January 15, 2014

Lisa A. Skumatz, Ph.D.
Skumatz Economic Research Associates (SERA)
762 Eldorado Drive
Superior, Co. 80027

RE: CL&P Review of the Connecticut Ground Source Heat Pump (GSHP) Impact Evaluation and Market Assessment

Dear Ms. Skumatz,

The Connecticut Light and Power Company (CL&P) is pleased to submit these written comments with regard to a draft evaluation report: *Connecticut Ground Source Heat Pump Impact Evaluation & Market Assessment* (Study), December 10, 2013, NMR Group, Inc. and DNV KEMA (authors). The draft Study was submitted to CL&P on December 10, 2013 with a request for comments to be provided by January 15, 2014.

The primary purpose of the Study was to provide performance and savings information on residential GSHPs to the administrators of the GSHP Program in Connecticut: the electric utilities (CL&P, The United Illuminating Company), and the Connecticut Energy Financing and Investment Authority (CEFIA). The objectives of the Study include the following:

- Quantify energy and peak demand savings of the Connecticut GSHP programs
- Quantify improvements in air quality
- Assess the GSHP program for potential improvements
- Assess the market for GSHPs in Connecticut

CL&P has conducted a thorough review of the Study and finds some of the results, conclusions and recommendations to be valid and beneficial. CL&P is proud that the Study recognizes that the utility GSHP program has been successful at pushing industry to higher standards of design and installation, providing energy savings, and providing quality assurance to customers. However, the Study is deficient and has several shortcomings. CL&P believes that some of the results within the Study may be based on flawed methodologies and several questionable and potentially incorrect assumptions regarding critical performance characteristics of GSHPs and

the purpose of the utility-administered GSHP program. In addition, the Study glosses over many important details which could help further refine and improve the utility GSHP program.

CL&P suggests that the Evaluation Consultant recommend a second draft of the Study be issued, with additional opportunity to provide comments on the second draft prior to the Study being finalized. The updated draft should provide additional detail on the methodology used, correct any significant errors in the methodology, and provide technical justification for the methodology and assumptions that were used. CL&P thanks the Evaluation Consultant for considering this request for a second draft. CL&P will limit comments on this draft primarily to the methodology and assumptions that were used (rather than the results) and reserves the right to provide additional comments on a second draft.

CL&P is pleased to be able to provide the following comments to the draft Study.

Program Staff Knowledge. Based on contractor interviews, the Study recommended that program staff obtain additional training in regards to ground source heat pumps. CL&P believes these comments may stem from contractor frustration when VIP submittals were rejected. CL&P is deeply troubled by this recommendation. It appears that some of these comments from contractors may have been made out of frustration as a result of having to comply with rigid design and installation criteria, which have been implemented by the utility program administrators for the protection of its customers. Currently, CL&P energy efficiency program staff includes five staff people who have successfully obtained certification from the International Ground Source Heat Pump Association (IGSHPA) - the gold standard in GSHP design. Additionally, one of these staff people is a Professional Engineer (PE). The primary program administrator during the time period of this study was a State of Connecticut-licensed HVAC contractor with 36 years of experience. The utilities have also coordinated and arranged IGSHPA certified training for contractors, offered training on the VIP tool, explained its use, and solicited feedback from contractors. CL&P is disappointed that the evaluators made such a recommendation without reaching out to CL&P to verify a lack of staff credentials, and requests that the Study recognize the expertise of the utility program staff that implements the utility GSHP Program.

Performance Comparison. The Study appears to compare measured GSHP performance to the manufacturers' rating data based on Air-Conditioning, Heating, and Refrigeration Institute (AHRI)[1] rating conditions. The measured energy usage appears to be appropriately based on the total system energy consumption. However, AHRI ratings do not include the fan power needed to overcome the resistance of the ducts, nor does it include pumping power necessary to overcome the resistance of the ground loop, i.e. AHRI rating only considers *partial* energy consumption of a GSHP unit.[2] The Study appears to make a one-to-one comparison between

