

Montgomery County Equipment Maintenance and Operations Center

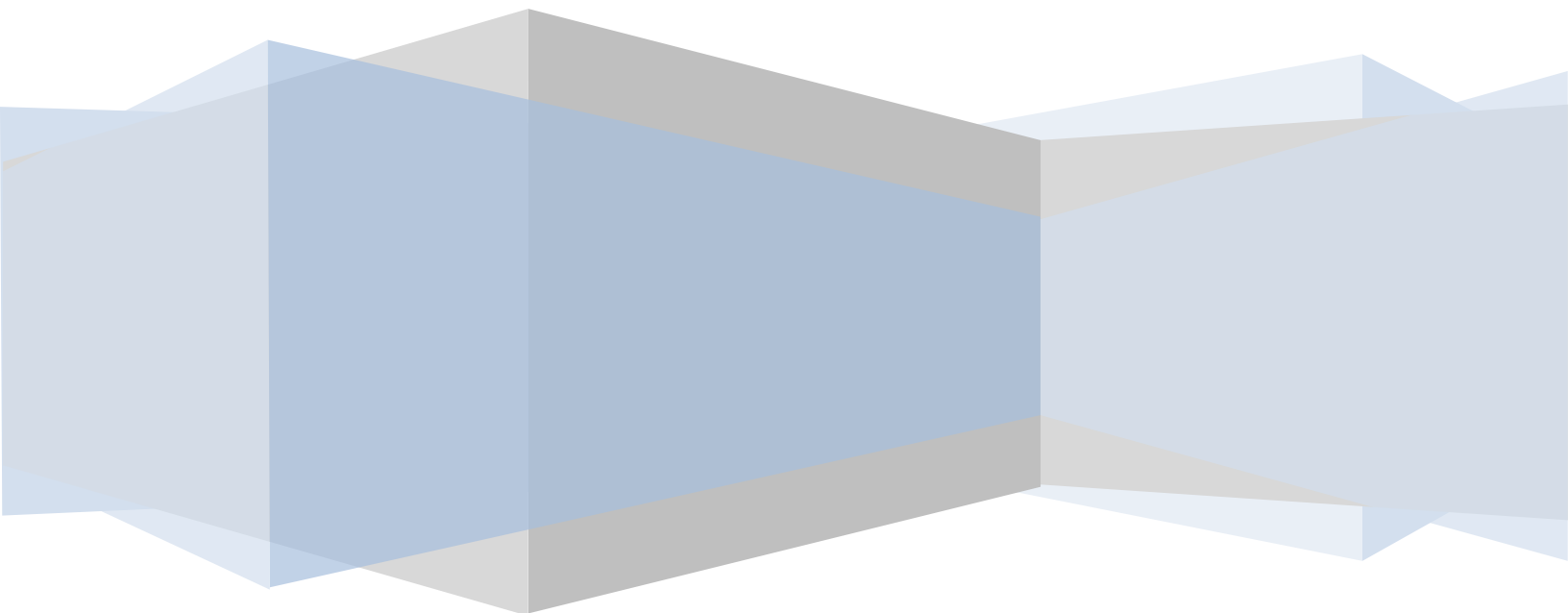
Technical Report 3

Mechanical Systems Existing Conditions Evaluation

Michael Tellep

Mechanical Option

Advisor: Moses Ling



Montgomery County Equipment Maintenance and Operations Center-Building 1

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Executive Summary:

The Montgomery County Equipment Maintenance and Operations Center, Building 1 (EMOC 1) is a 75,000 square foot building in Rockville, Maryland designed to be the new hub for Montgomery County's ground transportation services. EMOC 1 is a multi-purpose building consisting of both garage space for maintenance and office space for operations. The building is still under construction and is scheduled to be finished in February of 2013. The design strives for LEED silver or better.

This report will provide a summary of all of the major details pertaining to the building's mechanical system. These details will include but are not limited to design objectives, energy sources, cost, indoor and outdoor conditions, ventilation, heating and cooling, major components, operation, LEED certification, and an overall rating of the system.

EMOC 1 is a LEED silver design estimated to cost approximately \$15 million. The mechanical system adds \$26, 464 per year using 1,714 MBh of heating energy per year and 105.5 tons of cooling energy per year.

