STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-1. What is the anticipated heat rate of Invenergy's proposed facility when it is burning natural gas?

RESPONSE 2-1: Estimated Net Plant Heat Rate on natural gas: 6,254 BTU/kWh (HHV)

Basis:
Average annual temperature 52 deg. F, 74% relative humidity
Evaporative coolers off
Supplement duct firing off
100% load
New and clean condition

RESPONDENT: John Niland, Director Business Development, Invenergy

DATE: April 14, 2016

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

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2-2. What is the anticipated heat rate of Invenergy's proposed facility when it is burning ultra-low sulfur diesel fuel (ULSD)?

RESPONSE 2-1: Estimated Net Plant Heat Rate on ULSD: 7,171 BTU/kWh (HHV)

Basis:
Winter temperature 20 deg. F, 60% relative humidity
Evaporative coolers off
Supplement duct firing off
100% load
New and clean condition

RESPONDENT: John Niland, Director Business Development, Invenergy

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

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2-3. Does Invenergy anticipate burning any oil distillate other than ULSF? If yes, please explain.

RESPONSE 2-3: No.

RESPONDENT: John Niland, Director Business Development, Invenergy

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

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2-4. In Invenergy's internal documents, including financial pro-forma, how many hours per year does Invenergy calculate the proposed facility will run on ULSD or any oil distillate? (If the number of hours per year varies from year to year, please specify the number of hours for each operating year.)

RESPONSE 2-4: The Project's dual fuel capability is being provided so that the project can meet the ISO-New England's "Pay For Performance" requirement in the Tariff. We only use oil on an as needed basis, no specific number of hours per year has been determined or assumed in in our financial pro-forma. The plant air permit application states that Invenergy is proposing to permit the gas turbines to operate for the equivalent total ULSD fuel usage of up to 60 days per year at base load when natural gas is unavailable only. It is expected that the gas turbines will only fire ULSD fuel during the winter months when commercial and residential natural gas usage for heating purposes is at its peak. ULSD will be used when natural gas supply is not available.

RESPONDENT: John Niland, Director Business Development, Invenergy
Michael Fienblatt, ESS Group, Inc.

DATE: April 14, 2016

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
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2-5. In Invenergy's January 12, 2016 PowerPoint presentation to the EFSB, Slide 24, Invenergy projects $46 million in "energy cost savings" (not capacity costs) during the first three years of operation.

(a) For each of the first three years of operation, what assumption was made as to the number of hours during the operating year the plant would be operating at full load equivalent?
(b) For each of the first three years of operation, what assumption was made as to the number of hours during the operating year the plant would be burning ULSD?
(c) For each of the first three years, what assumption was made as to the number of megawatt-hours of energy the plant would sell into the ISO-NE market?

RESPONSE 2-5: The dispatch model determined the number of operating hours as an output based on the forecasted market power prices. No assumption was made relating to the number of hours operating or the number of hours on oil. The facility's ability to use oil is merely a backup, provided for electric reliability purposes in the event natural gas is not available. Natural Gas ("NG") was assumed to be available in every hour and NG was assumed to be the most economic fuel for the plant throughout the commitment period. All of the facility's production was assumed to be sold into the ISO-NE market and the dispatch model results for the 1x1 configuration from January 2016 are shown in the table below.

Year	**6/19-5/20**	**6/20-5/21**	**6/21-5/22**
GWh	4,207	4,130	3,975
hours operating	7,822	7,686	7,403
hours operating at full load	7,642	7,504	7,211

RESPONDENT: John Niland, Director Business Development, Invenergy
Mark Repsher, PA Consulting
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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC)
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2-6. In Invenergy's January 12, 2016 PowerPoint presentation to the EFSB, Slide 24, Invenergy projects $23 million in "energy cost savings per year" (not capacity costs) after the first three years of operation.

(a) How many additional years (beyond the first three) did Invenergy perform this calculation?

(b) For each year referred to in sub-section (a), above, for which "energy cost savings per year" were calculated, what assumption was made as to the number of hours during the operating year the plant was operating at full load equivalent?

(c) For each year referred to in sub-section (a), above, for which "energy cost savings per year" were calculated, what assumption was made as to the number of hours during the operating year the plant would be burning ULSD?

(d) For each year referred to in sub-section (a), above, for which "energy cost savings per year" were calculated, what assumption was made as to the number of megawatt hours of energy the plant would sell into the ISO-NE market?

