, 160 potential customers of the district heating system were contacted, and approximately 120 accepted appointments to have their buildings audited. In the end, we characterized the heat consumption of 106 buildings within the target area. These buildings were selected such that a variety of occupancy types and sizes would be represented. See Table 1.

Table 1: Buildings Assessed During the Heat-Demand Inquiry

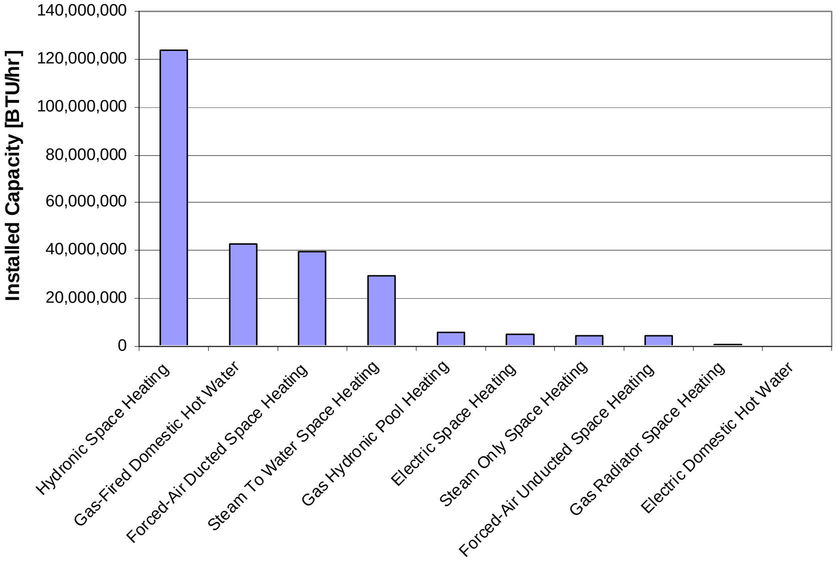
TYPE OF BUILDING	QUANTITY	% of the TOTAL QUANTITY	HEATED AREA [ft²]	HEATED AREA [m²]	PERCENTAGE of the TOTAL AREA
Apartments	1	0.9%	46,831	4,351	1.0%
Church	2	1.9%	37,410	3,476	0.8%
Commercial	18	17.0%	467,605	43,442	10.3%
Healthcare	1	0.9%	18,000	1,672	0.4%
Large_Hotel	12	11.3%	1,046,388	97,213	23.1%
Medium_Size_Hotel	3	2.8%	142,321	13,222	3.1%
Municipal	3	2.8%	33,200	3,084	0.7%
Museum	7	6.6%	159,811	14,847	3.5%
Offices	27	25.5%	1,470,900	136,651	32.5%
Residential	10	9.4%	16,252	1,510	0.4%
Restaurant	1	0.9%	4,500	418	0.1%
School	8	7.5%	504,087	46,831	11.2%
Shopping_Center	3	2.8%	427,036	39,673	9.4%
Small_Hotel	7	6.6%	71,568	6,649	1.6%
Swimming_Pool	1	0.9%	0	0	0.0%
Theater	2	1.9%	75,000	6,968	1.7%
TOTAL	**106**	**100.0%**	**4,520,910**	**420,006**	**100.0%**

Nearly every heating load in the assessed buildings was found to be served by natural gas, although a few buildings use some electric hot-water heating.

The energy audits were aimed at determining the required heating capacity of the district heating system (in BTU per hour), the total amount of heat (in BTU) that the system would need to deliver, and some general characteristics of how the heat would need to be delivered with respect to time and temperature.

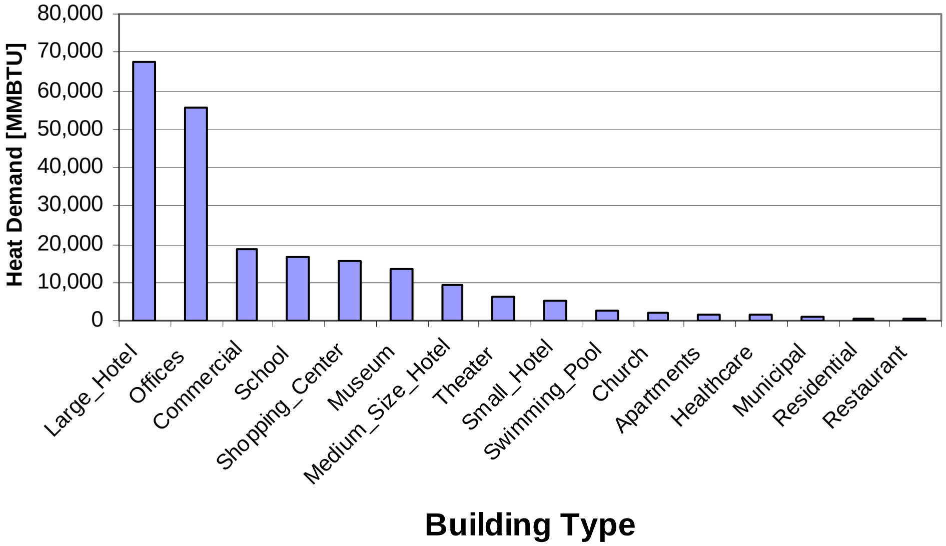
The total installed heating capacity in the 106 assessed buildings was found to be about 256 million BTU per hour. Almost half (48.4 percent) of this capacity is for hydronic space heat, followed by gas-fired domestic hot-water (16.6 percent), forced-air ducted space heating systems (15.5 percent), and steam-to-water space heating (11.5 percent). The installed heating capacity by type of heating system is shown in Figure 5.

Figure 5: Installed Nominal Heating Capacity in Assessed Buildings



The annual heat requirement of the assessed buildings totaled about 219 billion BTU, with the greatest percentage of heat required by large hotels. The heat demand for all building types are shown in Figure 6.

Figure 6: Total Annual Heat Demand of Assessed Buildings, by Type[2]



Analysis of Collected Energy Data

The data collected during the heat-demand inquiry was analyzed to enable an estimation of the heat-consumption behavior of buildings not assessed, to determine what fraction of

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[2] The abbreviation MMBTU denotes "million BTU". In energy parlance, each "M" denotes a multiplier of one thousand if using Imperial units. In the SI system of units, an "M" stands for mega, which has a multiplier of one million.

the total heating load could be served by a district heating system, and to characterize the heat-supply requirements of the proposed district energy system.

To enable extrapolation of the collected heating data to buildings not assessed, the data for similar building types were compared, and best estimates were made for the heating needs of each building type. This required analysis of the heating bills provide by building owners, as well as a determination of how oversized the installed heating systems were. (Many buildings have oversized heating systems, either for redundancy or due to a poor initial estimation of the building heat-load.) Results of this analysis are shown in Table 2 and Table 3. Table 2 shows the estimated number of hours the heating system for each type of building operates in a year. Lower numbers result from oversized systems.

Table 2: Adjusted Specific Nominal Heating Capacity and Full-Load Operating Hours for Assessed Building Types

Type of Building	Specific Nominal Capacity Average [BTU/hr*sqft]	 [kW/m²]	Full-Load Operating Hours Maximum [hrs]	 Minimum [hrs]	 Average [hrs]
Apartments	48.88	0.15	747	747	747
Church	56.77	0.18	994	632	806
Commercial	41.87	0.13	1,704	387	964
Healthcare	35.68	0.11	2,186	2,186	2,186
Large hotel	54.94	0.17	1,464	752	1,175
Medium size hotel	56.76	0.18	1,396	710	1,170
Municipal	31.14	0.10	1,309	569	1,087
Museum	44.42	0.14	1,659	912	1,231
Offices	37.58	0.12	2,218	308	1,005
Residential	52.47	0.17	982	624	795
Restaurant	56.89	0.18	1,027	1,027	1,027
School	44.77	0.14	841	338	745
Shopping center	36.83	0.12	1,028	882	994
Small hotel	49.65	0.16	2,086	1,025	1,530
Swimming pool	n.a.	n.a.	950	950	950
Theater	64.31	0.20	1,704	1,073	1,264

Table 3: Best Estimates for Specific Heat Demand of Santa Fe Buildings

Type of Building	Specific Heat Demand	
	[BTU/ft²]	[kWh/m²]
Apartments	36,540	115.3
Church	26,900	84.9
Commercial	40,400	127.4
Healthcare	78,000	246.1
Large hotel	66,400	209.5
Medium size hotel	66,400	209.5
Municipal	33,800	106.6
Museum	n.a.	n.a.
Offices	37,800	119.2
Residential	42,600	134.4
Restaurant	58,400	184.2
School	33,500	105.7
Shopping center	36,600	115.5
Small hotel	77,100	243.2
Swimming pool	n.a.	n.a.
Theater	120,300	379.5

The final steps of the heat-demand inquiry involved calculating the total heat-load potential (in BTU per hour) and total heat demand (in BTU per year) that would be served by the proposed district heating system. This required an assessment of which heat loads could realistically be served by the system. In general, heat loads that did not have hydronic delivery systems or were too small and too far from the district heating path to be economically connected to it, were excluded.

Results show that within the target area, about 218 million BTU per hour of load could be connected to the district heating system, and that about 224 billion BTU of heat would be needed annually. See Table 4.

Table 4: Connected Heat Load Potential and Substitutable Annual Heat Demand Within the Target Area

CATEGORY	CONNECTED HEAT LOAD		SUBSTITUT. HEAT DEMAND	
	[BTU/hr]	[kW]	[BTU/yr]	[kWh/yr]
Visited Buildings	162,241,023	47,548	172,067,729,550	50,427,889
Other existing Buildings	43,502,376	12,749	40,127,746,500	11,760,239
New Buildings	12,237,643	3,586	11,572,439,109	3,391,535
TOTAL	**217,981,042**	**63,884**	**223,767,915,159**	**65,579,663**

System Design

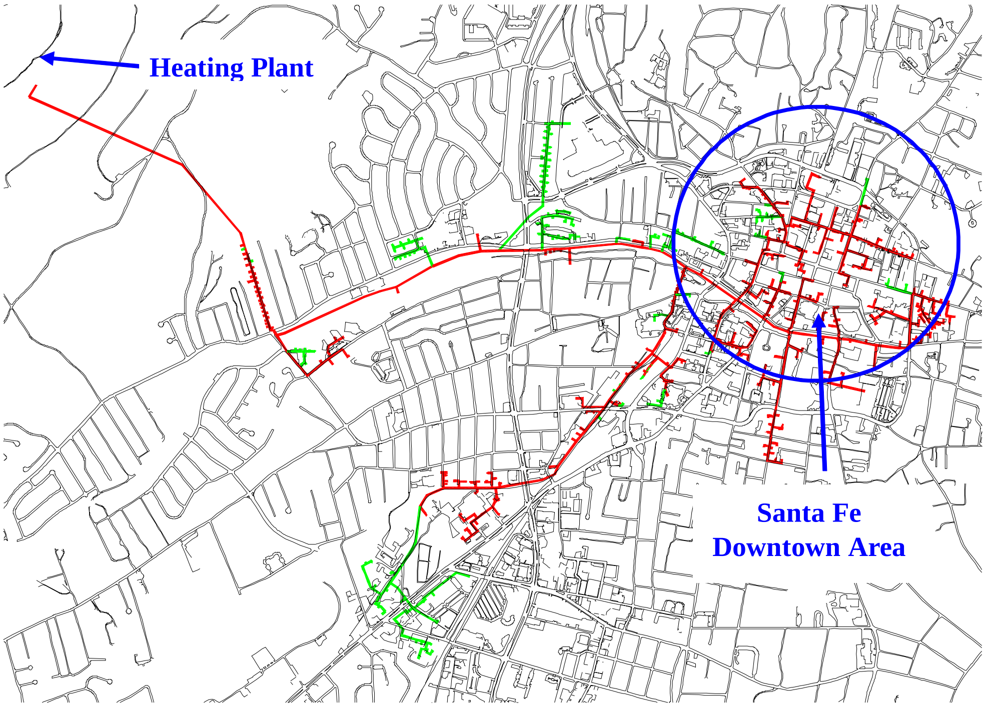
Using information from the heat-demand inquiry, initial designs were created for the network of pipes assuming two possible locations for the heating plant: the Waste-Transfer Station on Buckman Road, and the site of the old Coal-Fired Power Plant just southwest of the School for the Deaf. Heating plant designs were then created using a "heat-only" (HO) approach as well as a "combined heat and power" (CHP) design.

Design of the Network of Pipes

Pipe network designs are evaluated and compared based on many technical parameters, but most important among them is their heat utilization ratio, which expresses how much heat is sold annually to customers per foot of pipe, and their net utilization rate, which expresses how much of the heat generated by the heating plant reaches the customers. (The remainder is lost from the pipe network.) Together, these two factors tell more about the viability of the network design than any other parameter.

The first design of the network of pipes considered the Waste Transfer Station to be the location of the heating plant. The backbone of the network ran from the heating plant into downtown, and a secondary spur of the network ran southwest, roughly paralleling Cerrillos Road and allowing connection of the School for the Deaf. This network, which consists of about 18.5 miles of pipe and allows interconnection of about 545 customers, is shown in Figure 7.

Figure 7: Network of Pipes with Heating Plant at Waste Transfer Station



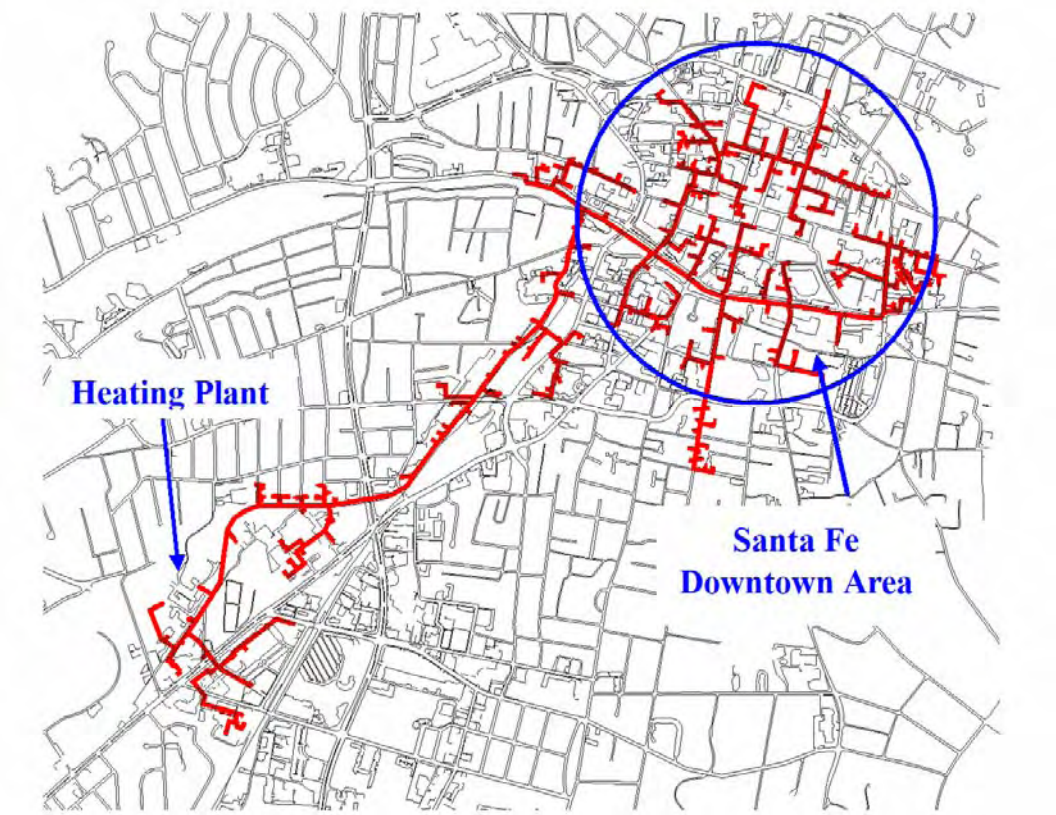
This network design had an initial heat-utilization ratio of 2.2 million BTU per foot-year, and a net utilization rate of 81 percent. Both results are within the range of viability for a district heating network. The design was later optimized by raising the delivery temperature to 212°F and excluding low-utilization pipe sections (shown in green). This reduced the number of customers being served to 362, but improved the heat utilization ratio to 2.7 million BTU per foot-year, and improved the net utilization rate to 84.1

percent. The higher delivery temperature also allowed a lower flow rate in the pipe, reducing the pressure drop in the pipe and allowing pipe with a lower pressure rating to be used.

A second design of the network of pipes in which the heating plant was located at the site of the former coal-fired power plant was also analyzed. This design would allow interconnection of 409 customers, and is shown in Figure 8. It is shorter (13.6 miles), has a higher optimized heat utilization ratio (3.4 million BTU per foot-year), and also has a higher net utilization rate (87.5 percent) than the first network design.

While this network design appeared to be more plausible at this stage, final decision on the network design is not made until after consideration of all costs for building, trenching, archaeology, permitting, and similar items.

Figure 8: Network of Pipes with Heating Plant at Old Coal-Fired Power Plant



Design of the Heating Plant

At each of the two possible locations for the heating plant, we studied two possible configurations: heat production only, and heat production plus electrical generation, or combined heat-and-power (CHP). For the CHP option, we looked at using a 1.1 MW generator and a 1.5 MW generator.

The components selected for the heating plant are summarized in Table 5, and discussed below.

Table 5: Components of the District Heating Plant

Storage	Outdoor storage on a paved surface
Fuel feeding	Sliding bar conveyor and fuel dosing system
Combustion technology	Moving grate furnace
Boiler technology (Heat Only)	Pressurized hot water boiler
Boiler technology (CHP)	Thermal oil boiler
Heat recovery	Economizer
CHP technology	Organic Rankine Cycle process
Flue gas cleaning	Multi-cyclone and wet electrostatic precipitator
Ash removal	Sliding bar and chain trough conveyor
Peak-load boiler	Gas-fired boiler

Storage Facilities

According to the results of our *Fuel Study Report* (Reference 1), various types of biomass like wood chips, bark and sawdust, are available as fuel for a district heating system. The expected particle size ranges from 0.1 to 20 inches (0.25 to 50 cm). The average moisture content is around 27 percent (w/w, w.b.)[3].

A mixture of several fuel sources of varying quality must be considered for the design of the storage area. The different types of biomass should be stored separately and mixed prior to combustion to maintain a constant fuel quality and stable conditions in the combustion zone.

Considering the dry weather conditions in Santa Fe, a roofed storage area is not necessary for wood chips and bark. Sawdust can also be stored outside, but the storage area must be enclosed by three walls and a roof to avoid dust emissions. All storage areas must be paved to minimize the contamination of biomass with dirt and stones during storage.

The storage capacity need not exceed 20 percent of the annual fuel demand of the heating plant. This capacity allows some flexibility in the choice of different fuel sources in terms of fuel quality and fuel costs but also implies the negotiation of long-term fuel supply contracts to ensure a sufficient fuel supply throughout the year.

Fuel Feeding

Since the particle size of the biomass used in the heating plant of the main system is expected to range up to 20 inches (50 cm), a sliding-bar conveyor is the appropriate fuel-feeding device.

The fuel-feeding devices must be designed for the fuel demand at maximum boiler capacity based on the fuel type with the lowest quality to ensure sufficient fuel supply to the boilers irrespective of the type of fuel used.

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[3] The symbols w/w and w.b. stand for "weight over weight" and "wet basis", respectively. The w/w means that the percentage given is based on weight (rather than volume), and w.b. means that the base weight is the green weight of the wood rather than its oven-dry weight.

Combustion Technology and Boiler
Several biomass sources will be needed to ensure a secure fuel supply given the high fuel demand of the heating plant. Using fuel from several vendors always results in variation of fuel quality. A moving-grate furnace is therefore the combustion technology of choice, as it is the most flexible in handling biomass of varying moisture content, ash content, and particle size. All biomass boilers considered here will feature moving-grate technology.

Two-stage combustion is also required in order to achieve complete biomass combustion (minimum content of unburned biomass/charcoal in the ash) and low emissions. In two-stage combustion, the primary and the secondary combustion chambers are separated in order to avoid back-mixing of the secondary air, and to separate the gasification and oxidation zones. The advantages of two-stage combustion are improved efficiency and lower emissions of CO, hydrocarbons, and NO_x.

The heat transfer from the flue-gas to the pressurized water of the district heating system takes place in the pressurized hot water boiler, which is installed downstream of the secondary combustion zone. See Figure 9. If a CHP unit is installed, thermal oil is used instead of pressurized hot water. See Figure 10.

The bottom ash from the combustion zone and the fly ash from the heat recovery system and multi-cyclone are collected and stored in an ash container.

Figure 9: Biomass-Fired Moving Grate Furnace with Horizontal Pressurized Hot Water Boiler and Ash Removal

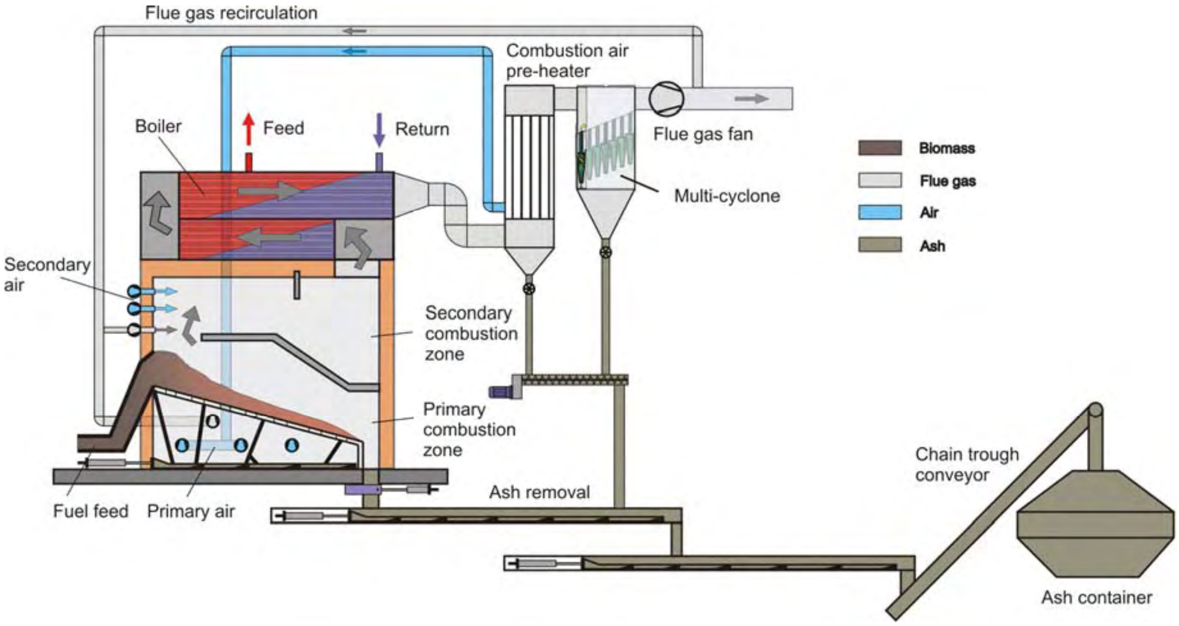
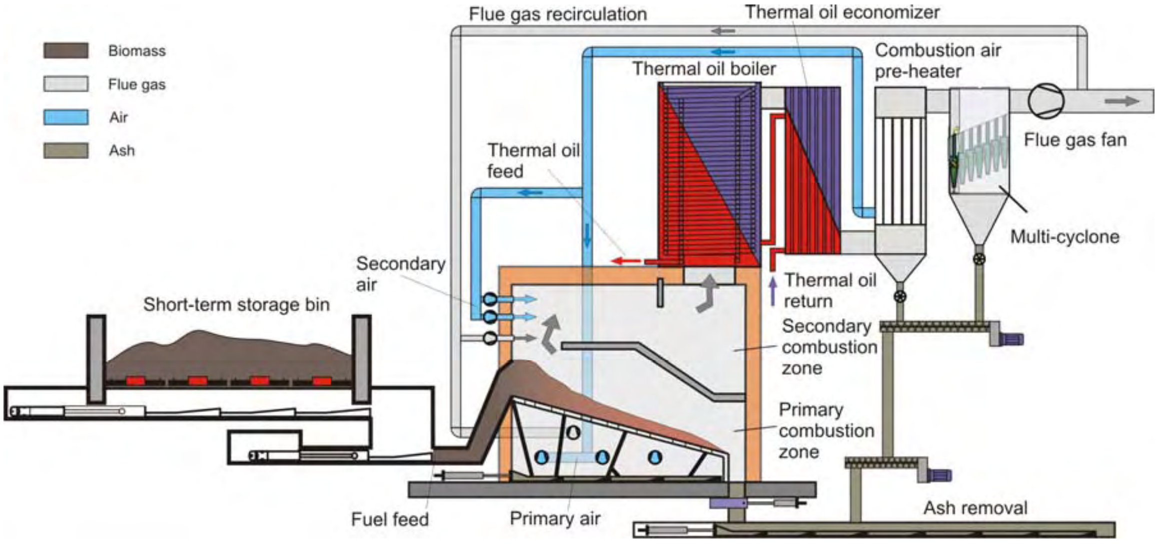


Figure 10: Biomass-Fired Moving Grate Furnace with Vertical Thermal Oil Boiler and Ash Removal



CHP Unit

The Organic Rankine Cycle (ORC) process is recommended for CHP applications based on the local constraints in Santa Fe and the experience of BIOS with small-scale biomass CHP technologies in Europe. The ORC process utilizes the conventional Rankine process, except that instead of water, an organic working medium with favorable thermodynamic properties is used.

The ORC process is connected to the thermal-oil boiler via a thermal-oil cycle. The ORC unit itself operates as a completely closed process using silicon oil as an organic working medium. This pressurized organic working medium is vaporized and slightly superheated by the thermal oil in the evaporator, and then expanded in an axial turbine connected directly to an asynchronous generator. Subsequently, the expanded silicon oil passes through a regenerator, where in-cycle heat recuperation takes place, before it enters the condenser. The condensation of the working medium takes place at a temperature that allows the heat recovered to be utilized as district heat. The liquid working medium then passes through the feed pumps to provide an appropriate pressure at the hot end of the cycle. See Figure 11.

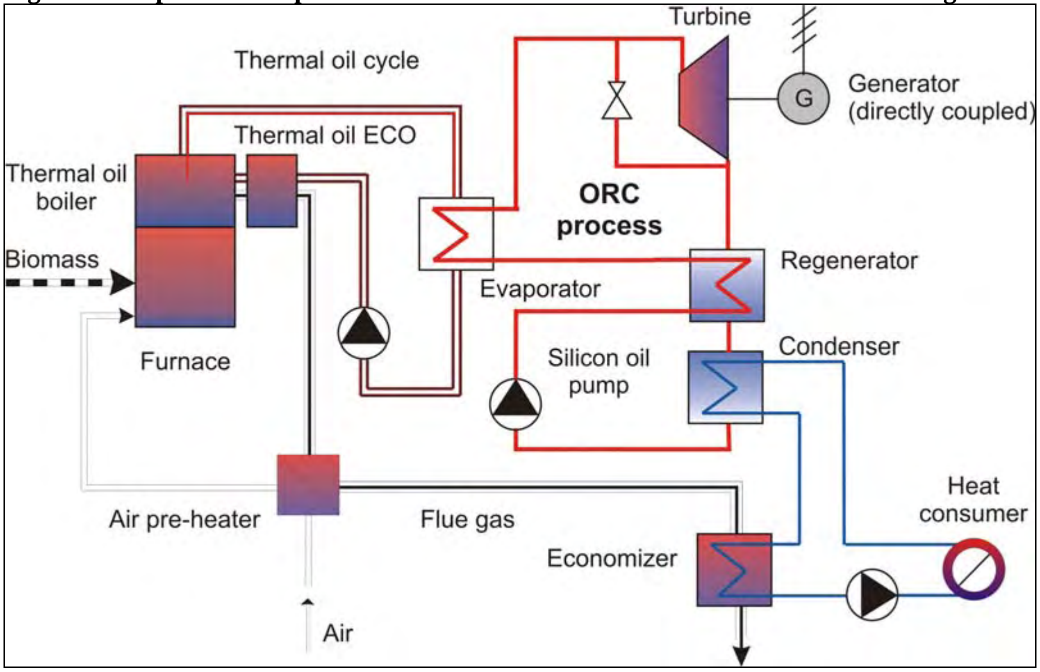
Since the ORC process features a closed cycle, there is no loss of the working fluid during normal operation. The process is fully automated, requiring only about 3 man-hours per week. This reduces the operating costs of the CHP plant considerably. Further advantages of the ORC process are:

- Low temperature and pressure levels;
- No specially trained personnel are needed (as would be required with a steam boiler);

- Higher electric fraction (about 15 percent, based on the fuel energy input) compared to conventional CHP plants of similar capacity using a low-pressure steam fire-tube boiler driving a turbine or piston engine;
- Electricity requirements of the biomass plant can be met using the ORC unit, offsetting retail electricity purchases and allowing stand-alone operation;
- Higher revenues due to sale of power (green credits and CO_2 credits apply);
- High flexibility and efficiency at partial load; and
- Long track record with geothermal applications, 6-year track record for biomass-fired ORC units.

An optimized implementation of the ORC unit in the heating plant, as shown in Figure 11, is important for efficient operation. The design must ensure high annual electricity production and utilization rates. Thermal oil heated to a temperature of 572°F serves as the heat supply medium for the ORC. The oil is heated by the hot flue gas from the combustion zone, which leaves the boiler at about 662°F, then passes through the economizer where it cools to about 536°F, and then through the combustion air pre-heater where it cools to about 428°F. Heat recovery from the flue gas is thus maximized, yielding a high electric efficiency.

Figure 11: Optimized Implementation of the ORC Unit in a Biomass-Fired Heating Plant

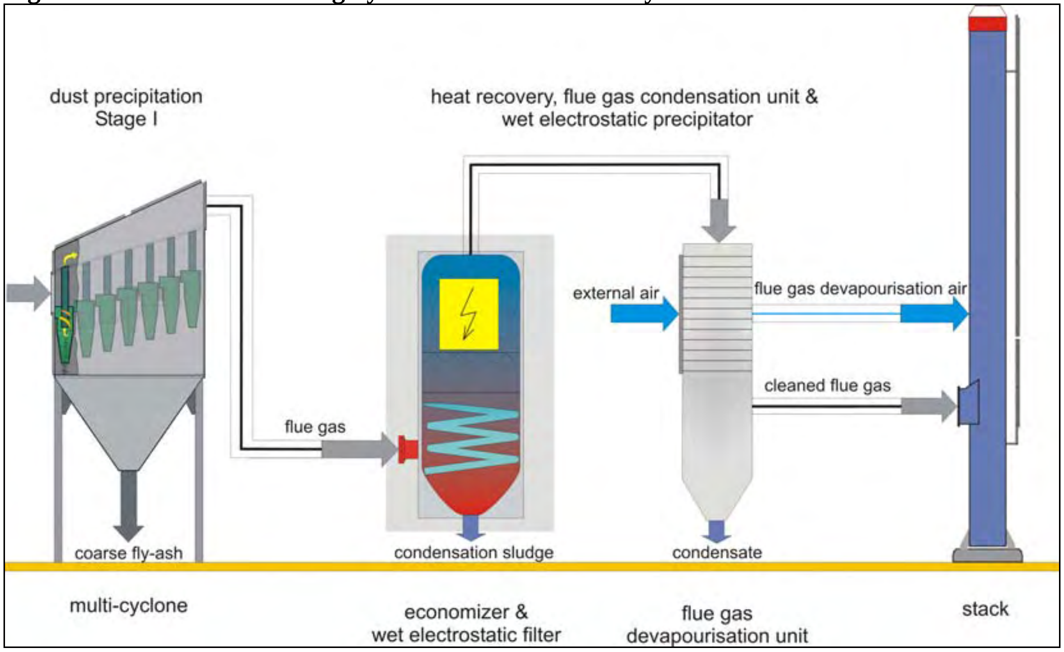


Flue Gas Cleaning and Heat Recovery
A flue-gas cleaning system (Figure 12) is necessary for the biomass-fired boilers to meet the emission limits set by the New Mexico Air Quality Bureau. Partial recovery of the remaining heat in the flue gas during cleaning further increases the total efficiency of the plant, which further reduces emissions (due to the reduced fuel input). It also improves the financial performance of the heating plant.

A multi-cyclone is used for precipitation of larger dust particles, and a combination of economizer, wet electrostatic precipitator, and water-vapor removal system are used to further clean the flue gas and to recover some of the remaining heat. The installation of an economizer can increase the annual utilization rate of the biomass-combustion system by about 10 percent, depending on the flue-gas temperature at the boiler outlet. (The higher the flue gas temperature at the boiler outlet, the more heat can be recovered and the greater the improvement in efficiency.)

In a wet dust precipitation system, any fly ash separated from the flue gas is collected as condensation sludge. This sludge is de-watered to a moisture content of about 50 percent by weight, and must be disposed of carefully due to its heavy metal content.

Figure 12: Flue Gas Cleaning System and Heat Recovery



A more detailed description of flue-gas cleaning technology is given in our *Preliminary Design Report* dated August, 2004. (Reference 2.)

Peak-Load Boiler(s)
One or two gas-fired boilers are used as peak-load boilers. The total nominal heating capacity of the boiler(s) depends on the size of the required back-up capacity. Since it is very unlikely that both installed biomass boilers will fail at the same time, back-up capacity is required only for the larger boiler and its heat-recovery unit.

