DISTRICT ENERGY
IN
MONTPELIER – VERMONT
CONCEPTS & REVUE

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EXECUTIVE SUMMARY

Biomass heating in the Capital Complex office buildings in Montpelier has been undertaken for over 50 years and it could easily be said to provide safe, reliable and inexpensive heating. The advancing age of the equipment and the desire of the City to revitalise the downtown and river-front area suggests strongly the need for an examination of the role of the heating plant.

Current heating methods within the city core, excluding the Capital Complex, results in almost $1.5 million leaving the community annually. A cooperative initiative involving City and State and the community could reduce this hemorrhage by developing an expanded district energy system for state and city buildings, generate environmental improvements for the community and enhance economic opportunities within the local area.

This report examines four district energy concepts that could each service 177 buildings, both existing and planned using locally supplied woodchip products as the principal energy source. The systems would deliver heat to their customers at a price comparable to, or lower than the current cost of energy. Each option would have a connected load of 73 MMBH. Several heating plant locations were considered, including the National Life of Vermont and a new building, adjacent to the existing Capital Complex heating plant, and architecturally compatible with the master plan.

The current heating plant at the Capital Complex is in good condition, but is aging and will inevitably be scheduled for major refurbishment. At the same time the City of Montpelier has considered implementation of it's "Capital District Master Plan". The plan compares the cost of the status quo option - that of rebuilding the existing plant - against the opportunities available for district energy. The cost to the State of maintaining the status quo is estimated between $2 and $3 million. The cost of implementing district energy is estimated between $11.8 and $13.3 million, financed out of the projects future earnings.

In establishing the economic impact of each option, the true cost of heating within Montpelier was determined. This cost included the cost of capital infrastructure (boiler, furnaces etc.), operations and maintenance and a methodology to derive this cost was developed and is described within the report. Energy data for the buildings too, were estimated using building floor area and associated environmental factors. Unit energy costs and environmental benefits could thereby be developed for current and proposed heating options.

Implementation of the project may be phased over several years using existing heating plants, integrating resource requirements with current City plans for infrastructure maintenance. The opportunity is therefore present to turn Montpelier into a showcase for eco-efficient, biomass district energy, with local resources being used to stabilise energy costs and enhance future business potential

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1 INTRODUCTION

Heating for the Capital Complex of state buildings in the City of Montpelier is at present provided by a combination of biomass (i.e woodchip) and oil boilers. The peak connected load for this network is approximately 12.2 MMBH (3.57 MWt[1]). The system has operated effectively for 50 years but is approaching the point where major refurbishment or replacement will be worth serious consideration. An opportunity therefore exists for the system needs to be reassessed with the inclusion of additional load in the form of a district energy system. The effect of servicing adjacent buildings with the heating loop would be to increase the effectiveness of the system, reduce the use of fossil fuels within the community and gradually reduce the cost of heating for the connected buildings.

The Community Energy Systems group of CANMET Energy Technology Center, a division of Natural Resources Canada, itself a department of the Canadian Federal Government was therefore commissioned to undertake this pre-feasibility assessment that evaluates the impact of a revised district energy system within Montpelier.

The use of energy within a community is fast becoming recognized as a key instrument for the development of a sustainable or eco-efficient community. The manner by which energy is managed will impact on its environmental and economic goals. An expanded biomass based district energy system in Montpelier will have many benefits and advantages over current practices and include:

- The displacement of heating oil and a reduction in green house gas emissions
- The increased employment level of the community, not only in the short term construction jobs but also in the long term maintenance and operation positions
- The increased retained earnings brought about by the increased utilization of local resources
- The compatibility with the Capital District Master Plan to employ "new layer of infrastructure" to recognize Montpelier's unique character and natural setting as well as the preservation of this image with the improvements needed in a modern State capital.
- The fuel flexibility that such a system provides with its distribution network.

This report outlines potential concepts for district energy applications within the City that aim to bring together these benefits.

2 HEAT DEMAND

The original state owned and operated heating system is located on land adjacent to the Winooski River as indicated in figure 1. The system encompasses the 16 key buildings identified in the graph. The system provides heating and domestic hot water for these buildings.

[1] See Appendix 1 for definitions of units

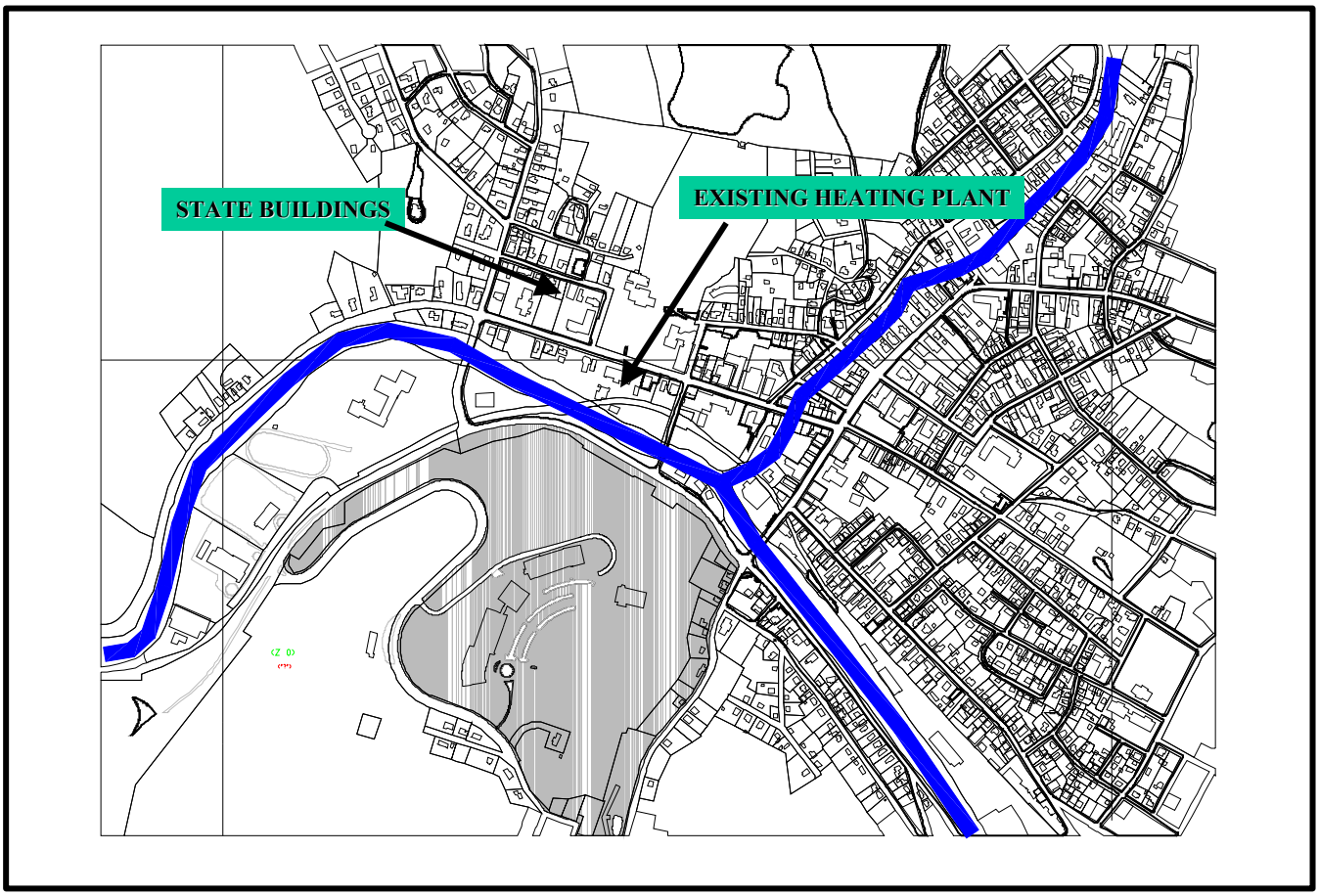

Figure 1: Montpelier, Vermont

To expand the existing system, the study assessed a number of buildings that were adjacent to the plant and exhibited heat demands large enough to warrant connection. Heating loads included both space heating and domestic hot water load and amounted to 177 buildings. These were primarily non-residential within the core of the city, along a corridor between State Street near Montpelier High School and East State Street, near to East State School. Several larger loads outside this core area (National Life, Vermont College) were also included. A list of these building is given in Appendix 2.

The buildings themselves offer a mix of commercial, office, educational and large residential energy users. A preliminary survey estimated a peak connected load of 72.7 MMBH (21.3 MWt) with the major consumers being the Capital Complex (12.2 MMBH), Vermont College (4.68 MMBH) and the schools (6.82 MMBH). It is anticipated that new construction of State buildings will provide new office buildings, office additions, a transit center and museum and this was also included within the energy estimate (6.04 MMBH).

All of these buildings exhibited the properties sought in district energy systems: they were either closely grouped or they were located in clusters. Superficially, three distinct districts could be created, separated by the Winooski River (figure 2):

- Area 1: north of the river and west of the river's split
- Area 2: north of the river and east of the river's split
- Area 3: south of the river.

