Ground Energy Support LLC
9 Madbury Rd Suite 402
Durham NH 03824
(603) 867-9762
www.groundenergy.com

REC 15-482

November 11, 2015

Debra Howland
Executive Director
State of New Hampshire
Public Utilities Commission
21 S. Fruit St, Suite 10
Concord, NH 03301-2429

NHPUC 13NOV15PM1:45

Dear Ms. Howland:

Please find enclosed the application for the geothermal heat pump system at 33 Cove Rd Salem NH to become registered as a Class-I Thermal generating facility pursuant to Puc 2500.

The contact information for the owner is:

Rory Neubauer
33 Cove Rd
Salem NH 03079
rory.neubauer@comcast.net

Mr. Neubauer will be using Revolution Energy Aggregation LLC as the Aggregator. Mr. Neubauer also seeks approval of using Ground Energy Support (GES) as the Independent Monitor even though she is also using metering equipment sold by GES, as approved for Rolling Dog Farm in DE 14-237.

As per the instructions, I have enclosed the originals and two copies and will forward electronic versions to yourself and Ms. Bernstein. Please let me know if you have any questions or need any additional information.

Respectfully,

J. Matthew Davis, Ph.D.
Vice President, CTO

Cc: Rory Neubauer

State of New Hampshire
Public Utilities Commission
21 S. Fruit Street, Suite 10, Concord, NH 03301-2429

DRAFT

APPLICATION FORM FOR

RENEWABLE ENERGY SOURCE ELIGIBILITY FOR
CLASS I THERMAL SOURCES WITH RENEWABLE THERMAL ENERGY CAPACITY
200,000 BTU/HR OR LESS

Pursuant to New Hampshire Administrative Code PUC 2500 Rules

- Please submit one (1) original and two (2) paper copies of the completed application and cover letter* to:
  Debra A. Howland
  Executive Director
  New Hampshire Public Utilities Commission
  21 South Fruit Street, Suite 10
  Concord, NH 03301-2429

- Send an electronic version of the completed application and the cover letter electronically to executive.director@puc.nh.gov.

* The cover letter must include complete contact information and identify the renewable energy class for which the applicant seeks eligibility. Pursuant to PUC 2505.01, the Commission is required to render a decision on an application within 45 days of receiving a completed application.

If you have any questions please contact Barbara Bernstein at (603) 271-6011 or Barbara.Bernstein@puc.nh.gov.

Only facilities that began operation after January 1, 2013 are eligible.

Is this facility part of a Commission approved aggregation?
Yes X No _____
Aggregator's Company Name: Revolution Energy Aggregation
Aggregator Contact Information: Mike Behrmann mike@rev-en.com

Contents

Attachment Labeling Instructions

Please label all attachments by Part and Question number to which they apply (e.g. Part 3-7). For electronic submission, name each attachment file using the Owner Name and Part and Question number (e.g. Pearson Part 3-7).

Part 1. General Application Information

Please provide the following information:

Applicant

Name: RORY NEUBAUER

Mailing Address: 33 COVE RD

Town/City: Salem State: NH Zip Code: 03079

Primary Contact: Rory Neubauer

Telephone: 617.834.0700 Cell:

Email Address: rory.neubauer@comcast.net

Facility

Name: NEUBAUER-GEO

Physical Address: 33 COVE RD

Town/City: Salem State: NH Zip Code: 03079

If the facility does not have a physical address, the Latitude: _____ & Longitude _____

Installer

Name: QUEST GEOTHERMAL

Installer License Number, if applicable: N/A

Mailing Address: 164 NH-108

Town/City: Somersworth State: NH Zip Code: 03878

Primary Contact: Stuart Smith

Telephone: 603-434-4278 Cell: 603-833-6240

Email Address: stuart@guestgeothermal.com

If the equipment was installed by the facility owner, check here: ☐

If the facility operator is different from the owner, please provide the following:

Facility Operator Name: _____

Facility Operator Telephone Number: _____

Independent Monitor

Name: GROUND ENERGY SUPPORT LLC

Mailing Address: 9 MADBURY RD SUITE 402

Town/City: DURHAM State: NH Zip Code: 03824

Primary Contact: Matt Davis

Telephone: (603) 867-9762 Cell: same

Email Address: mdavis@groundenergysupport.com

NEPOOL/GIS Asset ID and Facility Code

In order to qualify your facility's electrical production for RECs, you must register with the NEPOOL – GIS. Contact information for the GIS administrator follows:

James Webb
Registry Administrator, APX Environmental Markets
224 Airport Parkway, Suite 600, San Jose, CA 95110
Office: 408.517.2174
jwebb@apx.com

Mr. Webb will assist you in obtaining a GIS facility code and an ISO-New England asset ID number.

GIS Facility Code # NON56693 Asset ID #

Has the facility been certified under another non-federal jurisdiction's renewable portfolio standards?

Yes ☐ No ☒ x

If you selected yes, *please provide proof of certification in the form of an attached document as* ***Attachment 1-8.***
Attach any supplementary documentation that will help in classification of the facility as ***Attachment 1-9.***

Part 2. Technology Specific Data

All Technologies

Renewable energy source: **Solar** ☐ **Geothermal** ☒ **Biomass** ☐

Rated Thermal Capacity :

Btu/hr **55,300** MW equivalent **0.016**

Please show your calculation here: 55,300/3,412,000

Date of initial operation using renewable source: April, 2015

Part 3. Metering and Measurement of Thermal Energy and REC Calculations

This section covers the thermal metering system including methods for calculation and reporting useful thermal energy. **A copy of PUC 2506.04 of the RPS rules is included as Appendix A of this application.** Applicants for small thermal systems may choose to meter the thermal energy generated (Part 3A) or use a simplified approach employing run time meters (Part 3B) coupled with calculations to estimate energy production based on operating time.

Indicate method used and complete corresponding section of the application:

Select one	Attachment Number	Description
☐	3A (see page 5 – 6)	Metering with a Heat Meter pursuant to 2506.04(g)(1)
☐	3B-Solar (see page 7)	Runtime metering of solar thermal pursuant to 2506.04(h)
☒	3B-Geothermal (see page 7)	Runtime metering of geothermal pursuant to 2506.04(i)
☐	3B-Biomass (see page 8)	Runtime metering of biomass pursuant to 2506.04(j)

Only complete the section of the application that corresponds with the attachment number checked above.

3A. Metering with a Heat Meter

Using the table below, identify the thermal metering system packaged system or custom components (e.g., heat meters, flow meters, pressure and temperature sensors) used to measure the useful thermal energy and enter the accuracy of measurement for the entire system:

System or Component	Product name	Product Manufacturer	Model No.	Product Seller
N/A				
Total System Accuracy (Percent)		%		

Attach component specification sheets (Accuracy, Operating Ranges) as ***Attachment 3A-1.*** ☐

Attach a simple schematic identifying the location of each sensor that is part of the metering system as ***Attachment 3A-2.*** ☐

Check the applicable standard for meter accuracy prescribed in Puc 2506.04 among the six choices below (compliance with Puc 2506.04 shall be certified by a professional engineer licensed by the state of New Hampshire and in good standing):		
If the facility is using a liquid or air based system, check the method that applies:		
A	Installation and use of heat meters capable of meeting the accuracy provisions of European Standard EN 1434 published by CEN, the European Committee for Standardization. The heat meter shall have the highest Class flow meter that will cover the design flow range at the point of measurement and a temperature sensor pair of Class 5K or lower.	❑
B	Installation and use of meters that do not comply with European Standard EN 1434, provided that the manufacturers' guaranteed accuracy of the meters is ±5.0% or better,	❑
C	Use of an alternative metering method approved pursuant to Puc 2506.06.	❑