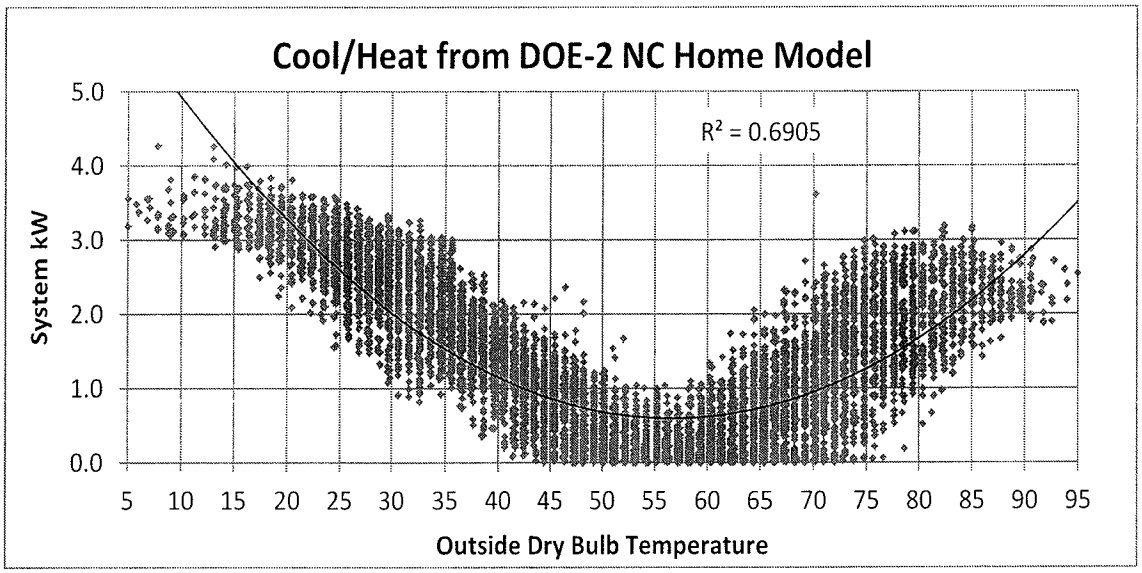
[1] http://www.ahrinet.org/geothermal+_+water_source+heat+pumps.aspx

[2] Residential Ground-Source Heat Pumps: In-Field System Performance and Energy Modelling. Steven Winters Associates Inc. Norwalk, CT

AHRI rated (partial) performance and actual measured (full) performance without attempting to adjust for the significant difference between the different criteria. The Study results should be corrected if necessary, or additional data should be provided, to appropriately address fan and pumping power under actual conditions (which are not currently addressed in the AHRI ratings), and the comparisons between installed and rated efficiencies should be adjusted accordingly. Any adjustments to AHRI ratings should be documented in future drafts of the Study. In addition, the Study should provide guidance on how the Program Savings Documentation (PSD) should be updated in conjunction with the new realization rates, and provide a precision value for the realization rates and savings estimates in the Study.

Metered Data. Based on Figures 1-1 and 1-2 from the Study, systems appear to be using significant amount of energy during shoulder periods. For example, based on Figure 1-2 (reproduced below) and normal weather patterns, it appears this system is using approximately 3,000 kWh annually during periods when there would be little or no heating or cooling load. Figure 1-1 shows similar results. This finding needs to be examined to identify what this energy is being used for (fan, standby load and zone controls, water, other), and appropriate recommendations made to reduce this load and increase energy savings.

Figure 1-2. DOE-2 New Construction Model GSHP System Power vs. Temperature



VIP Requirements. Based on several contractor interviews, the Study recommends that CL&P redesign its VIP spreadsheet to be more flexible. CL&P requests feedback on how the VIP tool

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http://www.builditsolar.com/Projects/SpaceHeating/InField%20PerformanceTestingofGSHP_updated%2011_11_2010.pdf

can be made more flexible. VIP program requirements attempt to strike a balance, ensuring a proper installation yet allowing for some measurement uncertainty. The requirements are reasonable, and experienced contractors typically do not have compliance issues. In some situations, VIP certifications are rejected, but only in cases where there are significant operating deficiencies that are identified, and only when the contractor fails to make appropriate corrections to the system. For example, the following is an example of a VIP which was rejected. Note that the VIP identified low water flow, high pumping power, low COP (-39%), and low capacity (-60%). Collectively, these results suggest that the GSHP unit was severely malfunctioning – a situation that would likely translate to very high energy bills. In this type of situation, CL&P program administrators work collaboratively with the installing contractor to identify and correct problems.