Hydronic System

The hydronic system is designed to allow the operation of the boilers and economizer at different temperature levels. Heating units which require low temperatures, such as the condenser of an ORC plant, can directly use the return of the pipe network. Other units such as economizers and boilers, which require higher return temperatures to avoid flue gas condensation, may either use the preheated return from other heating units or they can be equipped with a mixing valve in the return to ensure an optimal return temperature. Furthermore, the feeds of the individual heating units at different temperatures need to be appropriately mixed to allow the control of the supply temperature of the pipe network. This design ensures the efficient use of the heat produced in every boiler and economizer.

Control System

The control system of a biomass-fired district heating plant must continuously monitor and control furnace combustion temperature, system load and pressure, and emissions. It must furthermore adjust the supply temperature of the heating network according to the ambient air temperature, vary the flow rate in the network according to the heat being demanded, and control the water-treatment and pressure-maintenance systems.

Building

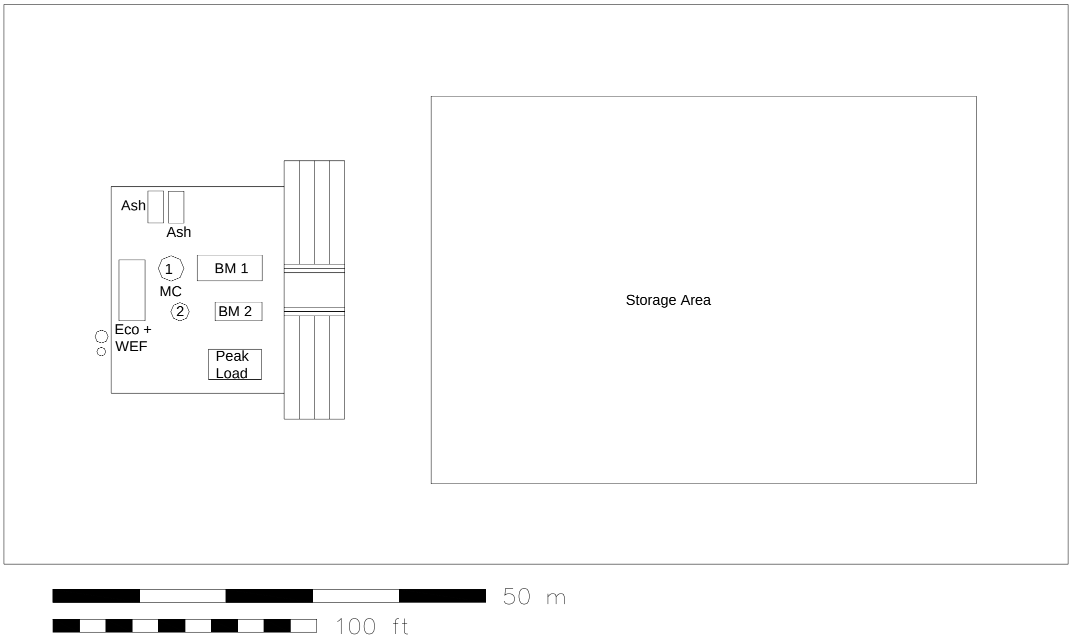
No preliminary design of the building is required if the heating plant is located at the Waste Transfer Station, since a building of appropriate size already exists. Efficient positioning of the principal components of the heating plant is still necessary to minimize the distances between the heating devices yet allow sufficient access for maintenance and cleaning.

Since there are no existing structures at the site of the former Coal-Fired Power Plant, a building for the heating plant must be designed. The following considerations apply:

- Accessibility for maintenance and cleaning
- Sufficient space for the ash-removal systems at the bottom of the boiler and the flue gas cleaning system, as well as for ash transport and storage equipment
- Small distance between the biomass-fired boilers in order to reduce investment costs for hydronic installations in the heating plant
- A fire break surrounding the CHP unit, for safety regulations
- Compliance with general building codes and safety regulations

Our suggested configuration of components is shown in Figure 13 below.

Figure 13: Suggested Positions of Major Heating-Plant Components,
Former Coal-Fired Power Plant, Heat Only



Notes: "Eco + WEF" represents "Economizer and Wet Electrostatic Filter". "MC" represents "multi-cyclone". "BM" represents "biomass boiler". "Peak Load" represents the gas-fired peak-load boiler.

Technical Performance of the Heating Plant

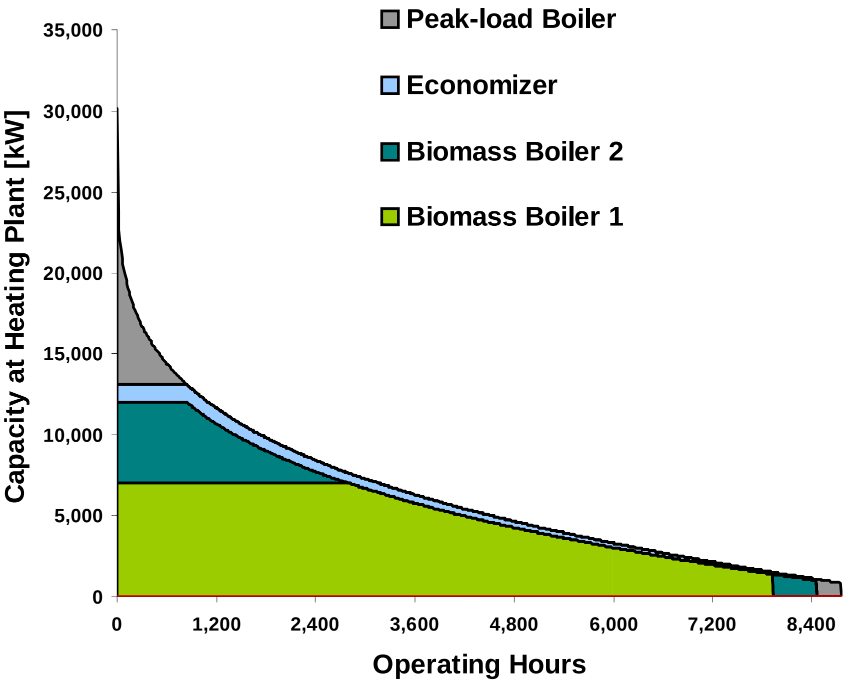
For each of the selected heating plant locations, system configurations were designed to best meet the required heat demand, assuming that heat consumers representing 80 percent of the heat demand sign up as customers of the system. The technical parameters of system performance were then calculated for both "Heat-Only" (HO) and "combined heat and power" (CHP) configurations.

Waste Transfer Station, Heat Only

This system required a base-load boiler of 23.9 million BTU per hour, a secondary boiler of 17.0 million BTU per hour, and an economizer of 3.7 million BTU per hour. A flue gas condensation unit was not included due to the lack of low-temperature heat consumers close to the heating plant and the relatively dry fuel available. A gas-fired peak-load boiler of 85.3 million BTU per hour is also included, and is large enough to meet the peak load even when the base-load boiler is out of service.

With this configuration, the base-load boiler supplies about 71 percent of the annual heat demand, the secondary boiler provides 16 percent, and the economizer provides 8 percent. The peak-load boiler provides 5 percent of the annual heat demand. (Figure 14.)

Figure 14: Annual Heat Demand Line, *Waste Transfer Station, Heat Only* Option



Note: Annual heat demand line based on a connection rate of 80 percent and a network pressure rating of 232 psi (16 bar)

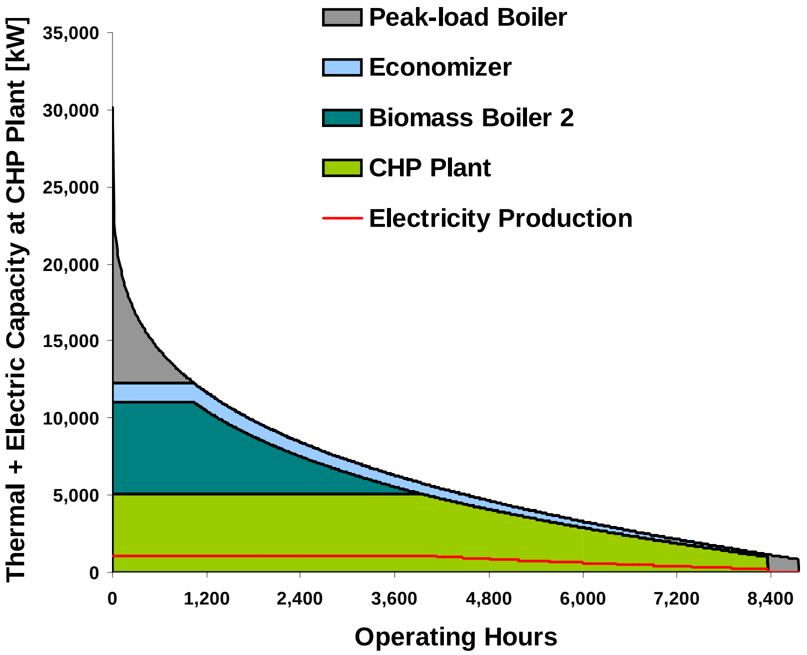
This heat-only configuration requires about 18,200 tons of wet fuel per year, producing 718 tons of ash. It produces 179,793 million BTU per year of heat at a thermal efficiency of 91.6 percent. The full-load operating hours for the biomass boilers—a measure of how well this asset is utilized—is 4027 hours, which is considered very good.

Waste Transfer Station, Combined Heat and Power (CHP)

This system required a base-load CHP plant with a nominal heating capacity of 17.5 million BTU per hour and an electrical capacity of 1.1 megawatts. (A 1.5 megawatt CHP was also studied, with similar results.) A secondary boiler of 20.1 million BTU per hour, and an economizer of 4.2 million BTU per hour are also included. A flue-gas condensation unit was not included due to the lack of low-temperature heat consumers close to the heating plant and the relatively dry fuel available. A gas-fired peak-load boiler of 82.9 million BTU per hour is also included, and is large enough to meet the peak load even when the base-load boiler is out of service.

With this configuration, the base-load CHP plant supplies about 59 percent of the annual heat demand, the secondary boiler provides 24 percent, and the economizer provides 10 percent. The peak-load boiler provides 7 percent of the annual heat demand. (Figure 15.)

Figure 15: Annual Heat Demand Line, *Waste Transfer Station, CHP* Option



Note: Annual heat demand line based on a connection rate of 80 percent and a network pressure rating of 232 psi (16 bar)

This CHP configuration requires about 20,550 tons of wet fuel per year, producing 811 tons of ash. It produces 176,726 million BTU per year of biomass-generated heat and 5,966 megawatt-hours of electricity at an overall thermal efficiency of 88.9 percent. The full-load operating hours for all biomass boilers is 4,184 hours, and the full-load hours of the CHP plant is 5,449 hours. These numbers again indicate good feasibility.

Old Coal-Fired Power Plant, Heat-Only and CHP

Siting the heating plant at the old Coal-Fired Power Plant location yielded similar performance results to those shown above for the Waste Transfer Station. A summary of the relevant performance parameters for the four cases is shown in Table 6.

Table 6: Performance Parameters for the Four Cases

Specific Classification Number	Unit	Recommended Values for Santa Fe	WTS Heat only	WTS ORC 1100	CFPP Heat only	CFPP ORC 1100
Annual utilization rate of the heating/CHP plant	[%]	> 85	91.6	88.9	91.6	88.9
Boiler full-load operating hours	[hours per yr.]	> 4,000	4,027	4,184	4,130	3,990
Network heat utilization ratio	[BTU/ft*yr]	> 1,560,000	2,156,000	2,156,000	2,681,440	2,681,440
Annual utilization rate of the network of pipes	[%]	> 80	84.1	84.1	87.5	87.5

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW.

SECTION 2: FINANCIAL CALCULATIONS

This section includes calculations of system costs and revenues, and a determination of the cost of producing heat and electricity with the system.

System Costs

The cost of energy from each of the four systems described above was calculated as described below.

Investment Costs

Prices of components of the heating plant and the network of pipes could not be obtained, despite our requests for non-binding budget estimates from construction companies and manufacturers in New Mexico and elsewhere around the country. The data used for the calculation of the investment costs were therefore based on well-verified values from European biomass-fired district heating/CHP plants provided by BIOS. Additional information was gathered through interviews and requests for quotations from European manufacturers who frequently export to the U.S. and Canadian market. The information gathered contained:

- Guideline quotations for components to be delivered to the U.S.
- Surcharges for transport costs, insurance and customs
- Additional costs for certifications according to ASME regulations
- Surcharges taking the recent steel price hike into consideration

These data were used to estimate the total investment costs of all relevant components of the district heating plant, on the basis of a delivery from European companies.

This approach provides a good indication of the investment costs to be expected for the different plant options investigated.

When the project moves forward into detailed design, a thorough investigation of domestic suppliers of components for the heating plant and the network of pipes must be conducted. Local companies should be utilized, to the greatest extent possible, for construction and operation of the biomass-fired heating plant—especially for construction of the buildings and storage facility, the hydronic and the electrical installations, and the trenching and backfilling work.

All investment costs, as well as heat and electricity production costs, are calculated according to *VDI Guideline 2067* (Reference 3). This standard is a product of the Association of German Engineers, and is the most common standard in Europe for calculating the financial performance of new energy plants.

Cost of Construction

Investment costs for buildings and storage areas were based on well-verified values from European biomass-fired district heating/CHP plants.

Investment costs for all components (building, storage facility, additional areas for parking and truck-turning, and utilities) were considered in the cost calculation for the option “Former Coal-Fired Power Plant”. The different building sizes required for the heat only and CHP options were also considered in the building costs.

Since the Waste Transfer Station already has fully functional buildings on site, only the costs for modifying these buildings to accommodate a heating plant were considered for this site.

The construction of buildings and storage facilities, and the electrical and plumbing work required, are expected to be done by local contractors.

Cost of Network of Pipes

Investment costs for the network of pipes were based on well-verified values from European biomass-fired district heating/CHP plants and guideline quotations for components to be delivered to the U.S.

Price estimates for the pipe network were adjusted to consider the recent steel price hike (with a surcharge between 10 and 30 percent, depending on the component). In addition, surcharges for transport (20 percent of the transported value), insurance (0.375 percent of the transported value), and customs (5 percent of the transported value) were considered. The values of the surcharges were obtained from interviews with European manufacturers that frequently export to U.S. and Canadian markets.

The costs for trenching and backfilling were based on information gathered from various biomass-fired district heating projects in Austria. (We requested non-binding offers for this work from local companies, but responses were not received in time to be included in the analysis.) The costs for trenching and backfilling were marked up by 20 percent to cover expected archaeology costs.

The costs for heat-transfer stations and their installation were based on well-verified values from comparable systems in Europe. Costs were marked up 20 percent to account for transport, insurance, customs, and any additional costs for certification to ASME standards. Table 7 shows the total costs for heat transfer stations and their installation.

Construction of the pipe network will take two to three years, because of its considerable size. The investment costs for the pipes, trenching and backfilling, and the heat transfer stations were therefore spread across three years in the calculation of dynamic payback.

Table 7: Total Costs (Including Investment and Installation Costs) of Heat Transfer Stations

Capacity of the Heat Transfer Station [BTU/hr]	[kW]	Number of Customers WTS	CFPP	Investment and Installation Costs [US$/Station]
51,000	15	101	70	4,793
102,000	30	56	53	4,793
171,000	50	40	38	5,672
256,000	75	34	34	6,122
341,000	100	30	29	7,306
427,000	125	10	10	7,924
512,000	150	8	7	9,072
597,000	175	13	12	12,037
682,000	200	5	4	12,205
853,000	250	7	7	13,415
1,024,000	300	8	7	14,483
1,365,000	400	8	8	16,007
1,706,000	500	9	9	17,615
3,412,000	1,000	23	23	24,539
5,118,000	1,500	5	5	28,691
6,824,000	2,000	2	2	32,843
10,236,000	3,000	2	2	41,159
13,648,000	4,000	1	1	49,463

Notes: "WTS" represents "Waste Transfer Station", and "CFPP" represents "Former Coal-Fired Power Plant". Investment and installation costs are based on well-verified values from European biomass-fired district heating plants. A surcharge of 20 percent on the investment costs was added to consider costs for transport, insurance, customs, and certifications according to ASME regulations.

The cost for construction of the pipe network is also based on similar experience from Europe. Trenching and backfilling can be done by local companies. Heat-transfer stations will be most likely supplied by European companies, and installed by local companies.

Cost of Mechanical Equipment

Investment costs for the mechanical equipment were based on well-verified values from European biomass-fired district heating/CHP plants, as well as on guideline quotations for delivery of these components to the U.S.

Prices for mechanical components such as the furnace and boiler, flue gas cleaning system, ash removal and storage devices, heat-recovery system, and fuel-feeding devices were adjusted to account for the recent hike in steel prices. (A surcharge of 8 percent was added). In addition, surcharges were added for transport (10 percent of the transported value), insurance (0.375 percent of the transported value), customs (5 percent of the transported value), and ASME certification (10 percent of transported value for furnace, boiler, and heat recovery system, and 3 percent for flue gas cleaning system, ash removal, storage components, and fuel feeding devices). These surcharges were also applied to the investment costs for the CHP plant. The amount of the surcharges were based on interviews with European manufacturers that frequently export to North America.

For components that will be supplied by domestic companies, including cranes, hydronic installations, steel construction, and peak-load boilers, a surcharge of 8 percent was added to account for the hike in steel prices.

No surcharges were added for the investment costs for electric installations, since these costs are not influenced by the steel price, and installation by a local company is expected.

Although a few American manufacturers of biomass furnaces were identified and contacted, the currently available information suggests that the biomass-fired boilers and accompanying equipment may need to be supplied and installed by European contractors. If non-binding quotes can be obtained from the few domestic vendors of this equipment, these prices can be substituted and the financial analysis adjusted accordingly.

Other components including cranes, hydronic installations, electric installations, steel construction, and peak load boilers, are expected to be supplied and installed by local companies.

The ORC unit for the CHP plant could be supplied by either a U.S. or a European company. The CHP plant is usually installed in the second year, after parts of the pipe network have become operational. The calculation of dynamic payback therefore considers this purchase being made in year 2.

Cost of Vehicles

Investment costs for two front-end loaders were estimated at $120,000 based on well-verified values from Europe.

Cost of Engineering

Engineering costs are generally given as a percentage of the investment costs. In this case, engineering costs for construction (building, storage, infrastructure) were estimated at 8 percent of construction costs. Engineering costs for all other components were estimated at 10 percent of investment costs. The total engineering costs are shown in the results of the heat and electricity production costs.

Miscellaneous Costs

Miscellaneous costs of $600,000 were included for all main district heating systems. Miscellaneous costs include charge for air permits (estimated at $10,000) and other costs that cannot be specified at this stage of the project.

Maintenance Costs

Annual maintenance costs were calculated as a percentage of the investment costs according to the method outlined in Reference 4, and are shown in the results of the heat and electricity production cost calculations.

Consumption-Related Costs

The costs for fuels consumed are calculated as described below. These prices were current at the time this analysis was carried out, and the analysis does not escalate prices over time. This analysis must therefore be updated as the project progresses.

Biomass Fuel Costs

The annual biomass demand is expected to be 18,000 to 21,000 tons, as discussed in Section 1, *Technical Performance of the Heating Plant*. The biomass price used represents the weighted average of all three main fuel sources, and was determined to be $1.81 per MMBTU, or about $20 per ton, based on an average net calorific value of about 5,400 BTU/lb (w.b.). See Reference 1.

Natural Gas Costs

The gas costs were determined according to the PNM Rate No. 54 for small volume gas services (Reference 5). The gas price consists of:

Access fee	$15 per month
Transmission fee	$0.06130 per therm
Distribution fee	$0.06070 per therm
Franchise fee	$0.01250 per therm
Market price for gas	$0.61913 per therm

The market price for gas was calculated from the average gas price based on the futures market for the months August 2004 to July 2005. The total gas price was calculated at $0.78308 per therm, or $7.83 per MMBTU.[4] The annual heat production by gas-fired boilers for every option investigated can be found in Reference 4.

Costs for Electricity

Costs for electricity were determined according to PNM Rate No. 3B for general power service (Reference 6). The costs depend on the time the energy is consumed (on-peak or off-peak), the amount of energy consumed, and the peak demand.

Customer charge	$192.00 per bill
On-peak demand charge (above 50 kW)	$3.84 per kW
Energy charge	
- First 80 on-peak kWh	$0.113964 per kWh
- Next 120 on-peak kWh	$0.086024 per kWh
- All additional on- and off-peak kWh	$0.037533 per kWh

On-peak demand refers to the time from 8:00 am to 8:00 pm from Monday to Friday. The rate for off-peak demand applies to all other times. The calculation of the electricity price is based on the assumption that electric energy is needed at a constant rate throughout the year. Although the actual electricity demand varies depending on the time of day and year, this approach is accurate enough for a first estimate.

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[4] Note that the cost-of-gas shown here is about 30 percent below the cost of gas as this report is being published. Since the consumption of gas at the heating plant represents a small fraction of the total operating costs, this difference has a small effect on total annual system costs. Revenues from the sale of biomass generated heat, however, which is assumed to be sold at the prevailing rate for gas-fired heat, increase significantly as gas prices rise. These calculations (presented later) have been updated where possible and noted in the discussion.

Table 8: Electricity Costs for the Main District Heating System

		WTS HO	WTS ORC 1100	CFPP HO	CFPP ORC 1100
Required capacity	[kW_{el}]	465	535	550	620
Specific electricity demand	[$kWh_{el}/MMBTU_{th}$]	5.9	7.9	5.9	7.9
Average annual electricity demand	[kWh/yr]	1,114,195	1,666,164	1,058,944	1,585,742
Electricity price	[US$/kWh]	0.084	0.078	0.089	0.083

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW. The required capacity was based on the electric capacity of the network pumps and the capacity demand in the heating plant. All results are based on a pressure rating of PN 16. The electricity price shown is without taxes.

Operation-Related and Other Costs

Labor Costs

The labor costs for heat production were calculated using the salaries for the following job categories obtained from http://www.salaries.com in July, 2004.

- General maintenance worker
- Electric/electronics technician
- Operations supervisor

The average costs for heat production were calculated at $30.00 per man-hour. The number of man-hours needed for supervising the heating plant (2,000) and the pipe network (2,000) are based on experience with similar systems. The man-hours for fuel manipulation are calculated in Table 9. Assuming a front-loader capacity of 7.8 yd^3, the number of manipulated loads per year was calculated using the annual fuel demand of the heating plant and the manipulation time per load.

In addition, annual labor costs for plant management were considered to be $36,000.

Table 9: Calculation of Man-Hours Required for Fuel Manipulation

		WTS HO	WTC ORC1100	CFPP HO	CFPP ORC 1100
Annual Fuel Demand	[yd^3]	93,065	105,192	87,498	100,481
Load Capacity (Front Loader)	[yd^3]	7.8	7.8	7.8	7.8
Loads per Year	ea.	11,859	13,405	11,150	12,804
Manipulation Time per Load	[min]	2.5	2.5	2.5	2.5
Man-hours for Fuel Manipulation	[hrs/yr]	494	559	465	534

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW.

In addition to the man-hours given above, the CHP options (combined heat and power) require an additional 300 man-hours per year at a cost of $36.78 per hour for the supervision of the Organic Rankine Cycle process.

Disposal Costs and Costs for Water Treatment and Operation Chemicals

The costs for the disposal of ash and sludge from the flue-gas cleaning system are based on empirical values from Austria. These were determined to be $109 per ton for bottom ash and cyclone fly ash and $163 per ton for sludge (if a wet electrostatic filter is used).

For a description of the calculation of the average annual amount of ash and sludge produced, see Reference 4.

The costs for waste-water discharge were calculated according to the City of Santa Fe Wastewater Utility Ordinance. (Reference 7.) The service fee for water dumping is $4.32 per month and the usage fee $2.50 per 1,000 gallons per month. Table 10 gives an overview of these additional operating costs.

The costs for water treatment chemicals were estimated based on empirical values for similar systems in Austria, and amount to $1,200 per year.

Table 10: Ash Disposal, Waste Water Discharge, and Water Treatment Costs

		WTS HO	**WTC ORC1100**	**CFPP HO**	**CFPP ORC 1100**
Waste water	[gal/yr]	1,258,000	1,422,000	1,183,000	1,358,000
Waste water discharge costs	[US$/yr]	3,200	3,600	3,000	3,400
Bottom and cyclone ash	[tons/yr]	718	811	675	775
Ash disposal costs	[US$/yr]	78,100	88,300	73,500	84,400
Condensation sludge	[tons/yr]	160	180	150	172
Sludge disposal costs	[US$/yr]	26,000	29,400	24,500	28,100
Total Disposal Costs	[US$/yr]	107,300	121,300	101,000	115,900
Water treatment chemicals	[US$/yr]	1,200	1,200	1,200	1,200
Total Costs	**[US$/yr]**	**108,500**	**122,500**	**102,200**	**117,100**

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW. For details of the calculation of the average annual ash, condensation sludge, and waste water (condensate) produced, see Reference 4.

Operating Costs of the CHP module

As discussed in our *Final Feasibility Report* (Reference 4), the annual costs of consumables other than fuel (lubricants, etc.) for the CHP module are estimated at 0.25 percent of the investment costs of the CHP module assuming full-load operation throughout the year. Based on a CHP plant investment cost of about $1,964,000, this amounts to $4,910 annually. Actual costs will be lower due to some expected partial-load operation of the CHP plant. Estimates are $3,060 for "Waste Transfer Station—Option 1c" (annual utilization rate of 62 percent) and $2,950 for the option "Former Coal-Fired Power Plant—Option 2b" (60 percent).

Lease Costs

The annual lease costs of $6,000 are based on property costs of $120,000 and an annual interest rate of 5 percent. The lease costs are estimated low since it is common for the host city to provide a grant or subsidy for the lease or purchase of any property required. This type of support for district heating plants is very common throughout Europe.

Other Costs

Other costs were estimated at 0.7 percent of the total investment costs per year, to cover things like insurance, accounting, administration, and other small costs.

System Revenues

The following is a calculation of revenues the system is expected to produce.

Revenues from Energy Sales

For calculating the financial performance, it is assumed that heat from the biomass system can be sold at the same price that customers are currently paying for heat from natural gas. Using the method outlined in Reference 8, we calculated the cost of heating with natural gas for the 12-month period ending June, 2006 at $13.99 per MMBTU for small commercial accounts and $14.93 for residential customers. Given the expected ratio of heat sales from the biomass system as designed, (91.3 percent to commercial customers, and 8.7 percent to residential), we calculated a blended price of heat for the system at $14.08 per MMBTU. This is the heat price assumed for system revenues from energy sales.

Table 11 shows the annual revenues due to sales of electricity and heat for the four design cases. The revenues from the feed-in tariff are also included.

Table 11: Annual Revenues of the Main District Heating System after Completion of Pipe Network

		WTS HO	WTS ORC 1100	CFPP HO	CFPP ORC 1100
Heat sold to customers	[MMBTU/yr]	159,904	159,904	158,040	158,040
Heat price	[US$/MMBTU]	14.08	14.08	14.08	14.08
Heat Sales	[US$]	2,251,448	2,251,448	2,225,203	2,225,203
Electricity produced	[MWh/yr]		5,996		5,784
Feed-in tariff	[US$/MWh]		60.00		60.00
Electricity Sales	[US$]		359,741		347,040
Annual Revenues	**[US$]**	**2,251,448**	**2,611,189**	**2,225,203**	**2,572,243**

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW. The amount of heat sold to customers is based on a connection rate of 80 percent. The amount of electricity produced per year is adjusted to a continuous two-boiler operation during winter. See Reference 4 for details.

Revenues from Connection Fees

A supply line, return line, and heat transfer station must be installed for every customer of the district heating system. Customers typically pay a connection fee to cover part of the cost of these items. The amount of the fee depends on the size of the service to be connected, and ranges from $2,040 (51,000 BTU/hr service) to $24,000 (13,600,000 BTU/hr service). See Table 12. Connection fees are a commonly used means for reducing the investment costs of a pipe network in Europe. If connection fees are not charged, investment subsidies must generally be increased to compensate.

Revenues from Sale of Credits

The sale of green credits or emission-reduction credits from the system is possible if the emission reductions can be certified. The landscape of this market is changing quickly, and a detailed discussion of available market mechanisms and their potential to generate revenues is presented in Section 3.

Table 12: Connection Fees for the Main District Heating Systems

Capacity of the Heat Transfer Station [BTU/hr]	[kW]	Connection Fee [US$]
51,000	15	2,040
102,000	30	2,040
171,000	50	2,400
256,000	75	2,580
341,000	100	3,060
427,000	125	3,300
512,000	150	3,420
597,000	175	4,740
682,000	200	4,800
853,000	250	5,220
1,024,000	300	5,700
1,365,000	400	6,480
1,706,000	500	7,260
3,412,000	1,000	10,800
5,118,000	1,500	13,200
6,824,000	2,000	15,600
10,236,000	3,000	19,800
13,648,000	4,000	24,000

Financing the Project

Investment Subsidies

A biomass-fired district heating system for downtown Santa Fe would represent an important investment in the infrastructure of the city. It is therefore suggested, and it is common practice throughout Europe, that the investment costs of the network of pipes (less any connection fees charged) be paid for with public or community funds.[5] Such subsidies have therefore been included in the financial calculations, and are shown in Table 13.

Additional investment subsidies for the heating plant or CHP plant were not considered in the calculations, as these investments are expected to pay for themselves through revenues.

Subsidies are generally paid about a year after the capital investment takes place, and this assumption was made in the calculation of the dynamic payback period.

Table 13: Suggested Subsidy Amount for the Main District Heating System

		WTS HO	WTS ORC 1100	CFPP HO	CFPP ORC 1100
Investment Cost of Pipe Network	[US$]	14,154,000	14,154,000	9,841,800	9,841,800
Total Connection Fees	[US$]	1,350,300	1,350,300	1,254,420	1,254,420
Balance Required (Suggested Subsidy)	[US$]	12,803,700	12,803,700	8,587,380	8,587,380
Total Investment Cost of System	[US$]	23,772,200	27,134,300	21,568,500	26,906,100
Suggested Subsidy as a % of Investment	%	53.9	47.2	39.8	31.9

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW. The investment costs of the network of pipes include costs of the pipe network, trenching and backfilling and heat transfer stations.

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[5] The word "subsidy" has a bad reputation in the U.S. Therefore, instead of calling the funding a subsidy, it may be more useful to call the district heat-pipe network "essential infrastructure", much like our sewer and water lines. When heating with gas is no longer viable, the necessity of this public investment will become more obvious.

Internal and External Financing

After a portion of the total investment costs have been covered by connection fees and subsidies, the remaining costs need to be financed by owner and/or debt capital. For the purpose of this study, 10 percent of the remaining costs were considered to be covered by owner capital with an annual internal interest rate of 5 percent. The remaining portion must be financed by loans or other financing methods. The duration of the loan was set at 15 years, with an annual interest rate of 5 percent. Table 14 summarizes the relevant financing parameters.

Table 14: Financing of the Main District Heating System

		WTS HO	WTS ORC 1100	CFPP HO	CFPP ORC 1100
Type of loan		payment of annuities	payment of annuities	payment of annuities	payment of annuities
Loan period	[years]	15	15	15	15
Interest rate of debt capital	[%]	5	5	5	5
Debt capital % of investment	[%]	36.4	43.1	48.9	57.1
Interest rate of owner capital	[%]	5	5	5	5
Owner capital % of investment*	[%]	63.6	56.9	51.1	42.9

Notes: "WTS" represents "Waste Transfer Station, and "CFPP" represents "Old Coal-Fired Power Plant". "HO" represents "Heat Only", and "ORC 1100" represents a CHP plant with an Organic Rankine Cycle and a nominal electric capacity of 1,100 kW.
** Owner capital includes connection fees and subsidies.*

The availability of other financing methods is dependent on the ownership model to be used for the system. Since this decision is yet to be made, no other specific financing methods were considered in the economic calculations.

Calculation of the Heat and Electricity Production Costs

All calculations of heat and electricity production costs are based on the *VDI Guideline 2067* (Reference 3). The discussion of results of each of the four cases has been updated since the analysis was performed to reflect the 34 percent rise in natural gas heating costs since that time.

Option 1a – Waste Transfer Station – Heat Only, PN 16

Table 15 shows the calculation of the heat production costs for Option 1a, “Waste Transfer Station - Heat Only” at a pressure rating of PN 16. The results show a heat production cost of $17.91 per MMBTU, which is reduced to $12.61 per MMBTU after the suggested subsidy according to Table 13 is provided.

Although the un-subsidized cost of heat is higher than what residents are currently paying, the price with the subsidy is 10 percent below the $13.99 per MMBTU now being paid by small commercial customers, and 16 percent below the $14.93 being paid by residential customers.

The highest specific-energy production costs occur for the network of pipes (pipes, trenching and backfilling, heat transfer stations), followed by biomass costs and costs for the biomass-fired furnace and boiler.

Based on the results of the calculations, a positive financial performance is achievable if the suggested investment subsidies are provided. Further increases in the cost of heating with natural gas, which are expected, will further improve the financial performance of this option.

A more detailed presentation of the calculation of specific energy costs is given in Reference 4.