If the facility is using a steam-based system, check the method that applies:		
A	Installation and use of meters with accuracy of ±3.0% or better.	❑
B	Installation and use of meters with system accuracy that do not meet 2.b.1) but are ±5% or better.	❑
C	Use of an alternative metering method approved pursuant to Puc 2506.06.	❑

Please summarize the manufacturer's recommended methods and frequency for metering system calibration and provide reference for source document (e.g. owners/operators manual):

REC Calculation Discount Factor	
REC Calculation Discount factor for meter accuracy. (Enter 0 if no discount is required):	____ %
If the meters used to measure useful thermal energy comply with the accuracy of the European Standard EN 1434 for liquid systems or use of meters with accuracy of ±3.0% or better for steam systems enter zero, for all other systems enter the sum total of the manufacturer's guaranteed accuracy of the meters used or the accuracy of the alternative method approved pursuant to Puc 2506.06.	____ %

3B-Solar *for Systems Using Solar Technologies*

This method for calculating useful thermal energy is based on the run time of the collector system's circulating pump. Please fill out the following information regarding the meter at your facility.

Product Name N/A

Product Manufacturer _____ Model Number _____

In order to calculate the useful energy produced by a solar thermal facility, please fill out the following information on variables determined one time for the calculations:

Variable	Definition	Value	Units
R	SRCC OG100 rating on Medium Radiation C Conditions		Thousands of Btu per day
L	Orientation and shading losses		Percentage as a decimal < 1
h	Conversion factor from SRCC OG100 to hourly basis	11	Hours per day

Please refer to Appendix A, Puc 2506.04 Metering of Sources that Produce Useful Thermal Energy subpart H to determine the useful thermal energy of your facility.

3B-Geothermal *for Systems Using Geothermal Thermal Technologies*

This method for calculating useful thermal energy is based on the run time of the system's ground loop pump. Please fill out the following information regarding the meter at your facility.

Product Name GxTracker

Product Manufacturer Ground Energy Support

Model Number GxT-Power

In order to calculate the useful energy produced by a geothermal thermal facility, please fill out the following information for each heat pump installed at facility:

AHRI Certified Heat Pump Performance Ratings

N	Manufacturer	Series/Model	Part Load		Full Load
			COP [-]	HC [MBtuH]	HC [MBtuH]
1	ClimateMaster	TES049A	4.40	30,400	36,700
2	ClimateMaster	TES026A	4.30	15,800	18,600

Total system heating capacity (sum of Full Load HC): 55,300

Please refer to Appendix A, Puc 2506.04 Metering of Sources that Produce Useful Thermal Energy Subpart I to determine the useful thermal energy of your facility.

3B-Biomass *for Systems Using Thermal Biomass Technologies*

This method for calculating useful thermal energy is based on the run time of the system's fuel auger. Please fill out the following information regarding the auger at your facility.

Product Name N/A

Product Manufacturer _____

Model Number _____

In order to calculate the useful energy produced by a solar thermal facility, please fill out the following information unless it is already given:

Variable	Definition	Value	Units
D	Default pellet density	0.0231	Pounds
R	Auger revolutions		Per hour
V	Auger feed volume Assume one of the following: a. 5 cubic inches per revolution for augers with a 2" inside diameter; b. 20 cubic inches per revolution for augers with a 3" inside diameter; c. 50 cubic inches per revolution for augers with a 4" inside diameter; d. 95 cubic inches per revolution for augers with a 5" inside diameter; or e. 150 cubic inches per revolution for augers with a 6" inside diameter		Cubic inches per auger revolution
EC	Default energy content of the fuel pellet	7870	Btu/lb
ASE	Default thermal efficiency (choose one):		Percentage converted to a decimal
	☐ *Based on the manufacturer's warranty*		
	☐ *Based on average seasonal thermal efficiency*		
	☐ *Based on default value of 65%*	0.65	

Please refer to Appendix A, Puc 2506.04 Metering of Sources that Produce Useful Thermal Energy Subpart J to determine the useful thermal energy of your facility.