Design Objectives and Requirements:

EMOC 1 is located in climate section 4A as show by Figure 1 below. Climate zone 4A is the upper range of subtropical climate. This means that both heating and cooling are necessary in sufficient quantities. However, neither is at an extreme.

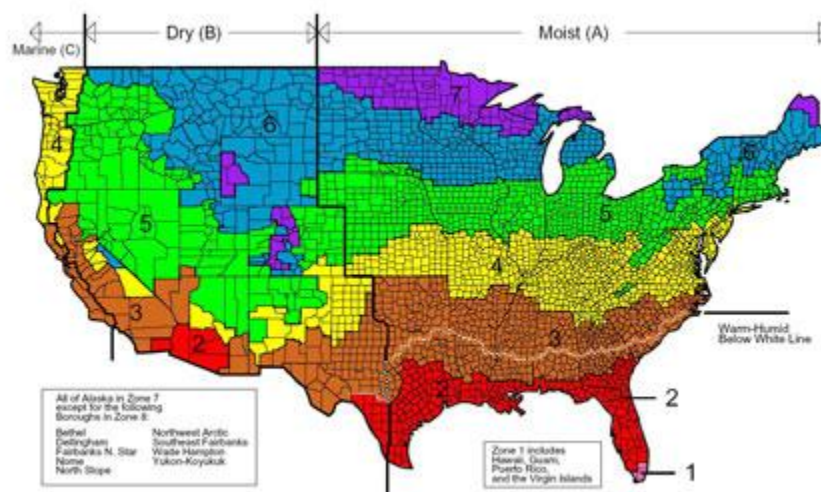


Figure 1 - US Climate Zones

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The design objectives for EMOC 1 are to provide comfortable and safe working spaces for both the office workers and garage workers. Because the building consists of two different occupancies, specific heating, cooling, and ventilation considerations were taken.

The Garage Spaces:

The garage spaces are unique for the fact that they require 100% outside air. Bus fumes, paint fumes, fuel fumes, and particulate matter all a handful of the items that contribute negatively to the air quality of the space and must be removed for the space to be safe. To save energy, the garage spaces are only serviced by Energy Recovery Units (ERUs) that provide heating and ventilating only. The cooling comes from the open garage doors and natural ventilation. This saves energy and is very practical considering that a workspace such as a garage space is unlike that of an office space in terms of expected air conditioning. Due to the inconsistency of the infiltration through the garage doors, exhaust fans are in place to force the required air changes if necessary. These exhaust fans are also part of the emergency ventilation system that activates if something such as a fuel spill were to occur.

The Office Spaces:

Within the same building as the garage and maintenance bays are offices that will be used for the daily operations of Montgomery County's transportations services. These spaces were treated just like regular office space and are positively pressurized in relation to the garage spaces so any opening between them does not harm the environment of the office spaces. The offices are serviced by Roof Top Units (RTUs) providing heating, ventilation, and air conditioning.

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Energy Sources and Rates:

The primary energy sources for EMOC 1 are electricity and natural gas, both provided by the City of Rockville, MD and Pepco. Natural Gas is used for heating and electricity is used for everything else. As part of the LEED certification system (discussed later), the City of Rockville and Pepco provides power from as many renewable sources as possible. Please see the rate tables for these utilities in Appendix A.

Site Cost:

The total annual site cost for running the mechanical system is approximately \$26,464.00 according to the Trane TRACE 700 analysis run for Technical Report 2. The following figure and table shows the cost breakdown on a monthly basis and on a heating/cooling basis per year:

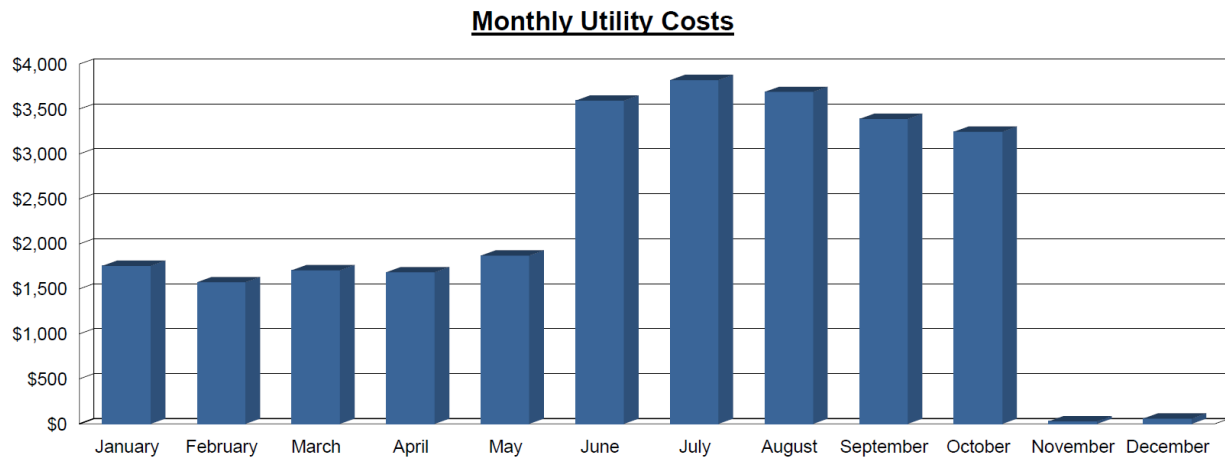


Figure 2 - Monthly Utility Costs

Table 1 - Annual Costs

Utility	Cost (\$/Yr)
Electric	26,061
Gas	363
Total	26,464

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Outdoor Design Conditions:

As shown in Figure 1 in the Design Objectives and Requirements section, EMOC 1 is located in an upper subtropical climate. This means that heating and cooling are both required, however neither is at an extreme. Summers can range from 75°F to 110°F and winters can range from 0°F to 45°F. Extreme days that are outside of those ranges are possible, however they are not common.

Humidity can be a problem in this climate zone. While the garage spaces are not air conditioned, the outside air being provided to the office spaces will require dehumidification as part of the air conditioning system. The weather data for Washington D.C. at Reagan Airport is applicable for EMOC 1 and is shown below:

TABLE C1 US Climatic Data

State City	Latitude		Longitude		I-P			No. Hrs. 8 a.m.–4 p.m. 55 < DB < 69°F 13 < DB < 21°C	SI		
	Elev. (ft)	HDD 65°F	CDD 50°F	Elev. (m)	HDD 18°C	CDD 10°C					
Virginia											
<u>Washington DC Reagan National AP</u>	<u>38.85</u>	<u>N</u>	<u>77.03</u>	<u>W</u>	<u>66</u>	<u>4,047</u>	<u>4,391</u>	<u>657</u>	<u>20</u>	<u>2,248</u>	<u>2,439</u>
US Minor Outlying Islands											
<u>Midway Island NAS</u>	<u>28.22</u>	<u>N</u>	<u>177.37</u>	<u>W</u>	<u>13</u>	<u>134</u>	<u>8,323</u>	<u>N.A.</u>	<u>4</u>	<u>74</u>	<u>4,624</u>
<u>Wake Island</u>	<u>19.28</u>	<u>N</u>	<u>166.65</u>	<u>E</u>	<u>12</u>	<u>0</u>	<u>11,097</u>	<u>N.A.</u>	<u>4</u>	<u>0</u>	<u>6,165</u>

Design Ventilation Requirements:

As found in Technical Report 1, the design ventilation requirements are as follows:

Table 2 - Ventilation Information

Occupancy Type	Ventilation Requirement
Garage	100% OA
Office	5 cfm/person
Kitchenette	Exhaust rate of 0.3 cfm/sf
Storage (Auto Materials)	Exhaust rate of 1.5 cfm/sf

Also, as an additional measure in the garage spaces, retractable vehicle exhaust units are installed in each bay. These units attach to the exhaust pipe of the vehicle and remove the contaminants from the building.

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Design Heating and Cooling Loads:

EMOC 1 has some very unique and, at times, unpredictable heating and cooling loads, especially in the garage spaces. This is another reason why the cooling of the garage spaces is done naturally through the garage doors and exhaust fans. The heating of the garage spaces is done through two Energy Recovery Units.

The office spaces are fairly standard in terms of their heating and cooling loads. The heating loads mainly come from infiltration and heat loss due to glazing, and the cooling loads mostly come from occupants, computers, and other office equipment.

A breakdown of the heating and cooling loads by unit (RTU, ERU, or HV) is shown below. Bear in mind that the RTUs service only the office spaces and the ERUs and HV unit service only the garage and auto storage spaces. These values were produced by an energy model in Trane TRACE 700 as part of Technical Report 2.