RESPONSE 2-6:

(a) For ratepayer savings, Invenergy only ran the model for seven years.
(b) No assumption was made relating to the number of operating hours, the model determined the plant dispatch based on demand in the ISO-NE market.
(c) No assumption was made for the number of hours on oil, and the model determined the most economic dispatch that resulted in the plant burning natural gas in all hours.
(d) The results of the plant dispatch was based on the assumption that all of the energy produced would be sold into the ISO-NE market.

RESPONDENT: John Niland, Director Business Development, Invenergy
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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

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APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
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2-7. (a) In Invenergy's projections of $46 million in "energy cost savings" (not capacity costs) during the first three years of operation, please state which of the following plants were included (and which were not included) in the dispatch model for each of Capacity Commitment Periods 10, 11, and 12 : Medway, Massachusetts (for the 200 MW that acquired a Capacity Supply Obligation in FCA-9); Brayton Point 1; Brayton Point 2; Brayton Point 3; Brayton Point 4; Bridgeport Harbor 2; Bridgeport Harbor 3; Bridgeport Harbor 6; Canal 1; Canal 2; Canal 3; Merrimack 1; Merrimack 2; Middletown 2; Middletown 3; Middletown 4; Montville 5; Montville 6; Mount Tom 1; Mystic 7 GT; New Haven Harbor; Newington 1; Norwalk Harbor 1; Norwalk Harbor 2; Schiller 4; Schiller 6; West Springfield 3; Yarmouth 1; Yarmouth 2; Yarmouth 3; Yarmouth 4.

(b) In Invenergy's projections for energy cost savings (not capacity costs) after the first three years of operation, which of the plants listed in sub-part (a) of this question were included (and which were not included) in the dispatch model for each additional Capacity Commitment Period for which Invenergy did modeling.

RESPONSE 2-7: (a) Any plant that has announced that its retirement would occur before June 1 2019 was not included When analyzing the energy savings "with" and "without" Clear River, retirement assumptions were held consistent (as well as the facilities, like Medway, that have acquired past Capacity Supply Obligations). See table below (I = Included; N = Not Included).

	FCA10	FCA11	FCA12	FCA13	FCA14	FCA15
Medway	I	I	I	I	I	I
Brayton Point 1	N	N	N	N	N	N
Brayton Point 2	N	N	N	N	N	N
Brayton Point 3	N	N	N	N	N	N
Brayton Point 4	N	N	N	N	N	N
Bridgeport Harbor 2	N	N	N	N	N	N
Bridgeport Harbor 3	I	I	N	N	N	N
Bridgeport Harbor 6	I	I	I	I	I	I
Canal 1	I	I	I	I	I	I
Canal 2	I	I	I	I	I	I
Canal 3	I	I	I	I	I	I
Merrimack 1	I	I	I	I	I	I
Merrimack 2	I	I	I	I	I	I
Middletown 2	I	I	I	I	I	I

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC)
APPLICATION TO CONSTRUCT AND OPERATE THE) Dkt. 4609
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,)
RHODE ISLAND)

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

Middletown 3	I	I	I	I	I	I
Middletown 4	I	I	I	I	I	I
Montville 5	I	I	I	I	I	N
Montville 6	I	I	I	I	I	I
Mount Tom 1	N	N	N	N	N	N
Mystic 7 GT	I	I	I	I	I	I
New Haven Harbor	I	I	I	I	I	I
Newington 1	I	I	I	I	I	I
Norwalk Harbor 1	N	N	N	N	N	N
Norwalk Harbor 2	N	N	N	N	N	N
Schiller 4	I	I	I	N	N	N
Schiller 6	I	I	I	I	I	I
West Springfield 3	I	I	I	I	I	I
Yarmouth 1	I	I	I	I	I	I
Yarmouth 2	I	I	I	I	I	I
Yarmouth 3	I	I	I	I	I	I
Yarmouth 4	I	I	I	I	I	I

(b) Any plant that has announced it retirement after June 1, 2019 would be removed from the model when its announced retirement date is reached. When analyzing the energy savings "with" and "without" Clear River, retirement assumptions were held consistent (as well as the facilities, like Medway, that have acquired past Capacity Supply Obligations).