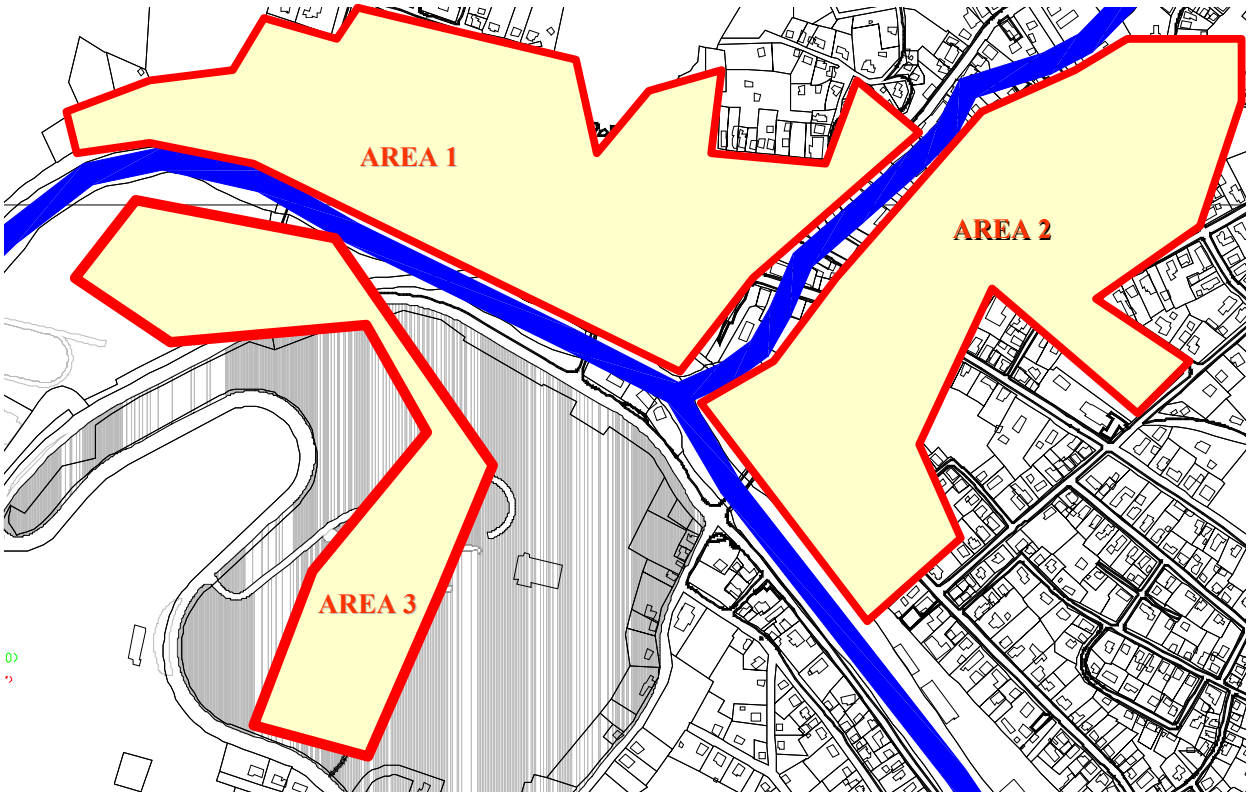

Figure 2: Scope of Study

The three buildings located south of Montpelier High School (Green Mountain Power, Vermont Department of Employment and Training, and the Vermont Department of Liquor Control) were not included in the study. Interconnection could not be justified by their small load and location, distant from either of the potential plant locations. Although the National Life building appears to be distant from the existing State plant, it's large load and thereby energy consumption justifies its connection.

The three areas demonstrate the potential for a phased project although for the purposes of the study their loads will be combined in a single system. A phased approach in this way may act to reduce initial capital requirements and may thereby benefit certain of the options over others. For example, expansion may be possible from the existing state system by connecting properties in Area 1, i.e those closest to the plant. As confidence with the system grew then inclusion of Area 2 might be considered, leading eventually to Area 3. In this way, capital requirements are less and risk is reduced through the inclusion of experience gained through operation.

The estimated heating load was determined using a building's usable area and heat loss factor. For the properties in Montpelier, a value of 25.4 BH/ft^2 (80 watts per square metre) was used and resulted in a peak load of 72.7 MMBH (21.3 MWt). In multi-use communities such as Areas 1 and 2, a diversification factor of 0.85 reduces this load by allowing for the overlapping demand of customers. Area 3 however does not exhibit such diversity in its demand profile and could not therefore reduce its estimated peak demand.

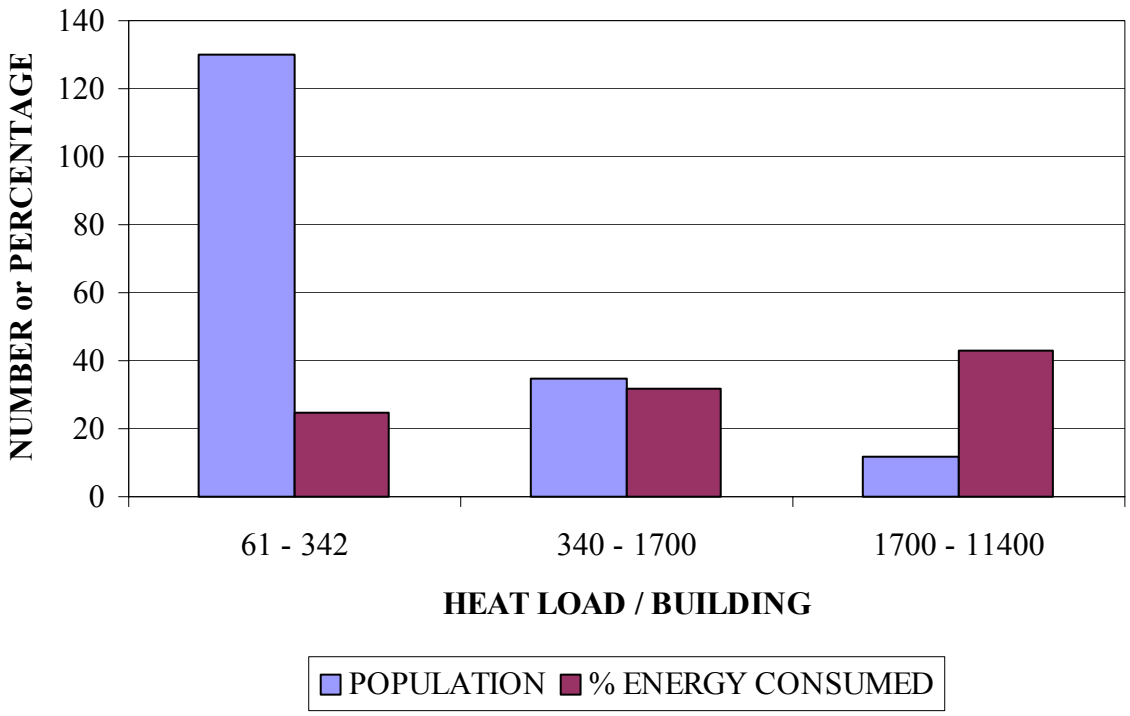

Figure 3: Breakdown of Loads and Energy Consumption

The individual loads ranged from 61 to 11,400 MBH with a breakdown as shown in figure 3. The majority of loads (73%) lay between 61 and 342 MBH (18 kWt to 100 kWt) but accounted for only 25% of the connected load. The next largest group (340 MBU to 1700 MBH) comprised 20% of buildings and 32% of the connected load. Large buildings, or those over 1700 MBH, make up the remaining connections and load.

2.1 FUEL USAGE

Many of the residential buildings (~80%) in Montpelier currently heat using #2 heating oil and individual furnaces or boilers. Liquified Propane is used in about 15% of the buildings while the remainder use electricity. Likewise, ~65% of the buildings employ a hot water system and 15% use a forced warm air system[2], both of these methods would readily accept hot water from a district energy system without minimal modification. The remaining 20% of customers use low-pressure steam and electricity and would require more extensive modifications if they were to convert to the district energy system. Unfortunately, these steam based customers include parts

[2] Estimates obtained from a previous survey

of the Capital Complex and the National Life buildings. . A dual-energy system can be designed and built although it should be remembered that a system that is designed for both steam and hot water must inevitably compromise some of the system's inherent advantages.

	Connected Load MMBH	Diversified Peak MMBH	Number of connections	Energy consumed MMBtu
Area 1	29.3	24.9	61	54,630
Area 2	28.7	24.4	113	53,600
Area 3	14.7	14.7	3	27,315
Totals	72.7	64.0	177	135,545

Table 1: Load Distribution

3 HEAT SUPPLY

The use of district energy concepts is not new to Montpelier. The Capital Complex buildings have been using the technology for over 50 years, circulating low-pressure steam from a central heating plant. Most of the sixteen connected buildings in the system convert the steam to hot water at site for use within the buildings themselves. The heating plant is located just north of the Winnooski River and currently uses both oil and wood chips as its source of energy. The plant has two oil (#6) boilers and one biomass boiler with a total installed capacity of near 31 MMBTU (9 MWt). The two oil boilers are dated but are in good condition. Between them they have a capacity of 20 MMBTU (6 MWt). Plant operations have a policy of maintaining an even split in heating duty between oil and woodchip so as to comply with Agency of Natural Resources Permit allowances and control emissions.