Table 15: Calculation of Heat Production Costs – Option 1a
Waste Transfer Station – Heat Only, Pressure Rating PN 16

	Investment costs	Capital costs	Mainten. costs	Cons. related costs	Operation related costs	Total energy costs	Specific energy costs
	US $	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / MMBTU
Construction costs							
Building	0	0	0	0	0	0	0.00
Fuel storage	240,000	13,146	2,400	0	0	15,546	0.10
Surrounding facility	0	0	0	0	0	0	0.00
Infrastructure	0	0	0	0	0	0	0.00
Network of pipes							
Pipes	8,118,000	456,733	40,590	0	0	497,323	3.11
Trenching / backfilling	2,806,800	157,915	14,034	0	0	171,949	1.08
Heat transfer stations	3,229,245	210,067	64,585	0	0	274,652	1.72
Mechanical equipment							
Furnace and boiler	1,812,000	145,400	54,360	0	0	199,760	1.25
Flue gas cleaning	1,495,200	119,979	29,904	0	0	149,883	0.94
Ash removal and storage	224,400	18,006	6,732	0	0	24,738	0.15
Heat recovery	243,600	19,547	4,872	0	0	24,419	0.15
Fuel feeding	217,200	17,429	6,516	0	0	23,945	0.15
Cranes	103,680	8,320	2,074	0	0	10,393	0.06
Electric installations	714,864	57,363	14,297	0	0	71,660	0.45
Hydronic installations	943,488	75,708	18,870	0	0	94,578	0.59
Steel construction	291,600	23,399	2,916	0	0	26,315	0.16
Peak-load coverage	520,800	41,790	5,208	0	0	46,998	0.29
CHP module	0	0	0	0	0	0	0.00
Vehicles	120,000	11,561	3,600	0	0	15,161	0.09
Engineering	2,091,288	148,071	0	0	0	148,071	0.93
Miscellaneous	600,000	48,146	12,000	0	0	60,146	0.38
Fuel costs							
Biomass	0	0	0	355,466	0	355,466	2.22
Natural gas	0	0	0	107,514	0	107,514	0.67
Operation related and other costs							
Heating plant related labor costs	0	0	0	0	171,000	171,000	1.07
CHP related labor costs	0	0	0	0	0	0	0.00
Electricity (auxiliary energy)	0	0	0	93,660	0	93,660	0.59
Other costs	0	0	0	0	166,405	166,405	1.04
Additional operating costs	0	0	0	0	108,500	108,600	0.68
Operating costs-CHP	0	0	0	0	0	0	0.00
Lease costs (property)	0	0	0	0	6,000	6,000	0.04
Sum of costs	23,772,165	1,572,579	282,958	556,640	451,905	2,864,182	17.91
Specific energy production costs (w/o subsidies)		9.83	1.77	3.48	2.83		17.91
Specific energy production costs (with subsidies)		4.53	1.77	3.48	2.83		12.61

Notes: "Mainten. Costs" refers to the maintenance costs. "Cons. related costs" refers to consumption related costs. "PN 16" refers to the maximum total pressure in the network of pipes (232 psi or 16 bar). "w/o" represents without. The specific energy production costs are related to the heat sold to the customers per year. All values refer to the fifth year after construction.

Option 1c - "Waste Transfer Station – ORC 1100, PN 16"

Table 16 shows the calculation of the heat and electricity production costs for Option 1c, "Waste Transfer Station – CHP ORC 1100" at a pressure rating of PN 16. The results show a combined heat-and-power production cost of $18.84 per MMBTU, which is reduced to $13.93 per MMBTU after the suggested subsidy according to Table 13 is provided.

Although the un-subsidized cost of heat and power for this option is higher than the $14.48 that customers are paying now[6], the price after application of the subsidy is about 4 percent less than is currently being paid.

The highest specific-energy production costs occur for the network of pipes (pipes, trenching and backfilling, heat transfer stations), followed by biomass costs and costs for the biomass-fired furnace and boiler.

Based on the results of the calculations, a positive financial performance is achievable if the suggested investment subsidies are provided. Further increases in the cost of heating with natural gas, which are expected, will further improve the financial performance of this option.

A more detailed presentation of the calculation of the specific energy costs is given in Reference 4.

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[6] Price shown is an aggregate price calculated using the cost of heat from natural gas and the feed-in tariff for green electricity.

Table 16: Calculation of Heat and Electricity Production Costs – Option 1c
Waste Transfer Station – ORC 1100, Pressure Rating PN 16

	Investment costs	Capital costs	Mainten. costs	Cons. related costs	Operation related costs	Total energy costs	Specific energy costs
	US $	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / MMBTU
Construction costs							
Building	0	0	0	0	0	0	0.00
Fuel storage	240,000	13,146	2,400	0	0	15,546	0.09
Surrounding facility	0	0	0	0	0	0	0.00
Infrastructure	0	0	0	0	0	0	0.00
Network of pipes							
Pipes	8,118,000	456,733	40,590	0	0	497,323	2.76
Trenching / backfilling	2,806,800	157,915	14,034	0	0	171,949	0.95
Heat transfer stations	3,229,245	210,067	64,585	0	0	274,652	1.52
Mechanical equipment							
Furnace and boiler	2,775,600	222,721	83,268	0	0	305,989	1.70
Flue gas cleaning	1,554,000	124,697	31,080	0	0	155,777	0.86
Ash removal and storage	224,400	18,006	6,732	0	0	24,738	0.14
Heat recovery	253,200	20,317	5,064	0	0	25,381	0.14
Fuel feeding	217,200	17,429	6,516	0	0	23,945	0.13
Cranes	84,240	6,760	1,685	0	0	8,444	0.05
Electric installations	832,356	66,790	16,647	0	0	83,438	0.46
Hydronic installations	938,045	75,271	18,761	0	0	94,032	0.52
Steel construction	259,200	20,799	2,592	0	0	23,391	0.13
Peak load coverage	520,800	41,790	5,208	0	0	46,998	0.26
CHP module	1,964,235	189,239	26,589	0	0	215,828	1.20
Vehicles	120,000	11,561	3,600	0	0	15,161	0.08
Engineering	2,396,932	174,745	0	0	0	174,745	0.97
Miscellaneous	600,000	48,146	12,000	0	0	60,146	0.33
Fuel costs							
Biomass	0	0	0	401,786	0	401,786	2.23
Natural gas	0	0	0	139,552	0	139,552	0.77
Operation related and other costs							
Heating plant related labor costs	0	0	0	0	174,000	174,000	0.96
CHP related labor costs	0	0	0	0	11,034	11,034	0.06
Electricity (auxiliary energy)	0	0	0	132,573	0	132,573	0.74
Other costs	0	0	0	0	189,940	189,940	1.05
Additional operating costs	0	0	0	0	122,500	122,500	0.68
Operating costs-CHP	0	0	0	0	3,055	3,055	0.02
Lease costs (property)	0	0	0	0	6,000	6,000	0.03
Sum of costs	27,134,253	1,876,133	341,351	673,910	506,549	3,397,923	18.84
Specific energy production costs (w/o subsidies)		10.40	1.89	3.74	2.81		18.84
Specific energy production costs (with subsidies)		5.49	1.89	3.74	2.81		13.93

Notes: "Mainten. Costs" refers to the maintenance costs. "Cons. related costs" refers to consumption related costs. "PN 16" refers to the maximum total pressure in the network of pipes (232 psi or 16 bar). "w/o" represents without. The specific energy production costs are related to the mixed price based on the heat and electricity sold to the customers per year. All values refer to the fifth year after construction.

Option 2a - “Former Coal-Fired Power Plant – Heat Only, PN 16”

Table 17 shows the calculation of the heat production costs for the option “Former Coal-Fired Power Plant - Heat Only” at a pressure rating of PN 16. The results show a heat production cost of $17.00 per MMBTU, which is reduced to $13.40 per MMBTU after the suggested subsidy according to Table 13 is provided.

Although the un-subsidized cost of heat is higher than what residents are currently paying, the price after application of the subsidy is 4 percent less than the $13.99 per MMBTU now being paid by small commercial customers, and 10 percent below the $14.93 being paid by residential customers.

The highest specific-energy production costs occur for the network of pipes (pipes, trenching and backfilling, heat transfer stations), followed by biomass costs and costs for the biomass-fired furnace and boiler.

Without subsidies, the heat production costs for this option are slightly lower than the comparable option at the Waste Transfer Station. The main reason for the better financial performance is the lower investment costs for the pipe network for this option, which influences financial performance more strongly than the additional construction costs required to put up buildings and other infrastructure at the old Coal-Fired Power Plant.

With subsidies provided, this option shows slightly higher heat-production costs than the comparable option located at the Waste Transfer Station. This is mainly due to the higher construction costs for buildings and storage facilities needed at this site. (The cost for the pipe network is lower, but the application of the subsidy nullifies this advantage.)

Based on the results of the calculations, a positive financial performance is achievable if the suggested investment subsidies are provided. Further increases in the cost of heating with natural gas, which are expected, will further improve the financial performance of this option.

A more detailed presentation of the calculation of specific energy costs is given in Reference 4.

Table 17: Calculation of the Heat Production Costs – Option 2a
Former Coal-Fired Power Plant – Heat Only, Pressure Rating PN 16

	Investment costs	Capital costs	Mainten. costs	Cons. related costs	Operation related costs	Total energy costs	Specific energy costs
	US $	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / MMBTU
Construction costs							
Building	1,389,600	76,118	13,896	0	0	90,014	0.57
Fuel storage	1,104,000	60,474	11,040	0	0	71,514	0.45
Surrounding facility	240,000	13,146	2,400	0	0	15,546	0.10
Infrastructure	144,000	7,888	1,440	0	0	9,328	0.06
Network of pipes							
Pipes	5,121,600	288,150	25,608	0	0	313,758	1.99
Trenching / backfilling	1,725,600	97,085	8,628	0	0	105,713	0.67
Heat transfer stations	2,994,604	194,803	59,892	0	0	254,695	1.61
Mechanical equipment							
Furnace and boiler	1,722,000	138,178	51,660	0	0	189,838	1.20
Flue gas cleaning	1,420,800	114,009	28,416	0	0	142,425	0.90
Ash removal and storage	213,600	17,140	6,408	0	0	23,548	0.15
Heat recovery	231,600	18,584	4,632	0	0	23,216	0.15
Fuel feeding	206,400	16,562	6,192	0	0	22,754	0.14
Cranes	103,680	8,320	2,074	0	0	10,393	0.07
Electric installations	679,200	54,501	13,584	0	0	68,085	0.43
Hydronic installations	896,400	71,929	17,928	0	0	89,857	0.57
Steel construction	291,600	23,399	2,916	0	0	26,315	0.17
Peak load coverage	520,800	41,790	5,208	0	0	46,998	0.30
CHP module	0	0	0	0	0	0	0.00
Vehicles	120,000	11,561	3,600	0	0	15,161	0.10
Engineering	1,842,996	127,041	0	0	0	127,041	0.80
Miscellaneous	600,000	48,146	12,000	0	0	60,146	0.38
Fuel costs							
Biomass	0	0	0	334,478	0	334,478	2.12
Natural gas	0	0	0	121,387	0	121,387	0.77
Operation related and other costs							
Heating plant related labor costs	0	0	0	0	171,000	171,000	1.08
CHP related labor costs	0	0	0	0	0	0	0.00
Electricity (auxiliary energy)	0	0	0	93,995	0	93,995	0.59
Other costs	0	0	0	0	150,979	150,979	0.96
Additional operating costs	0	0	0	0	102,200	102,200	0.65
Operating costs-CHP	0	0	0	0	0	0	0.00
Lease costs (property)	0	0	0	0	6,000	6,000	0.04
Sum of costs	21,568,480	1,428,823	277,522	549,861	430,179	2,686,385	17.00
Specific energy production costs (w/o subsidies)		9.04	1.76	3.48	2.72		17.00
Specific energy production costs (with subsidies)		5.44	1.76	3.48	2.72		13.40

Notes: "Mainten. Costs" refers to the maintenance costs. "Cons. related costs" refers to consumption related costs. "PN 16" refers to the maximum total pressure in the network of pipes (232 psi or 16 bar). "w/o" represents without. The specific energy production costs are related to the heat sold to the customers per year. All values refer to the fifth year after construction.

Option 2b - "Former Coal-Fired Power Plant – ORC 1100, PN 16"

Table 18 shows the calculation of the heat and electricity production costs for Option 2b, "Former Coal-Fired Power Plant – CHP ORC 1100" at a pressure rating of PN 16. The results show a combined heat-and-power production cost of $18.82 per MMBTU, which is reduced to $15.51 per MMBTU after the suggested subsidy according to Table 13 is provided.

Both the un-subsidized and the subsidized cost of heat and power for this option are higher than the $14.47 that customers are paying now[7].

The highest specific-energy production costs occur for the network of pipes (pipes, trenching and backfilling, heat transfer stations), followed by biomass costs and costs for the biomass-fired furnace and boiler.

Without subsidies, the heat and electricity production costs for this option are roughly equivalent to those costs for the comparable CHP option at the Waste Transfer Station. The two sites perform almost identically because the reduced investment cost for the network of pipes is offset by the higher investment costs needed for buildings and storage facilities.

With subsidies, this option shows considerably higher heat and electricity production costs than the comparable option at the Waste Transfer Station. This is mainly due to the higher construction costs for buildings and storage facilities needed at the site of the old Coal-Fired Power Plant. (The cost for the pipe network is considerably reduced if the plant is located at the old Coal-Fired Power Plant, but the investment subsidies nullify this advantage.)

Based on the results of the calculations, a positive financial performance is only possible through an increase in investment subsidies, heat price, feed-in tariff, or some combination of the three.

A more detailed presentation of the calculation of the specific energy costs is given in Reference 4.

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[7] Price shown is an aggregate price calculated using the cost of heat from natural gas and the feed-in tariff for green electricity.

Table 18: Calculation of Heat and Electricity Production Costs – Option 2b

Former Coal-Fired Power Plant – ORC 1100, Pressure Rating PN 16

	Investment costs	**Capital costs**	**Mainten. costs**	**Cons. related costs**	**Operation related costs**	**Total energy costs**	**Specific energy costs**
	US $	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / yr	US $ / MMBTU
Construction costs							
Building	2,739,600	150,066	27,396	0	0	177,462	1.00
Fuel storage	1,297,200	71,056	12,972	0	0	84,028	0.47
Surrounding facility	240,000	13,146	2,400	0	0	15,546	0.09
Infrastructure	144,000	7,888	1,440	0	0	9,328	0.05
Network of pipes							
Pipes	5,121,600	288,150	25,608	0	0	313,758	1.76
Trenching / backfilling	1,725,600	97,085	8,628	0	0	105,713	0.59
Heat transfer stations	2,994,604	194,803	59,892	0	0	254,695	1.43
Mechanical equipment							
Furnace and boiler	2,775,600	222,721	83,268	0	0	305,989	1.72
Flue gas cleaning	1,554,000	124,697	31,080	0	0	155,777	0.88
Ash removal and storage	224,400	18,006	6,732	0	0	24,738	0.14
Heat recovery	253,200	20,317	5,064	0	0	25,381	0.14
Fuel feeding	217,200	17,429	6,516	0	0	23,945	0.13
Cranes	84,240	6,760	1,685	0	0	8,444	0.05
Electric installations	832,356	66,790	16,647	0	0	83,438	0.47
Hydronic installations	938,045	75,271	18,761	0	0	94,032	0.53
Steel construction	259,200	20,799	2,592	0	0	23,391	0.13
Peak load coverage	520,800	41,790	5,208	0	0	46,998	0.26
CHP module	1,964,235	189,239	26,389	0	0	215,628	1.21
Vehicles	120,000	11,561	3,600	0	0	15,161	0.09
Engineering	2,300,172	162,469	0	0	0	162,469	0.91
Miscellaneous	600,000	48,146	12,000	0	0	60,146	0.34
Fuel costs							
Biomass	0	0	0	383,792	0	383,792	2.16
Natural gas	0	0	0	126,366	0	126,366	0.71
Operation related and other costs							
Heating plant related labor costs	0	0	0	0	174,000	174,000	0.98
CHP related labor costs	0	0	0	0	11,034	11,034	0.06
Electricity (auxiliary energy)	0	0	0	130,939	0	130,939	0.74
Other costs	0	0	0	0	188,342	188,342	1.06
Additional operating costs	0	0	0	0	117,100	117,100	0.66
Operating costs-CHP	0	0	0	0	2,947	2,947	0.02
Lease costs (property)	0	0	0	0	6,000	6,000	0.03
Sum of costs	26,906,051	1,848,192	357,878	641,097	499,423	3,346,590	18.82
Specific energy production costs (w/o subsidies)		10.40	2.01	3.61	2.81		18.82
Specific energy production costs (with subsidies)		7.08	2.01	3.61	2.81		15.51

Notes: "Mainten. Costs" refers to the maintenance costs. "Cons. related costs" refers to consumption related costs. "PN 16" refers to the maximum total pressure in the network of pipes (232 psi or 16 bar). "w/o" represents without. The specific energy production costs are related to the mixed price based on the heat and electricity sold to the customers per year. All values refer to the fifth year after construction.

Dynamic Payback Period and Capital Value of Investment

The results of the calculation of the dynamic payback period and capital value for a heat price of $10.44 per MMBTU (the price when the calculations were made) are displayed in the following graphs. Unfortunately these graphs could not be updated to reflect the prevailing price of $14.08 per MMBTU as this report was being printed. Where possible, we have included comments on the expected performance at the higher heat price.

All of the graphs consider that the suggested subsidies shown in Table 13 have been applied. The payback therefore refers to the investment in the energy plant only.

Detailed calculation sheets representing the first 20 years of operation can be found in Reference 4.

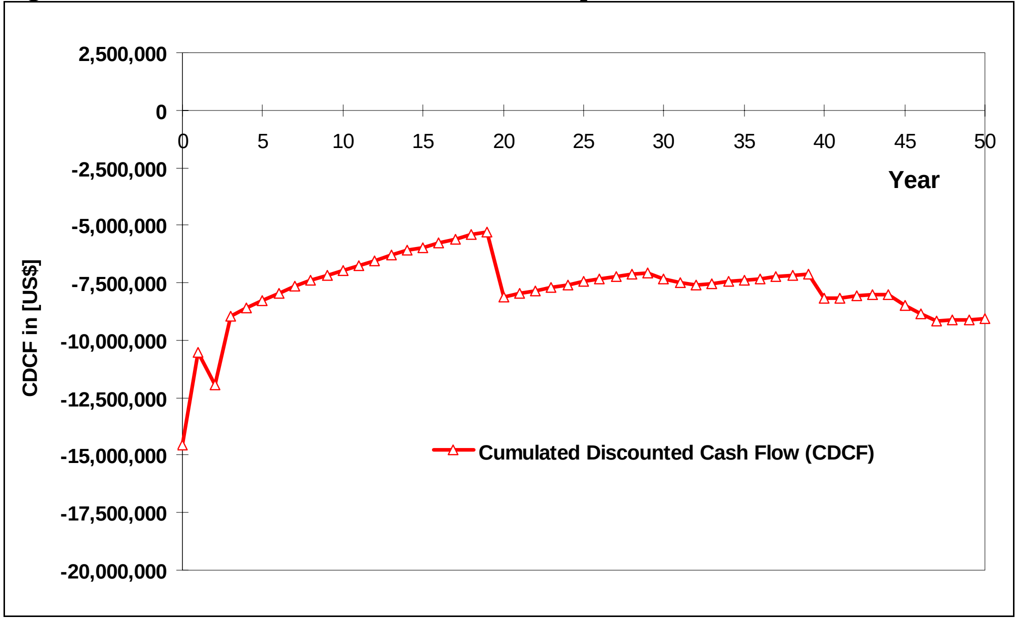
Option 1a – "Waste Transfer Station – Heat Only, PN 16"

Figure 16 shows the result of the calculation of the dynamic payback period at a heat price of $10.44 per MMBTU. The graph shows a negative financial performance, as expected from the calculation of the heat production costs based on *VDI Guideline 2067*.

At a heat price of $10.44 per MMBTU, a payback of the capital investment cannot be achieved. The capital value of the investment after 15 years amounts to $– 5,966,000. This value does not take into account the actual value of the installed equipment, however, which has an average useful life of about 23 years.

If updated to reflect the current heat price of $14.08, this option would show a dynamic payback period of 15 years.

Figure 16: Cumulated Discounted Cash Flow of Option 1a, Waste Transfer Station, Heat Only



Note: The graph shown is for a heat price of $10.44 per MMBTU, which is 26 percent less than the current cost of heat. Construction time for the pipe network was estimated at three years.

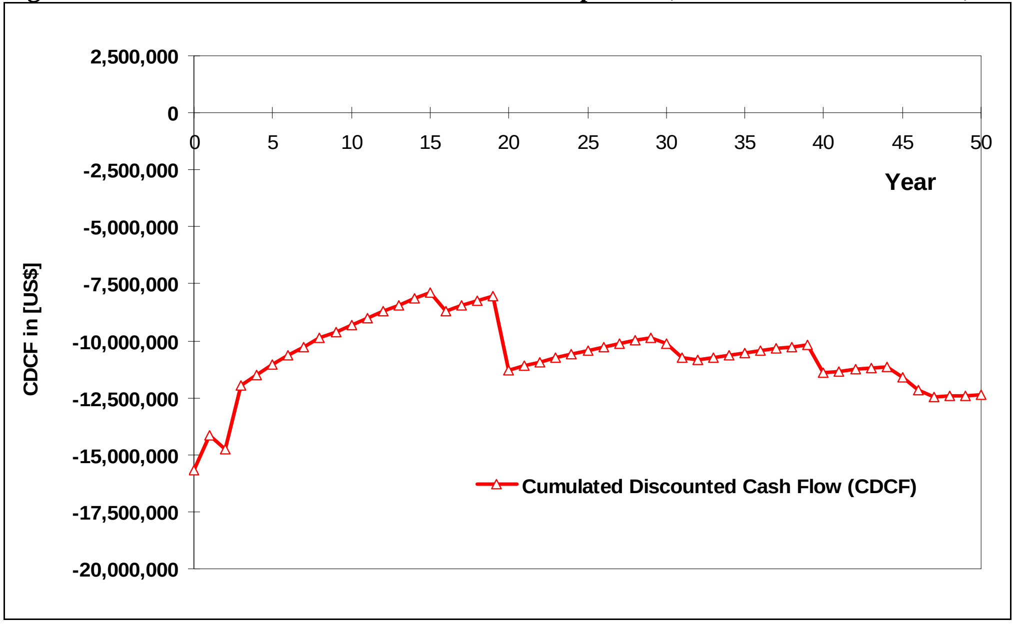
Option 1c - "Waste Transfer Station – ORC 1100, PN 16"

Figure 17 shows the result of the calculation of the dynamic payback period at a heat price of $10.44 per MMBTU. The graph shows a negative financial performance, as expected from the calculation of the heat production costs based on *VDI Guideline 2067*.

At a heat price of $10.44 per MMBTU, a payback of the capital investment cannot be achieved. The capital value of the investment after 15 years amounts to $– 7,906,000. This value does not take into account the actual value of the installed equipment, however, which has an average useful life of about 22 years. The lower capital value compared to the heat-only option is mainly caused by the additional investment costs for the CHP plant, which cannot be compensated by the annual revenues from the sale of green electricity.

If updated to reflect the current heat price of $14.08, this option would show a positive financial performance, but the dynamic payback period would exceed 15 years. A 10 percent further increase in heat price (to $15.47 per MMBTU) is needed for this investment to have a dynamic payback of 15 years.

Figure 17: Cumulated Discounted Cash Flow of Option 1c, "Waste Transfer Station, ORC 1100"



Notes: The graph shown is for a heat price of $10.44 per MMBTU, which is 26 percent less than the current cost of heat. Construction time for the pipe network was estimated at three years. The CHP plant is assumed to be installed in the second year.

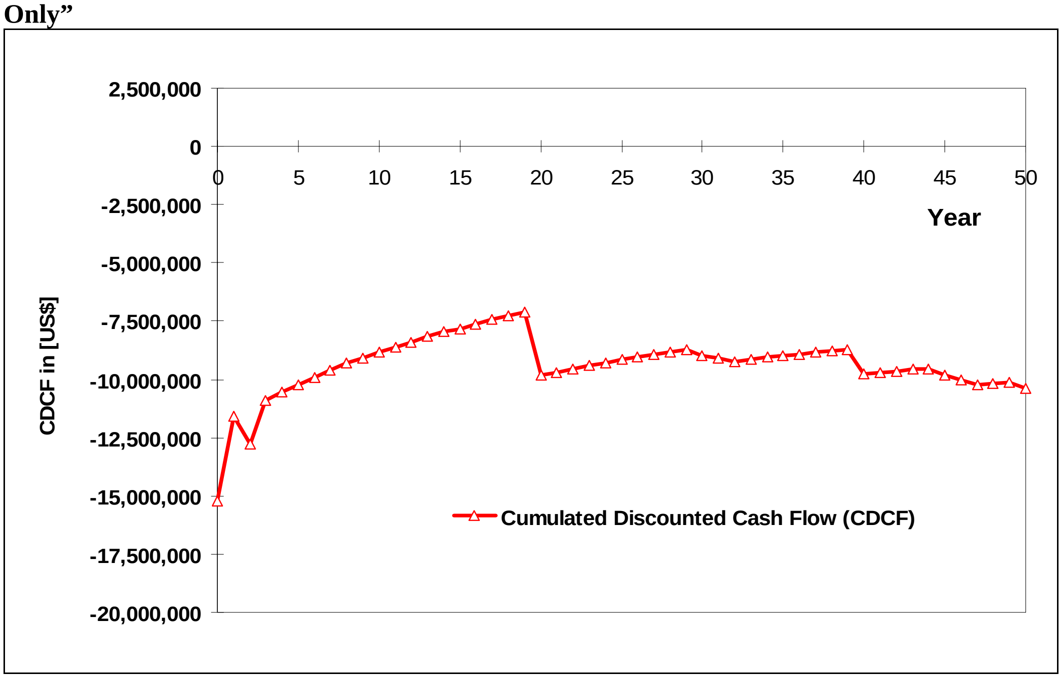
Option 2a - "Former Coal-Fired Power Plant – Heat Only, PN 16"

Figure 18 shows the result of the calculation of the dynamic payback period at a heat price of $10.44 per MMBTU. The graph shows a negative financial performance, as expected from the calculation of the heat production costs based on *VDI Guideline 2067*.

At a heat price of $10.44 per MMBTU, a payback of the capital investment cannot be achieved. The capital value of the investment after 15 years amounts to $– 7,819,000. This value does not take into account the actual value of the installed equipment, however, which has an average useful life of about 25 years. The lower capital value compared to Option 1a (Waste Transfer Station, Heat Only) is mainly caused by lower investment subsidies.

If updated to reflect the current heat price of $14.08, this option would show a positive financial performance, but the dynamic payback period would exceed 15 years. A 10 percent further increase in heat price (to $15.47 per MMBTU) is needed for this investment to have a dynamic payback of 15 years.

Figure 18: Cumulated Discounted Cash Flow of Option 2a, "Former Coal-Fired Power Plant, Heat Only"



Note: The graph shown is for a heat price of $10.44 per MMBTU, which is 26 percent less than the current cost of heat. Construction time for the pipe network was estimated at three years.

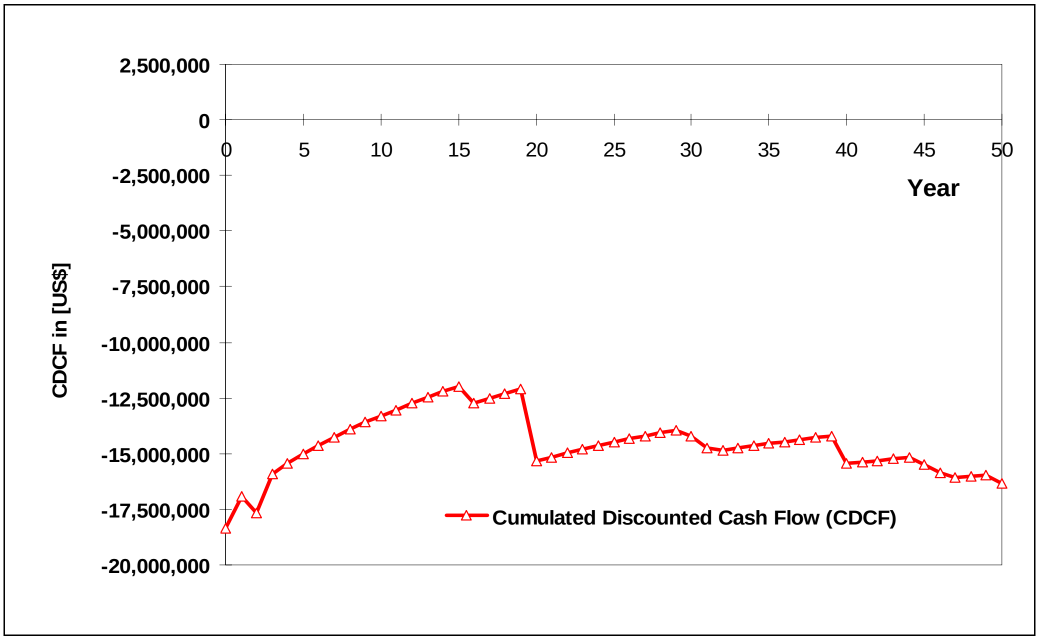
Option 2b - “Former Coal-Fired Power Plant – ORC 1100, PN 16”

Figure 19 shows the result of the calculation of the dynamic payback period at a heat price of $10.44 per MMBTU. The graph shows a negative financial performance, as expected from the calculation of the heat production costs based on *VDI Guideline 2067*.

At a heat price of $10.44 per MMBTU, a payback of the capital investment cannot be achieved. The capital value of the investment after 15 years amounts to $– 11,994,000. This value does not take into account the actual value of the installed equipment, however, which has an average useful life of about 25 years. The lower capital value compared to Option 1c (Waste Transfer Station, ORC 1100) is mainly caused by lower investment subsidies. The lower capital value compared to the heat only option (Option 2a) is mainly caused by the additional investment costs for the CHP plant, which cannot be compensated by the annual revenues from the sale of green electricity.

If updated to reflect the current heat price of $14.08, this option would still show a negative financial performance. A 29 percent further increase in heat price (to $18.11 per MMBTU) is needed for this investment to have a dynamic payback of 15 years.

Figure 19: Cumulated Discounted Cash Flow of Option 2b, “Former Coal-Fired Power Plant, ORC 1100”



Notes: The graph shown is for a heat price of $10.44 per MMBTU, which is 26 percent less than the current cost of heat. Construction time for the pipe network was estimated at three years. The CHP plant is assumed to be installed in the second year.

Summary and Conclusions on Financial Performance

Of the four options, Option 1a (Waste Transfer Station (WTS), Heat Only) features the best performance in terms of dynamic payback period and the capital value. Both of the design options at the WTS perform better than their counterparts at the Old Coal-Fired Power Plant (CFPP) because the built infrastructure at this location is useable, and therefore construction costs are reduced. The higher cost of the pipe network needed to reach the WTS does not adversely affect the financial performance because this cost is expected to be subsidized. If all options received the same dollar amount of subsidies, rather than subsidies according to the cost of the pipe network, the CFPP options would feature better financial performance than the WTS options.

The heat price necessary for a dynamic payback period of 15 years was determined to be $14.07 per MMBTU for Option 1a (Waste Transfer Station – Heat Only). As the current cost of heating with natural gas in Santa Fe has recently risen to $14.08 per MMBTU, this option should have a 15-year payback. Payback will likely improve further as heating costs continue to escalate.

The heat price necessary for a dynamic payback period of 15 years was calculated for the other three options as well. Options 1c (Waste Transfer Station – ORC 1100) and 2a (Former Coal-Fired Power Plant – Heat Only) require a heat price of about $15.50, and Option 2b (Former Coal-Fired Power Plant – ORC 1100) requires a heat price of $18.11 per MMBTU to reach a dynamic payback period of 15 years. At current escalation rates for heating costs, these levels should easily be reached in the next several years.

All of the graphs of cumulated discounted cash flow were based on a cost of heating with natural gas of $10.44 per MMBTU, which was the approximate cost when the analysis was performed. At that time, none of the four options showed a positive cash-flow compared to heating with natural gas. The more current price of $14.08 per MMBTU improved the dynamic payback considerably.

Depending on how the emissions-credit markets develop, the financial performance of the biomass system could improve significantly with the sale of credits. Since the CO_2 emissions reduction of the CHP options is considerably higher (due to the substitution of electricity generated by coal-fired power plants), the sale of CO_2 certificates has a greater impact on the CHP options. An estimation of the change in revenues from the sale of emissions credits is given in Table 19, although the $12.00 per ton price used is probably too optimistic for the U.S. emissions market. A more thorough discussion of the value of the emissions reductions appears in Section 3.

The possible utilization of bottom and cyclone fly ash can also improve financial performance. If the ash is given away for use as a fertilizer or construction material, or disposed of in the city landfill for free, the heat price required for a dynamic payback period of 15 years could be reduced to $13.72 per MMTBTU for Option 1a. This would also make the system competitive today.

The heat-only options have better financial performance than the CHP options due to the low feed-in tariff for green electricity ($0.06 per kWh), which cannot pay back the additional investment cost for the CHP plant. Higher feed-in tariffs for green electricity would improve financial performance of the CHP options. The feed-in tariff must increase to $0.096 in order for the two CHP options to achieve comparable financial performance with their heat-only counterparts. As long as feed-in tariffs remain below these values, the heat-only options show clear economic advantages. Again, a further discussion of the potential value of the green electricity generated appears in Section 3.

Table 19 summarizes the basic technical and economic parameters discussed in this section for all main grid options.