RESPONDENT: John Niland, Director Business Development, Invenergy
Mark Repsher, PA Consulting
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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
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RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

NOTE: THE CONSERVATION LAW FOUNDATION DELIBERATELY OMITTED DATA REQUESTS 2-8, 2-9, 2-10 AND 2-11 WHEN FILING ITS REQUEST WITH THE PUBLIC UTILITIES COMMISSION.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

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APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
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RHODE ISLAND	**)**	

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2-12. Invenergy states that its proposed facility will be useful to "balance the variable output from wind and solar resources" because of its "fast-start capability." (January 12, 2016 PowerPoint, Slide 25.) Please describe in detail the ability of the Invenergy's proposed plant to provide load following and regulation service to support variable-output resources.

RESPONSE 2-12: The Invenergy Clear River combined-cycle power plant is designed around the latest gas turbine technology that has been designated the "H" class. Clear River has selected the Power Island, which consists of a gas turbine, steam turbine and heat recovery steam generator ("HRSG") from GE which utilizes the GE 7HA.02 gas turbine integrated with state-of-the art steam turbine and HRSG technologies.

Clear River is able to provide a high efficiency gas turbine that delivers the lowest combined cycle plant heat rate and best-in-class operational flexibility. The 7HA.02 technology is the heart of the Clear River power plant, and any response to load or frequency is controlled through the gas turbine governor and control system. The control system has the ability for faster responding and more flexible plant response to market demands and has the ability to meet the needs of the ISO-NE as it experiences higher levels of renewable penetration. The Clear River plant is a dispatchable resource that provides high rates of load change, fast response to frequency and voltage variation, and is able to do all of this while providing efficient and reliable generation.

The H technology gas turbine utilized in the Clear River project has the ability to respond rapidly to the system operator's command signals. The gas turbine is capable of ramping load, increasing or decreasing, at a rate of 50 MW/minute per gas turbine. This corresponds to the equivalent of a typical 50 MW peaking plant coming online in 1 minute – a capability which is not technically feasible with today's peaking technology (average start times are 10 minutes or longer for a small peaking combustion turbine). The Clear River plant will be able to provide a constant bi-directional regulation service to the ISO-NE while maintaining emissions compliance and reliable, efficient active power control. In the case of Clear River, with a 2 unit configuration, the plant would be able to provide double the amount of regulation capacity explained herein.

The typical operating range of the Clear River plant will be from approximately 45% to 100% of plant base load. This wide operating range is made possible by the gas turbine turndown capability (ability to operate at partial loads while maintaining emissions compliance). The gas turbine, as previously noted, is capable of ramping from minimum load to base load at 50 MW/minute. The steam turbine output will lag behind the ramping rate of the gas turbine due to the thermal lag in steam generation. Considering the gas turbine contribution only, the ramping response range is equivalent to approximately 200 MW of output range per unit. The ISO-NE could utilize either or both of the Clear River units to meet +/- 100 MW of regulation capability by targeting the dispatch point of the plant at the mid-point of its regulation range on any given day. To put this into perspective, the Clear River plant (both unit contribution) could provide roughly 200 MW of load variability response within 2 minutes of receiving a dispatch response signal, and provide this continuous loading or deloading regulation service at a rate of 100 MW/minute around the setpoint. This capacity is more than enough to meet the entire current ISO-NE regulation requirement. This regulation response is delivered while maintaining stringent emission requirements from a resource that will have the lowest heat rate in the ISO-NE system.

GE has conducted testing to determine the capability of the 7HA gas turbine with regards to the FERC Order 755 regulation performance requirements. While ISO-NE and PJM's implementation of FERC Order 755 differ slightly in the way they control dynamic regulation resources, PJM's control signal is the most stringent for a gas turbine to comply with due to the speed of the command to change direction and magnitude. Both systems use a performance scoring mechanism. GE tested the 7HA's capability to follow the more stringent PJM Reg-D fast frequency regulation signal and was consistently able to produce performance scores >90% using the PJM ranking system. While the ISO-NE need for fast regulation resources, so called energy neutral resources, may be relatively low at the present time, the requirement will increase with higher levels of renewable penetration. A 2010 GE Energy Consulting study of the ISO-NE's renewable penetration capability, with varying levels of renewable penetration, projected the need for regulation to approximately double from the 2010 levels for a 20% renewable energy scenario.