With an aging plant comes the discussion of phase-out and replacement. The current plant is ideally located close to the main business district and to the Capital Complex buildings. It is however on land that the Master Plan envisions as a more people-friendly environment with access to the river. It is also located in the flood plain of the Winooski River. Siting a new plant away from this area would, no doubt, provide the city with recreational space but would likely impact the economics of the district energy system. Locating a new plant at the current site is not ruled out although such a plant would need to integrate with the Capital District Master Plan as well as compensate for possible flooding of the Winooski River.

Realistic alternative locations for a heating plant are limited, the exception being property near to the National Life building on the south side of the river in Area 3. In this location the plant could integrate the demands of the city with those of the insurance company. The current heating system at National Life consists of four boilers with an installed capacity of 41 MMBH. They use #4 oil. In addition, two newer boilers have a capacity of 25.3 MMBH. This location is however almost 1/3 mile (1675 ft) from the current state plant and the need for steam at both locations would necessitate a steam main of that length linking the two sites with heat exchangers to convert to hot water for the remainder of the system. Steam mains are traditionally

more expensive to install and maintain than transmission lines for hot water. Alternatively, the Capital Complex could complete its conversion from steam to hot water and utilise less expensive distribution piping, fewer heat exchangers and incur lower O&M costs.

3.1 PLANT CAPACITY

Combustion systems for solid fuels are traditionally more capital intensive than those for liquid, or gaseous fuels. With this in mind, there are two schools of thought regarding plant sizing. The first designs a biomass plant to meet the peak demand of the system, while the second designs the biomass plant to provide only the base load, i.e. ~40% of the estimated peak load. Oil fuelled boilers would provide the remaining heat demand. Obviously, a biomass plant sized to meet the peak heating load would satisfy all eventualities of the system but operate efficiently at full load for a minimal length of time. Conversely, a biomass plant that is sized to meet 40% of the peak demand will not meet all eventualities and only 87% of the system's energy needs. It will however have a lower capital cost. As noted earlier, the remaining heat load would be provided using oil fired units that have a lower capital (but a higher operating) cost. It should not be forgotten here that that it is often recommended that an oil-fired unit is installed as back-up/emergency in district energy systems.

Option 1 - Peak load using biomass only:- Three wood fired units would be required, supplemented by an oil-fired unit for back up. This configuration would consume about 18,100 tons of woodchips per year based on a fuel moisture content of 40% and a combustion efficiency of 75%.

Option 2 – Base load using biomass:- Two wood fired units and three oil fired units. This design would consume about 15,700 tons of wood products annually at a subsequently higher operating efficiency

4 OPTIONS FOR ANALYSIS

4.1 HEAT SOURCE DESIGN

Several location options have been proposed along with combinations of biomass and oil as fuels. These, linked with key common elements of the existing, distribution piping, heat exchangers, and customer connections provide a number of scenarios that may be considered.

For the analysis, a matrix of options was developed to cover all potential systems. An economic evaluation would then highlight the system most likely to present the community with greatest economic and environmental benefits. The evaluation considered the operational requirements of each scenario to develop a delivery cost for the heat from each system.

SYSTEM OPTION	PLANT LOCATION	LOAD - BIOMASS	LOAD – OIL
1	NATIONAL LIFE	100%	0%
2	NATIONAL LIFE	40%	60%
3	STATE COMPLEX	100%	0%
4	STATE COMPLEX	40%	60%

Table 2: Concept Options

- **SYSTEM OPTIONS 1 & 2**

A plant near National Life would serve the downtown core as well as the National Life building. The central plant would function best with National Life's involvement as a stakeholder in the project, as a provider of land and a customer of district energy. Depending upon compatibility and location, the existing equipment at the National Life heating plant might be incorporated in a peaking or back-up capacity. National Life's buildings are currently heated with steam and, while conversion of the building to hot water is possible, the equipment is relatively new (compared to the Capital Complex) and conversion might not be justified on a purely economic basis. A more likely solution is that the boiler system generate steam which is then condensed either at the National Life plant or at an energy conversion station at the Capital Complex.

To avoid the real estate demands of an energy conversion station, aging steam heaters within the Capital Complex offices could be converted to accept hot water directly. This would enable water transmission lines to be installed in place of the more expensive (to maintain) steam lines. An interim measure would be to utilise the existing State complex until conversion could be financed and undertaken.

Option 1 would serve a peak load of 64 MMBH and be required to produce 135,545 MMBtu of energy per year. Three biomass units rated at 21 MMBH minimum each would be required. For prudence, an oil unit of a similar capacity (21 MMBH) would be recommended as backup in the event that a wood fired unit failed. The most common reason for failure is feed system malfunction. Although this is often a short-term interruption, a failed feed system component may affect more than one boiler.

In Option 2, a biomass system designed to meet 40% of peak load would require two units of 12.8 MMBH. In addition, three oil-fired units, rated at 12.8 MMBH would be installed, possibly using existing units from the National Life plant. A similar approach to back-up would be used as in Option 1.

- **SYSTEM OPTIONS 3 & 4**

The second pair of options assumed that the proposed heating plant would be located at, or adjacent to, the current site beside the Winooski River. The plant would serve the same loads as were discussed for Options 1 and 2, those in the downtown core as well as the National Life plant. It would be still be a recommendation that the Capital complex heating system be converted to hot water although this conversion could be integrated with the development of the system in general. By necessity, the plant would provide steam to the National Life buildings although a smaller line would be required. The required new biomass unit and any new oil units would be of the same capacity as those described for Options 1 & 2 at the National Life plant. Unlike Option 2 that utilised existing boilers, the age and size of the State plant's oil units would preclude their inclusion. The capital cost estimate for this option would therefore assume all new equipment. However, as a compromise, some saving would be made in the reduced capaicty of the steam transmission line to the National Life plant.

4.2 DISTRIBUTION LAYOUT

Hot water piping in a district energy system distribution network is laid in pairs, one supplying the hot water, and the other returning the cooler water to the plant. Depending upon the prevailing weather conditions, the supply temperature for the heating loop could be as high as 230°F (110°C) in winter, or as low as 176°F (80°C) in summer. The driving factor is the need to ensure sufficient thermal differential (supply – return) for heat transfer to the building's heating equipment. The cost of the distribution system varies inversely to the temperature differential between the supply and the return line. The greater the differential, the lower the water flow rate, the smaller the piping, the lower the pumping requirements, and the lower the capital and operating costs. Traditional in-house heating systems are designed with a 20°F differential (180°F – 160°F) 'across the boiler' while district energy uses a higher supply temperature and encourages a differential of up to 104°F (40°C)**.** A system differential temperature of only 36°F was used in this design to accommodate the large number of existing residential systems and thereby minimise any requirement to change.

Piping is buried in road allowances and the routing must be considered carefully in the light of the in-street congestion present in many urban centers. The depth of the piping within the street would normally be 3ft (1m), modern piping and insulation technology not requiring the piping to be installed beneath the frost line. The exact piping location must be coordinated with the

appropriate city authorities so as to enable the coordination of piping and other infrastructure activities and the management of costs. Lines would be fitted with suitable tee-junctions to allow for future connections and manholes and inspection ports would ensure minimum inconvenience during maintenance periods.

In the Montpelier system, the largest pipe (excluding insulation) would be 12" diameter. Pipes would be thin wall steel with a high-density polyurethane insulation, surrounded by a thick nylon sheath. The piping system is designed for a pressure of 235 psig (16 bar). Plastic pipes may also be used in district energy systems however these are usually restricted to system peak loads of 6 to 10 MMBH and a maximum supply temperature of 194°F. A sketch of the piping/trench installation is shown as figure 4.

Analysing the piping sizes and requirements assumed a plant location near the State complex. It should be noted that the pipe layout with the plant located at the National Life site was similar. Piping sizes were the same for both with the exception of the line from National Life to the State complex, which increased from 6" diameter (150 mm) in Option 3 to 12" (300 mm) diameter in Option 1.