☐ If a thermal biomass facility, provide the New Hampshire Department of Environmental Services approval letter that the facility meets the provisions set forth in Puc 25005.02(d)15d as **Attachment 3-A.** (See the proposed best management practices that are consistent with the recommendations in the report entitled "Emission Controls for Small Wood-Fired Boilers" prepared for the US Forest Service, Western Forestry Leadership Coalition, by RSG, Inc., May 6, 2010 available at, http://www.wflccenter.org/news_pdf/361_pdf.pdf, as specified in Appendix B.

Part 4. Statements

The following statements must be completed by the owner/application preparer and a NH Professional Engineer attesting to the accuracy of the contents of the application pursuant to PUC 2505.02 (b) (14). An electronic signature is permitted pursuant to RSA 294-E.

Owner/Preparer Statement

STATEMENT

1. I, Rory Newbauer have reviewed the contents of this application and attest that it is accurate and is signed under the pains and penalties of perjury.
2. I, Rory Newbauer attest that the system is installed and operating in compliance with applicable building codes.

Applicant's Signature _____ Date 8/29/15

Applicant's Printed Name Rory Newbauer

If the applicant prepared the application leave the following blank

Preparer's Signature _____ Date 11/2/2015

Preparer's Printed Name J. Matthew Davis

Subscribed and sworn before me this 2nd Day of November (Month) in the year 2015

County of Strafford State of New Hampshire

My Commission Expires January 25, 2017

Notary Public/Justice of the Peace Seal My Commission Expires: _____ (date.)

NH Professional Engineer Affidavit

STATEMENT

I, Timothy M. Roos attest that this facility meets the requirements of the thermal REC eligibility requirements of Puc 2500, including the thermal metering and measurement methodologies and standards and REC calculation methodologies.

Professional Engineer's Signature _____ Date 10/28/15

NH Professional Engineer License Number 13296

PE Stamp

NH Independent Monitor:

Name: Matt Davis

Facility Contact:

Name: Rory Newbauer

Facility Location:

Street: 33 Cove Rd

Date: 8/29/15

City/Town: Salem

County: Rockingham

Heat Pump System Specifications

Ground Loop Supply Line: Pressure Tank [Y/N] | Water Filter [Y/N] | Flow Center [Y/N]

Source Type (check one): ☐ Ground Water (GWHP) **or** ☑ Ground Loop (GLHP)

Non-Ground Sources: Do any of the heat pumps have a supply other than ground loop? [Y/N]

N	Manufacturer	Model Series-Capacity	Name plate Photo	COP	HC	EER	Full Load HC
				Part Load, GWHP or GLHP			
1	ClimateMaster	TE5049A	☑	4.40	30,400	23.5	36,700
2	ClimateMaster	TE5026A	☑	4.30	15,800	24.5	18,600
3			☐				

Monitoring Equipment Inspection

Meter Manufacturer: Grnd Energy Support Model: GXT-PowerPlus

HP	EWT Sensor	LWT Sensor	Runtime Sensor	Run Cycle	✓
1	Type: OMP ID: 11339	Type: OMP ID: 11338	Type: CT ID: 10180	Start: 10:19 End: 10:27	☑
2	Type: OMP ID: 11336	Type: OMP ID: 11337	Type: CT ID: 10179	Start: 10:30 End: 10:50	☑
3	Type: ID:	Type: ID:	Type: ID:	Start: End:	☐

Temp sensors: **OMP**=on metal pipe; **OPP**=on plastic pipe; **TW**=thermal well, **HP**= inside heat pump

Runtime sensors: **CS**= current switch; **CT** = current transducer; **FM** = Flowmeter.

✓ indicates heat pump cycle was correctly recorded by meter.

Meter Readings:

☐ **ONLINE:** Connection type: ☐ Direct Ethernet ☑ Powerline Adapter ☐ Wireless

☐ **MANUAL:** Photograph meter display and note location of heating runtime [hrs]. ☐

Useful Thermal Energy:

Description of Use(s): Residential heating & cooling

Conditioned Space (Square Feet): 3800 SF

Unusual circumstances, if any: None.