In addition to regulation service, the Clear River project will provide additional benefits to the ISO-NE system. Historically, combined cycle power plants have been capable of relatively short startup times, when compared to coal- or oil-fired rankine-cycle plants, but the technology applied at Clear

River takes the capability to an enhanced level that is much more beneficial to the system operator. GE's Rapid Response technology provides for faster, more efficient, and lower emission startup profiles when compared to plants built just 5 or more years ago. For a conventional start plant, the gas turbine must hold at low loads and extend the start to control thermal stresses within the steam cycle equipment. The Rapid Response system thermally decouples the gas turbine and steam cycle equipment, thereby allowing the gas turbine to quickly start and ramp to minimum emissions compliance load while controlling the steam conditions to the steam-cycle equipment. This translates to approximately 100 MW of capacity (per gas turbine) coming online within 15 minutes of the start command; the equivalent of an average sized peaking plant with similar response times (assumes the plant was operated within the prior 8 hours). Another benefit to the ISO-NE from this technology is that the startup time has very little variability. A conventional combined-cycle plant, without Rapid Response, can have a significant startup time deviation from one start to the next. In a 2010 study of 7F combined cycle plants, GE found that the variability in start times for a hot start (8 hours or less since shutdown) was greater than 1 hour between similar plants and on various days at the same plant. This uncertainty in start time is due to the thermal variability of the system when attempting a start. When a plant fails to meet its load target for a dispatch hour it causes the system operator to temporarily dispatch a higher cost resource to meet the generation shortage until the plant reaches the dispatch level. The Rapid Response design provides highly predictable start durations by eliminating these system variations by allowing the gas turbine to load to a known level in a fixed time without the influences of the thermal condition of the balance of the plant.

Currently the FERC is reviewing the concept of implementing a primary frequency response requirement to the ISOs (FERC NOI Docket No. RM16-6-000). This inquiry is in response to the fact that the actual frequency response in the Eastern Interconnection has declined during the last two decades and increasing levels of variable generating resources threaten to worsen primary frequency and inertial response of the bulk electric system. This type of requirement is already in place in some other parts of the world with high levels of renewable penetration, such as many areas in Europe. This proposed concept would require generators to offer their unit capability for primary frequency response (droop control) into a competitive market. Today the droop requirement for generators >10 MW in the ISONE system is a 4-5% droop response. However, in a 2014 ISO-NE Reliability Committee study, the

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INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

ISO-NE found that some generator control systems are not responsive to frequency events, or were loaded to the point that the control system could not increase load. The Clear River project is ideally configured to provide compliant primary frequency response to the ISO-NE both in its current tariff construct as well as potential future requirements that may be implemented through the FERC NOI. The Clear River control system design includes advanced control algorithms which use a predictive approach to frequency control, essentially pre-positioning the control system to respond rapidly to frequency excursions. This function dynamically adjusts the machine response rate for rapid frequency or load transients by using a transient fuel-air control to stabilize the combustion system and reduce risk of Lean-Blow Out (LBO) trips during grid excursions (NERC advisory A-2008-06-26-02). In addition, the system prevents preselected load control from counteracting the droop response by dynamically revising the droop setting.

The unique ability of the 7HA.02 technology implemented at the Clear River project to operate over a wide range of load profiles, combined with the fast rate of load change ability, ability to provide fast frequency response, and accurately and efficiently meet startup instructions ensures that the Clear River plant will play a vital role in fulfilling ISO-NE's current and future reliability obligations, especially as more renewable generation is brought on line.

RESPONDENT: John Niland, Director Business Development, Invenergy

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-13. (a) What is the ramp time for the proposed s plant to go from cold start to full power output?

(b) What is the ramp rate in MW/minute going from cold start to full power output?

(c) What is the air-emissions profile when going from cold start to full power

RESPONSE 2-13: a) Total plant startup time is approximately 210 minutes from cold start to 100% plant load. Over the plant startup period, there are varying ramp rates and periods when load is held at a fixed point. First, the combustion turbine is started and ramped to full speed at which time the plant it is synchronized with the grid. Following grid synchronization, the combustion turbine load is increased to and held at the Minimum Emissions Compliant Load (MECL) while the heat recovery steam generator and the steam turbine are heated, and the steam turbine is rolled and starts contributing to load generation. After a period of time, the combustion turbine load and steam turbine loads are then increased to 100% with the steam turbine generator ramp lagging slightly behind the combustion turbine. On natural gas, the cold start time for the combustion turbine is 45 minutes from ignition to MECL.

(b) As stated in response (a) above, the plant ramp rate varies during the 210 minutes cold start time period. Between MECL and base load operation, the ramp rate is 50 MW/minute for the combustion turbine.