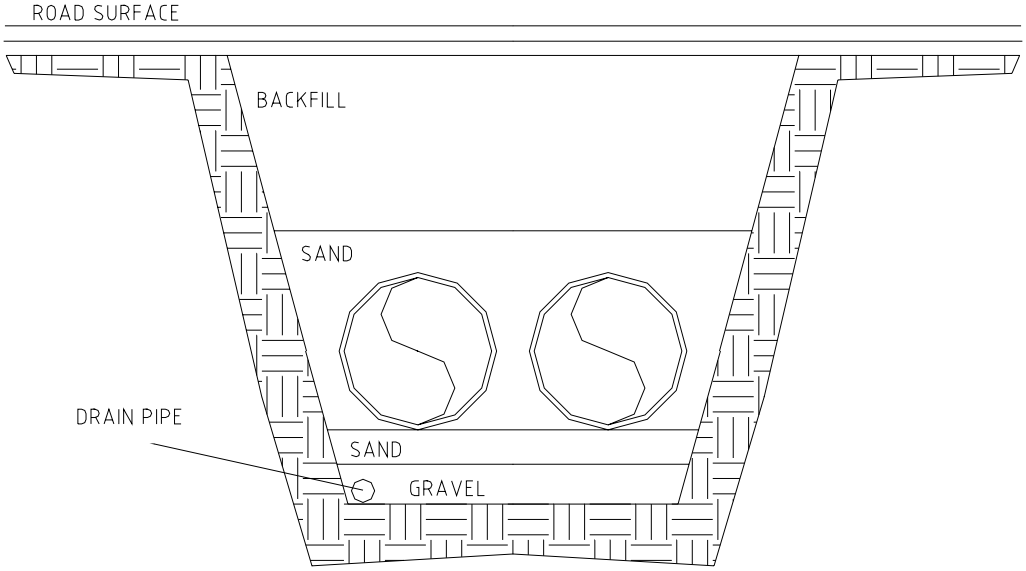

Figure 4: Typical trench/pipe arrangement

A preliminary distribution layout was developed encompassing all 177 buildings. The lines were sized to meet all of the building loads as well as respect pressure drop and maximum water velocity criteria. The total pipe trench using all buildings was calculated at 6.5 miles. The layout in Figure 5 represents only a preliminary route; a final design with input from The City of Montpelier will detail optimum routes.

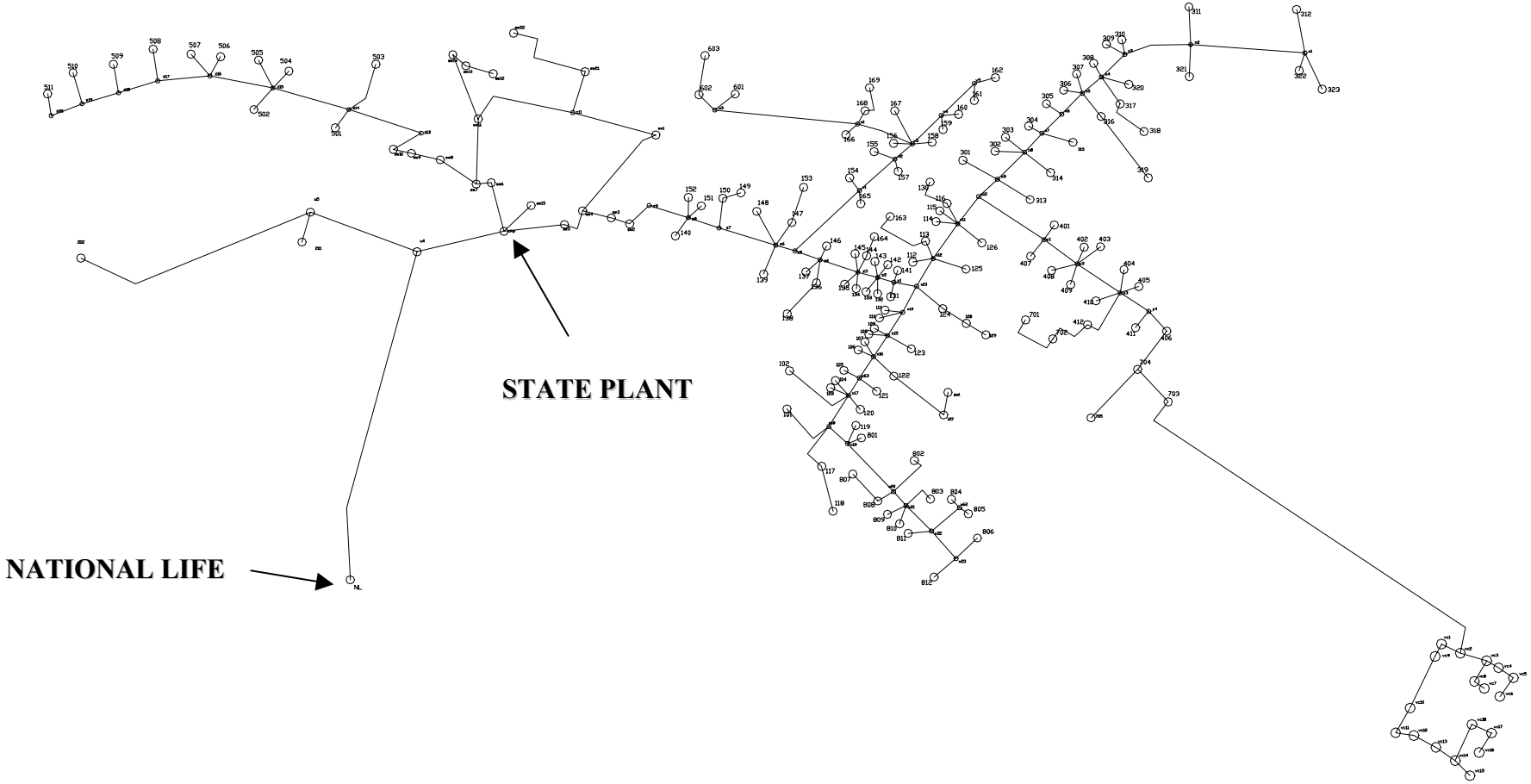

Figure 5: Preliminary Route

4.3 ENERGY TRANSFER STATION

In many district energy systems each building is isolated from the distribution piping by an Energy Transfer Station (ETS). This unit extracts the heat from the supply pipe and distributes this energy to the building. Each station comprises one or two compact, plate type heat exchangers. The principal exchanger would accommodate space heating while the second might provide heating for domestic hot water energy metering devices. Controls and monitoring systems would be incorporated. Energy transfer stations are usually located within each building load and would allow the district energy system to operate at optimal pressures without consideration for operating condition at each separate building. A typical energy transfer station is seen in Figure 6.

European district energy systems are well established and it is normal practice for customer to own their ETS units. However in North America the market is smaller and to assist with project up-take and customer buy-in it has been assumed that the ETS remains the responsibility of the district energy operator. The cost of the ETS and its installation is therefore included within the overall project. It should be noted however that any alterations within the building to accept district energy remains the responsibility of the building owner. ETS costs used in this study assumed connection to forced air, duct based systems. Interfacing with hydronic systems is less costly, avoiding the need for coils, and extensive piping.

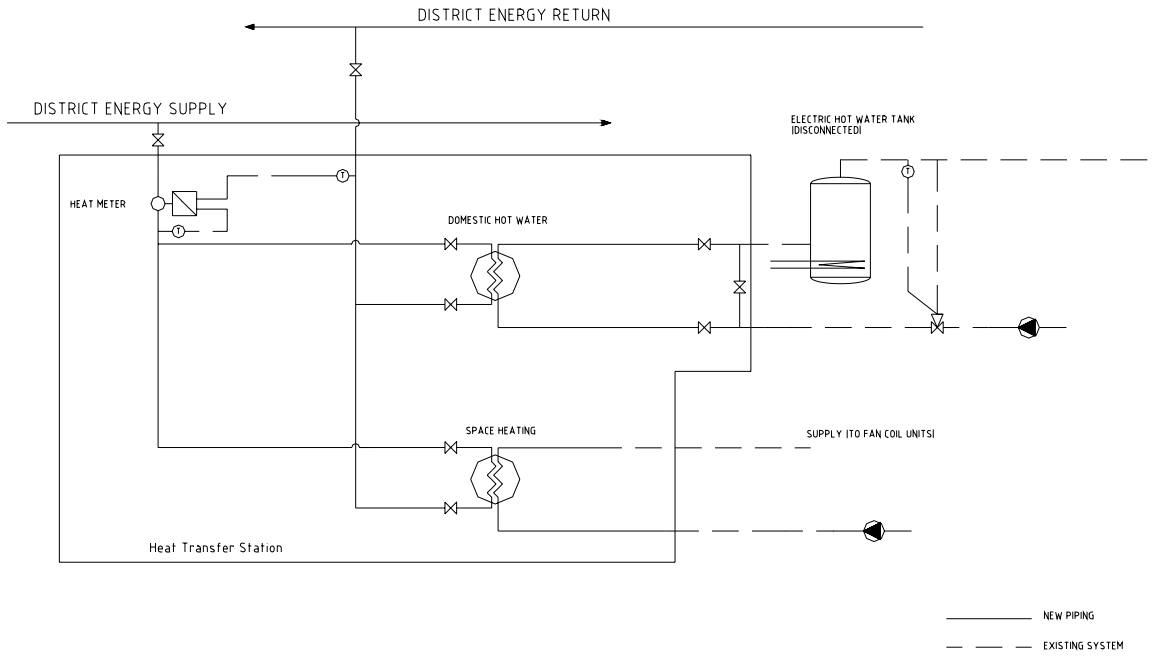

Figure 6: Energy Transfer Flowsheet

- **Alternative Approach**

With the number of smaller loads present in the Montpelier proposal it may prove feasible to reduce installation costs by utilising a cluster approach to energy transfer stations. A single heat

exchanger station could be devised to serve a number of several smaller loads rather than have an ETS located in each building. This concept has been used in Europe but is not common in North America due to the preference of district energy companies for large commercial loads. The intimate nature of many of the loads in Montpelier may justify this approach. Data from preliminary work at the Community Energy Systems of Natural Resources Canada suggests that savings of up to 35% may be achieved on the installation costs associated with the building interface. Convenient building groups would be identified and a single heat exchanger sized for the cluster load (e.g. 10 buildings to each heat exchanger). Each building within the cluster would be connected directly to the heat exchanger and its energy use monitored using an individual energy meter. Safety would be ensured using isolating valves. Cost savings would be had from the economy of scale provided by the larger 'regional' heat exchanger. The concept is shown in Figure 7.