Table 3 - Heating and Cooling by System

System	Parameter	Cooling	Heating
RTU-1	%OA	7.7	7.8
	cfm/sf	1.78	1.75
	cfm/ton	459.45	-
	sf/ton	257.49	-
RTU-2	%OA	18.4	15.3
	cfm/sf	0.97	0.97
	cfm/ton	292.68	-
	sf/ton	301.90	-
RTU-3	%OA	6.0	6.6
	cfm/sf	2.07	2.07
	cfm/ton	463.68	-
	sf/ton	224.35	-
ERU-1	%OA	-	100
	cfm/sf	-	0.25
	cfm/ton	-	-
	sf/ton	-	-
ERU-2	%OA	-	100
	cfm/sf	-	0.25
	cfm/ton	-	-
	sf/ton	-	-
HV-1	%OA	-	100
	cfm/sf	-	0.18
	cfm/ton	-	-
	sf/ton	-	-

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Annual Energy Use:

An analysis of the annual energy use by EMOC 1 was done as part of Technical Report 2 in Trane TRACE 700. The following is a breakdown of the annual energy use by system in the building:

Table 4 - Heating and Cooling Loads by System

Plant	System	Main Coil (tons or MBh)
Heating	RTU-1	79
	RTU-2	158
	RTU-3	77
	ERU-1	611
	ERU-2	714
	HV-1	75
Heating Total:		1,714 MBh
Cooling	RTU-1	28.6
	RTU-2	55.0
	RTU-3	22.0
Cooling Total:		105.6 tons

Major Mechanical Components:

EMOC 1 uses a number of different devices as part of its mechanical system. The following table shows the major components and their uses:

Device Type	Designation	Number in Building	Use
Rooftop Air Handling Unit	RTU	3	Heating, Ventilating, Air Conditioning
Energy Recovery Unit	ERU	2	Heating & Ventilating Only
Heating/Ventilating Unit	HV	1	Heating & Ventilating Only
Exhaust Fans	EF	77	Exhaust Only
Circulating Fans	CF	11	Interior Circulation Only

System Operation:

Rooftop Air Handling Units:

The RTUs are all bypass VAV systems with reheat. Air is drawn from the outside and mixed with return air which is then conditioned by the coils. The coils are the heat transfer surfaces that transfer either the heating or cooling energy from the plant water to the air going into the occupiable space of the building. The flow in these coils is determined by sensors throughout the building. If more load is detected and a lower or higher supply air temperature is needed, the flow changes accordingly. Also, VAV stands for Variable Air Volume. The volume of air being delivered to the space changes in accordance with the loads in the space and the operating schedules. The air volume will never drop below the required ventilation rate for each type of space.

Energy Recovery Units:

Energy recovery units are becoming more and more popular as they are proven to recover a decent amount of energy from the exhaust air from a space. When in a heating cycle, the exhaust air is usually at a much higher temperature than the outside air. If an energy recovery unit is not in place, unfortunately, this extra energy is lost to the atmosphere. An energy recovery unit draws the remaining thermal energy out of the exhaust air and reuses it to heat the incoming outside air.

Heating/Ventilating Unit:

The HV unit in the building is in place to heat some of the spaces that do not require regular cooling, but are not necessarily always open to the effects of the ERUs. This is a small unit and simply consists of a fan and a heating coil.

Exhaust Fans:

The EFs in EMOC 1 are very important for two reasons. First, they maintain a proper interior pressure in reference to the outdoor pressure. This is crucial for proper ventilation especially when no cooling is provided to the garage spaces. Second, they are part of the emergency exhaust system which activates if indoor air contaminants become unsafe. This emergency system is manually operated except for the case of a fire.

Circulating Fans:

Giant ceiling fans are in place in the garage spaces to circulate air and make the space more uniform. They bring the warmer air down to the level of the doors so the natural ventilation can take care of the heat.

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Lost Usable Space:

The mechanical system only has a few instances where usable space is lost. The first place is on the roof. EMOC 1 has a green roof over every possible square foot of the building. The mechanical units cannot be placed on a green roof, nor can a green roof be placed on top of them. Also on the roof of the lower level is a courtyard for the upper offices. A rooftop unit impedes this space from being larger and more aesthetically pleasing.

Second, the ceiling space in the garage areas is mainly mechanical equipment. This makes the placement of ceiling winches and other garage oriented equipment very difficult.