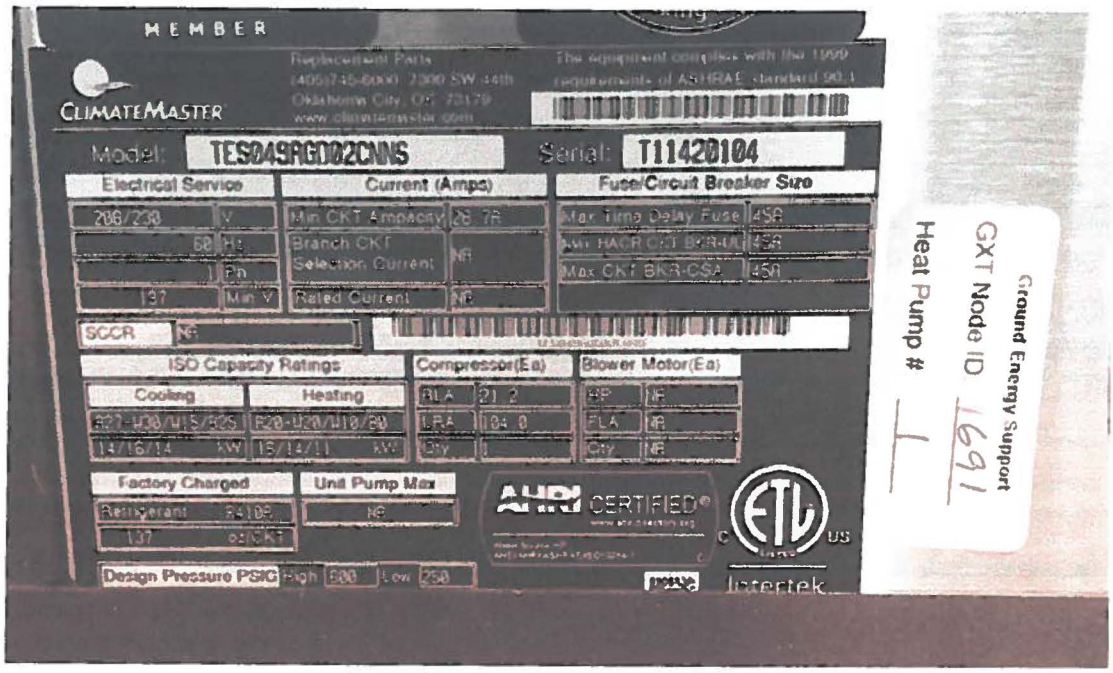
GL0181 is Elec Htd Water

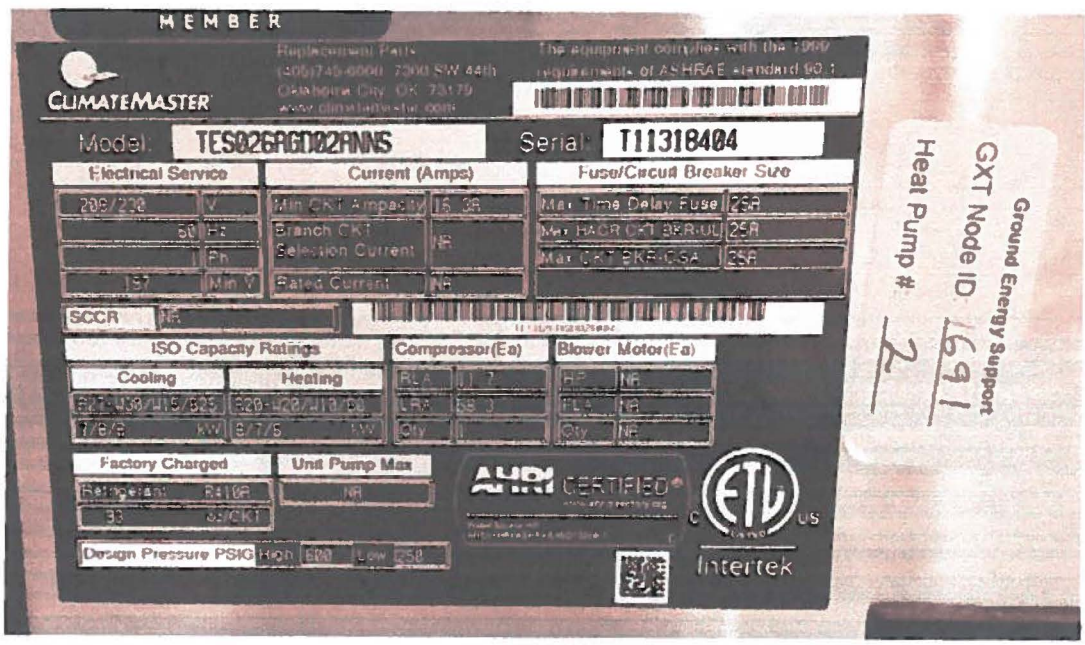
Total System Heating Capacity (sum of Full Load HC on previous page): 55300