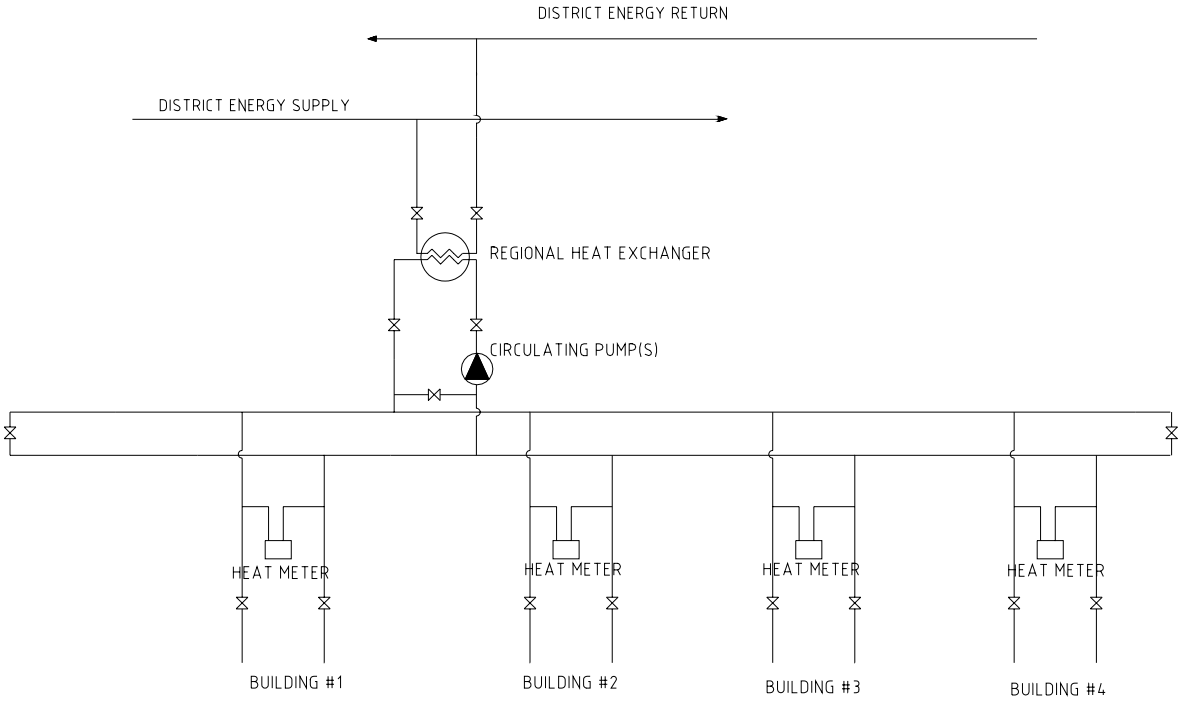

Figure 7: Multi-unit connections

4.4 COMBINED HEAT & POWER

Community interest in biomass fuelled district energy systems invariably leads to interest in biomass fuelled Combined Heat and Power (CHP). CHP can reduce energy costs significantly by creating additional revenue from the sales of electricity to the power grid but it must be remembered that the introduction of electrical generation will introduce into the project a new and greater level of operational and administrative complexity.

Ideally CHP involves the generation of steam from biomass combustion, electrical generation from that steam, followed by the use of the turbine exhaust (either as steam or condensed to form

hot water) for district heating. In this way the maximum energy is extracted from the fuel and the system operates at peak thermal efficiency. Using high-pressure steam directly from the boiler, without passing it first through the turbine negates the impact of electrical generation and should be avoided.

The requirement for 60 psig steam in the Capitol Complex and 15 psig steam in the National Life buildings limits the potential effectiveness of CHP by necessitating a backpressure turbine to be installed, designed for conditions appropriate to the heating systems. Assuming that the turbine exhaust satisfies the system's peak heating load then figure 8 below, illustrates the power output available from the turbine at various turbine exhaust conditions.

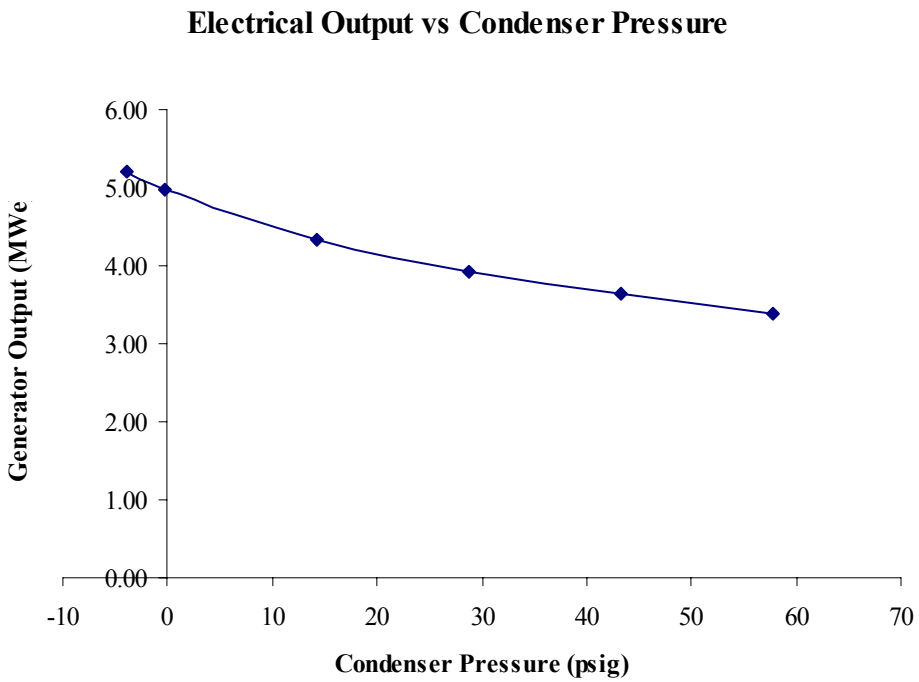

Figure 8: Generator Power vs Condenser Conditions

Electrical output increases significantly with reduced backpressure, providing an incremental addition of 1MWe between 60 psig and 15 psig and a further 1 MWe if hot water at 212°F was used instead. Using lower pressure steam may be limited by the swallowing capacity of the Capital Complex's heating network and thus the cost of building conversion must be compared against the incremental power generation benefits. As an example, the use of hot water rather than 60 psig steam would provide an incremental addition of 1.9MWe generation capacity. Operating for 8000 hours each year with electricity valued at $0.6 /kWh results in an incremental revenue of $912k. This additional revenue may justify the cost of building conversion.

Capital costs for CHP initiatives are primarily driven by the cost of the steam turbines and are typically estimates at $1,200 /kWe installed. Thus, a 5 MWe system could be estimated at $6 million.

4.5 SYSTEM OPERATING CONDITIONS

The system would operate at a peak supply temperature of 230^0F with a design return of 194^0F. As the peak load is reduced the supply temperature will be reduced until it reaches 176^0 F at which point will hold at that temperature. This minimum temperature will serve the domestic hot water loads in the community. This is a common approach in district heating systems and uses a variable flow rate to meet the heating requirements. A typical operating scenario for conditions at Montpelier is shown in Figure 9. Although the graph is in metric the concept remains the same.