Table 19: Summary of Dynamic Payback Period and Required Heat Price for the Four Cases

(all design cases are for pressure rating PN16)		**WTS, HO**	**WTS, ORC 1100**	**CFPP, HO**	**CFPP, ORC 1100**
Installed capacity (BM + ECO)	[MBTU/hr]	44,651	41,782	40,928	41,781
Network heat utilization ratio	[MMBTU/ft*yr]	2,156	2,156	2,681	2,681
Investment costs	[US$]	23,772,165	27,134,253	21,568,480	26,906,051
Specific investment costs	[US$/MBTU/hr]	532	649	527	644
Full load operating hours	[hrs/yr]	4,027	3,905	4,130	3,990
Subsidies (for the pipe network)	[% of inv. costs]	53.9	47.2	39.8	31.2
Subsidies (for the pipe network)	[US$]	12,813,197	12,813,197	8,586,412	8,586,412
CDCF after 15 years (at current heat price)	[US$]	-5,965,825	-7,906,427	-7,819,149	-11,993,884
Required subsidies (t_0 = 15 yrs)	[% of inv. costs]	81.0	79.0	79.0	80.0
Required subsidies (t_0 = 15 yrs)	[US$]	19,255,453	21,436,059	17,039,098	21,524,840
Required heat price (t_0 = 15 yrs)	[US $/MMBTU]	14.07	15.47	15.47	18.11
Required heat price (t_0 = 15 yrs) considering ash utilization	[US $/MMBTU]	13.72	14.77	14.95	17.58
Required heat price (t_0 = 15 yrs) considering CO_2 reduction	[US $/MMBTU]	13.36	14.24	14.60	16.88
Required heat price (t_0 = 15 yrs) cons. ash utiliz. & CO_2 reduction	[US $/MMBTU]	12.66	13.72	14.07	16.18

Notes: "BM" is biomass-fired boilers. "ECO" represents economizer. "CDCF" represents the cumulated discounted cash flow. The heat price used was $10.44 per MMBTU. "t0" represents the dynamic payback period. The CO2 credits are valued at $12.00 per ton of reduced CO2. "ORC 1100" refers to an Organic Rankine Cycle unit with a nominal electric capacity of 1,100 kW. A feed-in tariff of $0.06 per kWh for green electricity was used for the CHP options, and a connection rate of 80 percent was used for all options.

Sensitivity of Variables Affecting Financial Performance

The purpose of the sensitivity analysis is to show how variations in certain parameters might affect the financial performance of the project. The following parameters were investigated:

- Heat price
- Fuel price
- Investment costs
- Connection rate (percentage of target customers that sign up for service)
- Feed-in tariff (only for CHP plants)

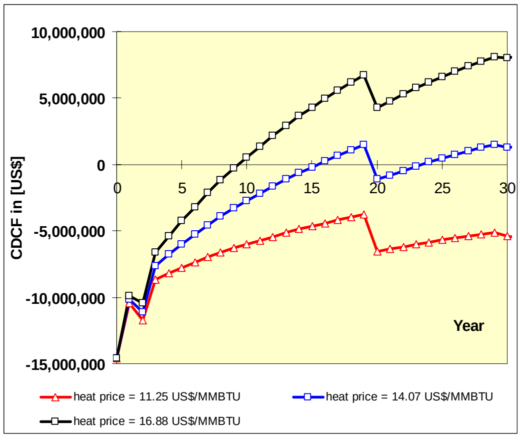
The blue line in each the following figures represents the baseline, which was calculated considering the subsidies and the heat price required for a payback period of 15 years, as shown in Table 19. The black and red lines show the effect of 20 percent variation in the parameter being investigated on the dynamic payback period.

For details on the methodology applied in the sensitivity analysis, see Reference 4.

Option 1a - “Waste Transfer Station – Heat Only, PN 16”

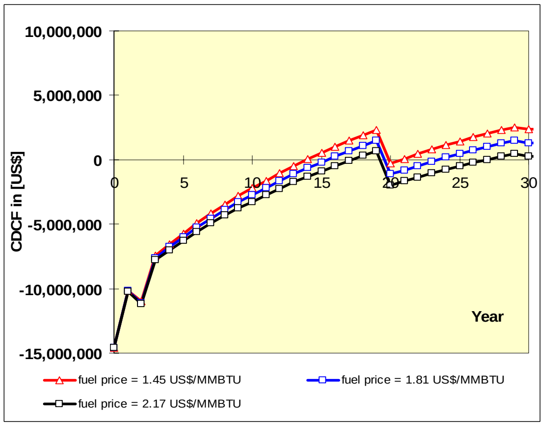
The following charts show the results of the sensitivity analysis for selected parameters.

Figure 20: Variation of the Heat Price, Option 1a, WTS – HO, PN 16



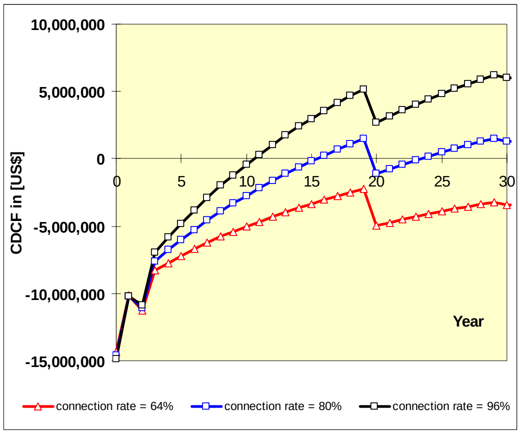
Note: The blue line (heat price = $14.07 per MMBTU) represents the baseline.

Figure 21: Variation of the Fuel Price, Option 1a, WTS – HO, PN 16



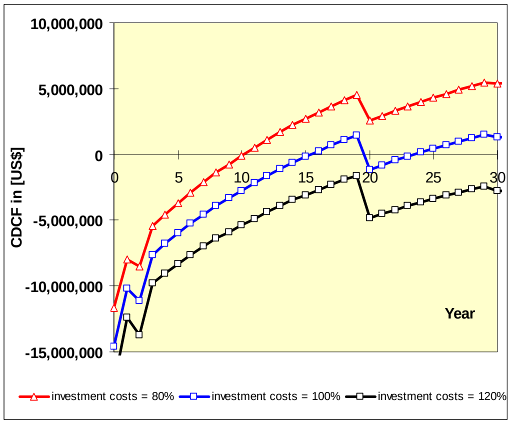
Note: The blue line (fuel price = $1.81 per MMBTU) represents the baseline.

Figure 22: Variation of the Connection Rate, Option 1a, WTS – HO, PN 16



Note: The blue line (connection rate = 80%) represents the baseline.

Figure 23: Variation of the Investment Costs, Option 1a, WTS – HO, PN 16

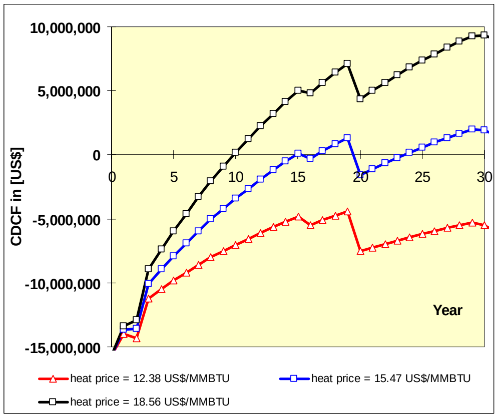


Note: The blue line (investment costs = 100%) represents the baseline.

Option 1c - “Waste Transfer Station – ORC 1100, PN 16”

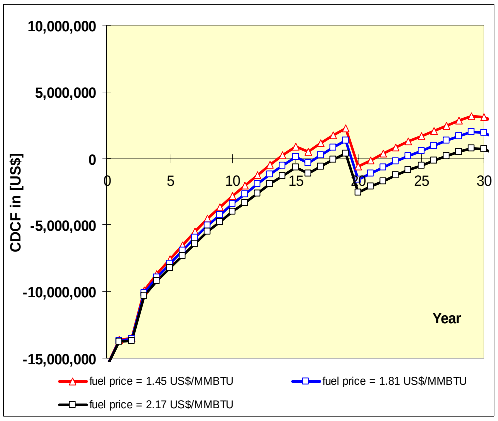
The following charts show the results of the sensitivity analysis for selected parameters.

Figure 24: Variation of the Heat Price, Option 1c, WTS – ORC 1100, PN 16



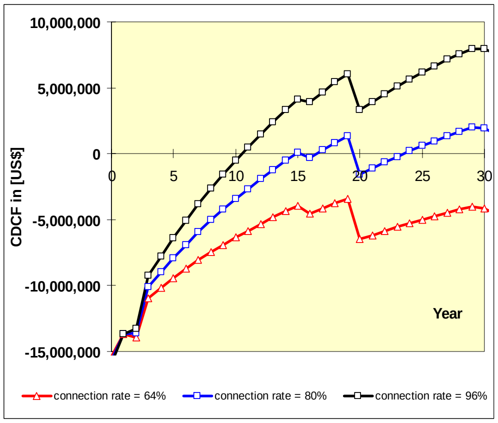
Note: The blue line (heat price = $15.47) represents the baseline.

Figure 25: Variation of the Fuel Price, Option 1c, WTS – ORC 1100, PN 16



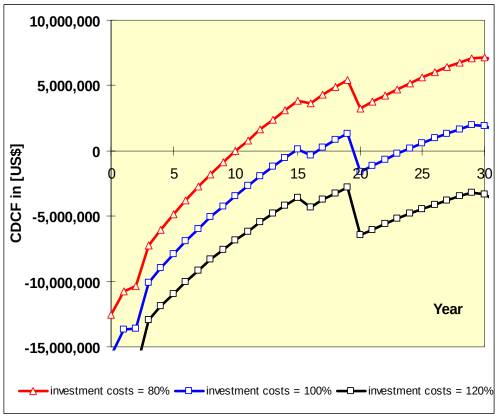
Note: The blue line (fuel price = $1.81) represents the baseline.

Figure 26: Variation of the Connection Rate, Option 1c, WTS – ORC 1100, PN 16



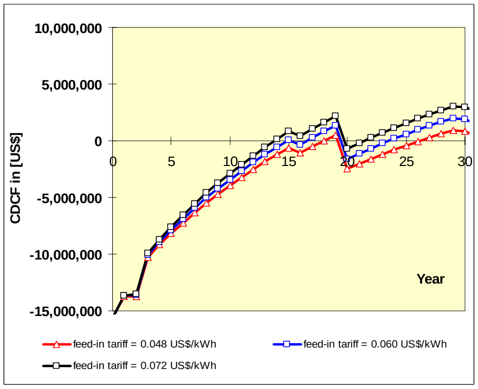
Note: The blue line (connection rate = 80%) represents the baseline

Figure 27: Variation of the Investment Costs, Option 1c, WTS – ORC 1100, PN 16



Note: The blue line (investment costs = 100%) represents the baseline.

Figure 28: Variation of the Feed-in Tariff, Option 1c, WTS – ORC 1100, PN 16

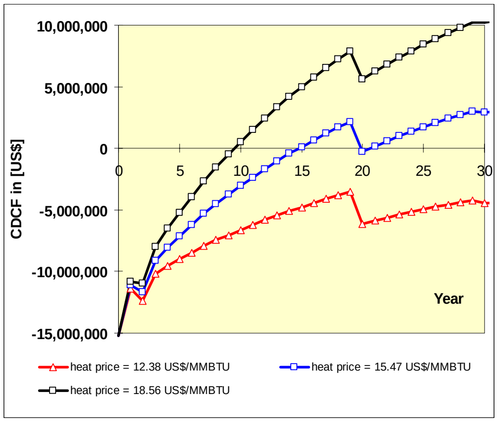


Note: The blue line (feed-in tariff = $0.06 per kWh) represents the baseline.

Option 2a - “Former Coal-Fired Power Plant – Heat Only, PN 16”

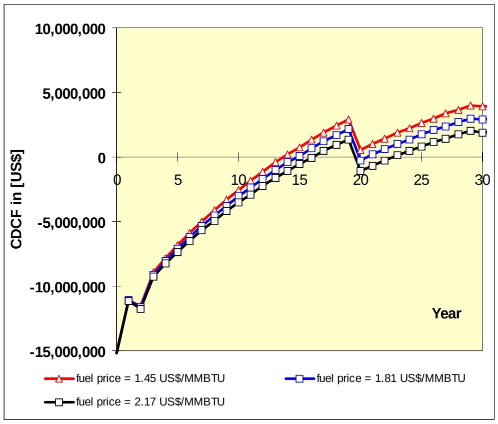
The following charts show the results of the sensitivity analysis for selected parameters.

Figure 29: Variation of the Heat Price, Option 2a, CFPP – HO, PN 16



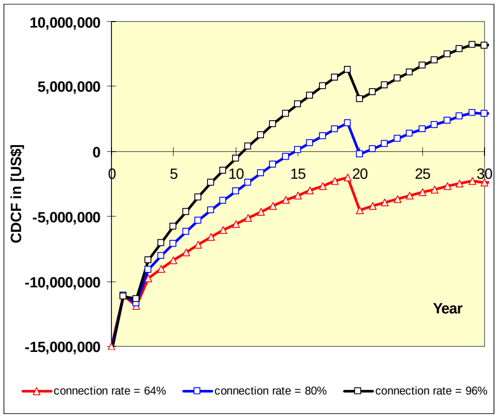
Note: The blue line (heat price = $15.47) represents the baseline.

Figure 30: Variation of the Fuel Price, Option 2a, CFPP – Heat Only, PN 16



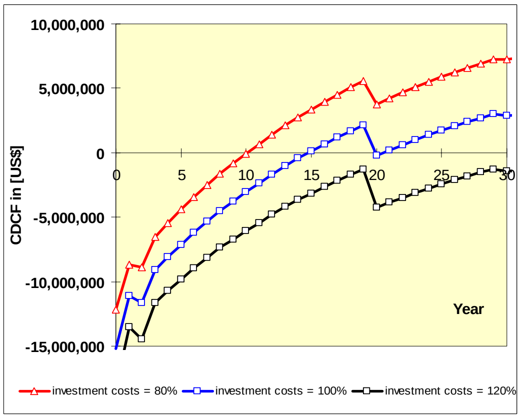
Note: The blue line (fuel price = $1.81 per MMBTU) represents the baseline.

Figure 31: Variation of the Connection Rate, Option 2a, CFPP – HO, PN 16



Note: The blue line (connection rate = 80%) represents the baseline.

Figure 32: Variation of the Investment Costs, Option 2a, CFPP – HO, PN 16

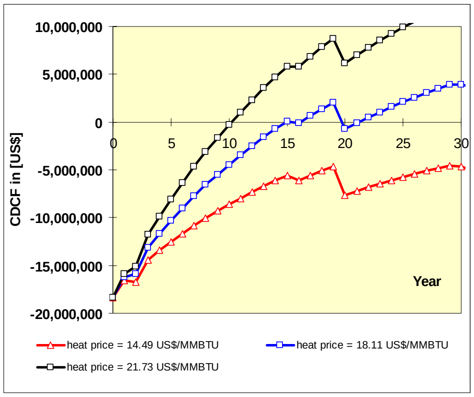


Note: The blue line (investment costs = 100%) represents the baseline.

Option 2b - “Former Coal-Fired Power Plant – ORC 1100, PN 16”

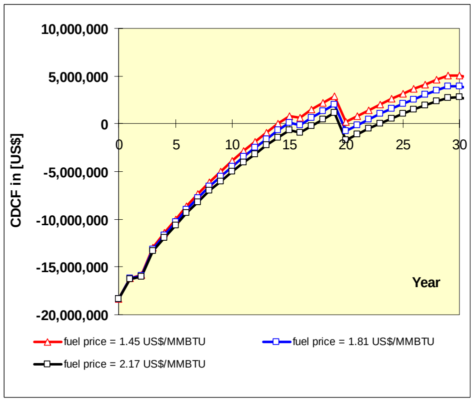
The following charts show the results of the sensitivity analysis for selected parameters.

Figure 33: Variation of the Heat Price, Option 2b, CFPP – ORC 1100, PN 16



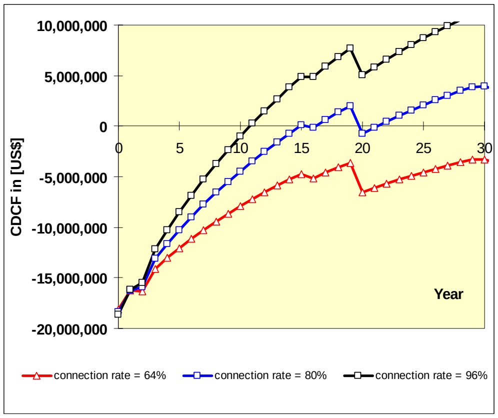
Note: The blue line (heat price = $18.11 per MMBTU) represents the baseline.

Figure 34: Variation of the Fuel Price, Option 2b, CFPP – ORC 1100, PN 16



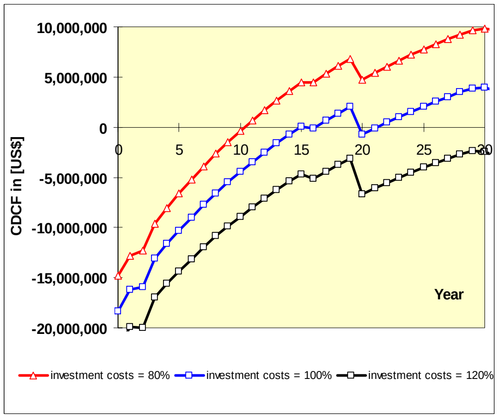
Note: The blue line (fuel price = $1.81 per MMBTU) represents the baseline.

Figure 35: Variation of the Connection Rate, Option 2b, CFPP – ORC 1100, PN 16



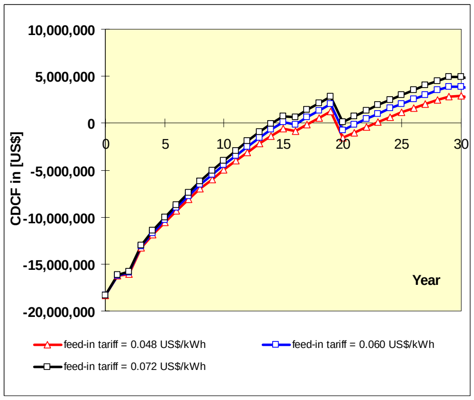
Note: The blue line (connection rate = 80%) represents the baseline.

Figure 36: Variation of the Investment Costs, Option 2b, CFPP – ORC 1100, PN 16



Note: The blue line (investment costs = 100%) represents the baseline.

Figure 37: Variation of the Feed-in Tariff, Option 2b, CFPP – ORC 1100, PN 16



Note: The blue line (feed-in tariff = $0.06 per kWh) represents the baseline.

Summary and Conclusions from the Sensitivity Analysis

The results of the sensitivity analysis show that the heat price has the greatest impact on the financial performance of the main grid options. A 20 percent increase in heat price reduces the dynamic payback period by more than 5 years to less than 10 years. Naturally, a 20 percent decrease in heat price has a strong negative effect on the financial performance. The influence of a variation in heat price is slightly smaller for the CHP options, since additional revenues can be generated by the sale of green electricity.

Moreover, a reduction of investment costs has a great impact on the financial performance of the main grids. 20 percent lower investment costs would lead to a dynamic payback period of 10 years. Thus, tough negotiations with potential contractors within the bidding phase are important.

A higher connection rate also influences financial performance significantly. The current connection rate of 80 percent represents a realistic but ambitious level. A 20 percent lower connection rate reduces financial performance significantly. Therefore a certain number of contracts must be signed prior to project implementation. A connection rate of 70 percent, with a realistic potential to achieve 80 percent within a short period of time, should be targeted. This result also points out that large heat consumers (e.g. companies that need heat for drying purposes) would influence financial performance in a very positive way. A search for process-heat consumers that could locate near the district heating plant, especially if a "Waste Transfer Station" option is selected, should therefore be considered.

The fuel price does not have a great impact on the financial performance of the main grid options. Even an increase of 20 percent has no strong negative influence, which is important for a stable long-term financial performance.

A 20 percent increase of the feed-in tariff only slightly reduces the payback period of the CHP-options. Only a considerable increase would substantially improve financial performance.

SECTION 3: EMISSIONS ESTIMATES AND CREDITS

Detailed emission estimates were carried out for the four biomass system options in order to evaluate the environmental impact of implementing a biomass system compared to the current baseline levels of emissions.

Two types of emissions analysis were performed: A *microanalysis*, which considers only the emissions resulting from the direct, local production and use of the heat and electricity, and a *macroanalysis*, which takes a more global view by also including the emissions created by transporting and processing fuels, emissions resulting from the consumption of electricity at the biomass plant, and the net reduction of emissions due to displacement of conventionally produced electricity by biomass-fired electricity from the CHP plant.

Both the microanalysis and the macroanalysis considered net emissions of carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrocarbons (C_xH_y) and particulate matter. The combustion of biomass is generally considered to produce no net carbon dioxide emissions, since the carbon released when biomass is burned is the same carbon that was sequestered during growth of the biomass. Carbon releases from burning biomass can thus be considered part of a natural carbon cycle, with a markedly different effect on the atmosphere compared to the combustion of fossil fuels.

A complete discussion of the methodology used for the emissions estimates can be found in Reference 4.

Results of the Microanalysis of Emissions

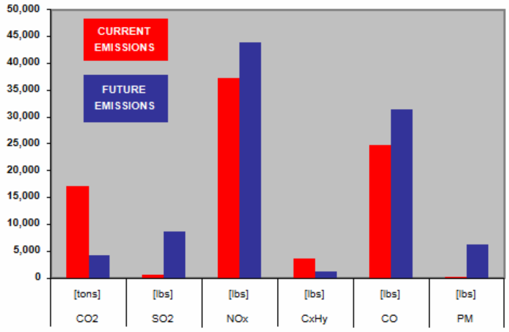
The results of the microanalysis for the four system options are shown in Figure 38 below. The calculations show a significant reduction in CO_2 and hydrocarbon emissions for all four design options. This is an important result, since emissions of carbon dioxide and hydrocarbons both contribute to the greenhouse effect. Emissions of NO_x and CO increased slightly in the microanalysis, however. And although total SO_2 and dust emissions of the biomass-fired boilers are very low due to efficient flue-gas cleaning, emissions of these pollutants also rise slightly compared to current levels because the combustion of natural gas emits virtually no sulfur or ash.

The microanalysis shows slightly better results for the heat-only options compared to the CHP options, which is expected because the CHP options consume additional fuel for electricity production, and the benefits of offsetting coal-fired electricity are not included in the microanalysis.

Figure 38: Results of Microanalysis of Annual Emissions for Four Design Cases

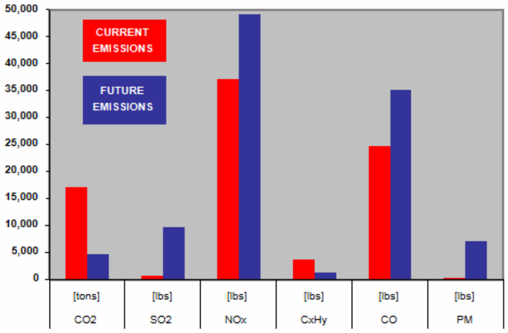
Waste Transfer Station, Heat Only

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	17,047.4	4,287.7
SO_2	[lbs]	619.9	8,674.6
NO_x	[lbs]	37,194.4	43,949.7
C_xH_y	[lbs]	3,719.4	1,256.4
CO	[lbs]	24,796.3	31,392.2
PM	[lbs]	310.0	6,277.3



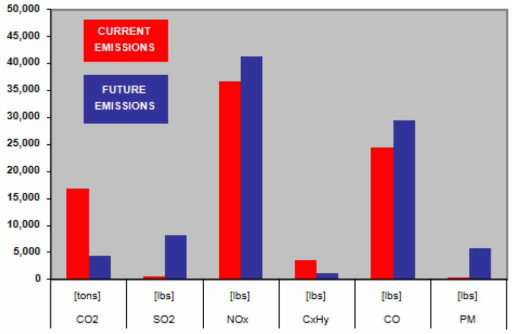
Waste Transfer Station, CHP

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	17,047.4	4,672.7
SO_2	[lbs]	619.9	9,720.3
NO_x	[lbs]	37,194.4	49,247.5
C_xH_y	[lbs]	3,719.4	1,407.8
CO	[lbs]	24,796.3	35,176.3
PM	[lbs]	310.0	7,034.0



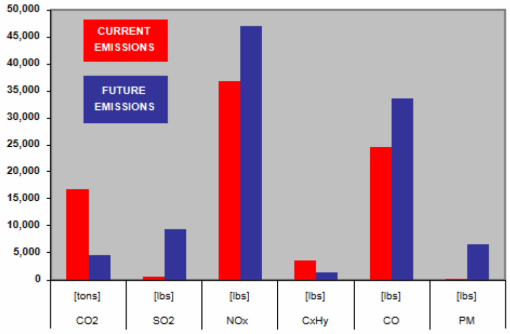
Coal-Fired Power Plant, Heat Only

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	16,848.7	4,361.3
SO_2	[lbs]	612.7	8,155.7
NO_x	[lbs]	36,760.8	41,321.4
C_xH_y	[lbs]	3,676.1	1,181.3
CO	[lbs]	24,507.2	29,514.9
PM	[lbs]	306.3	5,901.8



Coal-Fired Power Plant, CHP

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	16,848.7	4,515.2
SO_2	[lbs]	612.7	9,287.6
NO_x	[lbs]	36,760.8	47,055.2
C_xH_y	[lbs]	3,676.1	1,345.1
CO	[lbs]	24,507.2	33,610.4
PM	[lbs]	306.3	6,720.8



Results of the Macroanalysis of Emissions

The results of the macroanalysis for the four system options are shown in Figure 39 below. The macroanalysis results for the heat-only options show significant reductions in the emissions of carbon dioxide, hydrocarbons, and carbon monoxide. Releases of NO_x, SO_2, and particulates rise slightly compared to the base case, but once again total emissions of these pollutants is very low due to flue-gas treatment.

The CHP options fared much better than the heat-only options in the macroanalysis of emissions. In addition to considerable reductions in CO_2, CO and hydrocarbon, SO_2 and NO_x are also reduced due to the displacement of coal-fired electricity. Only particulate emissions show an increase in the macroanalysis of the CHP options, but again these emissions are very small.

Particulate emissions rise for all of the biomass options due to the fact that biomass is substituted for natural gas, an ash-free fuel. Although this presents a slight drawback from switching to biomass, it should be noted that the particulate emissions from biomass are quite small compared to particulate emissions from traffic and other sources. Regardless of this fact, additional filtration could be added to any of the proposed biomass facilities to cut particulate emissions by 75 percent below the values shown. The system cost would be increased, however.

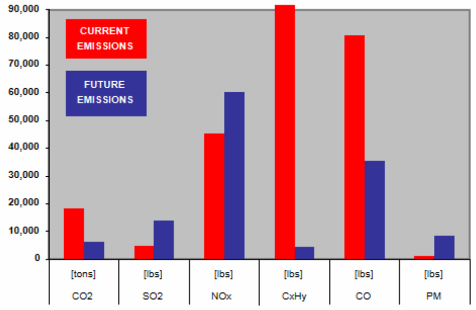
Similar reductions in the emissions of NO_x from biomass could also be achieved at additional cost. Using a selective non-catalytic reduction (SNCR) system, NO_x emissions could be cut by 60 percent. Again, however, it must be considered that even without the SNCR system, NO_x emissions are already well below similar emissions from traffic.

The primary environmental advantage of implementing a biomass system is the reduction of greenhouse gases such as CO_2 and hydrocarbons. Depending on the option selected, CO_2 emissions can be reduced by between 12,200 and 20,700 tons per year. This could go a long way toward meeting the City’s stated goals of reducing its contribution to climate change, and depending on how carbon markets develop, the reductions could represent an important monetary asset as well.

Figure 39: Results of Macroanalysis of Annual Emissions for Four Design Cases

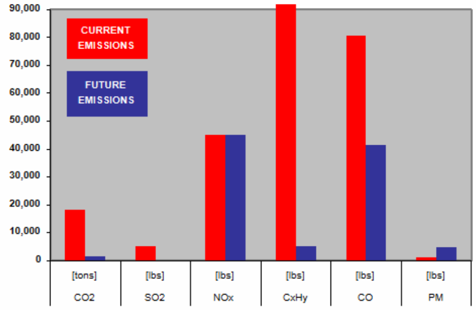
Waste Transfer Station, Heat Only

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	18,287.3	6,209.6
SO_2	[lbs]	4,959.3	13,876.0
NO_x	[lbs]	45,253.2	60,385.5
C_xH_y	[lbs]	309,953.5	4,588.8
CO	[lbs]	80,587.9	35,389.3
PM	[lbs]	1,239.8	8,342.0



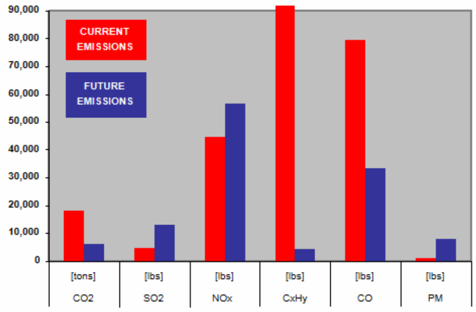
Waste Transfer Station, CHP

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	18,287.3	1,330.6
SO_2	[lbs]	4,959.3	-1,489.4
NO_x	[lbs]	45,253.2	45,000.6
C_xH_y	[lbs]	309,953.5	5,286.3
CO	[lbs]	80,587.9	41,457.8
PM	[lbs]	1,239.8	4,626.1



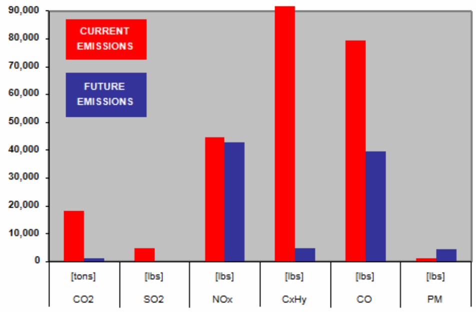
Coal-Fired Power Plant, Heat Only

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	18,074.1	6,192.2
SO_2	[lbs]	4,901.4	13,046.1
NO_x	[lbs]	44,725.7	56,774.3
C_xH_y	[lbs]	306,340.2	4,320.3
CO	[lbs]	79,648.4	33,274.0
PM	[lbs]	1,225.4	7,843.0



Coal-Fired Power Plant, CHP

Parameter	units	Current Emissions	Future Emissions
CO_2	[tons]	18,074.1	1,281.5
SO_2	[lbs]	4,901.4	-1,557.0
NO_x	[lbs]	44,725.7	42,833.2
C_xH_y	[lbs]	306,340.0	5,055.0
CO	[lbs]	79,648.4	39,638.8
PM	[lbs]	1,225.3	4,384.5



Market Value of Emissions Reductions

The CO_2 emissions reductions represent not only the most significant environmental advantage of the project, but also the opportunity to improve the financial performance of the project because of their potential value in the environmental commodities trade. In the following section, the potential value of the greenhouse gas emissions reductions will be considered when they are marketed within one of two vehicles:

1. Greenhouse Gas (GHG) Emissions Reductions
2. Renewable Energy Credits (RECs)

In each market context, the potential value of emissions reductions will be explored based on current and potential market conditions.

Credits as GHG Emissions Reductions

Though the United States was a party to the United Nations Framework Convention on Climate Change and a signator of the Kyoto Protocol, the U.S. has not ratified the treaty. Therefore, emissions reductions produced in the United States cannot be traded internationally under the Kyoto regulatory system. Furthermore, the United States has no national legislation regulating the production of GHG emissions. As a result, no compliance market for GHG emissions credits exists in the U.S., although a national voluntary market is emerging whereby GHG emissions can be traded through the Chicago Climate Exchange (CCX) or through private GHG emissions marketing firms.

In mandatory GHG markets, trading takes place in the form of emissions allowances that are issued, traded, and reconciled based on a legally binding cap and trade system. Though no such mandatory market exists in the United States, the CCX does issue, trade, and reconcile emissions allowances through its voluntary but legally binding registry and trading system. The CCX also has a program through which tradable CO_2 emissions offsets from renewable energy projects in the U.S. are registered and traded. In voluntary GHG retail markets, trading takes place in the form of emissions credits. The most common form of emissions reduction credit in the United States is the Verified Emissions Reduction (VER) credit. These credits are project-based emissions reductions derived from the difference between an established emissions baseline and the actual emissions reduction level achieved after the implementation of a GHG reduction project. (Zaborowsky, 2004)

Emissions reductions from the project could be marketed one of three ways:

1. As emissions allowances on the Chicago Climate Exchange (CCX)
2. As emissions offsets through the CCX
3. As VER credits on the voluntary GHG market.

CCX Emissions Allowances

The Chicago Climate Exchange (CCX) is a self-regulating exchange based on voluntary but legally binding commitments by its members. Members commit to a GHG emissions cap and are provided an allocation of emissions allowances. The cap is not a fixed level of emissions but rather a percentage reduction from a baseline. Members of the exchange who reduce their emissions beyond the fixed percentage are thus credited with surplus allowances, which are tradable. The allowances can be traded through CCX's electronic exchange with organizations that failed to meet their reduction targets and are in need of additional reduction allowances in order to meet their binding agreements.

The end of 2005 marked the completion of CCX's Phase I, by which time all members were to have reduced direct emissions by 4 percent below the baseline period of 1998-2001. Members that participate in Phase II, which began in January of 2006, must reduce emissions by an additional 2 percent below their baseline by 2010 to achieve the Phase II reduction target of 6 percent below baseline. New Phase II members' emission baselines are set using the annual average of emissions from facilities included in the baseline during 1998, 1999, 2000 and 2001. (CCX, 2006)

The City of Santa Fe is considering joining the CCX. (New Mexico has already joined, and was the first state to do so.) If the city were to own and operate the biomass system, the emissions reductions generated from the project could be traded as allowances on the CCX. However, in order for that to be possible, the city's baseline (emissions from the period 1998-2001) would have to include emissions generated in the area to be served by the system. Technically, the emissions from the area and the emissions reductions resulting from utilization of the biomass system belong to the individual consumers, whose carbon emissions decrease when their natural gas use has been displaced by biomass. Establishing ownership of emissions reductions may require that consumers waive and transfer their ownership of their emissions prior to the installation of the system. This step is essential if the city is to reap the value of emissions reductions under a municipal ownership model.