Nameplate Photographs:

See attached

Independent Monitor Signature: [signature] Date: 8/29/15


MEMBER
CLIMATEMASTER
Model: TES049RGD02CNNS
Serial: T11420104
Electrical Service
208/230 V
60 Hz
1 Ph
197 Min V
Current (Amps)
Min CKT Ampacity 28.7R
Branch CKT Selection Current NR
Rated Current NR
Fuse/Circuit Breaker Size
Max Time Delay Fuse 45R
Max HACR CKT BKR-UL 45R
Max CKT BKR-CSA 45R
SCCR NR
ISO Capacity Ratings
Cooling
Heating
14/16/14 kW
15/14/11 kW
Compressor(Ea)
RLA 21.2
LRA 104.0
Qty 1
Blower Motor(Ea)
HP NR
FLA NR
Qty NR
Factory Charged
Refrigerant R410A
137 oz/CKT
Unit Pump Max
NR
Design Pressure PSIG High 600 Low 250
AHRI CERTIFIED
ETL US
Intertek
Ground Energy Support
GXT Node ID 1691
Heat Pump # 1


MEMBER
CLIMATEMASTER
Model: TES026RGD02ANNS
Serial: T11318404
Electrical Service
208/230 V
60 Hz
1 Ph
187 Min V
Current (Amps)
Min CKT Ampacity 15.3R
Branch CKT Selection Current NR
Rated Current NR
Fuse/Circuit Breaker Size
Max Time Delay Fuse 25R
Max HACR CKT BKR-UL 25R
Max CKT BKR-CSA 25R
SCCR NR
ISO Capacity Ratings
Cooling
Heating
7.6/8 kW
8/7/5 kW
Compressor(Ea)
RLA 11.7
LRA 58.3
Qty 1
Blower Motor(Ea)
HP NR
FLA NR
Qty NR
Factory Charged
Refrigerant R410A
33 oz/CKT
Unit Pump Max
NR
Design Pressure PSIG High 600 Low 250
AHRI CERTIFIED
ETL US
Intertek
Ground Energy Support
GXT Node ID 1691
Heat Pump # 2

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www.ahridirectory.org

This combination qualifies for a Federal Energy Efficiency Tax Credit when placed in service between Jan 1, 2006 and Dec 31, 2016 and used in GLHP or GWHP application point.