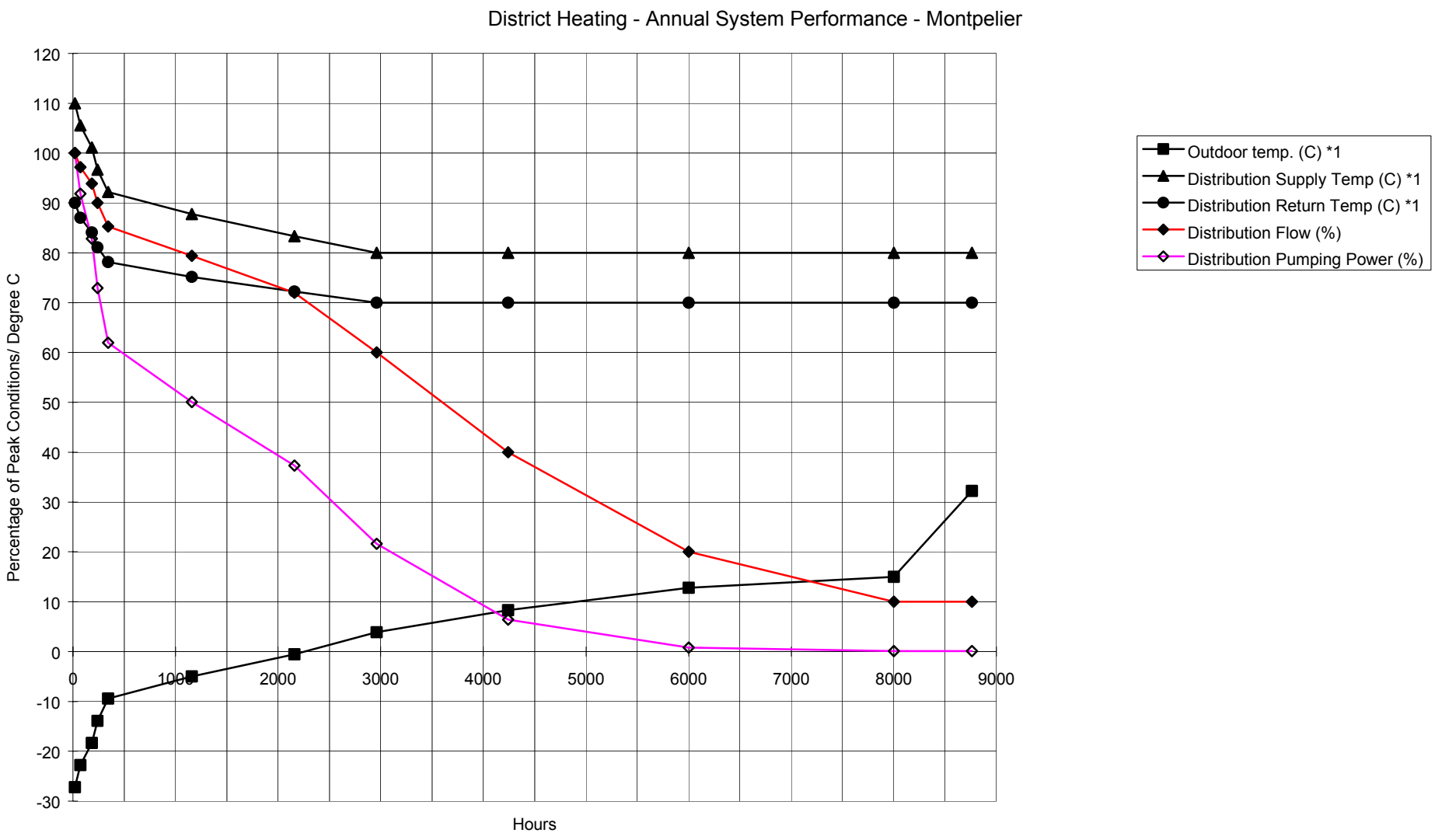

Figure 9: Operating Conditions – Montpelier District Energy

5 ECONOMIC ANALYSIS

5.1 ENERGY COSTS

Buildings within the study area consume fuel oil to generate approximately 80% of the 135,545 MMBTU of energy demanded annually. This is equivalent to 1,040,000 gallons of oil, worth $1.5 million to the community. This oil is imported to the City solely for heating purposes. The current cost (December 2000) of oil for small to medium sized consumers in Montpelier is $1.45 (US) per gallon although larger volume consumers pay less and residential consumers pay more. This is approximately twice the cost paid for oil in 1997 in the region and the upward trend can only be assumed to continue. While it is true that the money paid for this fuel does provide some level of benefit to the City in the form of services, delivery charges, local taxes, etc. the bulk leaves the community. Implementing district energy, with the system using lower cost biomass fuel, can reduce this level of 'financial export'. Furthermore, if the system is owned and operated by a Montpelier based organisation, then the retention increases with the company providing employment, revenue, salaries and additional tax base for the community.

5.2 COST OF HEAT

The average boiler operates with a seasonal efficiency of 75% and, with the current price of oil translates to $14.6/MMBtu ($50/MWh). This price reflects only to the energy component of building heat and does not include costs associated with controlling and maintaining a building's heating system. Equitable comparison of the cost of oil heat and district energy necessitates the inclusion of these capital and operating costs. With a largely residential community this is not always an easy comparison. For the analysis, it was assumed that the multiple heating systems could be equated to a centralised oil boiler. In this way typical capital and operating costs may be estimated. An estimate of the annualized capital and operating costs increases the cost of heating by oil to $16.7/MMBtu ($57/MWh). In the event that oil prices dropped by 25%, this cost would be reduced to $13/MMBtu. These costs are very conservative but may be used to compare with heat delivered by a biomass based district energy system. (In reality the O&M costs and capital replacement cost would be higher due to the diversity and number of oil fired systems currently in Montpelier when compared to a central oil fired plant. Although the two costs are derived in similar ways the central oil method will have smaller fixed capital costs and higher variable fuel costs when compared to the biomass central plant which has high fixed capital costs and low fuel costs. This major difference will tend to stabilise delivered fuel costs as the cost of the raw fuel begins to escalate. If however the price of woodchips were to increase dramatically or if another fuel were to become available at extremely low cost the district energy system (upon analyses) could switch fuels and/or combustion systems but leave the high cost infrastructure, distribution piping and heat exchange units, unaffected.

For the State heating plant the current cost of woodchips is $4.1/MMBtu ($14/MWh). It is estimated though that, with the larger volume of woodchips that would be required for a district heating system, this cost could be reduced to the range of $3 to $3.5/MMBtu. Records indicate that the cost of wood fuel has been stable for many years in the Montpelier region and has not experienced increases of the sort seen by the fuel oil market. This is due in part to several large

consumers of wood energy making the woodchip and wood fuel industry competitive. Another larger consumer such as the district heating system can only add to the competitive process.

Cost estimates are provided in Table 2 along with a comparison of estimates of the current heating methods in Montpelier using the above assumptions with a biomass district energy system using current oil and biomass raw fuel costs in the Montpelier region. For clarification, capital cost items include: distribution piping, energy transfer stations, biomass and oil fired boilers and back up units.

5.3 SNAPSHOT ANALYSIS

OPTION	LOAD (MMBH)	ANNUAL ENERGY (MMBtu)	HEATING PLANT (million)	Distribution (million)	Connection (million)	Total Project (million)	Annualised [3] capital (million)	O&M [4] and pumping cost (million)	Fuel cost (million)	Total annual cost (million)	**UNIT ENERGY COST ($/MMBtu)**
Status-Quo						$2-3[5]					**16.7**
1	64	135,545	$3.43	$5.5	$4.4	$13.33	$1.243	$0.35	$0.44	$2.03	**15.0**
2	64	135,545	$1.9	$5.5	$4.4	$11.80	$1.10	$0.32	$0.57	$1.99	**14.7**
3	64	135,545	$3.43	$5.3	$4.4	$13.13	$1.224	$0.34	$0.44	$2.00	**14.8**
4	64	135,545	$2.65	$5.3	$4.4	$12.35	$1.152	$0.33	$0.57	$2.05	**15.1**

Table 3: Comparison of Costs (all estimates $(US))

[3] Based on 20 years at 7% interest
[4] PY expenses are not included and are assumed to offset PYs associated with the central oil boiler scenario
[5] Cost to replace boilers at Capital Complex Heating Plant

5.4 CONCEPT VIABILITY

The final column of Table 3, snapshot analysis, indicates that providing energy to the community by means of a district energy system would be at a marginally lower cost than that incurred in replacing the existing Capital Complex plant and thereby maintaining the status quo. A district energy project is economically viable, reducing the cost of delivered heat by possibly 10% over the status quo. This reduction in the cost of customer heating, traditionally viewed as the prime goal for district energy, must secure not only City and State involvement but also private customers. Additional benefits such as environmental savings, long term price stability and retained earnings may need to be examined, quantified and appreciated to realise the full benefits of the concept.

The economic cost of the project to the City varies between $11.8 and $13.3 million, a significant amount to most communities. Financing infrastructure projects is conventionally done against city assets with the loan being repaid through (additional) city taxes. District energy deals with the transfer and sale of energy and thereby generates a cashflow stream. It is possible therefore that a loan application for district energy can thus be made against future system earnings, and enable city assets to be put against other capital projects. In estimating the delivery cost for energy the annualised costs for each project were estimated. For the capital costs, a mortgage type loan was assumed with a 20 year amortisation period. Thus, the total annual cost represents the minimum moneys that must be developed each year to offset the cost of the project. No allowance for risk or inflation is included.

The introduction of district energy to Montpelier will increase the quality of life for those people connected to the system, similar in some respects to the benefits of household connection to running water, sewer mains or transportation corridors. Quality of life improvements are readily recognised as being important to the development of sustainable communities by City and State authorities and both organisations should be encouraged to connect their buildings. Private customers such as many of those in Area 2 might need additional incentives to sign up, such as low cost loans or staggered payment schedules. The phased approach to construction discussed in section 2 can also alleviate some resistance by developing price stability into the cost of biomass energy and thereby increasing the differential between biomass and oil fired heating.