Other than these two items, the mechanical system is mainly out of the way of the rest of the building.

LEED Rating:

EMOC 1 is designed for LEED silver. The points for this rating come not only from the mechanical system, but from the construction techniques, site usage, and transportation methods. The points associated with the mechanical system are mainly associated with the garage spaces. Though they require a lot of heating during the winter, natural ventilation for the warmer months is heavily used. The ERUs provide a method of heat energy recovery during the colder months, and therefore add points to the LEED platform.

The office spaces are notable for the use of daylighting and occupancy sensors. The coordination of the interior lights and light level sensors saves electrical energy and lets the sun provide the lighting.

Overall Evaluation of Mechanical System:

This mechanical system is extremely efficient for a building of this type. Garage and maintenance bay buildings are usually drains for heating and cooling load, however, EMOC 1 works with the environment, and not against it. The system does not try to overpower nature and provide perfectly conditioned air in the maintenance spaces, but rather it allows the outdoor conditions to provide most of the compensation for the interior loads. This well-thought-out system achieves the design goals of providing a safe, comfortable, and productive environment for its occupants.

Overall, I believe this to be a good design. I will be looking at alternatives for these systems to potentially improve system performance later in the thesis.





A PHI Company

**MARYLAND
GENERAL SERVICE
SCHEDULE GS
UPDATED DECEMBER 1, 2011**

Standard Offer Service (Generation, Transmission including GRT, and PCA)

	<u>06/01/11 - 09/30/11</u>	<u>10/01/11 – 05/31/12</u>	<u>06/01/12 – 09/30/12</u>
Generation¹			
All kwh	\$ 0.09195 per kwh	\$ 0.08138 per kwh	\$ 0.08571 per kwh
Procurement Cost Adj.	www.pepco.com/md-rates for monthly rate		
	Billing Months of <u>June – October</u> (Summer)	Billing Months of <u>November – May</u> (Winter)	
Transmission²			
All kwh	\$ 0.00408 per kwh	\$ 0.00408 per kwh	
Gross Receipts Tax	2.0408% applied to transmission bill		
Distribution Service³			
Customer Charge	\$ 9.31 per month	\$ 9.31 per month	
All kwh	\$ 0.03615 per kwh	\$ 0.01911 per kwh	
Delivery Tax	www.pepco.com/md-rates for monthly rate		
MD Environmental Surcharge	www.pepco.com/md-rates for monthly rate		
Montgomery County Surc. or Prince Georges County Surc.	www.pepco.com/md-rates for monthly rate		
Universal Service Charge⁴	See page 28 of Pepco's MD Electric Rate Schedules		
Gross Receipts Tax	2.0408% applied to distribution bill excluding the GPC, and the Montgomery or Prince Georges County Surcharge		
Administrative Credit	www.pepco.com/md-rates for monthly rate		
Bill Stabilization Credit (BSA)⁵	www.pepco.com/md-rates for monthly rate		
EmPower MD Charge⁶	\$ 0.000167 per kwh	\$ 0.000167 per kwh	

¹ Effective Usage on and after June 1, 2012

² Effective Usage on and after August 10, 2011

³ Effective Usage on and after August 19, 2010

⁴ Effective March 1, 2005

⁵ Effective Billing Month of November, 2007

⁶ Effective Billing Month of March 2010

WASHINGTON GAS LIGHT COMPANY

MARYLAND

Firm Commercial and Industrial Sales Service

Rate Schedule No. 2

AVAILABILITY

Sales service under this schedule is available in the Maryland portion of the Company's service area for firm gas sales service to any customer classified Commercial and Industrial as defined in Section 1A. of the General Service Provisions.

RATE FOR MONTHLY CONSUMPTION

System Charge

Heating and/or Cooling

All billing months

(a) Normal Weather Annual Usage
less than 3,000 Therms \$18.15 per customer

(b) Normal Weather Annual Usage
3,000 Therms or more \$36.25 per customer

Applicability of (a) or (b) shall be determined each year in accordance with Section 1A. of the General Service Provisions.

Non-Heating and Non-Cooling

All billing months \$15.00 per customer

Distribution Charge

All gas used during the billing month:

First 300 therms	31.58¢ per therm
Next 6,700 therms	21.52¢ per therm
Over 7,000 therms	15.73¢ per therm

MARYLAND FRANCHISE TAX SURCHARGE

The Distribution Charge shall be subject to the Maryland Franchise Tax Surcharge in accordance with General Service Provision No. 27.