The value of emissions reductions from the biomass system, marketed as emissions allowances through the CCX, cannot be determined until the city's baseline has been determined and an assessment is taken of its current emissions compared to that baseline. Emissions from the area to be served and emissions reductions resulting from the biomass project are only a part of the city's total emissions that would be considered in its CCX emissions calculations.

For the city to sell its emissions reductions on the CCX, it would first have to join the exchange, secure ownership of the emissions reductions, and then make sure not to increase its emissions in other areas so as to negate the reductions from the biomass system. Before taking any of these steps, the city would want to work with CCX to determine its emissions baseline for the 1998-2001 period, with the inclusion of the area to be served by the biomass project, as it compares to future emissions estimates, with the inclusion of the biomass system, in order to ensure that surplus emissions allowances would result.

If the city were able to generate surplus emissions allowances with the biomass project, it could expect to sell allowances for around $4 per ton on the CCX. Their value in this case is about $52,000 annually, or roughly 2.2 percent of revenues.

CCX Offsets

If the biomass system is owned by an entity independent from the city, that entity would be eligible to participate in CCX's *Offset Provider* program. Through the *Offset Provider* program, owners of renewable energy projects that offset CO_2 emissions can register those offsets with the exchange and market them directly to exchange members. In order to qualify for the program, the reductions from the biomass project would need to be verified by one of CCX's approved Verifiers. Once the project receives verification, the Offset Provider (the owner of the biomass project), could sell the emission offsets on the exchange. Based on the current trading price of around $4.00/ton, the sale of emissions offsets generated by the project could be expected to generate $52,000 annually.

Selling the reductions as Emissions Offsets through the CCX has a number of advantages. First, the emissions reductions created by the biomass project would be a sure source of revenue because they would not be pooled with other emissions and assessed based on the emissions reduction commitments involved with CCX membership. Second, because *Offset Providers* are not members of the Exchange, the owner of the biomass project and, subsequently, the owner of the emissions reductions created by the project, would not be bound to the multi-year commitment required for members. This would allow the owner of the system to respond to the changing GHG and renewable energy commodities markets in order to ensure that the value of the emissions reductions is maximized.

Voluntary CO_2 Markets

Another way for value of the emissions reductions created by the biomass project to be realized is to sell them as VERs on the voluntary CO_2 market. An emerging trend in the US is for individuals, corporations, and even events to purchase small volumes of emission reductions through "carbon retailers" from projects that have consumer appeal, creating a voluntary GHG emissions market. In addition, voluntary commitments made by major corporations, through governmental programs such as DOE's *Climate Leaders* and EPA's *Climate Challenge*, as well as non-governmental programs such as *Climate Neutral*, have contributed significantly to growth in this arena.

In order for the emissions reductions from the biomass project to be sold on the voluntary GHG retail market, a third-party verification of emissions reductions would be required. Emissions reductions would be derived from the difference between an established emissions baseline and the actual emissions reduction level achieved after the implementation of the biomass project.

In the case of the district energy project, in which a fossil fuel is compared with a renewable one, the emissions baseline for the VER is the level of emissions produced from pre-project levels of natural gas consumption (current emissions levels). Presumably this method would yield roughly the same 13,000 tons per year of reductions. The value of the reductions varies based on demand, and the brokerage firm Evolution Markets reports VER prices ranging from $0.50 to $2.50 per ton. Credits in this market could thus be valued at $6,500 - $32,500 annually.

In order to market VERs generated by the biomass project, the owner of the system would have to work with a carbon marketing firm such as Cantor Fitzgerald to identify prospective buyers and negotiate sales. While the voluntary retail market is growing and is certainly a viable immediate option for biomass generated emissions reductions, it is a buyer-driven market with less reliable pricing and less institutional credibility than the Chicago Climate Exchange's registry and trading system. These issues may become increasingly important as movements toward a mandatory GHG market in the U.S. begin to emerge.

Securing Value for Future Compliance Markets

In an uncertain regulatory environment and a buyer-driven U.S. voluntary market, holders of emission reduction credits may choose to hold on to those credits for use in future regulatory schemes. This may be a good idea as the international carbon market continues to grow and state and national efforts in the U.S. make inroads toward the creation of a national regulatory GHG system.

The volume traded on the international GHG emissions market has more than doubled since 2002 with 70 million tons of CO_2 emissions traded as of November, 2003. The vast majority of this volume was exchanged in order to meet countries' commitments under the Kyoto Protocol. While the current U.S. administration has no intention of ratifying the Protocol, many analysts predict that it is not a question of if, but when, the U.S. will be forced to follow through with the commitments it made under the Kyoto Protocol. California has meanwhile signed into law a binding commitment to reduce its emissions to 1990 levels, and other states are developing cap and trade systems and carbon-offset investment funds.

The most far-reaching development may be the creation of the Regional Greenhouse Gas Initiative (RGGI) in the northeast. The RGGI's primary goal is to develop a regional GHG reduction policy. Currently the RGGI has nine northeastern states as participating members with several additional states and Canadian provinces as observers. While the RGGI development process is still in its infancy, it represents a huge step toward regional regulation and it lays important groundwork for the creation of a national GHG reduction policy.

The adoption of the Kyoto Protocol or the creation of a national cap and trade system would radically alter the U.S. GHG market. Even shifts in state incentives could improve the options available to sellers, if they choose to wait and see. However, in order to preserve or even enhance the value of credits, the owner of the biomass project should probably register the reductions with one of the various climate partnerships that have been established in recent years.

Market Vehicle #2: Renewable Energy Credits (RECs)

One alternative to traditional emissions reduction marketing is available in the form of Renewable Energy Credits. A Renewable Energy Credit (REC) turns the benefits associated with renewable energy into a tradable commodity that can be bought and sold separately from the associated electricity. RECs are measured in the same units as electricity, typically in kilowatt-hours or megawatt-hours. In a REC trading system, a windmill that has generated 100 megawatt-hours of electricity has simultaneously generated 100 megawatt-hours of RECs. The added value of these “green tags” may be used to offset the costs of production, making renewable energy more competitive. Ultimately, certification gives consumers the ability to demonstrate their preference for renewable energy in the open market.

The market for RECs is more fluid than for GHGs in large part because many states, by adopting a Renewable Portfolio Standard, now require that utilities include renewable energy in their energy portfolios. Most allow the renewable requirement to be met with the purchase of RECs as an alternative to actually building the renewable generating capacity. The mandatory REC market in the US has been estimated to be as large as $140 million.[8]

RECs are also regularly sold retail directly to energy consumers, who view them as a way to support the introduction of renewable energy into the grid in spite of the fact that the green energy never reaches their home or business. This voluntary market contributes an estimated $15-45 million annually to the total REC market.

RECs are distinct from emissions reductions in that instead of certifying reduced emissions (which may come from fuel-switching, efficiency, or renewable technologies) they simply certify that energy has been produced by a renewable source. This distinction presents a dilemma for the biomass project because RECs, until recently, have been limited to electricity. Recent efforts have been made to develop REC standards that would allow thermal energy from renewable sources to be certified and sold. Green-E, an initiative of the Center for Resource Solutions (CRS) is developing such a program, and recent correspondence with them suggests that the biomass project would qualify for certification.

Summary and Conclusions Regarding Emissions Reductions

The CO_2 emissions trading market in the United States is still in its nascent stage. Currently, no national mandatory market for CO_2 emissions exists. Because of this, the markets for GHG emissions reductions remain fractured and inconsistent. The varying quality of voluntary emissions reductions protocols, and the diverse objectives of buyers, contribute to market uncertainty.

A significant choice for the owner of the biomass system and its GHG credits is whether to sell them now or hold onto them until their value increases with the ratification of the Kyoto Protocol or the inception of national GHG regulatory policy. If the owner of the system decides to hold on to the credits, they should join a registry. If the owner of the biomass system decides that it would like to liquidate GHG reductions immediately, it will have at least four options available to it:

1) If the City owns the system, it can join the Chicago Climate Exchange and potentially sell surplus Emission Allowances to other Exchange members;

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[8] More data is available from the U.S. Department of Energy’s Green Power Network at http://www.eere.energy.gov/greenpower/

2) A newly formed entity independent from the City can sell Emissions Offsets generated from the project on the exchange with no binding future commitments;
3) The owner can work with a carbon marketing firm to attempt to sell their reductions to private organizations with emissions reduction goals.
4) The owner could pursue Renewable Energy Certification and market the Renewable Energy Credits generated by the biomass project through mandatory and/or voluntary markets.

As the landscape of this market continues to evolve, a periodic re-evaluation of the relative merits of each of these paths will be required before a sound decision can be made.

SECTION 4: BIOMASS FUEL STUDY

The characterization of the biomass fuel supply surrounding Santa Fe is a necessary prerequisite to designing optimal systems for fuel-handling, combustion and flue-gas cleaning, and ash-handling.

In an effort to determine the availability, quality, and cost of biomass fuel available to the proposed district energy system, we undertook a study of local biomass from three sources: residues from forest-thinning projects, municipal green-waste from landfills, and commercial green-waste from wood-processing operations.

The following specific steps were carried out for the fuel study:

- **Identification of available biomass sources in the Santa Fe area.** We focused on fuels within a 50-mile radius, from forest-thinning projects, municipal waste streams, and commercial fuel sources.
- **Determination of the sustainable yield of biomass from these sources.** To estimate sustainable yields, we interviewed forest specialists, recycling coordinators, and managers or owners of wood processing facilities.
- **Investigation of the biomass fuel costs.** We sought to determine the total cost to obtain fuel from the identified sources, including material and transport costs. To do this, we interviewed forest specialists, recycling coordinators, and managers or owners of wood processing facilities. We also studied the trend of biomass fuel prices in Europe.
- **Determination of the quality of the available biomass fuels.** We collected 10 representative biomass samples from a variety of sources, and studied the physical characteristics (moisture content, particle size) and chemical characteristics (ash content, net calorific value, composition). We also interviewed forest specialists, recycling coordinators, and managers or owners of wood processing facilities.
- **Characterization of ash and evaluation of their utilization potential.** We determined the chemical composition of the ashes that would be produced from combustion of the biomass, and evaluated the potential for environmentally sound utilization of the ash. In addition to the chemical analysis, we also interviewed soil scientists and studied ash utilization from biomass systems in Europe.
- **Formulation of recommendations regarding fuel preparation, logistics, and storage.** To ensure acceptable fuel quality at reasonable prices, we developed recommendations for ensuring appropriate levels of fuel reliability and quality at a reasonable fuel price. These recommendations were based on the results of the quality and quantity surveys, including the assessments of potential fuel sources, interviews with forest specialists and recycling coordinators, and discussions with managers or owners of wood processing facilities.
- **Formulation of recommendations for appropriate thermal conversion of the biomass fuels.** Based on the fuels studied, we determined the requirements for ensuring efficient thermal utilization, acceptable availability of the combustion

plant, and high fuel flexibility. This included specification of the fuel feeding system, the furnace and boiler technologies, the flue-gas cleaning system, and the ash-handling system.

A detailed report on the fuel-study effort is shown as Reference 1.

Fuel from Thinning Projects

The 50-mile radius comprising our study area includes three Forest Ranger Districts: Espanola, Jemez, and Pecos. In the three years preceding our study, more than 6,000 acres were thinned within the study area – far less than what needs to be thinned annually to reduce fire danger, according to experts. State Forestry Fuels Specialist James T. Johnston expects the rate of thinning in the Wildland Urban Interface (WUI) areas within our study area to increase by 1,000 to 2,000 acres *per year* over the next 13 years. Dan Key, Fire Management Officer for the Jemez Ranger District, requested funding to thin or clear 5,400 acres in 2005 – a small fraction of the 250,000 acres of WUI that he hopes to thin within his district.

We made a resource assessment of five major thinning operations currently in progress in the following locations: the Santa Fe Watershed, Los Alamos County, Cochiti Mesa, Monument Canyon, and Apache Canyon. As we were only conducting a resource assessment, we did not consider regulatory restrictions that might prevent removal of the fuel from any project.

Our estimations of the rate at which each of these projects could sustainably generate biomass fuel rely heavily on a rule of thumb provided by James T. Johnson, which states that the amount of material removed during first-pass thinning is about three times the amount that would need to be removed to achieve the same result five years later. To determine a sustainable annual yield, then, we divided the amount of material removed during first-pass thinning by fifteen. Note that the result gives an approximate annual amortization of fuel availability, while in actuality the fuel is not available annually.

Using this technique, and gathering best available estimates of tonnages to be removed from each of the targeted thinning projects, we estimated that these five thinning projects would produce more than 21,000 tons of total biomass in 2004, with 2,900 tons available per year on a sustainable basis from these projects. Projections of increased thinning activity suggest that the sustainable yield from local thinning operations could grow to nearly 40,000 tons per year by 2010 and to more than 100,000 tons per year by 2016.

While the projected yields from forest thinning look promising, the cost of the fuel is projected to be considerably higher than fuel from other sources. Our 2004 estimate of $6.60 per MMBTU for biomass fuel from forest operations included only $1.20 per MMBTU for transport, but subsequent increases in hauling costs suggest that the current delivered cost of this fuel will be considerably higher.

Fuel From Municipal Sources

There are several landfills and transfer stations within the study area, although at the time of our study, most were sending their green waste to the Caja del Rio site where it was being chipped and made available at no cost for mulch and erosion control. In 2006, Caja del Rio stopped accepting green waste, and it is now diverted to the Buckman Transfer Station. Two other transfer stations that process their own green waste are Jacona (near Pojoaque) and Eldorado. All of these sites are within 20 miles of downtown Santa Fe. A map showing the locations of these transfer stations appears in Reference 1.

Most of the green-waste arriving at municipal sites is from piñon trees cleared from private land. Also represented in the landfills are juniper and even a small amount of ponderosa pine. The incoming material is processed with a tub grinder into 3-inch chips that are arranged in piles about ten feet high and turned periodically to prevent spontaneous combustion. The storage areas are unpaved, which has significant negative consequences on the ash content of the stored biomass due to contamination with rocks and dirt. The climate is dry enough in New Mexico that the piles are left outside, as even a hard rain penetrates only the first few inches of the piles.

In 2003, the Caja del Rio landfill processed more than 14,000 tons of green waste – about four times their normal amount – as a result of the drought and subsequent piñon die-off. In 2004, Solid Waste Coordinator Justin Stockdale reported a monthly average of 800 tons of incoming waste, with a spike typically occurring in July or August when fire danger is highest. Records from the Buckman Transfer Station suggest the long-term, sustainable yield from this source is about 2,500 tons per year. Jacona and Eldorado receive an average of 350-500 tons each of green-waste material per year. Combined, these three sources could thus be reasonably expected to sustainably provide about 3,500 tons per year of green waste. See Table 20.

Table 20: Sustainable Fuel Availability from Municipal Green Waste Sources within 50 Miles of Santa Fe

Municipal Green Waste Source	Yield 2003 [tons/yr]	Sustainable [tons/yr]
Caja del Rio Landfill	14,108	2,500
Jacona Transfer Station	500	500
El Dorado Transfer Station	500	500
Totals	**15,108**	**3,500**

Note that the quantities shown represent the amount of biomass that residents and businesses have been willing to pay to dispose of. Presumably these quantities would rise if biomass became desirable and green-waste tipping fees were reduced or eliminated.

The fact that municipal green-waste is currently considered a burden suggests that municipal sources of biomass fuel will be very affordable. A number of variables make it difficult to predict what that actual cost will be, however.

The first consideration in determining the cost of the material for use as biomass fuel is competition. The landfills all make small amounts of the material available to homeowners for free to use as mulch. For larger quantities, including all of the truckloads that has been hauled away by the New Mexico Department of Transportation for use as mulch on road-building projects, the Caja del Rio charges $2.00 per ton. A new biosolids composting project proposed by the City of Santa Fe seeks to utilize about 6,000 tons of green waste per year, creating additional competition that could raise its price further.

The second issue of cost relates to improving the quality of the material such that it can be used as fuel. For proper combustion in a biomass-fired boiler, steps would need to be taken to avoid contamination of the biomass with rocks and dirt. This likely means paving an area for processing and storing the chips, again adding to the cost of the fuel.

The third variable is hauling cost. When we conducted our fuel study in 2004, the City of Santa Fe had a fleet of 110-yard haulers with walking floors – ideal for transporting woodchips. Based on hourly charges quoted to use these trucks in 2004, we estimated the cost of hauling biomass from municipal landfills to a heating plant at $1.74 to $4.36 per ton. The fleet of trucks has since been sold, however, and with the recent hikes in diesel fuel costs, commercial haulers are now quoting $33 to $43 per ton to move biomass.

The net result of these three variables is that although we estimated a delivered fuel price from municipal sources in 2004 of $1.08 per million BTU, the price could be closer to $4.73 per million BTU if hauling must be contracted at commercial rates.

Note that the Buckman Waste Transfer Station was identified as one of the sites that is well suited for the heating plant. Building the heating plant at this location would make the discussion of hauling costs moot, as biomass is already being hauled to the site by residents and businesses seeking to dispose of it. Eliminating the green-waste tipping fee, or perhaps even offering to pay for the fuel, could greatly increase the amount of biomass brought to the site.

Fuel From Commercial Sources

There are many businesses within the study area involved in processing wood, but for our study only the 10 most productive potential suppliers were selected and evaluated. It could nonetheless be possible to aggregate the smaller suppliers for a more significant supply than is shown here. Table 21 gives an overview of the 10 most productive potential suppliers within a 50-mile radius of Santa Fe.

Table 21: Large Commercial Green-Waste Sources Within 50 Miles of Santa Fe

Commercial Source	Proximity [miles]	Tree Species	Material Type	Yield 2003 [tons/yr]
Barela Timber	50 miles	Ponderosa Pine	pole shavings (chips, sawdust, bark)	7,500
Norton Hill Wood Co	in town	Ponderosa Pine	bark, wood, sawdust	25
Sauter White	20 miles	Spruce, Douglas Fir, Pine	chips	7,500
Hansens Lumber	10 miles	Ponderosa, Spruce, White Fir	sawdust	50
WH Moore Cash Lumber	20 miles	Ponderosa, Fir, Engelman Spruce	bark/ wood	5,000
Spotted Owl Timber Inc	10 miles	Aspen, Spruce, Ponderosa, Fir	bark/wood	3,500
Alpine Builders Supply	in town	Sugar pine, Hardwoods(Oak)	sawdust, scrap	100
New Mexico Vigas & Timbers	20 miles	Ponderosa, Engelman Spruce, White Fir	bark/wood	450
Cook's True Value	20 miles	Ponderosa, Hardwoods	scrap, pallets, sawdust	3
Conley Lumber Mills LLC	20 miles	Ponderosa Pine	bark/wood	300
			Total:	**24,428**

Currently the biomass waste produced at these sites is either sold or given away for use as mulch to private landowners or landscape contractors. We assumed that these products could be made available as an energy source for a district heating system, as they would likely have more value in that application than they do as mulch.

Based on discussions with the owners of each of the facilities, the cost to purchase biomass fuel from each commercial source is shown in Table 22 below.

Table 22: Cost of Primary Waste from Commercial Green-Waste Sources

Commercial Green Waste Source	Green Waste Product	Yards/year	Cost/yard	Tons/year	Cost/ton
Barela Timber	Bark	29,132	$1.67	7,283	$6.68
Norton Hill Wood Co	Bark	100	$2.58	25	$10.32
Sauter White	Wood Chips	30,000	$2.58	7,500	$10.32
Hansens Lumber	Sawdust	250	$2.58	31	$20.64
WH Moore Cash Lumber	Bark/Wood Chips	20,000	$4.00	5,000	$16.00
Spotted Owl Timber Inc	Bark/Wood Chips	15,000	$2.75	3,750	$11.00
Alpine Builders Supply	Sawdust/Scrap Wood	700	$2.58	88	$20.64
New Mexico Vigas & Timbers	Bark/Wood Chips	1,800	$2.58	450	$10.32
Cook's True Value	Scrap/Sawdust/Pallets	12	$2.58	1	$20.64
Conley Lumber Mills LLC	Bark/Wood Chips	1,200	$3.33	300	$13.32
Totals / Averages		**98,194**	**$2.63**	**24,428**	**$10.59**

Using our 2004 estimate of hauling costs at $4.36 per ton, the total cost of delivered fuel from commercial sources was estimated at about $15 per ton, or $1.39 per million BTU. Using an average of our more recent estimates of $38 per ton for commercial hauling, the total fuel price could be closer to $48.60 per ton, or $5.05 per million BTU.

Analysis of Fuel Samples

A summary of the sample analyses is included below. Detailed information regarding the chemical analysis and ash content of each sample is contained in the full report posted online.

Sample #1: Caja Del Rio Landfill, Santa Fe

This sample is a mixture of Juniper (Juniperus monosperma) and Pinon (Pinus edulis) woods and was taken from a south-facing wood chip pile that is one to six months old. The sample contains high ash content, due in particular to significant amounts of silicon and aluminum in the sample. The analysis results indicate that the high ash content of the sample is mainly due to contamination with mineral matter (sand, earth, and stones), which can most probably be attributed to storage and manipulation of the fuel on unpaved surfaces at the landfill site. The increased ash content also reduces the amount of organic matter per kilogram of dry substance, and therefore the gross calorific value of the fuel sample. Moreover, the sample contains relatively high concentrations of sodium and iron. The water content of 20.4 percent (w/w, w.b.) is rather low, probably due to the long storage time and the dry climate in Santa Fe. From a combustion point of view, the high ash content has to be carefully considered in selection of appropriate furnace, boiler, flue gas cleaning and ash-handling technologies. This material can be considered a relatively dry fuel of moderate quality.

Sample #2: Caja Del Rio Landfill, Santa Fe

This material is a mixture of Juniper (Juniperus monosperma) and Pinon (Pinus edulis) woods. It was taken from the middle of a pile between 1 and 6 months old. The ash content of this sample is extremely high due once again to the significant presence of silicon and aluminum. The analysis results indicate that the material is heavily contaminated with mineral matter (sand, earth, stones), which can be attributed to the storage and manipulation of the fuel on unpaved surfaces at the landfill site. Moreover, the sample contains high contents of potassium and iron as well as very high sodium levels. The amount of nickel is also higher than the mean value for European wood chips and bark. The high ash content reduces the amount of organic matter per kilogram of dry substance, and therefore the gross calorific value of the fuel sample. The water content of 20 percent (w/w, w.b.) is rather low and is likely due to the long storage time and the dry climate in Santa Fe. From a combustion point of view, the extremely high ash content as well as the high concentrations of K and Na make utilization of this material as a fuel difficult. This material is not recommended for combustion unless mixed with a higher quality wood fuel.

Sample #3: Caja Del Rio Landfill, Santa Fe

This sample is a mixture of Juniper (Juniperus monosperma) and Pinon (Pinus edulis) woods. It was taken from a north-facing pile between 1 and 6 months old. The sample contains very high ash content, due in particular to the significant presence of silicon, aluminum and iron. The potassium and sodium contents are also high. The analysis results show that severe contamination with mineral matter has taken place (from sand, earth, and stones), which can again be attributed to storage and manipulation of the fuel on unpaved surfaces at the landfill site. The high ash content also reduces the amount of organic matter per kg dry substance and therefore the gross calorific value of the fuel sample. The water content of 30.1 percent (w/w, w.b.) is moderate for a biomass fuel but high compared to the other two analyzed samples from the Caja Del Rio Landfill. From a combustion point of view, the very high ash content as well as the high concentrations of K and Na make utilization of this material as a fuel difficult. This material is not recommended for combustion unless mixed with a higher quality wood fuel.

Sample #4: Spotted Owl Timber Inc., Santa Fe

This sample is a mixture of bark and wood from Aspen, Engleman Spruce, Ponderosa Pine, Douglas Fir and White Fir woods. It was taken from a large pile that is one to four weeks old. The material contains high ash content due to the significant amounts of silicon, aluminum, and iron identified. The amount of sodium in the sample is also high. The material is contaminated with mineral matter (including sand, earth, and stones), which is likely due to storage and manipulation of the fuel on unpaved surfaces. The increased ash content also reduces the amount of organic matter per kilogram of dry substance, and therefore the gross calorific value of the fuel sample. The water content of 27.9 percent (w/w, w.b.) is rather low, and is probably due to the long storage time of the logs prior to processing and the dry climate in Santa Fe. From a combustion point of view, the high ash content must be considered in selection of appropriate furnace, boiler, flue-gas cleaning and ash handling technology. If appropriate combustion equipment is used, it can be considered a semi-dry fuel of moderate quality.

Sample #5: Spotted Owl Timber Inc., Santa Fe

This sample is a mixture of bark and wood comprised of Aspen, Engleman Spruce, Ponderosa Pine, Douglas Fir and White Fir woods taken from a small pile between 1 and 5 days old. This material is comparable to untreated woody biomass fuels (sawmill byproducts) from central Europe. The relatively high water content of 49.3 percent (w/w, w.b.) can be attributed to the freshness of the sample and to the rain that was falling during sample collection. (The pile from which the sample was taken was quite small and rain was penetrating the whole pile.) Fresh sawmill by-products in European conditions have water contents between 50 and 58 percent (w/w, w.b.). From a combustion point of view, this fuel can be utilized without restriction and can be considered a moist fuel of good quality.

Sample #6: Spotted Owl Timber Inc., Santa Fe

This material is a mixture of sawdust from Aspen, Engleman Spruce, Ponderosa Pine, Douglas Fir and White Fir woods taken from a small pile estimated to be one to four weeks old. This material is comparable to untreated woody biomass fuels (sawmill by-products) from central Europe. The relatively high water content of 47 percent (w/w, w.b.) can be attributed to the freshness of the sample and to the rain that was falling during sample collection. (The pile from which the sample was taken was quite small and rain was penetrating the whole pile.) From a combustion point of view, this fuel can be utilized without restriction and can be considered a moist fuel of good quality.

Sample #7: Albuquerque Area River Thinning Project

This sample is a mixture of Salt Cedar (Tamarix spp.), Russian Olive (Elaeagnus angustifolia) and Cottonwood (Populus wislizeni). Compared to the wood fuel compositions given in the BIOS database, this material contains a high sodium level, but the carbon content is slightly lower than that in average wood fuel samples from central Europe. The content of sulfur in the sample is high and the nitrogen content can be classified as very high compared to typical natural wood fuels. The water content of 11.8 percent (w/w, w.b.) is very low, which increases the net calorific value of the fuel per unit weight. From a combustion point of view, this fuel can be utilized as a dry and energy-rich wood fuel in furnaces suitable for ash-rich biomass. Special consideration should be taken to minimize NOx emissions via selection and design of the combustion technology if using this biomass as fuel, due to its high nitrogen content.

Sample #8: Los Lunas Area River Thinning Project

This mixture of Salt Cedar (Tamarix spp.), Russian Olive (Elaeagnus angustifolia) and Cottonwood (Populus wislizeni) was chipped in March of 2004. It contains extremely high sulfur levels and high concentrations of nitrogen, chlorine and sodium compared to natural wood fuels from central Europe. The water content of 15.9 percent (w/w, w.b.) is very low, increasing the net calorific value of the fuel per unit weight. From a combustion point of view this fuel is dry and energy-rich, but special consideration should be taken to select a combustion technology that minimizes the formation of SOx and NOx. Due to its extremely high sulfur content, utilization of this material as a fuel is difficult and cannot be recommended until test runs with this fuel have been performed and evaluated. This biomass fuel is therefore not recommended for combustion unless mixed with a higher quality wood fuel.

Sample #10: East Mountain Thinning Project

This material is a mixture of Pinon (Pinus edulis) and Juniper (Juniperus monosperma) woods. Compared to other samples from thinning projects, the water content in this sample of 42.8 percent (w/w, w.b.) is relatively high. This can possibly be explained by the freshness of the material. This sample is comparable with untreated woody biomass fuels from Austria. From a combustion point of view, this fuel can be utilized in furnaces suitable for ash-rich biomass fuels. For such equipment, this sample can be considered a moist fuel of good quality.

Sample #12: Pecos Wilderness Thinning Project

This sample is a mixture of Ponderosa Pine (Pinus ponderosa) and Pinon (Pinus edulis), which was collected from the forest floor. The sample has a high ash content, due in particular to high silicon, aluminum and iron levels. This finding appears to be due to contamination of the fuel with mineral impurities such as sand, earth, and stones. Furthermore, the concentration of sodium is high in comparison to wood chips and bark fuels from central Europe. The water content of 8.8 percent (w/w, w.b.) is very low, increasing the net calorific value of the fuel per unit weight. From a combustion point of view, this fuel can be utilized in furnaces suitable for ash-rich biomass fuels. For such equipment it can be considered a dry and energy-rich fuel of medium quality.

SECTION 5: ECONOMIC BENEFITS OF THE SYSTEM

Deriving economic benefits for the community—or more correctly, attempting to avoid severe economic hardships—has always been the primary motivation of this project. And while the technical and financial analyses took by far the most time, and the fascination with biomass technology garnered by far the most attention, the study of how to create economic benefits in the local community was by far the most difficult. Gaining familiarity with a range of system behaviors—from the degradation of natural gas resources, to utility-price impacts on low-income families, to the leakage of energy dollars from the community—and then learning how to synthesize this information such that it can be used to create a beneficial energy system, turned out to be a task of enormous complexity. The work described herein attempts to begin the process of furthering our understanding of the relationship of energy to our economy.

Our economics work took place on several parallel tracks. First, Local Energy compared the historical trends in natural gas heating costs and income to assess the budget squeeze that is developing—especially in low-income households. We asked economist Dr. Kelly O'Donnell to characterize the energy burden for households in Santa Fe County, based on data from the 2000 census. We then tapped renowned localization expert Michael Shuman to compare the energy-dollar flows and their economic multiplier effects for biomass heat and natural gas heat. Finally, we worked with Loretta McGrath to compare the relative merits of ownership models for the new biomass system including cooperative, municipal, trust, and community corporation. (The discussion of ownership models appears in Section 7.)

The fascination with biomass technology can easily overshadow the complex and sobering discussion of the impacts rising energy costs have on low-income families. Regardless, maintaining an economic focus is critical if we intend to bring new energy projects online in ways that generate lasting and meaningful benefits for communities.

The discussion of natural gas resource degradation is not included here, but can be found in the first section of Reference 15. A background knowledge of depletion as a driver of the current supply/demand imbalance is helpful for understanding that prices for natural gas will continue to increase sharply and unpredictably. A recognition that gaseous fossil-fuels are finite, and that we must eventually switch to something else anyway, is also helpful. The real point of the work presented here, however, is to show how to best make the transition to avoid the worst of the hardships that are already beginning to take hold.

Energy and Income Trends

As energy prices continue to rise faster than incomes, household budgets tighten. Although this occurs in households across the economic spectrum, the impact is regressive in that the burden this creates is greatest in low-income households. An in-depth look at this situation follows.

History of Household Income

Median household income rose 15.6 percent nationwide between 1984 and 2005 after adjusting for inflation.[9] In New Mexico, however, inflation-adjusted household income grew just 1.6 percent over the same period, and remains nearly 20 percent below the national average. Households in Santa Fe County fare much better than New Mexico as a whole, keeping pace with the rest of the nation, on average.[10] See Figure 40.

The income-trends shown in Figure 40 combine data from all income brackets to show a single, overall trend. Figure 41 breaks the New Mexico income data into deciles to show how well the various income brackets have fared. While the upper income brackets have clearly gained ground over the last 24 years, middle wage-earners have seen more modest gains and the bottom 10 percent of wage earners have lost ground.