GSHP Field Verification Worksheet--Closed Loop

Customer Name	Address	Town	Zip	Date	Installer	Technician
XXXXX	XXXXX					
Manufacturer	Model #	Year built		Nominal tons	Desuperheater?	Version 1.4
XXXXX	XXXXX			4	Y	

Manufacturers Performance Data Inputs

Are P/T Ports Present?				Enter GPM and PSI data for closest EWT		
Y	ECM blower speed setting in CFM, top left (C9,blue) only			Factory coil data, GPM top row / PSI bottom row		
Blower Type	1700			6	9	12
ECM				2.3	4.4	7

Assessment Disable desuperheater, check registers open, I.D. circuit breakers

Filter condition	Coil condition	Strip heat present?	Strip heat controlled by correct thermostat stage?		
Clean	Clean	Y	Y		
Supply plenum (in. w.g.)	Return plenum (in w.g.)	Total blower ESP		Air Flow CFM	
0.15	0.15	0.30		1700	

Capacity Test Disable strip heater during test

Operating mode	After 20 Minutes run time:	In	Out	Difference		GPM (meas.)
H	Air temp at air handler	64	92	28		4.6
	Water temperature	47	42	5	GPM	GPM/nom ton
	Water Pressure	12.5	11	1.5	4.6	1.1

Power consumption--Heat pump unit			Power consumption--pump			ARI compare:
Amps	Volts	--	Amps	Volts	--	Low water flow
11.2	242		1.5	242		High pump pwr

How is Pump powered?	Net Equipment Watts	Net pump watts
Through equipment	2013	290

Results

Total Capacity (water side)	--	HE (measured)	Unit watts	Unit COP	System watts	System COP
17,904	--	11,038	2013	2.6	2304	2.3
Capacity factory spec	--	HE factory spec	Watts factory sp	Unit COP spec		ARI 330 COP
44,400	--	32,600	3480	4		3.74
Capacity diff (%)		HE difference (%)	Watts diff. %	COP diff %		System COP diff
-60%		-66%	-42%	-30%		-39%
Low Capacity		Low HE	Low unit powe	Low COP		To compare

Notes/Comments:

1st FI Unit	CLP PA revised to Heat Controller Eng Guide on 1/14/09
2)	specs are pure water,lower of dual volt systems@ 70Deg EAT no corrections
3)	COP is ISO 13256 not AHRI 330
	Failed VIP, Check water flow.

The tool mirrors typical manufacturer start-up procedures[3] and was developed in an effort to reduce the number of problematic GSHP installations. CL&P recognizes that some contractors

[3] See for example, http://www.waterfurnace.com/literature/5series/IM2500AN.pdf.

feel that the tool represents unnecessary work. However, CL&P feels strongly that the tool helps provide quality assurance to its customers (as is the case above where a problematic installation was identified) and contributes to the very high level of customer satisfaction reported by the Study (98%). CL&P requests that the Study provide guidance on pass/fail guidelines that can be used by the utility program administrators going forward. The guidelines should be reasonable, allow for some degree of measurement uncertainty, yet provide assurance to customers that systems are designed and installed properly.

VIP Tool Recommendations. The VIP tool was developed by CL&P with the help of a nationally recognized expert on building science and GSHPs[4] in 2006. CL&P believes (as the Study pointed out) that the tool has tremendous value in helping contractors understand performance characteristics of GSHPs and ensure that systems are installed correctly. The VIP program has been acknowledged by a nationally recognized GSHP designer[5] as leading-edge, and anecdotally has helped mitigate many problematic installations, thus saving customers considerable energy, expense, and aggravation.

CL&P was expecting that the Study would provide concrete technical recommendations on how the VIP tool can be further enhanced to better provide additional assurance that systems are installed correctly and operating efficiently. To that point, the Study states that "special emphasis was placed on gathering descriptive and performance data on the ground source heat pumps and their associated systems, including compressors, fans, pumps, desuperheaters and ground loops".