ISSUED: May 25, 2010

EFFECTIVE: For service rendered on and after June 1, 2010

Roberta W. Sims – Vice President, Regulatory Affairs & Energy Acquisition

Firm Commercial and Industrial Sales Service - Rate Schedule No. 2 (Continued)

Purchased Gas Charge

The Purchased Gas Charge per therm shall be computed in accordance with Section 16 of the General Service Provisions and applies to all gas used during the billing month.

REVENUE NORMALIZATION ADJUSTMENT

The Distribution Charge shall be subject to the Revenue Normalization Adjustment (RNA) in accordance with General Service Provision No. 30.

MINIMUM MONTHLY BILL

The minimum monthly bill for sales service shall be the System Charge.

LATE PAYMENT CHARGE

All bills are due and payable when rendered and the charges stated apply when the bills are paid within twenty days after date of rendition. If bills are not paid within twenty days after rendition, a late payment charge will be added equal to one and one-half percent of the unpaid bill and at the end of the first nominal thirty-day billing interval after that, an additional charge of one and one-half percent of any portion of the original amount which remains unpaid, and at the end of the second thirty-day nominal billing interval, an additional charge will be made equal to 2 percent of any portion of the original amount which remains unpaid at that time; however, the total of such charges shall not exceed 5%.

FIRM CREDIT ADJUSTMENT

The charges for sales service specified in this schedule shall be subject to the Firm Credit Adjustment (FCA) in accordance with General Service Provision No. 20.

GAS SUPPLY REALIGNMENT ADJUSTMENT

The distribution charge shall be subject to the Gas Supply Realignment Adjustment (GSRA) in accordance with General Service Provision No. 26.

SPECIAL PROVISION – UNMETERED GAS FOR LIGHTING

- A. Unmetered gas sales service is available under this schedule for outdoor gas lights installed on the Company's side (upstream) of the meter on or before September 29, 1999, provided:
1. The lights conform with the Company's General Service Provisions; and,
 2. The posts and lamps are owned by and installed and maintained at the expense of the customer or property owner.

ISSUED: September 1, 2005

EFFECTIVE: For meter readings on and after October 1, 2005

Adrian P. Chapman - Vice President, Regulatory Affairs & Energy Acquisition

Firm Commercial and Industrial Sales Service - Rate Schedule No. 2 (Continued)

SPECIAL PROVISION – UNMETERED FOR GAS LIGHTING (Continued)

- B. The monthly gas consumption of the light or lights used in each installation shall be determined by multiplying the aggregate rated hourly input capacity of the light(s) by 730 hours, adjusted to reflect hours of use if applicable, and converting the product (rounded to the nearest 100 cubic feet) to therms.
- C. Where the customer does not use metered gas for other purposes under this schedule, unmetered gas used for lighting shall be billed at the rates contained herein. But where the customer also uses metered gas under this schedule, the unmetered gas used for lighting shall be added to the metered usage and the total usage billed at the rates contained herein.

CHARGE FOR TEMPORARY DISCONTINUANCE OF SERVICE

Whenever sales service under this rate schedule has been temporarily discontinued at the request of the customer, a charge equal to the System Charge times the number of months of discontinued service will be made for reestablishing such service.

GROSS RECEIPTS TAX SURCHARGE

Amounts billed to customers shall include a surcharge to reflect any increase or decrease in the effective gross receipts tax rate from the effective gross receipts tax rate in effect at the time the sales agreement became effective for service. The surcharge factor shall be computed as follows where R represents the decimal equivalent of the changed rate and E represents the existing gross receipts tax rate.

$$\text{Surcharge Factor} = (R - E) / (1 - R)$$

Such surcharge factor or any subsequently revised factor shall become effective along with the billing of revenues to which the changed gross receipts tax rate first applies. The amount of such charge shall be shown separately on bills rendered to customers.

GENERAL SERVICE PROVISIONS

Except as otherwise specifically provided herein, the application of this schedule is subject to the General Service Provisions of the Company as they may be in effect from time to time, and as filed with the Public Service Commission.

ISSUED: September 27, 2002

EFFECTIVE: For meter readings on and after September 30, 2002

Adrian P. Chapman - Vice President, Regulatory Affairs & Energy Acquisition