Figure 40: Median Household Income, Adjusted for Inflation (2005 Dollars)

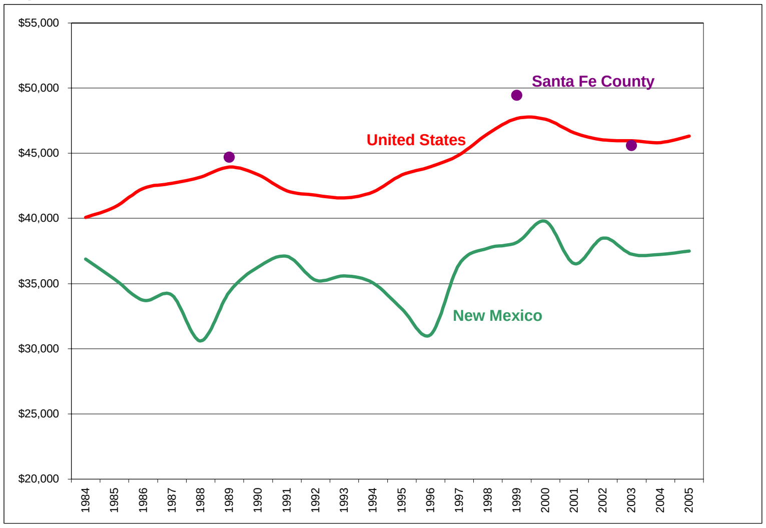
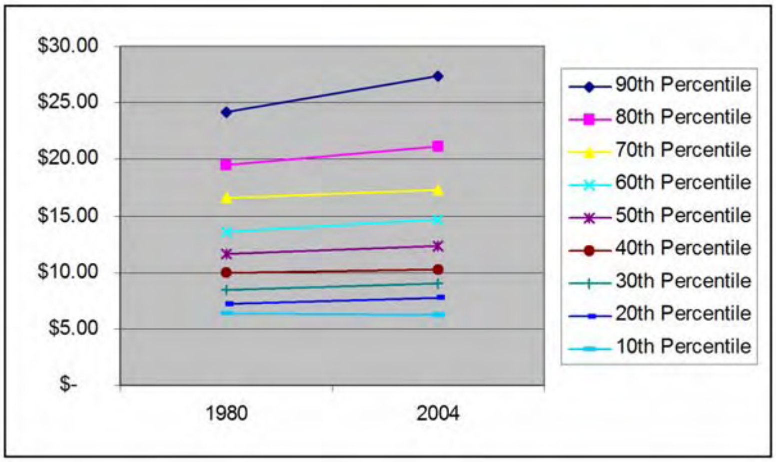


Figure 41: Wages by Decile of New Mexico Population, in 2004 Dollars



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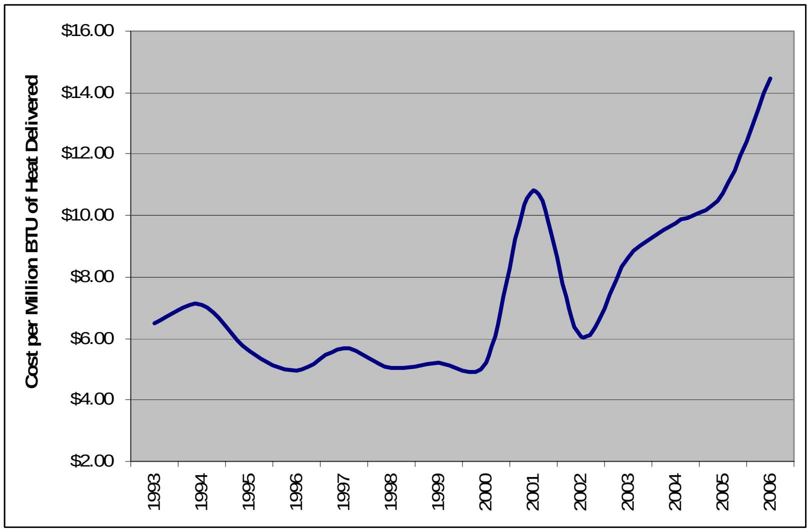
[9] U.S. Census Bureau http://www.census.gov/hhes/income/histinc/h08.html
[10] U.S. Census Bureau http://quickfacts.census.gov/qfd/states/35/35049lk.html

History of Home-Heating Costs

While increases in income have been modest at best over the past 20 years, the recent rise in home-heating costs has been dramatic. The historical cost to heat a residence with utility gas from Public Service Company of New Mexico (PNM) is shown in Figure 42.[11]

Figure 42: Cost of Residential Space Heating with Natural Gas from PNM, in 2005 Dollars



Source: Local Energy and Public Service Company of New Mexico

Note that in addition to the generally upward trend in recent years, the year-to-year fluctuation in price has recently become very large, suggesting some destabilization in the market for this commodity. The sharp rise in prices in 2001 was indeed the result of a supply crisis, in which reserves of gas-in-storage shrunk to unprecedented lows and the market feared a shortfall. (Reference 9.) Rapid price increases in the years that followed reflect a growing concern that another shortfall will develop, and given the persistent trend of growing demand and falling supply, it is inevitable.[12]

The Squeeze on Household Budgets

Between 1993 and 2005, the cost to heat a home with natural gas from PNM increased 65 percent in real dollars, while real median household income over the same period grew by about 5 percent. As bad as that sounds, the reality is considerably worse because lower-income workers, already more heavily burdened by high utility bills, saw their

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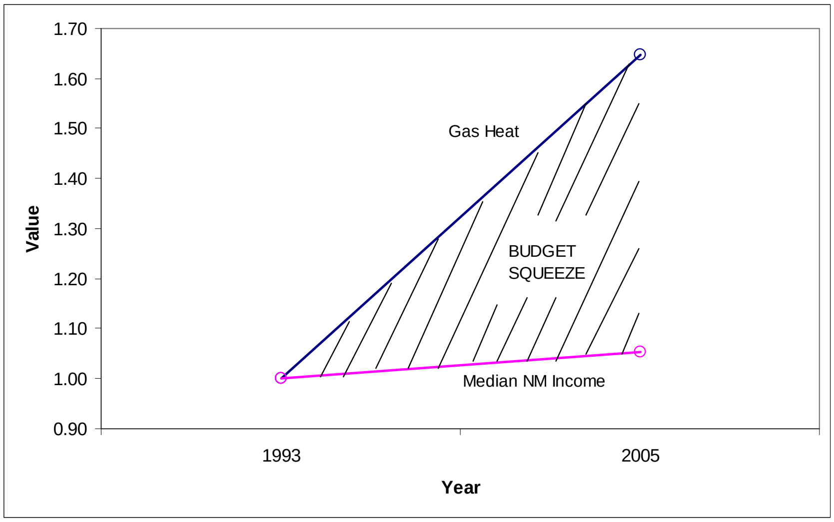
[11] Local Energy calculates the current, normalized price of heating with natural gas using a method that allows comparison of year-to-year space-heating costs. We begin with actual PNM charges for gas and delivery, and apply heating-degree-day (HDD) weighting factors to account for seasonal variations in the amount of gas purchased each month. The weighting is important because the price of gas now routinely fluctuates by some 40 percent over the course of a year, and price hikes in cold months have a tremendous effect on heating costs. To avoid skewing the data for a particular year's weather, we use historical-average HDD data rather than current-year data. We then divide the result by the average efficiency by which the gas is converted to heat, estimated at 75 percent. This is less than advertised boiler efficiency, which tells only how efficient a boiler is when it is running. When boilers repeatedly cycle on and off, additional losses occur during heat-up and cool-down, reducing the operating efficiency considerably. See Ref. 8.

[12] Domestic production of natural gas peaked in 1973 and has been falling ever since, despite dramatic increases in well drilling. This is, of course, consistent with resource depletion.

incomes decline over this period. Moreover, the squeeze worsened considerably in 2006, as space-heating costs jumped another 39 percent above 2005 levels.

Figure 43: Normalized New Mexico Incomes and Gas Heating Costs, in 2005 Dollars



Studies of the regressive hardships created when energy costs shoot upward were made following the oil shocks of 1973 and 1979, with some of the best known publications being *Energy and Equity: Rising Energy Prices and the Living Standards of Lower Income Americans* in 1983, and *Beyond Oil* in 1986. [References 10 and 11]. The current price shocks have inspired the publication of *Energy Cost Burdens on American Families: Americans are Feeling the Pinch of Skyrocketing Energy Prices*, which came from a group called *Americans for Balanced Energy Choices*, which ironically promotes coal as the solution.

The most important distinction that should be made between the current energy crisis and those of the 1970's is that this time around, the price hikes are a result of a structural failure of the industry that is rooted in *resource limitations*, whereas the early incidents were caused by political events.[13] The oil and gas industry faces an inexorable problem of declining resource quality that, despite their best efforts, prevents the supply increases needed to re-stabilize prices. Our current problem of energy price instability will not go away as long as we continue our heavy dependence on depleting resources.

Cost-Burden of Home Heating in Santa Fe County

Our characterization of the energy cost burden in New Mexico and in Santa Fe County was done by Dr. Kelly O'Donnell, an economist who has since been appointed Economic Development Deputy Secretary by Governor Bill Richardson. O'Donnell used data from the 2000 census to determine the following:

- Twelve percent of Santa Fe County residents live in poverty, and 31 percent live in "low-income" households, defined as households with an income of less than

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[13] *Oil prices rose sharply in October, 1973 when the Arab Oil Embargo began, and again in April, 1979 shortly after the Shah was deposed at the start of the Iranian Revolution. Prices later collapsed when Reagan took office and the American hostages were released, and remained relatively low over the 20 years that followed.*

twice the federal poverty threshold. “*Thus, almost one-third of the county’s population is vulnerable to economic hardship resulting from wide swings in energy costs*”, writes O’Donnell.

- Seventy percent of all households in Santa Fe County heat with natural gas. This amounts to nearly 37,000 households.
- About 69 percent of impoverished residents of Santa Fe County heat with natural gas.
- The more than 40,000 low-income residents of Santa Fe County in 2000 had an average energy cost burden of 8.1 percent of gross income. A threshold of affordability of 6 percent is often assumed in similar research studies. Fixed-income residents in Santa Fe had an average energy burden of 5.7 percent.
- County residents living in mobile homes and duplexes had the higher energy burdens, averaging 5 percent, compared with residents of other types of homes.
- Of the County residents living on agricultural properties, 12 percent had an energy cost burden exceeding the affordability threshold of 6 percent.

Concerned that a large biomass project could raise the cost of wood, we also asked O’Donnell to characterize households that heat with wood in Santa Fe County. Here’s what she found:

- About 1800 households, or 3.4 percent of all households in Santa Fe County, stated that wood was their primary heating fuel. More than two-thirds of these households (68 percent) also pay for natural gas, and nearly all of them (96 percent) have electricity.
- About 38 percent of wood-heating residents in the County are low-income, while nearly half (47 percent) have incomes exceeding three times the federal poverty threshold. For all of New Mexico, fully 62 percent of wood-heaters live in low-income households.
- The average energy burden of wood-heaters is 6.6 percent in Santa Fe County and 7.6 percent statewide.

Given the energy burden already shouldered by wood-heaters, clearly care must be taken to avoid driving up the cost of fuel for these households.

The full report prepared by O’Donnell for Local Energy appear as Reference 12 and is available online.

As burdensome as energy costs were when the 2000 census was taken, as described in O'Donnell's report, it must be considered that the cost of heating a home with natural gas in Santa Fe has more than tripled since that time. Assuming a 15 percent growth in income for New Mexicans over the same period, and noting that home heating represents about half of a home energy bill, we can estimate that the home energy burden today is about a third higher than reported by O'Donnell. In other words, households that were straddling the affordability threshold of 6 percent in 2000 are now likely to be suffering an 8 percent burden—significantly above the threshold of affordability. The cost of retail motor gasoline has also doubled over this same period, further heightening the burden on low-income families. (Reference 13).

Why are rising heating costs hardest on low-income families**?**

Although virtually all households must tighten their budgets in response to higher energy costs, the impact is greatest on low-income families because:

1. *Lower-income families have less disposable income with which to absorb new expenses such as higher utility bills.*
2. *Rising energy costs generally result in higher costs for all consumer goods, since these goods are made, packaged, and transported with energy. So lower-income consumers not only have less disposable income, but the disposable income they do have doesn't go as far in the marketplace. The combined effect is a significant loss of purchasing power.*
3. *Renters suffer more than homeowners, and the rental market is dominated by lower income residents. The landlord/tenant relationship inhibits energy conservation investments, so rental units generally cost more to heat than owner occupied housing. Landlords also tend to raise rents in response to energy price increases to cover their increased operating expenses.*
4. *Municipalities, feeling the squeeze themselves, often cut social service programs in response to higher energy costs.*

- Based on 'Energy and Equity' (Reference 10)

Quantification of Local Economic Benefits

Using data generated by our engineering team from BIOS, and assuming that 80 percent of the $24 million needed for the project would be borrowed at 6 percent interest, we calculated the cost of heat from the new biomass system at $16.63 per million BTU of heat delivered. That price is 11 percent higher than the $14.93 per MMBTU that residential gas customers in Santa Fe paid for heat during the 12-month period from July 2005 through June 2006, and nearly 19 percent higher than the $13.99 paid by commercial heat customers. If biomass-generated heat is more expensive than natural gas, what benefit can be derived from switching to biomass?

There are at least two primary reasons that switching to biomass might benefit Santa Fe's economy. The first is that natural gas prices have recently destabilized, such that over the past four heating seasons the cost of heating with natural gas in Santa Fe has increased by a staggering 28 percent per year. The growing imbalance between supply and demand is widely known to be the cause, and there is considerable, credible evidence that the natural gas industry, despite best efforts, is powerless to re-balance the market. The gas fields they are already drilling—now at a rate of more than 20,000 wells annually—are simply getting tired, and the new fields they want to drill cannot be brought online fast enough to keep pace with the decline of existing fields.

But even if the price of natural gas could be stabilized, it may be beneficial to switch to biomass for another reason. If the switch to biomass resulted in a greater retention of energy dollars in the local community, the increase in local economic activity could be significant.

We asked economist, attorney, author, and localization expert Michael Shuman to characterize the energy-dollar flows for our proposed biomass system and for the current situation in which these same buildings are heated with natural gas, and to compare the economic value of the two paths. His analysis is summarized below, and his full report is shown as Reference 14.

The "Localness" of Energy Expenditures

Shuman begins by looking at expenditures made by Public Service Company of New Mexico (PNM), the investor-owned utility from which natural gas and natural gas delivery services are purchased in Santa Fe.[14] Any expenditures made within the boundary of Santa Fe County were considered local. Shuman used PNM's 2003 10-K filing to the Securities and Exchange Commission to get a breakdown of the company's expenditures, and then estimated the local content of each type of expenditure. Expenditures like "earnings" and "cost of energy" were estimated to have no local content, for instance, since PNM is neither owned in Santa Fe County nor do they purchase any energy from sources within the county. But "customer-related expenses" and "taxes other than income" were considered 100 percent local. Other categories were estimated at either 25-, 50-, or 75-percent local.

Using this method, Shuman estimates that only about 14.5 cents of every dollar paid to PNM by Santa Fe County residents for natural gas and its delivery stays in Santa Fe County. The other 85.5 cents "leaks out" of the county to PNM's non-local employees and suppliers, as well as to their investors.

Next, Shuman sought to determine the local character of expenses associated with the biomass heating system. He separately considered capital expenditures, purchases of fuel, annual operating expenditures, and finance payments, and used estimates of these costs prepared by our engineering team from BIOS. Shuman estimated that about 24 percent of the $23.5 million in capital costs would be spent locally, and that 33 percent of the fuel purchases would be paid to sources within Santa Fe County. Of the $1.3 million in annual operating and maintenance expenditures, 57 percent were estimated to be local. Two cases were considered regarding interest payments: one in which the financing was done with bonds (0 percent local), and the other with financing from locally owned sources (100 percent local). Shuman notes that with an outreach campaign, some or all of the bonds could possibly be purchased by local residents and locally owned banks, adding a local component to the interest payments for the bond-finance case.

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[14] Some businesses in Santa Fe purchase natural gas from Wasatch, a competitive gas supplier, and then pay PNM to deliver it. Economically the effect is basically the same, as neither purchase of fuel has any local content.

Application of Economic Multipliers

Before comparing the streams of local expenditure for the biomass and natural-gas cases, Shuman applied economic multipliers to the various types of expenditures using selected multiplier values from the RIMS-II database. These multipliers account for the fact that each time money is spent locally, a portion of that money gets re-spent locally, creating economic activity beyond the initial expenditure. The principles of economic multipliers are well established, and the benefits of the multiplier effect are explained in the highlighted box.

Project Lifetime

Shuman used a 50-year project lifetime over which to track and compare the economic value of the two paths, which we will now call "switch to biomass" and "stick with gas". The 50-year timeframe was based on the expected lifetime of the network of pipes (the single most costly asset) and drawing upon experience and practice with similar systems in Europe.

Escalation of Fuel Costs

One complication with Shuman's projections is that expenditures for the "stick with gas" case are expected to rise considerably over 50 years. (Rapidly rising gas costs are, in fact, the primary reason Local Energy decided to undertake the study in the first place.) Obviously, steeper increases in future gas prices mean that the benefits of switching to an alternative will be greater, but the problem is that the uncertainty of natural gas prices looking forward is so great that the benefits of switching to biomass are difficult to quantify. While we made an attempt to estimate future gas prices for the sake of the analysis, it should be recognized that there is an

Multiplier Benefits *(from Michael Shuman, see Reference 14)*

"*Whenever a governmental entity undertakes a project, the costs and benefits to everyone living under its jurisdiction need to be evaluated. In the case of energy projects, where the status quo requires importation of outside resources, perhaps the most significant factor is the economic multiplier.*

The economic multiplier is a key factor in community economics: Each time an individual purchases a good or service, he or she sets in motion ripples far beyond the initial transaction. And the more frequent and intense those ripples within a defined economic system, the stronger that system is. Consider a consumer in New Mexico who buys an apple for a dollar from a farmer in Washington state via mail order. That farmer, in turn, may use that dollar to buy toothpaste at a nearby store. The store owner then might use the same dollar to pay an employee who spends the dollar at a local bookstore. In this way the initial transaction cascades into a series of transactions that reverberate throughout a community economy.

From the perspective of a locality, a key to prosperity is to keep as much of the multiplier within the community as possible. In the example above, the consumer in New Mexico, as well as his neighbors, may be better off if he buys the apple from a local farmer. To the extent that all the resulting transactions – the toothpaste purchase, the employee pay, the bookstore expenditure – are kept within New Mexico, the entire state experiences more jobs, income, and wealth.

Keeping the multiplier local also benefits state and local taxing authorities. The transactions from a mail-order purchase of an apple will boost the tax base in Washington state, which will be able to tax the consequent increases in wages, income, property value, and sales. The transactions from a local purchase of an apple, in contrast, will enrich the tax base of New Mexico. Because taxes usually lead to public expenditures, they too exert a multiplier effect.

Several recent studies have underscored that local expenditures have a significantly higher multiplier than non-local expenditures. For example, a study done by Civic Economics in 2003 found that every $100 spent at a planned Borders bookstore in Austin, Texas, would lead to $13 being re-spent into the local economy. The expenditure of $100 at two local bookstores, in contrast, would circulate $45, roughly three times the multiplier. Similar studies in the United States and the United Kingdom confirm that local expenditures contribute two to three times the multiplier as non-local expenditures. The reason is simple: Local businesses spend more money locally – on local management, local services, local advertising, and local profits."

additional benefit, not considered here, which emanates from weaning the community off of a fuel that it has no control over whatsoever.

Ultimately, Shuman elected to use historical price data from the U.S. Energy Information Administration to project how natural gas prices might behave in the future. Shuman used weighted-average monthly data (weighted to account for the fact that more gas is purchased in colder months) from 1987 to 2005, and calculated that over the past 18 years, the cost of heating with natural gas has risen 1.64 percent per year, after adjusting for inflation. Similar calculations showed a 5.13 percent annual increase over the past 10 years and a 14.12 percent annual increase over the past three years. Since the price of gas affects the outcome so significantly, Shuman ran his analysis under all three of the price-rise scenarios. Note that even Shuman's "high" price-rise scenario for natural-gas heat is only half the rate at which it has been rising in Santa Fe over the past four years.

We set the biomass fuel price at $30 per ton, and after considerable discussion, we decided not to escalate the price of biomass for the analysis—essentially treating it as if it will only rise at the rate of inflation. The experience from more than 30-years of biomass development in Europe confirms that these assumptions are reasonable, and a biomass boiler manufacturer from Vermont reported that the 20-year history of that market shows an average of only a 1 percent annual rise in the fuel cost. In any event, with a biomass system the cost of fuel amounts to only about 13 percent of the customer's bill, whereas with natural gas the fuel cost can comprise upwards of 85 percent of the bill.

Calculation of Long-Term Economic Impact

To determine the long-term economic impact of switching to biomass, Shuman first calculates the total expenditure required over 50 years to buy heat from natural gas, and compares it to the total expenditure that would be made if the switch to biomass is made. He next calculates the local multiplier benefits that would accrue as a result of heat purchases for each case. To determine the net advantage of switching, Shuman considers the total savings realized by customers of the biomass energy system, and to this savings he adds the value created by the local multiplier effect of their purchases. He then subtracts the multiplier benefit that would have been realized had they continued purchasing their energy from natural gas. Results of this analysis for the three price-rise scenarios for gas are shown in Table 23. All calculations to this point assume the project uses traditional IRB finance for 80 percent of the capital requirements.

Table 23: Long-Term Economic Benefit of Switching to Biomass

Annual Rise in Gas-Heat Price:	**1.64%**	**5.13%**	**14.12%**
Cumulative Gas Expenditures	191,782,108	547,653,819	13,076,393,148
Cumulative Multiplier Benefits	(61,133,782)	(174,573,893)	(4,168,320,907)
Cumulative Biomass Expenditures	(132,993,597)	(132,993,597)	(132,993,597)
Cumulative Multiplier Benefits	81,886,362	81,886,362	81,886,362
Cumulative Project Benefit	**79,541,091**	**321,972,690**	**8,856,965,006**
Less Cumulative Subsidy *(see below)*	(369,843)	(180,923)	(154,772)
Net Cost-Benefit	**$ 79,171,247**	**$ 321,791,767**	**$ 8,856,810,234**

Note that in order to make the switch to biomass more palatable, Shuman suggests that the cost of biomass heat should initially be subsidized to bring it in line with the cost of gas heat. Since the cost of heating with gas is rising so rapidly, the subsidy is only needed for the first four years in the low-rise case, and only for one year in the high-rise case.

Discounting of Future Benefits

Shuman contemplates whether it is useful to apply a discount rate to the future stream of benefits. He notes that a discount rate should reflect the time-cost of money without inflation and without risk, and argues that several studies of government bonds and the highest grade of industrial bonds suggest that the real time-cost of money is very close to zero. He furthermore comments that his analysis already factors out inflation by calculating price-rise scenarios for natural gas using inflation-adjusted values, such that the price increases reflect real cost-rise patterns. However, given that the Federal Reserve at that time was expected to raise interest rates another point or two (which they have done—the prime rate has risen from 4 to 6 percent since his analysis), Shuman re-calculates the present value of the future stream of benefits using a 2 percent discount rate. This result, alongside results for using local financing instead of IRB’s, is shown in Table 24 below.

Table 24: Effect of Discounting and Financing on Long-Term Economic Benefits

Annual Rise in Gas-Heat Price:	**1.64%**	**5.13%**	**14.12%**
Net Benefit, Undiscounted, IRB Finance	79,171,247	321,791,767	8,856,810,234
Net Benefit, Discounted, IRB Finance	26,864,059	68,878,713	1,117,623,825
Net Benefit, Discounted, Local Finance	49,193,878	91,208,531	1,139,953,644

Discussion of Shuman’s Benefits Analysis

Shuman shows that under all scenarios, the system benefits the community. If natural gas prices rise 14.12 percent faster than inflation, the economic benefit to the community over the 50-year life of the system is $8.8 billion—or $1.1 billion if discounting of future value is appropriate. Regardless of the of whether the benefit amounts to $1 billion or $9 billion, it is clear that the system provides significant value to the community.

There are several reasons why Shuman’s quantification of benefits may be conservative. First, he calculated natural gas price trends using EIA data, giving national average trends rather than the local trend. Although he had good reasons for doing this, the actual price trend in Santa Fe has been considerably more severe. Local Energy repeated Shuman’s calculation of the escalation rates using local gas-price data, and found the 10- and 3-year trends to be 6.7 and 21.1 percent per year, respectively, compared to the 5.1 and 14.1 percent annual increases used by Shuman. The cost of heating with gas in Santa Fe is thus rising 30 to 50 percent faster than the national average.

The second reason the analysis may be conservative is that in Shuman’s model, as gas utility bills rise, the dollars generated from the local multiplier benefits of these purchases rise accordingly. At first this seems appropriate, as Shuman showed that about 14.5 cents of every dollar spent on a gas utility bill stays in the local economy. The problem is that the primary driver of higher utility bills is the cost of the gas itself, and this portion of the expenditure has no local content at all. The components of gas bills that have the greatest local content are maintenance of the pipes and customer care—neither of which rise very much as gas prices skyrocket.

Finally, for all the value of numerical models, they are just that. Their value, and Shuman’s model is a great example, is that they help quantify something that is difficult to quantify. The secondary effects of higher energy prices, however, don’t show up in the model. In the model, residents continue to purchase gas at higher and higher prices, but the harsh reality of what happens to a community when basic necessities become unaffordable is known all too well.

SECTION 6: OUTREACH AND EDUCATION

Local Energy and its engineering colleagues from BIOS were well prepared to handle the technical aspects of this project, but we clearly underestimated the amount of outreach that would be required to gain acceptance for the project. We faced city and county administrations that were unaware of the energy predicament they were facing with oil and gas degradation, and were cautious about turning to trees as an energy source. The public had no idea what "biomass" was, and the idea of using it to gain local self-reliance was foreign to them, and sometimes frightening. Would logging trucks soon begin rolling through neighborhoods?

Throughout the three-year term of the project, we did our best to keep the discussion about the project alive and moving forward. We gave lectures and presentations about the project, and we set up information tables about it at local events. We were interviewed about the project several times on radio stations, both here and in Colorado. We wrote articles, and forwarded the articles that were written about us to our e-news list. We wove the principles of community-based energy, and the potential of biomass, into the courses we taught. Our documentary video, which we showed to the public on four occasions and to private audiences many times, was invaluable.

Each of these efforts are discussed in greater detail below, and a summary of our outreach activities is shown in Figure 44.

Film Screenings

We held four public showings of our film, *Santa Fe's Energy Solution: A Biomass Future*, and we also showed it several times in other venues, including to the Santa Fe Board of County Commissioners and to the State Land Trust Advisory Board. After each showing we held a question and answer session, and noted that the questions became far more insightful than they had been at the start of the project. We showed the film to more than 450 people of our own initiative, and we know that many of the 100 recipients of the DVD watched it, as they complemented us on the work. Some have even remarked that they showed the film in their classrooms.

Mark Sardella answers questions following a screening of Local Energy's documentary film on biomass district energy in Santa Fe.

Event Tables

We set up tables and pubic events in and around Santa Fe to increase awareness and understanding of our project. Although this means of outreach is extremely time-intensive, it proved to be an excellent way to distribute literature and answer questions about the project on a one-on-one basis.

Christian Casillas discusses energy self-reliance with a resident of Santa Fe.

Figure 44: Education and Outreach Activities Related to the Project

Film Screenings	*Organizer*	*Venue or Publication*	*City*	*Title*	*Attend*
March 20, 2006	Local Energy	Jean Cocteau Theater	Santa Fe	Santa Fe's Biomass Future	150
March 30, 2006	Local Energy	Cinema Café	Santa Fe	Santa Fe's Biomass Future	100
April 11, 2006	State Land Trust Adv. Board	State Land Trust Lecture Hall	Santa Fe	Santa Fe's Biomass Future	75
October 23, 2006	Michelle Mosser	Design Week Santa Fe	Santa Fe	Santa Fe's Biomass Future	12
December 3, 2006	Santa Fe Film Expo	Jean Cocteau Theater	Santa Fe	Santa Fe's Biomass Future	100
				Total	**437**
Event Tables					
December 9, 2003	City of Santa Fe	Sweeney Center Bark Beetle Event	Santa Fe	BFDE for Santa Fe	-
June 25, 2004	KTAO Radio	Taos Solar Music Festival	Taos	BFDE for Santa Fe	-
July 10, 2004	Local Energy	Railyard Fair	Santa Fe	BFDE for Santa Fe	-
August 3, 2004	Shannon Sollit	Peace Day on the Plaza	Santa Fe	BFDE for Santa Fe	-
Lectures					
October 16, 2003	Arina Pittman	Ecoversity	Santa Fe	Solving Energy Problems	8
March 2, 2004	Rotary	Santa Fe Centro Rotary	Santa Fe	Developing Biomass in light of Lessons Learned	40
April 7, 2004	Rotary	Rotary Club of Santa Fe Del Sur	Santa Fe	Developing Biomass in light of Lessons Learned	40
April 16, 2004	Amy Pilling/Ecoversity	Ecoversity Classroom	Santa Fe	Solving Energy Problems	8
May 6, 2004	Amy Pilling/Ecoversity	Ecoversity	Santa Fe	What's the Energy Problem?	8
July 10, 2004	Lou Schreiber	SFCC Classroom	Santa Fe	Community-Based Energy	6
October 1, 2004	Monte del Sol Charter Sch.	Monte del Sol Charter Sch.	Santa Fe	Sustainable Energy Panel - Basis of the Solution	20
October 28, 2004	Lisa Adler	College of Santa Fe	Santa Fe	The Physics, Economics, and Politics of Energy	15
March 29, 2006	Kevin Lavelle	Santa Fe Comm. College	Santa Fe	Community-based energy and BFDE	10
April 9, 2006	Scott Pitman	Ecoversity Classroom	Santa Fe	Community-based energy and BFDE	25
April 11, 2006	Arina Pittman	Ecoversity Classroom	Santa Fe	Global Energy Problems, Community-Based Solutions	15
August 15, 2006	Arina Pittman	Ecoversity Classroom	Santa Fe	Introduction to Sustainable Energy	15
October 5, 2006	Arina Pittman	Ecoversity Classroom	Santa Fe	Community-Based Energy Solutions	35
October 20, 2006	Kevin Lavelle	College of Santa Fe:	Santa Fe	Innov. and Ethics: Case Studies of Green Technologies	20
October 23, 2006	Michelle Mosser	Design Week Santa Fe	Santa Fe	Community Based Energy	18
October 28, 2006	Michelle Mosser	Design Week Santa Fe	Santa Fe	Art of Sustainable Energy	8
				Total	**291**
Presentations					
August 24, 2003	Local Energy	Biofest	Tesuque	Energy Self-Reliance for Santa Fe	75
September 10, 2003	Art Buffard?	SF Lodgers Assoc. Board	Santa Fe	The SF Biomass District Energy Project	18
October 14, 2003	Harry Montoya	Board of County Commissioners	Santa Fe	The SF Biomass District Energy Project	30
October 14, 2003	SF City Government	SF City Public Works Committee	Santa Fe	The SF Biomass District Energy Project	15
November 12, 2003	Lleta Scoggins	SF Railyard Community Corp Boardroom	Santa Fe	Biomass District Energy for Santa Fe	15
November 21, 2003	Local Energy	Hotel Santa Fe	Santa Fe	Overview of BFDE	35
May 1, 2004	Sarah Laeng Gilliatt	Institute for Nonviolent Economics Conf.	Santa Fe	Global Energy Problems, Local Energy Solutions	8
September 27, 2004	Jim McLaughlin	SFCC Board Room	Santa Fe	Biomass Energy at SFCC	30
January 27, 2005	Austrian Biomass Assoc.	Central European Biomass Conference	Graz, Austria	Bioenergy in the USA	650
January 27, 2005	SFCC Board	SFCC Board Room	Santa Fe	BFDE Update - SFCC MG	20
March 8, 2005	SF Alliance	The Travel Bug	Santa Fe	Biomass in Austria	50
May 18, 2005	Harry Browne	Gila Resources Info Project - 2020 Visions	Silver City	Local Energy Sustainability	100
October 15, 2005	Amy Pilling/Bioneers	NM Bioneers - Energy Track	Albuquerque	Energy Paths to a Sustainable New Mexico	75
October 26, 2005	Craig Fiels	Lensic Theater - Angelou Plan	Santa Fe	Energy, Sustainability, and Economic Development	400
November 4, 2005	Carlota Baca	NM Assoc. of Grantmakers Annual Conf.	Ruidoso	Energy Price Effects on Nonprofits and Foundations	20
November 12, 2005	Local Energy	Open House at Local Energy	Santa Fe	Progress on BFDE, Energy Localization	40
January 25, 2006	SFCC	SFCC Jemez Room	Santa Fe	Center for Community Sustainability	12
May 13, 2006	Sopris Foundation	Innovative Ideas for a New West	Aspen	The Return to Community Based Energy	300
June 12, 2006	Grayson Schaffer	Outside Magazine Conf. Room	Santa Fe	Community Based Energy	15
June 22, 2006	Heidi Tilton/Wells Fargo	Wells Fargo Private Client Svcs. - SFCC	Santa Fe	Investing in Energy Solutions	100
July 11, 2006	NACUBO	Campus of the Future Conference	Honolulu	LE and SFCC: Collaboration for Energy Conservation	8
August 29, 2006	Rachel Wood	Santa Clara Tribal Council	Espanola	Biomass District Energy at South Housing	30
October 2, 2006	NNMCC	President's Conf. Room	Espanola	Biomass District Energy at NNMCC	10
November 27, 2006	Rachel Wood	South Housing Board of Directors	Espanola	Biomass District Energy at South Housing	8
December 17, 2006	Rachel Wood	South Housing Residents - SC Pueblo	Espanola	Biomass District Energy at South Housing	17
January, 2004	Courtney White	Quivira Coalition Annual Conference	Albuquerque	Developing Biomass in light of Lessons Learned	50
				Total	**2131**
Radio Interviews					
October 18, 2006	John Biethan	America The Green Podcast	Santa Fe	Localize Your Energy	-
October 27, 2003	Diego Mulligan	The Journey Home	Santa Fe	Energy Resource Degradation, Local Solutions	-
May 4, 2006	Piper Foster	Radio Interview w/ Piper	Denver	Sopric Conf. / Biomass Projects in Santa Fe	-
Courses Taught					
October 2, 2004	Lou Schreiber - Contin. Ed.	Santa Fe Community College	Santa Fe	Introduction to Energy Systems	14
March 12, 2005	Lou Schreiber - Contin. Ed.	Santa Fe Community College	Santa Fe	Introduction to Energy Systems	6
February 24, 2006	Lou Schreiber	Santa Fe Community College	Santa Fe	Biomass Energy Vocations	12
May 8, 2006	Arina / EcoVersity	Ecoversity Classroom	Santa Fe	EBV - Sustainable Energy	8
September 4, 2006	Arina / EcoVersity	Ecoversity Classroom	Santa Fe	EBV - Sustainable Energy	6
				Total	**46**
Articles by Local Energy					
January 27, 2005	Austrian Biomass Assoc.	Central European Biomass Conf. Proc.	Graz, Austria	Bioenergy in the USA	-
November 1, 2005	Gershon Siegel	The Eldorado Sun	Santa Fe	Community-Based Energy	-
December 1, 2005	Gershon Siegel	The Eldorado Sun	Santa Fe	Community-Based Energy - Response Letter	-
October 10, 2006	Earth Care International	Sustainable Santa Fe Guide	Santa Fe	Santa Fe Steams Ahead with Sustainable Energy	-
Articles about the Project					
July 15, 2003	Richard Barr	Santa Fe New Mexican	Santa Fe	Let's Begin Investing in Local Energy	-
September 12, 2003	Jeff Tollefson	Santa Fe New Mexican	Santa Fe	Forest Thinnings Could be Source of Heat	-
September 30, 2003	Adam Rankin	Albuquerque Journal	Albuquerque	Forests May Help Keep City Warm	-
January 1, 2004	Gail Snyder	Eldorado Sun	Santa Fe	Plunging Santa Fe into Hot Water	-
January 12, 2004	Andrew Webb	NM Business Weekly	Albuquerque	Getting off the Gas: SF Group Aims to Heat City With Wood	-
February 6, 2004	Julie Ann Grimm	Santa Fe New Mexican	Santa Fe	Hot Alternative: Group would burn dead pinons to heat downtown	-
February 6, 2004	Adam Rankin	Albuquerque Journal	Albuquerque	Dead Trees Could Heat Up Railyard	-
August 4, 2004	Julie Ann Grimm	Santa Fe New Mexican	Santa Fe	Firm Studies Biomass Heat for Santa Fe	-
September 7, 2004	Adam Rankin	Albuquerque Journal	Albuquerque	SFCC is Biomass Heating Hopeful	-
October 27, 2005	Bob Quick	Santa Fe New Mexican	Santa Fe	City Celebrates First-Year Achievements	-
November 2, 2005	Zane Fischer	Santa Fe Reporter	Santa Fe	Some Like it Hot: Mark Sardella Kicks Some Biomass	-
March 22, 2006	Nathan Dinsdale	Santa Fe Reporter	Santa Fe	Santa Feans Hot for Energy Film	-
October 5, 2006	Nancy Zimmerman	Santa Fe Trend	Santa Fe	A Biomass Future for Santa Fe	-

Lectures, Presentations, and Interviews.