The status quo, alluded to earlier assumes that the existing heating plant that services the Capital Complex offices will be phased out and replaced. The budget for renewal is estimated at between $2 and $3 million when complete. The incremental cost of a district energy system could therefore fall to $9 million and a payback[6] of 16 years for the most likely projects, Option 2 and 3. To determine a rate of return for the project requires a detailed understanding of the implementation schedule and the potential customer build-up rate.

5.5 STABILIZED ENERGY COSTS

The cost of delivered energy in Montpelier under current practices using individual furnaces or boilers is made up mostly from fuel (oil) costs and is subject to escalation in oil prices. With a district energy system, as proposed in this study, the majority of the energy cost is fixed under the capital expenditures. Biomass fuel is less expensive (28%) than oil and accounts for

[6] Payback refers to the number of years of full power operation to repay the investment

approximately 25% of the delivered energy cost. Increases in biomass fuel cost will therefore have a lower impact on overall cost. District energy systems are therefore seen as a major cost stabiliser in times of fuel escalation. Billing for each customer would reflect by indictaing the two aspects of the energy cost, one that is fixed to reflect the capital cost of the system, and one that varies with the amount of energy used.

5.6 RELATED BENEFITS

From the environmental perspective there is merit to the reducing the city's dependence on fossil fuels. Biomass is considered as CO_2– neutral and thus the replacement of oil with biomass generated heat will provide maximum Green-House Gas GHG benefit to the community. In the event that GHG reductions become a tradable item then Montpelier will be in a position to benefit financially from the undertaking.

The use of biomass in the form of wood-chips will also reinforce the local wood-chip industry. With the increased capacity of the biomass system then leverage will exist for lower unit fuel costs. Similarly, joint purchases with other related and nearby users may also act to raise the quality of wood chip production, reduce the overall cost of production and feed back into the woodlot industry to incent further woodland regeneration.

In the city itself, the Master Plan proposes a 'user-friendly' river-front to make better use of the land, much of which is now vacant. The removal and reconstruction of a new heating plant could highlight the intent of this plan by emphasising the use of biomass (green) and integrating with the other aspects of the plan (user-friendly). Aesthetically designed buildings, making use of passive solar design could create a centerpiece for the area, drawing people to the park for public events etc.

5.7 OWNERSHIP MODELS

The matter of ownership of a district energy system is an issue that can be resolved only after the structure of the project becomes apparent. Many cities claim ownership of a district energy system and consider at the outset that they, or one of their Utilities will be the "rightful" home for the project. They then endeavor to 'force-fit' the project to the home's environment. There is no fundamental reason why City Hall or the State should be the automatic mechanism by which a district energy project proceeds.

A City has a responsibility to its citizens to ensure that the ultimate project owner demonstrates a full understanding with the project principles and possesses the best resources with which to apply those principles. It is in the city's best interest to examine the marketplace for interested parties who should then be asked to prove their suitability for the task. To maximise environmental and economic benefit to the community, operators of district energy systems must be cost competitive and demonstrate capabilities in at least the design and installation of in-ground infrastructure, marketing, and sales in competition with private sector suppliers.

District energy is essentially the buying and selling of energy with the project encompassing three primary elements: the provision/purchasing of energy, the distribution of energy, and the consumption/selling of energy. The role of the City may cover none, one, two, or all of the three

areas. However, for district energy to be used as a tool to influence development and activity within the community the City should at least be involved with the distribution portion of the project. Whether this is by owning the distribution system, or by acting with others to direct the system's scope and extent. The final position must be determined according to the City's willingness to accept risk.

5.7.1 In-House project – Risks / benefits

A publicly owned community energy system is typically established as a city utility, either a new utility or as an extension in mandate for an existing body. These utilities may establish a community energy utility for a number of reasons. Usually they recognize benefits such as environmental enhancement and economic development by keeping energy dollars within the community. Montpelier is in the business of maximizing public good while meeting their own bottom line and as such may see justification in proceeding with projects that are significant in public benefit but that do not meet high return on investment that is demanded by the private sector.

By definition, a fully publicly owned and operated system offers the potential for equalizing access to all members of the community. While some areas of the city might offer clusters that meet a private sector's criteria for acceptance, a private sector operator may have little or no incentive to subsidize other areas if their inclusion negatively impacts the project's overall return. For example, Montpelier might proceed with a starter project in conjunction with the Capitol Complex, using the existing boiler plant to service some of the downtown buildings. This establishes the concept. As the level of perceived risk is reduced, then the private sector may be willing to become involved and accept a more dominant role.

Initiating a district energy system is not cheap and many factors act to limit a city's willingness to become involved. These include:

1) borrowing power is already heavily committed;
2) residents may not appreciate the contribution of community energy systems and may object to investments in areas where existing private sector energy companies already exist;
3) an insufficient number of people, skills or commitment to make the city an effective champion.

Montpelier must confirm internally that the environment, energy efficiency and economic development are included within its mandate and that the socio-economic benefits of the project justify its involvement. It should then ascertain whether there are private sector developers or utilities within the community that would be willing to participate in such a system. Initial co-ordination by the community is essential since by owning or developing the project, the city can affect the energy use patterns within the community to, say, increase the use of local resources (biomass). Once this objective has been achieved, the system might then be sold to recover all or part of the investment.

5.7.2 Public / Private Venture – Risks / benefits

The role of the private sector is to look for instruments with which to increase the value of their investments. Any opportunity that has an acceptable level of risk, a return commensurate with that risk, and a good potential for growth becomes a candidate for investment. However, if the private sector were alone in developing a wide-scale district energy system then the risk of getting customers, rights of way, etc., could be perceived as unacceptable. Let the City of Montpelier take responsibility for part of the project. In this way it can use its skill to promote the community benefit, and thereby reduce the perceived level of risk. The return on private sector investment increases to become acceptable.

5.8 ENVIRONMENTAL ANALYSIS

A district energy system in Montpelier based on concepts in this study would displace 906,000 to 1,040,000 gallons of heating oil, annually. With biomass being considered as CO_2 - neutral then the maximum benefit would be obtained in terms of greenhouse gas reduction. Also, by displacing oil, a reduction in the associated NO_x and SO_x is also obtained. While the CO2 emitted from Montpelier will contribute to the overall green house emissions worldwide NOx and SOx may have a more local affect. The physical location of the City may contain NOx and SOx emissions, which are precursors to acid rain, within the mountain valley. The level of displacement of the various gases and their environmental impact are as shown below:

Emission	**Emissions tons/yr**	**Environmental Impacts**
CO_2	11,300 to 13,000	Greenhouse gas
NOx	8 to 9	Acid rain precursors
SOx	22 to 25	Acid rain precursors

Table 4 Fuel Oil Emissions/ Impact

6 CONCLUSIONS

The analysis presents scenarios for district energy systems within Montpelier. While the results do not suggest strong private sector involvement, the City may see significant benefits to pursuing the project further. The key recommendations are as follows.

1. A district energy system, based at either the National Life Building or adjacent to the existing Capital Complex heating plant could be developed to provide downtown Montpelier with an immediate heating cost similar to or lower than the existing cost of fossil fuel heating.
2. The project could integrate with large energy users such as the State Capital Complex and National Life of Vermont.
3. The project could be constructed in a phased arrangement, initially servicing the local buildings followed by expansion to the more outlying properties.
4. Some incentive to proceed originates from the synergy that a phasing out of the existing Capital Complex heating plant would bring in conjunction with the desires of the proposed Capital District Master Plan.
5. Conversion of the State buildings to accept hot water should be considered a long-term goal.

7 NEXT STEPS

In the City of Montpelier, district energy based on a biomass boiler plant could reduce CO2 emissions by up to 13,000 tons/yr and reduce the annual cash flow out of the local economy. In addition, the more efficient and economical source of energy and the increase in flexibility of potential energy sources would provide stability in the energy costs for future years making the region a more attractive place to live and do business.

The report demonstrates that a biomass based energy system with sufficient heating demand can provide thermal energy at a cost that justifies the construction of a district energy system within a reasonable timeframe. Furthermore, given a reasonable level of inflation in the price of heat, a biomass based energy supply should continue to be a competitive source of energy. The environmental benefit of CHP is also clearly demonstrated.

The inclusion of the Capitol Complex and the National Life buildings can be seen as a real asset to the project in that the incorporation of their demands enables the generation of more economical heat. Also, their presence within the projects offers boiler capacity for back-up or peaking use; thereby reducing the required capital expenditure.

From these conclusions, there can be seen a series of positive steps that can be taken toward project implementation:

1. The City of Montpelier, the State of Vermont and National Life should confirm their willingness to co-operate and further examine district energy as a means of reducing greenhouse gas emissions and overall heating and cooling costs. Both parties should establish

a joint working group, to develop the project further. The Working Group should appoint a Chairperson and, if necessary tender a contract for the secretarial and liaison tasks such as:

- Facilitation of meetings, working group or otherwise;
- Preparation and production of marketing and public information literature;
- Preparation of, and presentation to customers, developers, councils, etc.;
- Preparation and execution of Expression of Interest documentation in accordance with existing City guidelines;
- Coordination of the evaluation process

2. The Working Group should work through the stakeholders to confirm details on the heating loads of the various buildings, industries and heating plants suggested within the area and ascertain the level of interest within major building owners. It is suggested that, as an initial first step the project focus upon the Capitol complex and the immediate downtown core.