Certificate of Product Ratings

AHRI Certified Reference Number: 5591629 Date: 8/29/2015 †Status: Active

Product: Water/Brine to Air Heat Pump Split System
Model Number: TES/P049A
Indoor Model Number: TAC049A
Manufacturer: CLIMATE MASTER, INC.
Trade/Brand name: TRANQUILITY 27 DIGITAL SPLIT

HP 1

Rated as follows in accordance with ANSI/AHRI/ASHRAE/ISO Standard 13256-1 for Water-to-Air and Brine-To-Air Heat Pumps and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

Air Flow Rate - Cooling:	1550.0 / 1550.0	Air Flow Rate - Cooling - Part Load	1400.0 / 1400.0
Air Flow Rate - Heating:	1650.0 / 1650.0	Air Flow Rate - Heating - Part Load	1400.0 / 1400.0

WLHP (Water-Loop Heat Pumps)	**Full Load**	**Part Load**
Cooling Capacity(Btuh)	48000 / 48000	35600 / 35600
Cooling EER Rating(Btuh/watt)	16.10 / 16.10	17.10 / 17.10
Cooling Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00
Heating Capacity(Btuh)	54500 / 54500	42800 / 42800
Heating COP(watt/watt)	5.20 / 5.20	6.00 / 6.00
Heating Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00
GWHP (Ground-Water Heat Pumps)		
Cooling Capacity(Btuh)	52700 / 52700	40000 / 40000
Cooling EER Rating(Btuh/watt)	23.40 / 23.40	28.10 / 28.10
Cooling Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00
Heating Capacity(Btuh)	47200 / 47200	35300 / 35300
Heating COP(watt/watt)	4.70 / 4.70	5.10 / 5.10
Heating Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00
GLHP (Ground-Loop Heat Pumps)		
Cooling Capacity(Btuh)	48800 / 48800	38600 / 38600
Cooling EER Rating(Btuh/watt)	17.70 / 17.70	23.50 / 23.50
Cooling Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00
Heating Capacity(Btuh)	36700 / 36700	30400 / 30400
Heating COP(watt/watt)	4.00 / 4.00	4.40 / 4.40
Heating Fluid Flow Rate(gpm)	12.00 / 12.00	11.00 / 11.00

* Ratings followed by an asterisk (*) indicate a voluntary rerate of previously published data, unless accompanied with a WAS, which indicates an involuntary rerate.

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CERTIFICATE NO.: 130853394609075334

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This combination qualifies for a Federal Energy Efficiency Tax Credit when placed in service between Jan 1, 2006 and Dec 31, 2016 and used in GLHP or GWHP application point.

Certificate of Product Ratings

AHRI Certified Reference Number: 5590833 Date: 8/29/2015 †Status: Active

Product: Water/Brine to Air Heat Pump Split System
Model Number: TES/P026A
Indoor Model Number: TAC026A
Manufacturer: CLIMATE MASTER, INC.
Trade/Brand name: TRANQUILITY 27 SPLIT

HP 2

Rated as follows in accordance with ANSI/AHRI/ASHRAE/ISO Standard 13256-1 for Water-to-Air and Brine-To-Air Heat Pumps and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

Air Flow Rate - Cooling:	850.0 / 850.0	Air Flow Rate - Cooling - Part Load	750.0 / 750.0
Air Flow Rate - Heating:	950.0 / 950.0	Air Flow Rate - Heating - Part Load	850.0 / 850.0

WLHP (Water-Loop Heat Pumps)	**Full Load**	**Part Load**
Cooling Capacity(Btuh)	25000 / 25000	19200 / 19200
Cooling EER Rating(Btuh/watt)	16.20 / 16.20	17.90 / 17.90
Cooling Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00
Heating Capacity(Btuh)	28500 / 28500	22500 / 22500
Heating COP(watt/watt)	5.20 / 5.20	6.00 / 6.00
Heating Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00
GWHP (Ground-Water Heat Pumps)		
Cooling Capacity(Btuh)	27900 / 27900	21700 / 21700
Cooling EER Rating(Btuh/watt)	24.40 / 24.40	29.90 / 29.90
Cooling Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00
Heating Capacity(Btuh)	24400 / 24400	18400 / 18400
Heating COP(watt/watt)	4.70 / 4.70	5.00 / 5.00
Heating Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00
GLHP (Ground-Loop Heat Pumps)		
Cooling Capacity(Btuh)	25700 / 25700	20700 / 20700
Cooling EER Rating(Btuh/watt)	18.20 / 18.20	24.50 / 24.50
Cooling Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00
Heating Capacity(Btuh)	18600 / 18600	15800 / 15800
Heating COP(watt/watt)	3.80 / 3.80	4.30 / 4.30
Heating Fluid Flow Rate(gpm)	8.00 / 8.00	7.00 / 7.00

* Ratings followed by an asterisk (*) indicate a voluntary rerate of previously published data, unless accompanied with a WAS, which indicates an involuntary rerate.