Unfortunately, the Study failed to provide any meaningful feedback on the design and performance of these system components which could be used to aid the utility program administrators. Specifically, CL&P requests that the Study provide specific feedback on the VIP tool's effectiveness as well as technical and programmatic modifications that can be incorporated into future iterations of the VIP tool and utility program offering. The Study should provide results on how effective the tool is at controlling critical performance variables including pumping power, fan power, water flow, static pressure, etc. The Study should validate the VIP tool and its components and/or make specific recommendations for improvements on how the tool works, measurements that should be taken, calculations within the tool, and pass/fail criteria that should be used.

Loop Design and Ground Loop Performance. The results of this section seemed to gloss over and ignore critical design and performance results. Loop design (including loop size, layout, pipe selection, existence of turbulence within the loop, thermal conductivity of the

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[4] Bruce Harley, Conservation Services Group. See http://www.builditsolar.com/Projects/SpaceHeating/Builder's%20Guide%20to%20GeoThermal.pdf

[5] Utility staff conversations with Terry Proffer. Mr. Proffer is an IGSHPA accredited installer, IGSHPA/NATE certified installation trainer, Certified GeoExchange Designer (CGD), and AEE/IGSHPA CGD trainer. http://www.majorgeothermal.com

ground and pump selection) is a critical component of GSHP design and installation. The Study's surprisingly simple conclusion was that loops were performing satisfactorily based on a calculation of heat extraction. While this finding may be true, it fails to indicate whether loop designs were optimized based on initial cost, pipe selection, pumping power, etc. For example, a loop field can be poorly designed (e.g. large field, small diameter pipe, high pumping power, high water flow) and still extract (or reject in cooling mode) sufficient heat. However, in this example, the initial cost may be higher and the system could cost significantly more to operate. The results of the long term metering should include detailed findings in regards to loop design and ground loop performance. Furthermore, program recommendations should be made where appropriate to ensure that loop designs are optimized, not just functioning.

Duct Leakage and Building Shell Measurements. The results of this section again appear to gloss over critical program components. CL&P requests that duct leakage and building shell measurements be included in the Study, and that recommendations be made that can further enhance the effectiveness of the utility GSHP program by tightening duct and shell requirements, thus providing additional energy savings to customers.

System Sizing. The Study suggests that most systems are grossly oversized for cooling, but appropriately sized for heating. However, the Study fails to mention the existence of dual-speed equipment (note that most equipment in the sample appears to be dual speed equipment). One recognized advantage of installing dual-speed equipment is that the heating and cooling loads can be better matched to equipment capacities by sizing the heating load to the maximum heating capacity of the equipment and sizing the cooling load to the low-speed cooling, mitigating the oversizing factor. Thus, dual speed equipment allows customers to reap the benefits of more efficient and effective cooling by running on low speed during the cooling season. CL&P suggest that the Study make recommendations in regard to system sizing that appropriately consider the existence of dual-speed equipment.

Net-to-Gross. The utility net-to-gross calculations are based on customer interviews which assess how effective incentives are at steering customers towards a GSHP. While the results are informative and shed light on the customer decision making process, they fail to consider that the utility savings is based on successful design and installation (verified based on successful VIP completion). However, the results (net-to-gross) are based on the assumption that the purpose of the utility incentive program is to provide an incentive to customers for installing a GSHP in place of a fossil fuel heating system. The primary purpose of the utility incentive is to ensure a high efficiency, *properly performing* system. While it is true that some customers would install a GSHP without utility incentives, it is possible that some of these systems would be plagued by design and installation problems absent the utility program. Therefore, CL&P suggests that the utility net-to-gross ratios should also consider how effective the utility VIP program is at ensuring proper installation (and thus generating energy savings), rather than relying exclusively on customer interviews and their decision to install a GSHP.

Lastly, CL&P is requesting that all data and modeling results pertaining to the Study be included in the appendices.

Thank you for the opportunity to provide these constructive comments.

Very truly yours,

Joseph Swift
Operations Supervisor