3. Unless there is definite instruction that the project be retained in-house, the more comprehensive understanding of the required heating loads should enable the Working Group to prepare, and issue a call for Expressions of Interest. The expression should cover the provision of any, or all of the following; heating services, business partnership potential, engineering development of distribution systems, energy marketing services. Potential bidders may include private sector companies, city utilities, or other departments of the city or state. The document need not include exact details of piping routes, contractual details, etc. but rather focus on general interest in the project. As the level of understanding increases, details will be developed to the mutual agreement of all parties.

4. Based on the response to the call, the Working Group should establish a short list of potential project participants and re-evaluate the role of the city in the project. The group will thereby determine optimum resource level required and in the event that a public/private partnership is considered then the ownership split should be defined so as to benefit the community. It is anticipated that work to this phase could be completed within an initial six month period;

5. The Working Group should request a more detailed concept from each short listed bidder and thereby determine a prioritized list of bidders and a firm understanding of the resources required of each partner, according to their capabilities and accepted level of risk.

6. In conjunction with the most favoured bidder, a detailed evaluation can be undertaken looking at the engineering and business aspects of the project. Land availability, piping routes, building interconnections, and other related costs may be determined. For this work to proceed a consultant may be required.

7. Given indications of economic acceptability in the feasibility study, the Working Group would liaise between representatives of the various participants to conclude the working structure for each project organisation. Agreement (franchise or otherwise) for each operation will be sought from the City or respective authorities;

8. With the commitment of each group towards the project, financing and construction will lead to commissioning.

The above is a global pathway to project initiation and may vary as the project proceeds. However as an initial step it is a reasonable way to create bargaining power for a community with limited investment. By determining the level of interest in the project, both outside and inside the community, proponents receive a clear signal as to the value of the project and hence can solidify the role that it wishes to adopt.

Appendix 1: Units & Conversion Factors

Energy	BTU	British Thermal Unit
	MBTU	x1,000 BTU
	MMBTU	x1,000,000 BTU
	MWh	MegaWatt-hour = 3.41 MMBTU
Power	BTH	British Thermal Unit – hour
	MBTH	x1,000 BTH
	MMBTH	x1,000,000 BTH
	MWt	MegaWatt (thermal) = 947 BTH
	MWe	MegaWatt (electrical)
Temperature	F	degrees Farenheit
	C	degrees Celcius = 1.8F
Volume	Gal	US Gallons
Mass	lb	pound
	t	Ton
	t/a	Ton / year
	Kg	kilogram = 2.25 lb
Length	ft	foot
	m	metre

Appendix 2 Montpelier Study Area Building Loads and Locations

Building	Address		Peak Load kW
Laundromat	2-8	Barre St.	18
County Sheriff	16	Elm St.	18
Flashback Photo	97	State St.	21
State Employees	155	State St.	22
Matt's Mini Mart	41?	Elm St.	22
2-story white	161	State St.	23
East State School back bldg.	56	East State	23
Huntsman's	4	Langdon	24
Grey, 3 story	150	No. Main	24
MacPherson	16-18	State St.	24
VT League of Cities and Towns	12.5	Main	24
Trinity Methodist	137	No. Main	25
Unitarian Church	134	No. Main	25
St. Augustines	18-20	Barre St.	25
First Baptist	34	School	25
Gary Home	149	No. Main	25
Bethany Church	109-115	Main	25
St. Augustine's rectory	34	Barre St.	25
Blue, brown trim	6-8	Cedar St.	25
VT Association of Realtors	148	State St.	25
Sarducci's	7	Main	26
Grey, 2 story	148	No. Main	26
Woodbury College	57-61	Elm St.	26
Play it Again Sam	66	Main	26
Dr. Nist	152	No. Main	27
Cream colored	39	Barre St.	27
Hecht	8	Court St.	27
Capitol Video/Julios	44	Main	27
Subway/Charlie-O's	68-72	Main	27
Laundromat	46-54	Elm St.	27
Cheney Brock Saudeck	159	State St.	27
White, 5 story	6-8	Hillside	28
Sammy's, etc.	23-25	State St.	28
VT Federal Bank	99-101	State St.	28
VT Bar	35-37	Court St.	28
Green	41-45	Court St.	28
Reddish brown	27	School	29
White - Martin's	55	East State	30
Social Security	33	School	30
Black Tie	37	Barre St.	31
The Garage	58	State St.	31
Brick (Be Our guest)	35	School	31
Light brown, mauve shutters	28	East State	33
White colonial	145	No. Main	33
Brown shingle	38	School	33
Angeleno's	15	Barre St.	34
Dark grey	39	School	34
Mauve, purple trim	144	No. Main	34
Century 21	147	State St.	35

BPOE chimney	31	Barre St.	35
Blue Seal	23	Barre St.	35
VFW	19-23	Main	35
Grey	167-169	No. Main	35
Guare and Sons	30	School	36
Yellow, brown trim	36-42	East State	37
3-story white	163	State St.	37
CHP	144	State St.	37
Brooks Drug	60	Main	37
Critics Choice	28-38	Main	38
Light brown, brown trim	1-3	Court St.	38
Patterson and Walke	140	No. Main	38
Jan's Beauty Boutique	154	No. Main	39
Tan	32	School	39
Capitol Market	124-128	Main	39
Old Elm St. Apts.	81-87	Elm St.	39
VT State Medical Society	136	No. Main	39
Bellini's	38	Elm St.	40
White, blue trim	40	Barre St.	40
Manghis	26-28	School	41
VCIL/Sheridan	11	East State	42
Main St. Chiropractic	146	No. Main	43
Level Nine	5-7	State St.	43
Housing & Conservation Board	149	State St.	44
Capitol Theater	93	State St.	44
Kellogg Hubbard Library	135	No. Main	45
OM Fisher House	153	State St.	45
Old Elm St. Apts.	73-79	Elm St.	47
Old Elm St. Apts.	65-71	Elm St.	47
Times Argus	112-116	Main	47
Yankee Paperback	7-9	Langdon	48
VT Trading Co.	2-6	State St.	50
Police station			50
State st	46	State St.	51
VALIC	138	No. Main	54
County Court House	61	State St.	55
Beige, nice trim paint	171	No. Main	58
Inn Annex	2-4	Baird	59
Brooks Drug/Wells Constr.	64	Main	59
Minute Man	8-14	State St.	60
Denis Ricker & Brown	17	State St.	60
Fiddleheads	52-56	State St.	61
Rivendell Books	100-110	Main	63
VT National	13	State St.	64
Capitol Stationers/Main St. Apts.	54	Main	65
Montpelier Rec Center	55	Barre St.	66
OBriens/VNB	7	Main	67
Savoy Theater	22-26	Main	72
Aubuchon/Somers	32-42	Main	73
Diamond/CLF	15-23	East State	73
Jailhouse Common	22-28	Elm St.	76
Inn at Montpelier	147	No. Main	77
First In Fitness	11-15	Pitkin	77
Rialto Bldg.	26-42	State St.	78
Grey, white pillars	157	State St.	79

Old Chitt. Bank	41-45	State St.	79	
NECI	118-122	Main	80	
Masonic Hall	156	No. Main	80	
New Elm St. Apts	89-105	Elm St.	94	
Capitol Dry Cleaners	46-50	State St.	94	
Seguin Bldg.	7-7.5	Bridge	100	
Onion River Sports	8-20	Langdon	100	
Coffee Corner	79-83	Main	101	
Union Block - left (Sherman)	20-26	State St.	103	
Mont. Apts./China Star	11-15	Main	112	
US Post Office/Federal Bldg.	87	State St.	113	
Howard Bank	90-98	Main	118	
Brick, 4 story, offices	7	Court St.	118	
3-story apts., brick	7	Baird	120	
Grand Union	4	Main	130	
Rite Aid	27-35	Main	133	
Brick office building	141	No. Main	135	
Capitol Apts.	49	Greenwood	140	
New England Tel.	23-25	School	143	
Christ Church	64	State St.	172	
St. Michaels School	46	Barre St.	173	
Union Mutual Insurance	139-145	State St.	186	
Mont. Public Schools, etc.	52-58	Barre St.	188	
East State School	56	East State	190	
Credit Union	72	Bailey	213	
Bear Pond Books	73	Main	215	
VT Mutual Insurance	89	State St.	272	
City Hall/Fire Station	22	Main	276	
MHA, Pioneer Apts.	155	No. Main	285	
Main Street Middle School	90	No. Main	394	
Union School	108	Park Ave.	431	
City Center	89	Main	645	
Capitol Plaza	84-100	State St.	651	
High school	73	Green Mountain	663	
National Life (all bldgs.)		Nat. Life	3383	
			14542	
State Buildings			3575	16 Bldgs
Sub Total			**18117**	
Vermont College			1370	18 bldgs
New and additions at State			1770	
Total			**21257**	