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CERTIFICATE NO.: 130853395497206106

Geothermal Heat Pump Runtime Metering

Document applies to:

GxTracker-Basic
GxTracker-Power
GxTracker-PowerPlus

The GxTracker™ is an easy-to-install web-based monitoring system that displays ground source heat pump (GSHP) system operating data an online data portal.

Heat Pump runtimes are stored in separate heating- and cooling-runtime registers and can be used to compute Useful Thermal Energy produced in compliance with New Hampshire Public Utilities Commission (Proposed) Rule 2500.

System Components: Each GxTracker Monitoring System consists of three essential components to measure heating runtime:

- Ethernet gateway to transmit data to GES server
- On-pipe temperature sensor pair to measure entering and leaving water temperatures (EWT and LWT)
- Current or flow sensing device to detect heat pump activity

System Requirements:

- Always-on internet connection.*
- Exposed entering and leaving water pipes.
- Up to three geothermal heat pumps.

* *Thermal energy produced when GxTracker is offline will not be reported and Thermal RECs are forfeited.*

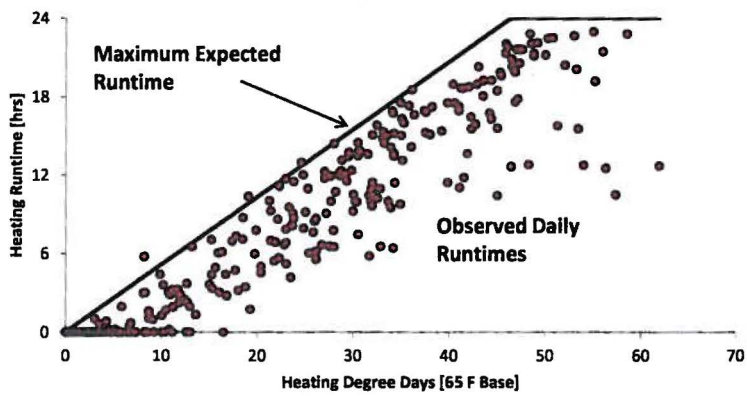
Operating Algorithm:

1. Heat Pump data is posted to GES server once per minute using local internet connection.
2. Heat Pump On/Off status determined from electric input to compressor (current switch, current transducer, or watt meter) or inline flowmeter.
3. **If EWT > LWT,** time interval is registered as "HEATING"
   If EWT < LWT, time interval is registered as "COOLING"
4. **Thermal Energy Produced (*Q*)** is calculated daily using the AHRI Certified COP and Heating Capacity (*HC*) and the metered heating runtime (*t*). $$Q = \frac{HC \cdot (COP - 1) \cdot t}{COP}$$

Quality Assurance: AHRI Certified COP and Heating Capacity and the continuous heat pump operating data are stored in a centralized and secure database, insuring reliable calculation of runtimes and the corresponding thermal energy production. Raw data is backed-up daily to an offsite location and stored for at least 90 days, allowing for independent verification, if necessary.

Quality Control: For geothermal heat pumps that are providing building heating and cooling, GES develops a characteristic usage profile for each facility based on average outdoor air temperatures. GES staff are alerted to significant departures from the profile, enabling a check of meter operation and accuracy.

Runtime Accuracy: The nominal 1-minute sampling interval used by the GxTracker devices result in a typical daily runtime error of less than 0.5%.



Calibration Requirements: Metering of heating-mode runtimes uses amperage and temperature thresholds that exceed the sensor and drift errors of any sensors used; therefore no calibration is required.