(c) Under a cold start on natural gas between ignition and MECL, each unit has the following emissions:

- NOx: 196 lbs/event
- CO: 133 lbs/event
- PM/PM10/PM2.5: 9lbs/event

Under a cold start on ULSD, each unit has the following emissions:

- NOx: 198 lbs/event
- CO: 304 lbs/event
- PM/PM10/PM2.5: 53lbs/event

Note: After reaching MECL, the unit is in compliance with operational emissions limits from MECL to full load output.

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
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INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
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INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-14. (a) What is the ramp time for the proposed plant to go from warm start to full power output?

(b) What is the ramp rate in MW/minute going from warm start to full power output?

RESPONSE 2-14:

(a) Total plant startup time is approximately 40 minutes from warm start to 100% plant load. Over the plant startup period, there are varying ramp rates and periods when load is held at a fixed point. First, the combustion turbine is started and ramped to full speed at which time the plant is synchronized with the grid. Following grid synchronization, the combustion turbine load is increased to and held at MECL while the heat recovery steam generator and the steam turbine are heated, and the steam turbine is rolled and starts contributing to load generation. After a period of time, the combustion turbine load and steam turbine loads are then increased to 100% with the steam turbine generator ramp lagging slightly behind the combustion turbine. On natural gas, the warm start time for the combustion turbine is 40 minutes from ignition to MECL.

(b) As stated in response (a) above, the plant ramp rate varies during the start period. Between MECL and base load operating points, the ramp rate is 50 MW/minute for the combustion turbine.

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-15. What is the ramp rate for the proposed plant during normal operations?

RESPONSE 2-15: 100 MW/Min (maximum of 50MW/Min per combustion turbine) Between MECL and base load operation, the ramp rate for the combustion turbine is 50 MW/minute/unit. Steam turbine load ramping will lag the combustion turbine ramping as the plant is loaded from MECL to full plant load

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

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2-16. What is the anticipated minimum, normal operation level of the proposed plant?

RESPONSE 2-16: At average ambient conditions, the anticipated minimum normal operating load is MECL, which is approximately 30% load on natural gas (59 deg. F GE Case No. 19).

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
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RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-17. What is the lowest load at which the proposed plant will be able to run and still be within the anticipated emission allowances of its Clean Air Act permits?

RESPONSE 2-17: At average ambient conditions, the anticipated minimum normal operating load is MECL, which is approximately 30% load on natural gas (59 deg. F GE Case No. 19).

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STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

PUBLIC UTILITIES COMMISSION

IN RE: INVENERGY THERMAL DEVELOPMENT LLC	**)**	
APPLICATION TO CONSTRUCT AND OPERATE THE	**)**	**Dkt. 4609**
CLEAR RIVER ENERGY CENTER, BURRILLVILLE,	**)**	
RHODE ISLAND	**)**	

INVENERGY THERMAL DEVELOPMENT LLC'S REPONSES TO CONSERVATION LAW FOUNDATION'S SECOND DATA REQUEST

2-18. This question relates to Invenergy's response to CLF Data Request 1.3, and the worksheets attached thereto.

(a) Did Invenergy perform the necessary modeling for every hour in the operating years?

(b) On the first chart appended to this response, which hours of the operating day are included in the column labeled "on peak" and which hours are included in the column labeled "off peak"?

(c) Did you model every hour of the operating day separately with a unique, different demand level for every hour corresponding to the ISO's load forecast for that hour?

(d) If yes, state the projected savings during the 20 hours of greatest savings every month, and create a table reflecting projected savings for those 20 hours per month; and a separate table for all other peak hours.

RESPONSE 2-18:

a) Yes.
b) On-Peak hours are defined as hour ending 8:00 to hour ending 23:00. The remaining hours, hour ending 24:00 to hour ending 7:00 comprise the off-peak period.
c) Yes.
d) We have not determined this value.

RESPONDENT: John Niland, Director Business Development, Invenergy
Mark Repsher, PA Consulting
Ryan Hardy, PA Consulting

DATE: April 14, 2016

INVENERGY THERMAL ENERGY
By its Attorneys,

/s/ Nicole M. Verdi____________________
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Dated: April 25, 2016

CERTIFICATE OF SERVICE

I hereby certify that on April 14, 2016, I delivered a true copy of the foregoing responses to Conservation Law Foundation's Data Requests via electronic mail to the parties on the attached service list.

___/s/ Nicole M. Verdi______________________