We gave more than 40 lectures and presentations that were either directly about the project or about the principles and research behind the project. All together, these talks were attended by nearly 2,500 people. Venues included local schools (Monte del Sol Charter School, EcoVersity, Santa Fe Community College, College of Santa Fe), trade conferences, and the local chapters of Rotary International. We also spoke in front of businesses with interest in the project, such as the Santa Fe Lodger's Association, and to groups and civic leaders interested in pursuing similar projects at their facilities or in their communities. We also gave several radio interviews about the project, and were interviewed a number of times by local papers and publications.

Sardella shows the hardships of higher energy costs at the Lensic in Santa Fe

Courses Taught

We developed a continuing-education course entitled Introduction to Sustainable Energy, which uses the community-based energy principles developed for the biomass project as the central theme. We ran the course twice at the Santa Fe Community College, and twenty students completed the course. This course also formed the basis for a 2-week training that we offered at EcoVersity in Santa Fe, which graduated another 14 students.

The Santa Fe Community College purchased this biomass unit to use with the training program developed by Local Energy.

Finally, we developed a course in biomass vocations for the Santa Fe Community College, and ran the course once with 12 students. Several of the students went on to pursue biomass projects or businesses, and the college hopes to use the course to train operators for the new biomass heating system they are currently developing.

Articles by Local Energy

In additional to all the technical reports delivered on the project, we wrote one technical paper and two news articles about the project. The paper, entitled *Bioenergy in the USA*, was delivered at the 2005 Eastern European Biomass Conference to about 650 attendees, and appears in the conference proceedings. See Reference 15. We also wrote *Community-Based Energy: A Return is Long Overdue* to promote the central concept of the project, and it was published in the Sun Monthly (Reference 16) and *Santa Fe Steams Ahead with Sustainable Energy* for the *Sustainable Santa Fe Resource Guide 2006*, which distributed about 40,000 copies in the local area.

For the beneficiaries of the fossil-fueled orgy of wealth and excess, no amount of environmental damage and no level of geopolitical risk will ever justify changing the system.

Community-Based Energy
A RETURN IS LONG OVERDUE

by Mark Sardella

Articles about the Project

Our work attracted a fair amount of press, all of which was favorable. Of the largest papers in the area, and not including articles that we wrote ourselves, we were covered by the Santa Fe New Mexican (5 articles), The Albuquerque Journal (3 articles), the Santa Fe Reporter (2 articles), the New Mexico Business Weekly (1 article), and the Sun Monthly (1 article). Some of the best coverage came much more recently, as we were featured in the Fall 2006/Winter 2007 issue of Santa Fe Trend, with a circulation of about 30,000.

AROUND TOWN
interview

A Biomass Future for Santa Fe

PHOTOGRAPHS BY DAVID ALFAYA

With heating costs spiraling upward and global warming increasing apace, finding a way to meet these challenges is becoming ever more urgent. Mark Sardella, executive director of the Santa Fe–based nonprofit Local Energy, believes he's got a workable solution to address those problems that simultaneously boosts the local economy. After conducting a two-year study of the feasibility of replacing downtown Santa Fe's natural-gas heat with biomass-fired heat, Sardella is convinced that the city is ready to lead the way to a clean, affordable, efficient use of local resources.

Local Energy's biomass project was featured in the Fall 2006/Winter 2007 issue of Santa Fe Trend, giving details of the project in question and answer format.

Although the press coverage was favorable, several letters to the editor expressed concerns about emissions from the project and the problems with digging up the streets of Santa Fe. One reader wrote to the Sun Monthly:

> *…Hotel, restaurant and shop owners would suffer due to lack of tourist access while construction was on going for years. And, Lord have mercy, excavators [will] dig up more of my relatives' graves downtown near the Palace of the Governor…*

To which we responded:

> *…the increased retention of energy dollars in our local community will create enormous economic benefits – large enough that we may be able to recover from the damage that higher heating costs will inflict up until the system becomes operational. Finally, the idea behind building a sustainable community here is to leave a gift to your descendents, such that they might have an opportunity to live, as you have, on their ancestral lands.*

Further Outreach

We had hoped at the start of the project to do more work in surrounding communities, but soon realized that a concentrated focus was required locally if the project was to move forward. We nonetheless initiated discussions with representatives from Silver City, El Rito, Las Vegas, Espanola, and Chimayo in New Mexico, and with mayors and commissioners from Durango, Carbondale, and Aspen in Colorado. We have also talked with several Indian tribes about gaining energy self-reliance using biomass, including Santa Clara, Santo Domingo, and San Felipe. Thus far the discussions have been very positive, and many have resulted in interest in follow-on work.

SECTION 7: MODELS FOR IMPLEMENTATION

The technical work provided by BIOS discusses the technology that is believed to be most appropriate for the project. The financial calculations of Section 2 show how much money is needed, and how the system will perform financially under various conditions. O'Donnell's work in the Economics section shows the vulnerability of local residents to high heating costs, and Shuman's analysis quantifies the potential benefits of localization.

In this section, we consider the possible ownership models for the system. And just as with the technical, financial, and economic components of the project, it will be similarly important to stay focused on the core goals of the project when considering ownership models. If we were merely trying to put more renewable energy in the community, the problem would be relatively simple. Creating a degree of local self-reliance in energy, stemming the growing tide of energy-dollars leaving the community, and dealing with the regressive hardships of higher energy bills, together present a far greater challenge. Innovative ownership models, and policies to support them, will clearly be required.

After much discussion with economists, attorneys, and others involved with our project, we settled on four possible ownership models that seem to have the best potential for anchoring the project to the local community and ensuring that the benefits accrue primarily to the local community. The four models we investigated are:

- **Municipal Ownership:** Requires governmental involvement in allocating capital into the energy sector specifically for local renewable energy development. Financing could come from industrial revenue bonds (IRBs) and/or in part from the state.
- **Community Trust:** Financed from the same sources as Municipal Ownership, but the community-owned assets are held in perpetuity, in accordance with the trust agreement, for the purpose of providing sustainable energy for the local community. Any income generated by these assets is reinvested through the trust.
- **Cooperative Ownership:** Financed from public and private sources, the assets would be owned by the members of the cooperative, as with our rural electric coops. A percentage of any profits are secured in an investment fund for further development of local energy projects.
- **Community Corporation:** Utilizes conventional, private ownership strategies except that stock owners must be local residents. One variant allows issuance of non-voting stock to non-residents. This model supports socially responsible and local investment strategies.

A brief discussion of each ownership model follows. Our full report on ownership models, prepared by Loretta McGrath, is available online. (Reference 17.) Sections of that report are also included in the Appendix.

Municipal Ownership

More than 2,000 communities throughout the United States operate municipal utilities, including seven communities in New Mexico.[15] Advantages commonly cited include greater control of community wealth, and lower rates. Municipal utilities can often sell energy for less than their investor-owned counterparts because they have no need to generate profit. When they do operate at a profit, it accrues directly to the community.

The greatest advantage of a municipal utility is that profits and community interests are not pitted against one another, as they often are with investor-owned utilities (IOUs). This leads to very different decisions regarding the energy system. For example, one way IOUs increase profits is by making large investments, which earn guaranteed returns. This encourages them to perpetually push to build new power lines. But a municipal utility operates from a perspective of lowest system cost, and is therefore more likely to look for ways to defer investments in new power lines. They can do this by aggressively pursuing energy efficiency and distributed generation projects, even going as far as to offer incentives such as feed-in tariffs to encourage private development of strategically located generating capacity on the distribution network. Municipal utilities can also put a high importance on other community priorities, including large-scale penetration of renewable energy or promotion of social equity through progressive rate structures.

All of these well-established advantages for municipal electric utilities would apply to Santa Fe's district heating system if it is built under this model. Possible disadvantages, however, include susceptibility to corruption and difficulties related to the inherent incompatibility of short-term political tenures and long-term planning needs of energy utilities.

Community Energy Trusts

Trusts are entities that are defined by *trust property*, a *trust agreement*, and a *trustee*. Community trusts have commonly been set up to ensure long-term, sustainable stewardship of land, and more recently this model has been used to create "energy trusts". Additionally, at least two land trusts—the Northern California Land Trust and the Lopez Island Community Trust Producer's Cooperative—are known to be implementing renewable energy projects. Details on these projects can be found in the Appendix.

Using the community trust model for Santa Fe's district heating system may have additional benefits beyond those discussed above under municipal ownership. One of the greatest advantages is that the trust agreement could ensure that energy assets are held in perpetuity for the benefit of the community, eliminating the possibility of selling off of the assets under changing political winds.

The greatest difficulties with implementing the trust model might be writing the trust agreement in a way that ensures that issues of equity, energy security, and sustainability are met, and selecting the best possible trustee for upholding the community's interests.

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[15] The seven communities with public power utilities in New Mexico are Aztec, Farmington, Gallup, Los Alamos, Raton, Springer, and Truth or Consequences.

Notwithstanding these challenges, the trust appears to be a highly promising and progressive model for implementing biomass district heating systems in Santa Fe.

Cooperative Ownership

The National Cooperative Business Association defines a cooperative as "an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise." Cooperatives can be distinguished from other ownership models by the fact that they are owned by their members (either consumers or producers), they are not-for-profit, and their governance structure allows only one vote per member. They have been around for at least one hundred and fifty years, and today nearly 10 percent of retail electricity sales accrue to utilities operating under a cooperative ownership model.

Producer cooperatives are common, and one idea for Santa Fe might be to facilitate the creation of a biomass fuel producers cooperative, which could even have an ownership stake in district heating systems. This would give woodcutters assurance of an outlet for their product, while giving Santa Fe added security that fuel will always be available for their heating needs. The USDA has a *Rural Cooperative Development Program* that provides significant assistance for setting up producer cooperatives.

Advantages of employing the cooperative model include its nonprofit, democratic structure, and the high level of community commitment that it typically engenders. As a democratic model, however, cooperatives can be slow and unwieldy in their governance, and they are not immune to corruption and mismanagement.

Community Corporations

Community corporations can take on many legal forms, including for-profits, nonprofits, cooperatives, and public enterprises. They are distinguished from conventional corporations in that there is a residential requirement on stock ownership. Variations on this theme are discussed in detail in Reference 18.

Anchoring a corporation to a community through stock ownership requirements is an attempt to preserve the many advantages of the corporate structure (particularly its ability to attract capital) while attempting to control liabilities related to corporate loyalty. When the best interests of a community are pitted against the fiduciary interests of a corporation, the board of the corporation is *required* to act on behalf of shareholders. Any breach of this fiduciary obligation may be punishable under federal and state laws. The hope with a community corporation is that stockholders that are local residents are less likely to pit their financial interests against the welfare of their own community.

Selecting an Ownership Model

Any of the four ownership models discussed in this section could likely achieve the objectives of the biomass district heating project provided that appropriate criteria are set and adhered to throughout the process. Such criteria might include ensuring that structures and incentives are put in place to encourage efficiency, integrity, and care for the long-term, sustainable energy needs of the community.

Based on our research, the community energy trust appears to be the most powerful and progressive model available for achieving the stated goals, and a biomass fuel-producers cooperative is likely to be the best instrument for spreading the benefits to surrounding communities and improving the security of the fuel supply. The unique and high-profile nature of this project should enhance its ability to attract capital even under these less conventional ownership models, and the value of being the first city in the United States to deploy a community-based model to heat its entire downtown district with renewable energy will provide additional benefits beyond any discussed in this report.

CONCLUSIONS

Over the past three years, as this study was being carried out, the cost of heating with natural gas in Santa Fe has risen by 83 percent. This shocking increase in heating costs was entirely predictable. In fact, our research on the degradation of North American natural gas resources—the driving force behind increasing heating costs—was what set this project in motion in the first place.

Three years later, the question we still get asked most often is, “Will there be enough trees to operate the system years into the future?” At first the question seemed irritating, especially given the precariousness of our gas supply, which will never be renewed. But more and more, we realized the question was reassuring. The inherent respect that a tree commands, perhaps due to its 300-million year ancestry on the planet, can keep us from making the mistakes with biomass that we made with natural gas. We must stay hopeful.

One of the main goals of this study was to develop some of the principles and practices that can help us become better stewards of energy resources. This begins with efficient use of the resources, which is why we partnered with BIOS. No other engineering firm has taken biomass combustion efficiency to their level. With classic Austrian precision, honed with 30 years of experience, they showed Santa Fe how to best lay out a heat-pipe network, configure a boiler plant, and manage fuel. Their models of financial performance are financial grade, as the Santa Fe Community College has proven, and only need to be updated with current prices before Santa Fe can move forward as well.

Beyond technological efficiency, our study shows how to be economically efficient. O’Donnell’s characterization of energy cost burdens in Santa Fe shows the importance of directing the economic benefits generated by the system to lower-income families. Shuman showed how large the energy-dollar leakage really is, and the degree to which it can be plugged with the project.

Finally, McGrath’s research on the relative advantages of several progressive models for ownership of the system should facilitate creation of an entity that respects the community and the stake its members have in securing their energy future. If fossil-energy resources with their global reach inspired globalization and interdependence, then local energy resources must inspire a re-focusing on community and local self-reliance.

As shown in this report, a biomass-fired district heating system for Santa Fe is technically feasible, economically beneficial, and environmentally important. It can be built under a progressive ownership model that provides security to the community of a long-term, sustainable energy supply. There is more than ample fuel in the region, even before thinning operations are ramped up as needed.

What’s more, building the system is absolutely necessary. Sitting idly by while Santa Feans shell out more and more money each year, deepening their dependence on a depleting resource, would be unconscionable. This report is not the answer to Santa Fe’s energy problems, but we hope it can serve as guide to begin the process of restoring energy self-reliance to a community that desperately needs it.

APPENDIX

Below are relevant sections of Reference 17 that describe the four ownership models investigated for the Santa Fe Biomass-Fired Districting Heating project. The full report is available online at *http://www.localenergy.org/documentLibrary.htm*

Municipal Ownership

Over the last two decades, local economies have been influenced by fluctuating global markets and increased corporate dominance. As a result, local governments are creating municipal enterprises to promote local economic development and ensure greater control of community wealth. The municipalization of energy utilities is a direct step communities are taking as the threat of rising fossil fuel prices impacts local economies.

Public power companies, municipal and cooperative, are primarily not-for-profit electric utilities that are locally owned and operated by the people they serve. In addition to providing electricity for public use, public power utilities also maintain an infrastructure for other public services including natural gas, water, sewer and increasingly, telecommunications. Municipal utilities can include territory outside of city limits and some serve part of a city. Unlike publicly owned utilities, private investor-owned utilities (IOUs) are owned by investors who can trade shares listed on the stock exchange.

Public power companies can own wires and power plants. They can also own wholesale power to resell. At the federal level, the federal government owns hydroelectric and nuclear power generation. They sell power to cities, states and the wholesale market. Some states own and operate regional power authorities including generation, transmission, and other services needed by customers. At the local level, many municipal governments across the U.S. own and operate gas and electric enterprises to serve their communities, while others only own wires. Local governments who only own wires purchase their power and, as wholesalers, can resell it to their customers. The rates that public power companies charge are based on operating costs. Unlike IOUs, municipal enterprises garner no profit or return on investment.[16]

In the United States, 2,010 communities have created public power utilities over the last one hundred years. Sixteen new public power utility companies have formed in the last ten years, while 72 have been created over the last thirty years. Publicly-owned utilities provide electric service needs for more than 40 million Americans, 14 percent of all electricity consumers. [17]

While the trend seems promising for local energy ownership, consider the following:[18]

- The 223 IOUs in the U.S. still generate 40.9 percent of electricity per kilowatt-hour
- Public power utilities generate 9.8 percent of electricity per kilowatt-hour
- Cooperatives, serving many rural locations generate 4.1 percent
- The remainder is generated by federal power agencies, non-utilities and power marketers

Electric revenue sales generated in 2003 by the utility sector reveal more investor-owned dominance:

- IOUs generated $167,586 million dollars in 2003
- Public power companies' generated $40,534 million in 2003

Public power advocates claim the benefits of their service include:
- low rates
- local control over utility policies
- commitment to and from the community
- public accountability
- unparalleled responsive customer service
- local economic development benefits

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[16] Local Power, "Community Choice vs. Deregulation, Regulation & Public Power" (San Francisco, CA),from website http://www.local.org

[17] APPA "Shining a Light on Public Service", (Washington, D.C), p.1. Accessed 8/23/06.

[18] APPA, *2005-06 Annual Directory & Statistical Report*, pp 21-22. (Energy Information Association EIA Form EIA-861), pp. 21-22.

While these benefits provided by municipal utilities are laudable, municipal energy generation needs to shift from high polluting coal-fired plants to renewable energy. Many cities nationwide are setting their own goals for reducing greenhouse gas emissions. Because of their size and scale, municipalities are in a good position to take responsibility and immediate action for their carbon-dioxide emissions. Municipalities can assume responsibility by enacting policies and efficiency standards, creating educational programs for citizens within all sectors of the community and providing incentives for residents, business, and industry to use renewable energy sources.

Communities now served by IOUs are exploring the possibility of municipalizing their electric utility to secure the benefits of locally-owned public power. Fifty years of data from the U.S. Department of Energy asserts that IOUs charge more for electricity on average than public power systems.[19] In 2003, the most recent data year,

- residential customers of IOUs paid rates that averaged 10 percent higher than those paid by customers of publicly owned utility systems
- commercial customers of IOUs paid electric rates that were 7 percent higher on average than commercial customers who purchased public power

Revenue generated from municipal utility districts is often reinvested in the general fund. In 2002, municipal power company income totaled $39.6 billion in the U.S. while municipal power company general fund contributions totaled $2.3 billion. [20]

- The median amount of revenue contributed by public power systems in 2000, the most current year for which data was available, was 14 percent higher than IOUs after taxes, tax equivalents, and contributions to state and local governments were considered
- Public power utilities contributed 5.7 percent of electric operating revenues vs. 5 percent for IOUs
- Not only is the IOU contribution rate lower, but the median amount they contributed has recently declined 16 percent, from 5.8 percent in 1998 to 5.0 percent in 2000 [21]

Municipalization

Municipalization, the opposite of privatization, is the transfer of corporations or other assets to municipal ownership. Transfer can be from private ownership or from other levels of government. Municipalization often occurs when IOU providers fail to expand services sufficiently to outlying rural and poor populations. A good example is the recent trend in municipal ownership of telecommunication services. Sometimes municipalities become intolerant with price gouging and poor customer service. After Oregon's community of Hermiston recently shifted from an investor-owned utility to a municipally-owned one, they now pay lower prices for energy and benefit from improved customer service. In 1998, one of the largest public power utilities, the Long Island Power Authority (LIPA) replaced the investor-owned Long Island Lighting Company. After LIPA bought the IOU, LIPA reduced electric rates by an average of 20 percent, saved customers more than $2 billion, and has estimated that the rate cut has expanded the region's economy by $12 billion.[22]

In the US, municipalization often refers to incorporation of an entire county into its municipality which leaves no unincorporated areas. Incorporation often ends a county's *de facto home rule* which allows it to act as the municipal service provider in unincorporated areas. As with utilities, the county's assets end up being distributed among the cities, unlikely if the incorporation process is gradual instead of all at once.

One of the more well-known examples of municipalization in the U.S is SMUD, the Sacramento Municipal Utility District which has been selling electricity since 1946. When rolling blackouts affected the state of California in December of 2000, the average residential customer of SMUD paid almost $20 less than customers of the IOU, PG & E, for the same services. When deregulation resulted in price hikes and blackouts, other California municipally-owned utilities such as the Los Angeles Department of Water and Power were still able to protect their customers as well.[23] While benefits such as these exist from municipally-owned utility companies, they are often underrepresented in the mainstream media.

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[19] Ibid, p.42. www.APPAnet.org

[20] The Democracy Collaborative website. Accessed 7/6/06. http://www.community-wealth.org/strategies/panel/municipal/index.html

[21] APPA, "Payments and Contributions by Public Power Distribution Systems to State and Local Governments," 2000 Data. (APPA, 2002)

[22] APPA, "Straight Answers to False Charges Against Public Power," p36.

[23] Rachel Brahinsky, "A Tale of Three Cities," in *Yes! A Journal of Positive Futures*, Summer 2001, p46. Bainbridge, Island, WA. www.yesmagazine.org

When a community chooses to shift to a municipally-owned system or form one, it usually takes three to four years on average. Some systems have been formed in one to two years while the most hard-won municipalization campaigns took seven or eight years to complete. Sometimes communities who choose to establish public power utilities have already experienced long-term dissatisfaction with an IOU system. High rates and poor customer service, or negotiating for electric service that meets a community's needs is common reason for a shift to municipal power**.** Dozens of communities across the U.S. consider their time and money a worthy investment if it means they have local control and ownership of their energy needs.

In instances where it takes years for a municipality to convert their energy utility, it is often due to the obstacles and legal battles that IOUs create to fight a city for the system. Pertinent examples include Las Cruces, New Mexico and Massena, New York who each spent about 7 years trying to overcome the legal hurdles created by the IOU. In the end, when Massena won, it saved its customers $25 million in the first 10 years of operation with millions more in savings since then. After their struggle and years of paying some of the highest electric rates in the country, Las Cruces does not own their system. Las Cruces did win important concessions with a short-term franchise, a large settlement payment, and the future option to purchase facilities.[24]

Civic Advantages of Municipal Ownership

A major benefit of municipal ownership lies in the fact that municipalities are place-based companies like consumer-owned utility cooperatives and non-profit organizations. They are managed by local people, serve local energy needs and offer local control over utility policies. Since they are public enterprises shaped by and accountable to place and constituents, they can be structured to reduce weaknesses and maximize community control rather than be dominated by a select group of politicians. Short-term deals, brokered between politicians and utilities, can often drain local resources and have long-term fiscal and social consequences for a community. Many public power utilities appoint citizen panels to advise them on all aspects of the company, from services to reliability and rates, thereby minimizing the possibility of corruption and fiscal leakage. [25]

Community citizens have a direct voice in the policy and utility decisions that affect them. Public power meetings are open to the public unlike IOU meetings which are often conducted in secret with key stakeholders. Resident citizens, empowered to elect board members of local utilities instead of politicians appointing them, can reduce political corruption. If local communities enact strict campaign-finance reform and lobbying laws they could increase the likelihood of community representation at all levels of the public power company while creating a check and balance system against corruption.

Economic Benefits

Public power companies assert two primary major benefits compared to IOUs: lower rates and excellent customer service. Typically, public power companies offer lower electricity rates because utility rates are determined by local people who govern the utility. In addition, the governing body is limited by bond covenants. In addition, municipal utilities have an obligation to base rates upon the cost of serving the different types of customers within their service area: residents, commercial customers and industry. [26]

As Michael Shuman notes, public power corporations can be more responsive to a community than an IOU because the U.S. Securities and Exchange Commission (SEC), requires public power companies to reveal certain financial aspects of their business. In addition, in their required annual meeting, public power company shareholders elect board of directors members. [27]

> Due to lower rates and lower business costs, public power companies are preparing their communities for the future by pursuing new technologies as an integral part of community growth. Countering their reputation as being outdated and inefficient, some public power companies are now offering telecommunications services at competitive prices as part of their economic development plans. Such initiatives are a backlash to the refusal of private companies to offer such services to smaller towns deemed economically unattractive.[28]

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[24] APPA, " Straight Answers to False Charges Against Public Power," p.37.

[25] Michael Shuman, in *Going Local: Creating Self-Reliant Communities in a Global Age*, (New York: Routledge, 2000), p.99.

[26] APPA, " Straight Answers to False Charges Against Public Power," p.23

[27] Michael Shuman, in *Going Local: Creating Self-Reliant Communities in a Global Age*, (New York: Routledge, 2000), p.85.

[28] APPA, " Straight Answers to False Charges Against Public Power," p.22.

The American Public Power Association asserts that publicly-owned power companies stimulate their local economies in the following ways: [29]

- Lower electric prices give consumers more money to spend on local goods and services
- Local dollars stay in the community unlike IOU dollars which are sent to companies in other states or countries
- Public power systems do business with local financial institutions and make purchases from local businesses
- Salaries earned by local utility employees are spent in the community for housing, groceries and other services
- Payroll dollars multiply in value to the community as they are spent locally by businesses and their employees
- Economists estimate that based on the multiplier effect, each payroll dollar circulates through the local economy five to ten times

Disadvantages

Municipal utilities have been known for their inefficiency and susceptibility to corruption, especially as commercial activities expand. On a fundamental level, municipal enterprises are also subject to change in leadership every two to four years which creates inconsistencies and wide fluctuations in political ideology over long periods of time. Short-term planning based on political tenure is insufficient to meet the long-term planning needs of a community. Elected officials often regard the common assets of a municipality from a shorter perspective when compared to the long-term view that is required to protect common assets for future generations. Unfortunately, public officials' decisions are influenced by their ideology and at times, by their political and financial gain. Sometimes public officials are more interested in protecting their public reputations by making concessions that bolster their budgets than protecting the common good. Some elected officials will sell off public assets before leaving office. Such action is becoming the norm today in the U.S. where community assets such as schools, parks, community centers and shipping ports are now being sold in the private sector. [30]

While other nationwide cities move to municipalization of electricity power, as in the recent case of New York City and Oregon, the energy sector in the state of New Mexico is monopolized by the private investor-owned utility, Public Service Company of New Mexico (PNM). According to 2003 data from the American Public Power Association, seven public power companies in New Mexico serve 64,418 residents, 8.4 percent of the total residential customers in the state.[31]

Community Energy Trust

A community energy trust is an emerging ownership model for the development of local energy, a means by which a neighborhood, community, village, or region can own, finance and maintain their own renewable energy project while securing the assets in perpetuity for future generations. The local community could be as small as a neighborhood, a village within a pueblo, or as large as an entire city or bioregion.

A nationwide search for community energy trust models reveals few are currently in existence in the United States. However, we can look to several initiatives within the Community Land Trust movement, a few Energy Trusts, and two other trust models to provide some ideas for creating a community energy trust.

The first section covers two initiatives which call themselves "energy trusts": the Massachusetts Renewable Energy Trust and the Oregon Energy Trust. The second section includes a description of the Community Land Trust (CLT) model and successful CLT models in the U.S and New Mexico. Additionally, two CLT projects which are implementing renewable energy production are highlighted: the Northern California Land Trust and the Lopez Island Community Trust Producer's Cooperative. The third section is a summary of two other trust ideas, the Alaska Permanent Fund and the Sky Trust.

Renewable Energy: Energy from and for the Commons

A community-energy trust is based on the premise that energy from the sun, wind, water, sky and publicly-owned land and forests belong to everyone and must be held in trust for current and future generations. Recent initiatives to privatize and propertize these elements are indicators of a future in which all that was

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[29] Ibid, p.23.

[30] Shuman, 2000, p. 100.

[31] APPA, *2005-06 Annual Directory & Statistical Report,* (Source: Energy Information Administration Form EIA-861, 2003 data), p.32. Data reflects full-service and delivery-only customers.

once held as the commons, the shared natural inheritance of all people, could eventually be owned by a few.[32] The question remains as to whether all energy sources will be subject to market influences, or new models of community ownership will emerge to support renewable energy initiatives which utilize aspects of the market and create assets that benefit a community's present and future residents.

Many unanswered questions exist such as:

- Who constitutes a commons and a community?
- Who should be designated as the trustee of an energy commons and what is the role of the trustee?
- How will an energy trust be held in perpetuity?
- What property is to be held in trust? Who owns the energy system infrastructure? Are all aspects of the trust held in the commons or are some privatized?
- How is the community benefit of the trust measured?
- What are the limitations and weaknesses of the trust agreement?

Advantages

The models discussed in this section suggest that a community energy trust, similar in structure to the community land trust, could be a realistic and dynamic model for the future. With rising fossil fuel costs and decreasing supplies, the present time is ideal for community planning in this direction. The current pathway of energy creation and consumption is fraught with inefficiencies, high levels of pollution with global ramifications and supportive of a way of life that is exhaustible and in the end, violent. Renewable energy initiatives, if developed sufficiently, could provide communities with energy security, improved community health, a democratic structure, localized control, and direct local economic benefits.

Since the trust model is a long-term strategy to protect the commons for future generations, this ownership strategy challenges the meaning of market-driven notions of ownership. The model furthers the idea that consumption of the earth's natural resources needs to be kept in balance with restoration initiatives. Developing different kinds of trusts which oversee that management of the commons, separate from state control, and with built in protective measures, is a significant step in securing community energy for the future. Smaller communities, whose scale of consumption is limited to what they can produce, can prepare by forming energy trusts and encouraging their citizens to think and plan in proactive ways. Subsequently, when communities recognize the immediate economic benefits of conservation they may make the necessary changes to live in more sustainable and restorative ways. Ownership merges with stewardship: communities borrow and restore natural resources instead of extinguishing them through over-consumption.

Disadvantages

One of the most critical unanswered questions is: Who can be the trustee for an energy commons and how will it be protected from corruption? Another primary financial disadvantage of CLTs is that they are still highly dependent on government grants for fiscal support**.** Finally, the feasibility of developing a community-owned energy trust which utilizes renewable energy sources is dependent on necessary changes in local and state governance structures. Hopefully, policies which support renewable energy development can be enacted prudently and thereby make it possible for a community energy trust to exist.

A Community Energy Trust Model

In a community-owned energy system, the energy trust, like a land trust could own the land, while supporters of the trust, perhaps community members or a neighborhood, could own the home on the land (with some gain in value returning to the homeowner similar to CLT homeownership models), as well as a share in a locally-owned renewable energy source (such as a wind turbine, solar PV system or biomass-fired boiler). The trust could own the energy grid, with feed-in tariffs[33] used to provide competition and

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[32] Peter Barnes, "Capitalism, The Commons and Divine Right," *Lecture from the Twenty-Third Annual E.F. Schumacher Lecture.* (Stockbridge, Mass: E.F. Schumacher Society, October 2003), p.8.www.smallisbeautiful.org/publications.htm.

[33] Feed-in tariffs have been used successfully in Europe to promote renewable energy development. See European PV Association, " European PV Assocations' Position Paper on a Feed-In Tariff for Photovoltaic Solar Electricity", (2005), p.2. "A feed-in tariff obliges a utility to purchase electricity generated by renewable energy producers in its service area at a tariff which public authorities determine and guarantee for a specific period of time. The tariff usually extends for twenty years. The value of a FiT, Feed-in Tariff is determined as the full price per kWh received by an independent producer of renewable energy which also includes a premium above or in addition to the market price. However, it does not include tax rebates or other subsidies a government pays for production. How tariffs are defined differs according to the technology used such as biomass, wind, solar etc, and depends both on the country and resource conditions. (e.g. solar irradiation). In addition, a FiT rate for new installations is reduced each year to encourage a decrease in production costs." www.epiaorg/documents/FeedinTariffEPIA.pdf.

incentives for local investors who could potentially form a producer's cooperative. Community investors would be identified as permanent local residents who own shares with voting privileges. Governance could be similar to cooperatives: one person, one vote regardless of how many shares a person owns. When someone dies, their ownership dies with them or can be passed onto family members who still only have one vote per person.

Legalities of community energy ownership are complex. Further research is needed to focus on the legal, economic and structural complexities of establishing a community energy trust. A comprehensive model which addresses energy security and energy equity for all residents is the challenge of our time.

Renewable Energy Trusts

Ownership models such as the Oregon Energy Trust and the Massachusetts Renewable Energy Trust are examples of state-supported efforts to promote renewable energy use and development. Both trust models accumulate funds by charging public citizens fees for renewable energy development. On the demand side**,** their programs aim to educate citizen customers and possible stakeholders. On the supply side, they provide financial support to renewable energy producers.

Energy Trust of Oregon, Inc. was organized as a non-profit corporation in 2002 for the purpose of investing funds in energy conservation, subsidizing the costs of renewable energy sources and encouraging the transformation of the energy market in Oregon. The Energy Trust funds were generated through a 1999 energy restructuring law. The two largest investor-owned utilities were required to collect a three percent "public purposes charge" from their customers. Part of the public-purpose funding has been channeled into K-12 schools and energy assistance for low-income housing customers.[34]

The Energy Trust also guides electrical energy work through a grant agreement with the Oregon Public Utility Commission (OPUC). Key stakeholders and interested parties helped to guide the development of the grant agreement. In addition, the Energy Trust administers gas conservation programs for residential and commercial customers of NW Natural. NW charges residential and commercial customers a 1.5 percent surcharge of a total monthly billed amount. Then the Energy Trust uses the fund to promote energy conservation and transforming the market to increased renewable energy use to benefit NW's Oregon customers.

As of July 2006, Energy Trust also works with Cascade Natural Gas Corporation in Oregon to provide energy efficiency services to residential and business customers. All of these combined programs are part of the agreement with OPUC which still oversees the Energy Trust.

Energy Trust also supports the development of wind power projects which range in size from the smallest at less than 1kW to large utility scale wind farms that produce a minimum of 10MW of electricity. Energy Trust supports farmers, ranchers, municipalities and landowners who would like to install small turbines which produce 1000 watts to approximately 600 kilowatts, on their land. Locally-owned community scale projects are commercial-sized but produce less than 10MW. Annually, millions of dollars are reserved from the Energy Trust to use for large-utility scale project development.[35]

The Massachusetts Renewable Energy Trust

The Massachusetts Technology Collaborative (MTC) is "the state's development agency for renewable energy and the innovation economy" and oversees the Massachusetts Renewable Energy Trust, a $150 million trust.[36] The Trust "seeks to maximize environmental and economic benefits for the Commonwealth's citizens by pioneering clean energy technologies and fostering the emergence of sustainable markets for electricity generated from renewable sources."[37]

Created in 1997 as a part of the Massachusetts electricity restructuring legislation, the Trust is financed by a system benefits charge. The charge as of 2004, was $.05 cents per kWh of customers' electricity bills,

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[34] Energy Trust website, p. 1. Accessed at http://www.energytrust.org/who/index/html

[35] Energy Trust of Oregon, 2006. http://www.energytrust.org/RR/wind/index.html. Accessed 8/15/06.

[36] Karlynn S.Cory and Nils Bolgen, "Long Term Revenue Support to Help Developers Secure Project Financing" from *Wind Energy Finance-Capital Markets and FutureTrends Session"* (Massachusetts, March 31, 2004), p.5.www.masstech.org

[37] Renewable Energy Trust website accessed 5/23/06 at/www.masstech.org/renewableenergy/index.htm.

collected from ratepayers of all classes, excluding municipal utility customers, and deposited into a trust fund. The annual collection amount totaled $25 million.[38]

The Trust's Goals are: "to increase the supply of and demand for energy from clean resources; promote the development of a vibrant Massachusetts renewable energy industry; and maximize the benefit of renewables to the Massachusetts ratepayer."
Addressing demand and supply side issues, they have created multiple programs with four focus areas: a Clean Energy Program, an Industry Support program, a Green Buildings and Infrastructure program and a Policy unit.[39] For more information, see Appendix B.

Community Land Trust
A community land trust (CLT) is a democratically governed nonprofit organization that owns land and holds it in trust for a community and individuals. CLTs help low and middle-income homebuyers to secure housing and an equity return on their investment while preserving affordability for future residents. When a shareholder decides to leave the land, he or she must resell their share back to the trust. This guarantees the land to be held in perpetuity for future generations and guarantees affordable homeownership to low and middle-income populations. Appreciation of the land provides the trust with equity to acquire additional land and structures in the future.

The basic principle of a community land trust is that appreciation of land is turned to a community's advantage. Despite escalating median home prices in adjacent neighborhoods, disinvested neighborhoods, when acquired by land trusts, begin to thrive. Through CLT assistance, low-income people can remain in their neighborhoods where their families may have lived for generations. In other gentrified locations, CLTs preserve the last parcels of land in cities and popular small communities before skyrocketing prices make it impossible for low-income residents to live there. A frequent misconception of CLTs is that they preserve land from development, but in many cases they are specifically concerned with providing and preserving affordable housing on the land.

Community Land Trusts have been in existence for over a hundred years. As of 2004,

- 112 are incorporated providing over 6,000 housing units comprised of more than 12,000 residents nationwide.
- 82 percent of residents have incomes less than 50 percent of their areas' median income,
- 32 percent of residents are non-white[40]

The values and structure of a community land trust are unique to a community's needs and location but CLTs share two common features: a distinct approach to owning real estate and a distinct approach to community-based governance.[41]

Distinct Approach to Ownership:
- Acquires land for the community
- Provides access for low-income people
- Maintains affordable prices
- Preserves owner-occupancy
- Creates multi-family buildings
- Helps new homeowners
- Has a flexible approach

CLTs acquire land for a community but they treat land and home ownership differently. If vacant land is acquired, CLTs may arrange for housing and other buildings and structures to be developed on it. Sometimes both land and buildings are purchased together and the buildings are renovated. In any case, the land is held permanently by the land trust while the buildings, which can serve different needs, can be owned by those who purchase them. Whenever possible, CLTs try to help people purchase their own homes on the land. When a CLT sells homes, it leases the underlying land to the homeowners through a long-term

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[38] Karlynn S.Cory and Nils Bolgen, "Long Term Revenue Support to Help Developers Secure Project Financing" from *Wind Energy Finance-Capital Markets and Future Trends Session"* (Massachusetts, March 31, 2004), p.5.www.masstech.org

[39] See the Renewable Energy Trust of the Massachusetts Renewable Energy Trust website at www.masstech.org

[40] From the Community-Wealth website , www.community-wealth.org/strategies/panel/clts/index.html Accessed 7/6/06.

[41] Institute for Community Economics (ICE), p,1. at http://www.iceclt.org/clt/cltmodel.html Accessed on 8/4/06.

(usually 99-year) renewable lease. Residents and their descendents have the right to use the land for as long as they wish to live in the community.

When CLT homeowners decide to move out of their homes, they can sell them under certain restrictions which are agreed upon when they first bought their home. The land lease requires that the home be sold either back to the community land trust or to another lower income household for an affordable price based on a certain formula determined by the CLT.

Distinct Approach to Governance

As democratically structured organizations, or "membership organizations", CLTs have an open membership and a Board of Directors elected by members. Usually voting members comprise two groups:

- One group is made up of all the people who live in CLT homes (or use CLT land in other ways)
- A second group is made up of people in the community who are interested in what the CLT is doing, namely, CLT neighbors and people who may want to have CLT homes in the future

The Board of Directors is a balanced composition of three different types of directors for the purpose of protecting CLT residents and the whole community:

- representatives of resident members
- representatives of people who are not CLT residents
- representatives of the broader community interest

Exemplary Models

The largest CLT in the US, founded in 1984, is the Burlington Community Land Trust, regarded as the pioneer in the CLT movement. By purchasing and rehabilitating houses and apartments, building new homes, providing transitional housing, and securing covenants for affordable condominiums, they have been extraordinarily successful in housing a large number of people. BCLT's success in part is due to the assistance it has received from the municipality of Burlington, the Vermont Housing and Conservation Board, and other partners. In a city of 40,000 people, the Burlington Community Trust has:

- 2,500 members
- More than 370 single-family shared appreciation homes and condos
- 125 coop apartments
- 380 rental apartments on land trust property

Community Land Trust Partners with Allied Organizations

A promising trend is that community land trusts are forming partnerships with other allied organizations. If these partnerships are growing, it's a natural next step for community land trusts to harness and develop their own community-owned renewable energy systems.[42]

Community Land Trusts in New Mexico

New Mexico has several land trusts including the Santa Fe Community Housing Trust in Santa Fe, Sawmill Community Land Trust in Albuquerque, and the Taos Land Trust in Taos.

The Santa Fe Community Housing Trust is a nonprofit community development organization operating in Northern New Mexico since 1991. The Trust established the Santa Fe Affordable Housing Roundtable and the Santa Fe Affordable Housing Trust Fund, a multi-million dollar fund to enhance nonprofit housing production. Partnering with businesses, nonprofits and local government, they have produced and renovated housing, including 220 affordable homes which have been developed and sold throughout Santa Fe. The Housing Trust controls resale prices of homes they build, acquire, renovate and sell. They utilize mechanisms such as land leases, shared appreciation mortgages and land-use restrictions while paying close attention to long-term affordability.

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[42] Heather Mc Cullough, Sharing the Wealth: Resident Ownership Mechanisms (Oakland, Calif.: PolicyLink, 2001), p.96 based on interview with Julie Orvis. See also Property and Values: Alternatives to Public and Private Ownership, ed. Charles Geisler and Gail Daneker (Washington, D.C.: Island Press, 2000) and the Institute for Community Economics, www.iceclt.org/.Source referred to in Alperovitz, p 94. The following CLTs are beginning to reach out to other organizations: "The community land trust in Concord, New Hampshire, is working with the Neighborhood Reinvestment Corporation on an IDA program to help families save for homeownership. North Camden CLT in New Jersey has spear-headed a comprehensive community planning initiative. Durham Community Land Trust in North Carolina provides construction job training for community residents. The Burlington Community Land Trust has been a mainstay of the city's Enterprise Community, cleaning brownfield sites, developing community facilities for various social service organizations, and redeveloping abandoned commercial buildings.

The Sawmill Community Land Trust is a 501(c)(3) nonprofit corporation created in 1997 by the Sawmill Advisory Council to create affordable housing and economic viability to the Sawmill neighborhood in Albuquerque, New Mexico. The Trust has built a strong base for community action. They acquire and hold land for the community and provide secure affordable access to land, housing and jobs for local residents. Accomplishments include reducing absentee ownership by gaining control over local land use, providing affordable housing for low to moderate income residents, promoting resident ownership and control of the Sawmill neighborhood and protecting affordable housing for future residents.[43]

The Taos Land Trust is a nonprofit, nongovernmental public service organization founded in 1988 which serves north central New Mexico. Its primary mission is to help preserve land with agricultural value, scenic vistas, significant habitat, or historical sites through direct preservation, conservation partnerships, education, and land use planning matters." This trust is based on a land stewardship model that holds land and conservation easements in perpetuity.[44]

Community Land Trusts and Community-Owned Energy

A sample query of community land trust experts from the National Community Land Trust Network in the U.S. confirmed that few partnerships exist between community land trusts and locally-owned and independent renewable energy providers.[45] CLT experts have identified several Community Land Trusts who are planning and implementing community-owned renewable energy systems. The Lopez Community Land Trust on Lopez Island, Washington and the Northern California Land Trust in Berkeley and Oakland California may be the forerunners of a trend toward partnerships that form among community developments organizations for the purpose of securing locally-owned renewable energy.

The Lopez Community Land Trust on Lopez Island, Washington (LCLT) is currently in the process of forming a producer's cooperative. The project idea developed when the LCLT began planning a new housing development for the land trust and realized that a zero net-use of energy was a major priority. They appealed to the local community to see if there was sufficient interest to pursue the idea. What they found was an overwhelming county wide interest in the project. From there the idea of a producer's cooperative developed with the mission "to provide economic and environmental benefits to islanders by exploring, developing and maintaining renewable energy resources through establishing a producer's cooperative owned by producers/investors of renewable energy systems."[46]

Their goal is to help San Juan County become the nation's leading Green Power community. They've recently received a matching grant through the USDA Rural Business Enterprise Grant as part of an effort to support small emerging businesses in rural areas. The Cooperative has hosted a Community Wind Summit, participated in a business training course, offered tours of local solar, wind and small hydro sites and conducted initial feasibility studies on solar, biodiesel, solar water pre-heat units, and energy audits. A sample survey conducted by the Lopez Community Land Trust has identified thirty interested parties planning to invest over $600,000 in renewable energy resources within the next 1-5 years in San Juan County.[47]

The Northern California Land Trust is currently in the formation stages of building resident and CLT-owned PV systems funded in part by the new Renewable Tax Credits on their projects in Berkeley and Oakland, CA.[48]

Other Promising Trust Models

The Alaska Permanent Fund and the Sky Trust both provide protection of the commons by assigning monetary value to common assets like oil and gas resources on state land and the sky or atmosphere.

The Alaska Permanent Fund,

The official mission of the Alaska Permanent Fund is "to produce income to benefit all generations of Alaskans."[49] This fund, created in the 1970's, was initially formed from capital that came from oil leases on state land in Prudhoe Bay and deposited into an account for the benefit of all citizens of Alaska. Alaskans

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[43] Sawmill Community Land Trust. http://www.sawmillclt.org accessed 8/4/06

[44] SeeTaos Land Trust for more information at www.taoslandtrust.org

[45] Based on conversation with ICE staff and responses from members of the National Network of Community Land Trusts in August 2006.

[46] Based on a conversation with Sandy Bishop at the Lopez Community Land Trust in August 2006.

[47] Ibid.

[48] Information from Ian Winters, Executive Director of Northern California Land Trust, August 2006.

[49] Peter Barnes, *Who Owns the Sky*, (Washington: Island Press, 2001) p. 53, and the Alaska Permanent Fund website at www.apfc.org

amended their state constitution to create the permanent fund and separated it from the state legislature. Since each Alaskan is entitled to an equal share of this resource, they, and not the legislature, decide on how to spend it. Twenty-five percent of the state's oil revenue is deposited yearly into the fund. A significant provision requires that the state legislature cannot spend the money in the fund without voter approval.[50]. The fund has grown steadily over the past sixteen years into a $27 billion diversified portfolio that pays each Alaska citizen a yearly dividend. Children's dividends are held in interest-bearing accounts until they reach the age of eighteen. As of 2003, the annual dividend was $1,540.[51]

The Sky Trust
The Sky Trust is an idea developed by Peter Barnes, co-founder of the socially responsible telephone company, *Working Assets*. This trust "is based on the premise that the sky belongs to everyone and must be held in trust for future generations." [52] The commons is a huge natural and cultural inheritance that all human beings share once they are born. The commons consists of complex natural systems and elements like the sky, oceans, rivers, sun and wind. Culturally, the commons includes the collective intellectual accomplishments of humans like language, DNA and various technologies. While corporations and individuals often take ownership credit for the commons, the commons really belongs to all people and from that standpoint, should be managed with equity and preservation as a basis.[53]

The sky, or atmosphere, is an immense, though limited, commons that could be managed with equity and preservation in mind by requiring polluters to purchase emission permits from a trust that represents all citizens. The income from the Sky trust could be used to benefit the public good like the equal dividends Alaskans receive from the Alaska Permanent Fund. A distinct advantage of the Sky Trust model is that it requires that polluters pay for contaminating the commons with industrial wastes. Instead of polluters externalizing their costs through the dumping of wastes, costs are internalized. The Congressional Budget Office conducted a study in 2000 and found that the Sky Trust, of all cap-and-trade systems that might be used to reduce carbon emissions, was "the easiest to implement, would have the most positive effect on household incomes, and would result in the lowest cost to society."[54]

Peter Barnes states a central point that is also applicable to renewable energy development involving the assignment of initial pollution rights. "This is not just an abstract philosophical question. Because carbon is so pervasive in our economy, literally trillions of dollars are at stake, and the choice must be made whether this money should flow from pollutees to polluters or vice-versa. It's a case where "divine right" is worth a great deal of money."[55]

The increasing privatization of the commons remains a real threat to the preservation of it for the benefit of all citizens and all life. How the commons should and could be protected for greatest community benefit is still in question for the immediate and long-term future.

Cooperative Ownership: Consumer and Producer Cooperatives

The cooperative as an organizational form has been in worldwide use for over a hundred and fifty years, originating in England in 1844 with the Rochdale Equitable Pioneers Society. The success of the principles and practices established there continue today as U.S. co-ops alone serve over 120 million members in nearly every industry including agriculture, energy, financial services, housing, telecommunications and others. As energy prices rise, all cooperative sectors will be affected, highlighting the viability of the cooperative model for locally-owned renewable energy systems. Since cooperatives in all sectors generally support one another, their established networks could create a significant demand for locally-owned renewable energy in the near future.[56]

The National Cooperative Business Association defines a cooperative as "an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise."[57] Two cooperative forms are suitable

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[50] Ibid, p.51.
[51] Peter Barnes, "Capitalism, The Commons and Divine Right," *Lecture from the Twenty-Third Annual E.F. Schumacher Lecture.* (Stockbridge, Mass: E.F. Schumacher Society, October 2003), p.17. www.smallisbeautiful.org/publications.htm
[52] Ibid.
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Co-Op Statistics from NCBA website, http://www.ncba.org/abcoop/stats.cfm
[57] NCBA, website: http://ncba.org/abcoop/abvalue.cfm. Accessed 9/5/06

ownership models for renewable energy: consumer and producer cooperatives. Consumer cooperatives are public organizations owned by the consumers they serve. The rural electric cooperative, in existence in the United States since the 1930's, is an example of a consumer utility cooperative.

Cooperatives can be distinguished from other ownership models by the fact that they are owned by their members, either consumers or producers, they are not-for-profit, and their governance structure which follows the Cooperative Principles, allows only one vote per member. The rural electric cooperative model is described in detail as an example of a cooperatively-owned utility system. Advantages and drawbacks of cooperatives are also discussed in the sections that follow.

Cooperative Principles

Cooperatives across the world generally use the same operating principles that were adopted by the International Cooperative Alliance in 1995. These principles identify an organization as a cooperative and provide the following set of operating values:[58]

- Voluntary and Open Membership. Cooperatives are voluntary organizations and are open to all citizens who use the services and are willing to abide by membership rules and responsibilities
- Democratic Member Control: Cooperatives are democratically-governed by members who set policies and make decisions. The board of directors is locally-elected at an annual meeting. Each member has one vote.
- Members' Economic Participation: Members contribute equitably to, and democratically control, the capital of their cooperative. Net savings after payment is made to member patrons in proportion to their patronage.
- Autonomy and Independence: Cooperatives are autonomous, self-help organizations controlled by their members.
- Education, Training, and Information: Cooperatives provide education and training for their members, elected representatives, managers, and employees so they can contribute effectively to the development of their cooperatives.
- Cooperation among Cooperatives: Cooperatives serve their members most effectively and strengthen the cooperative movement by working together.
- Concern for Community: While focusing on member needs, cooperatives work for the sustainable development of their communities.

Rural Electric Cooperatives

The creation of the Rural Electrification Administration (REA) in 1935 by President Franklin D. Roosevelt catalyzed the formation of electric cooperatives in rural communities across the U.S. Rural electric cooperatives are private, independently owned, not-for-profit electric utilities owned by the consumer-members they serve. As democratically governed businesses, they are organized under the Cooperative or Rochdale Principles**,** which anchor them in their service communities and ensure that they are closely regulated by their consumer members.[59]

While rural electric cooperatives generally serve fewer customers than municipally-owned and investor-owned utilities, over 900 cooperatives provide 39 million customers with reliable electric power and technologically advanced service in remote and urban areas of the U.S.[60] According to the National Rural Electric Cooperative Association (NRECA), there are currently sixteen electric cooperatives in New Mexico and two NRECA affiliated members.[61]

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[58] National Rural Electric Association, "From Co-Op 101: Cooperative Principles. http://www.nreca.org/AboutUs/Co-op101.htm See also the National Cooperative Business Association website, Co-op Principles and Values at http://www.ncba.org/abcoop.abvalues.cfm

[59] National Cooperative Business Association, "About Cooperatives" at www.ncba.org/abcoop/abvalues.cfm.

[60] National Rural Electric Cooperative Association @ http://www.nreca.org/AboutUs/Co-op101.htm.

[61] Ibid. NRECA is the national service organization that represents the national interests of rural electric cooperatives and their consumer members. Each of the 47 member states has one representative who serves on the NRECA board of directors. The NRECA advocates on behalf of consumer-cooperatives on energy, operational, rural community and economic development issues. Membership in the NRECA includes organizations formed by rural electric cooperatives: supply and manufacturing cooperatives, generation and transmission cooperatives, data processing cooperatives, regional and statewide trade and service associations, and employee credit unions. http://www.nreca.org/AboutUs/Overview.htm

Membership in the National Rural Electric Cooperative Association is composed of voting and non-voting members. Voting members pay annual dues specified in the bylaws of NRECA and guide the future direction of the organization by electing representatives to the NRECA Board of Directors. Voting members consist of three types: Distribution members, Generation and Transmission Members and Service members. Voting members typically consist of electric distribution cooperatives, G & T cooperatives, nonprofit associations and corporations, public utility districts, and

The following statistics exemplify the collective strength of smaller-scale energy initiatives as a countervailing option to investor-owned utility dominance. More than 900 electric cooperatives consist of 864 distribution and 66 G &T cooperatives. Together they serve:[62]

- 12 percent of the nation's population
- 39 million people in 47 states
- 17 million customers including businesses, homes, schools, churches, farms, irrigation systems, and other establishments
- 2,500 of 3,141 counties in the U.S. or 80 percent of the nation's counties

To provide their broad-scale energy services, rural electric cooperatives:

- Own assets worth $92 billion compared to $162 billion for publicly-owned utilities and $660 billion for investor-owned utilities
- Own and maintain 2.4 million miles or 43 percent of the nation's electric distribution lines, covering three quarters of the nation's landmass
- Deliver 10 percent of the total kilowatt hours sold in the U.S. each year
- Generate nearly 5 percent of the total electricity produced in the U.S. each year
- Employ 65,000 people in the United States
- Pay more than $1 billion in state and local taxes

Advantages

The cooperative model has many advantages for supporting local economies. To function well, cooperatives are highly dependent on committed volunteer members who are willing to organize themselves cooperatively and accept responsibility for providing their communities with reliable, safe and economical energy. Members agree to share a set of common values that aren't necessarily present in investor-owned utilities.

Benefits of cooperatives include:

- Greater Accountability: Co-ops are locally owned and operated and often members are neighbors.
- Priority to Customer-Owners: Since rural electric cooperatives are consumer-owned, they prioritize their customers first. Members express higher than average satisfaction with the services they receive.
- At-Cost Service: As not-for-profit businesses, they deliver energy to their consumer customers at the cost of service unlike IOU's which deliver profits to shareholders.
- Community Investment: To ensure efficient and technologically advanced service, electric coops reinvest their resources into their membership. Money, expertise and time are allocated to strengthen relationships with customers and build the local economy.
- Appropriate Economy of Scale: Rural electric cooperatives provide reliable electric and telecommunication services, often where and when large investor-owned utilities find it economically undesirable.
- Renewable Energy Proponents: Five rural electric cooperatives have been recognized by the Department of Energy as part of the Green Power 'Top Ten' rankings for utilities in the U.S. that participate in and promote green power programs.[63]

Disadvantages:

As a democratic model, cooperatives can be slow and unwieldy in their governance which can deter communities from forming them. The word "cooperative" can often have connotations of consensus decision-making requirements and long-winded meetings where incompatible independently-minded

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government corporations. All members are engaged in the distribution, transmission and service of electrical energy for cooperatives and their members. Non voting members consist of affiliate members (usually cooperatives whose objectives and services support electric coops), Associate members (usually for-profit corporations who provide necessary goods and services) and International Members (electric utilities, international governments and associations from 65 countries). From Membership Information at http://www.nreca.org/AboutUs/Overview/MembershipInformation.htm.

[62] NRECA, "Co-Ops By the Numbers. Source is 2004 EIA, RUS Data, CFC, NRECA Strategic Analysis, updated January, 2006. " (http://www.nreca.org/AboutUs/Co-op101/CooperativeFacts.htm Accessed 9/3/06.

[63] George Stuteville, "Co-ops Move onto DOE's Green Power 'Top Ten' Lists," *Electric Co-Op Today.* http://www.nreca.org/main/NRECA/AboutUs/CooperativeDifference/greenpower.htm. Accessed 9/3/06.

community members struggle to find common ground. However, the success of cooperatives nationwide can be attributed in part to the interest and willingness of community members to share the cooperative values of self-help, self-responsibility, democracy, equality, equity and solidarity.[64]

Like investor-owned and municipally-owned power companies, cooperatives are susceptible to corruption, but less so since they are non-profit entities. Community members, by assuming responsibility for the organization, can keep the Board diversified enough so all members' ideas, concerns and initiatives are equally represented in decisions that affect the membership.

The cooperative ownership model does not guarantee that renewable energy use will be optimized unless it is built into the bylaw structure. In the 1970's and 1980's cooperatives willingly supported nuclear energy production. Coal-fired power plants still provide a substantial percentage of their electric power today.

All types of utilities, investor-owned, municipally-owned and electric cooperatives receive some type of subsidy from the federal government. Research conducted by Nobel Laureate economics professor Lawrence R. Klein of the University of Pennsylvania reveals that electric cooperatives receive the least amount of subsidy per customer. Considering the fact that electric cooperatives serve an average of seven customers per mile compared to thirty-five for IOU's and forty-seven for municipally owned utilities, the difference in subsidy benefits for each type of utility is even greater. [65]
Cooperatives often operate on the premise of net revenue sharing or patronage. Patronage is a function of use. If patronage is contingent on use, it could actually discourage energy conservation. The more customers use, the more benefit in revenue. Members would be incentivized to use more energy to receive more economic benefit. Additionally, if all owners are given an equal share, it can discourage large investors from participating. [66]

Rural electric cooperatives are often limited by large investor-owned utility companies who influence policy in favor of their stakeholders' investments. The National Rural Electric Cooperative Association (NRECA) is a national organization that advocates for cooperatives and their members. In response to efforts by IOUs to deregulate the utility industry, the NRECA has focused particular efforts on a range of protections for cooperatives including: the right to have access to reliable, safe and affordable electric power; the right of electric cooperatives to be treated fairly and recognized for their unique approach to business, the right for citizens to join together to form a consumer-owned not-for-profit electric utility and the right to determine the choice of energy services that can be provided by a not-for-profit utility.[67] The question remains as to whether the NRECA has enough leveraging power to counteract IOU influences on deregulation. Some rural electric cooperatives struggle to offer lower rates to their customers without being penalized by IOUs who often have guaranteed rates of profit.

Co-ops and Green Power
Rural electric cooperatives have been strong advocates for Green Power programs over the last ten years:

- More than 550 rural electric systems offer their members an option to purchase green power, about 2/3 of all systems
- A generation and transmission cooperative (G &T) or other power supplier provides most of the renewable energy to the co-op who then resells the green power to their consumers
- Wind or biomass sources provide most of the renewable energy to electric cooperatives
- Co-ops have supported the use of renewable energy for the last decade
- "Electric co-ops support responsible development of cost-effective renewable sources as a means to provide safe, reliable power for their members at affordable rates."[68]

The Department of Energy has recognized five electric co-ops in their 'Top Ten' Green Power rankings for utilities that participate in and promote green power programs.[69] In 2003, G & T cooperatives in the

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[64] NCBA website on values at :www.ncba.org/abcoop.abvalues.cfm.
[65] NRECA, "Co-op 101: Cooperative Principles, at www.nreca.org/AboutUs/Co-op101.htm
[66] Notes from a conversation between Michael Shuman and Mark Sardella in August, 2006.
[67] NRECA, "Electric Consumer Bill of Rights" approved by the NRECA at its 57th Annual Meeting in March 1999. http://www.nreca.org/AboutUs/Co-op101/ElectricConsumerBillOfRights.htm.) Accessed 9/12/06.
[68] NRECA, "Co-Op Green Power Map" at www. nreca.org
[69] George Stuteville, "Co-ops Move onto DOE's Green Power 'Top Ten' Lists," *Electric Co-Op Today.* http://www.nreca.org/main/NRECA/AboutUs/CooperativeDifference/greenpower.htm. Accessed 9/3/06.The DOE uses three categories for their rankings: total % of consumer-members enrolled in a green power program, establishing pricing premiums for new consumer-member driven power projects and total kWh sales from renewable sources. DOE surmises creative marketing strategies for success of green power programs and "the rate premium that customers pay for green power has dropped as fossil fuel prices have increased."

U.S. generated more than 60 MW of renewable energy and purchased more than 200 MW from renewable energy resources operated by various developers.[70]

Producer Cooperatives

Producer cooperatives are publicly-owned businesses that are owned by their producers or workers. Worker co-ops, such as Cooperative Home Care Associates of the Bronx, are owned by their employees.[71] Mondragon, well known as one of the leading examples of successful producer cooperatives has operated in Spain since the 1950's and has 90 industrial producer cooperatives and 160 affiliated cooperatives.[72]

The Lopez Commmunity Land Trust on Lopez Island, is an emerging example of a producer cooperative designed specifically for renewable energy producers. As part of an initiative to have net zero energy use for a new housing development of the LCLT, members surveyed local residents and non-profits to determine community interest in creating a renewable energy producer cooperative. What initially began as a project for one island has captured the interest of the entire OPALCO served County comprising a group of 160 islands. Most of the energy will be generated for four main islands. The OPALCO Consumers Cooperative has been in existence since the 1940's. The Producers' cooperative will generate renewable energy which will be served through the OPALCO-owned grid to residents and businesses. The project is in a planning stage so LCLT hasn't decided what energy sources will be used to generate local renewable energy.[73]

These examples demonstrate that producer cooperatives, created, owned and maintained by members of a community, can be equally successful as conventional businesses while also contributing to community self-reliance.

Community Corporations

Corporations are publicly or privately held businesses or associations chartered to act as an individual. They take many forms and include nonprofits, cooperatives, publicly-owned corporations, worker-owned companies, and publicly or privately-owned conventional corporations. Michael Shuman, in his book, *Going Local* uses the term "community corporation" to refer to "for-profits with a residential restriction, as well as cooperatives, nonprofits, and public enterprises." [74] The residential restriction Shuman discusses is a caveat that distinguishes conventional corporations from community corporations and requires that corporations of all forms adhere to certain standards.

Residential restrictions could require that only community members own voting shares of stock. Other requirements might include living-wage ordinances, high environmental standards, purchasing local goods and services before outsourcing, and using local banks and credit unions to finance local projects.[75] As community leaders encourage such practices among local businesses, they are in effect affirming commercial viability while at the same time strengthening the idea that the long-term well-being and health of a community is dependent upon such restrictions. Corporations in any form have flaws, however well-intentioned they may be. How a corporation conducts its business practices in multiple arenas should determine whether it is beneficial to a community rather than what it claims to do.

If more communities developed such criteria for business, it would pressure conventional corporations to be more accountable in their business practices. Offering incentives to local businesses that could provide the same service with loyalty to the community as an added benefit would inspire confidence in the community. In Arizona, the White Mountain Stewardship Contract of the Apache-Sitgreaves National Forest was recently awarded to a local partnership instead of a large non-local corporation who bid on the contract. One of the deciding factors was the fact that the smaller partnership is local and rooted in the community. Local environmental organizations support the contract for the same reason.[76]

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[70] Brenda Kleinjan, "Raising the Bar, Area Co-ops Set Renewable Energy Goal" by Brenda Kleinjan, Director of Communications, South Dakota Rural Electric Association., 2005. http://www.nreca.org/main/NRECA/AboutUs/CooperativeDifference/Raisingthe Bar.htm. Accessed 9/3/06.

[71] Shuman, 2000, p86.

[72] Shuman, 2000, p84.

[73] Conversation with Sandy Bishop at LCLT in August, 2006.

[74] Shuman, 2000, p102-103. For a more thorough discussion of community corporations, see pp. 83-105 in Michael Shuman's book, *Going Local*. New York: Routledge, 2000.

[75] Shuman, p100-101.

[76] Josh McDaniel, "Bioenergy Fuels Community-Based Forestry in Arizona." August 14, 2006, p.1. Published on the website, SustainableBusiness.com. Accessed 9/7/06 at www.sustainablebusiness.com.

Communities are beginning to see the multiple benefits of doing business locally. The Arizona Community Based Forestry project was created to reduce hazardous amounts of wood products from the local forest and use them as renewable sources of fuel. The partnership, between a wood-contracting business and a manufacturer of wood stoves, was awarded a ten-year guarantee of raw material by the Forest Service. The long-term commitment from the Forest Service has enabled other small businesses to secure loans and has had an immediate positive impact on the local economy. The University of Arizona conducted a study which shows that 13 firms in the area that purchase products from the partnership have formed with local expenditures of $12 million annually. The firms employ 450 full-time employees, people who live in and near the forest. The stewardship project is well on its way to building a community-based economy.[77]

When communities choose to experiment with such restrictions, they challenge traditional corporate practices such as maximizing profits at the expense of the commons and the uncompromising pursuit of growth and expansion. Of course, not all conventional corporations are detrimental, like all businesses, they need to be commercially viable. Unfortunately, conventional corporations fulfill stakeholder profits first which often means compromises that have adverse effects on local economies.

A community can prioritize businesses that provide essential services like energy, food and clothing, housing, water, health services, and transportation. Then, they are less vulnerable to external sources for basic needs. If large corporations provide such services, then leave town for higher profits elsewhere, it can be devastating to smaller communities. Giving priority to local businesses that are health-promoting instead of merely producing unnecessary goods for export to other locations builds community wealth. Once basic needs are met, other local enterprises that promote cultural arts can flourish.

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[77] McDaniel, 2006, p. 2.

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