STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

In the Matter of Verified Petition of Albany Engineering Corporation for a Declaratory Ruling Regarding the Eligibility of the Mechanicville Hydroelectric Station to Participate in the Remote Net Metering Program Under Public Service Law Section 66-j	:	Case 15-E-0698

STATE OF NEW YORK)
) ss.
COUNTY OF ALBANY)

AFFIDAVIT OF JAMES A. BESHA, P.E.

1. I am President of Albany Engineering Corporation (AEC). I have been a professional engineer in the practice of hydroelectric engineering since 1976 (40 years). I am licensed in New York State and I am a long-standing (23 year) member of the Institute of Electrical and Electronics Engineers (IEEE). I make this statement in support of AEC's petition seeking reconsideration of the *Declaratory Ruling on the 2 Mw Standard for Net Metering Eligibility at a Hydroelectric Facility* issued by the New York Public Service Commission on February 23, 2016.

2. In particular, in this affidavit I present facts concerning the independent manner in which the two separate generating systems at the Mechanicville Station are operated; the rated capacity of the hydroelectric generators; and certain electrical engineering principles and historical facts that are relevant to understanding the nameplate capacity of those generators.

3. The Mechanicville Station comprises two individual, wholly separate, electrical power supply systems. Each system is composed of three 40 Hertz (Hz, previously referred to as

"Cycle") water turbine-driven generators of 750 kilovolt-amps (kVA) capacity, apparent power, and 600 kilowatts (kW), real power. The nameplate capacity of each 40 Hz system is, therefore, 1,800 kW.

4. Each 40 Hz system is mechanically connected to a frequency converter consisting of a 12,000 volt 60 Hz motor and a 60 Hz synchronous generator. Each 60 Hz synchronous generator is rated at 2,500 kVA with a Power Factor (PF) of 0.8. The nameplate capacity for each 60 Hz synchronous generator is, therefore, 2,500 kVA × 0.8 PF or 2,000 kW.

5. Each 60 Hz synchronous generator is directly connected to an individual, wholly separate 34,500 volt electrical bus in the National Grid electrical substation through an individual, wholly separate generator step-up transformer.

6. Neither the 40 Hz systems nor the 60 Hz synchronous generators share any equipment or services related to the generation of electricity: there are no air compressors in the powerhouse, neither the 40 Hz generator systems nor the 60 Hz synchronous generators are dependent upon station service from the other, all generators (40 Hz and 60 Hz) have separate and distinct alarm and security devices.

7. Each of the six hydraulic turbines in the Mechanicville Station directly drives a three-phase alternating current generator designed by Charles Proteus Steinmetz (considered to be the father of alternating current electrical power engineering) and built by the General Electric Company (GE) in 1897.

8. The generator nameplate for the six generators in the Mechanicville Station is shown in a photograph included as **Exhibit 1**. The model designation of each of the six generators is identified by the specific type, class, form, and voltage provided on the nameplate: ATB-40-750-114-A-12000. GE historically utilized standard nomenclature to identify its

alternating current generators, so to determine the precise model designation I obtained GE's "Nomenclature Instructions" from the Museum of Science and Industry in Schenectady, New York. A copy is attached as **Exhibit 2**. With regard to TYPE: ATB refers to alternating current generator, three phase, revolving field. With regard to CLASS: 40 indicates the number of poles, 750 indicates capacity in kVA, and 114 indicates synchronous speed in RPM. The nameplate also documents that the generator current is 36 amperes and the voltage is 12,000 volts. As was typical for generators of this early vintage, the nameplate does not specify the design power factor.

9. In addition to being specifically included in the model designation, the generator rating can be calculated by multiplying the nameplate voltage, 12,000 volts or 12 kV, by the nameplate current of 36 amperes and multiplying that result by 1.7321. This factor of 1.7321 is equal to the square root of three (3), which is the electrical engineering factor used to derive power expressed in kVA in a balanced three phase alternating current electrical circuit.

10. For alternating current generators, the nameplate kW rating is determined by multiplying the generator kVA rating by the PF the generator was designed to provide. PF quantifies the ability of the generator to furnish "real power" (expressed in kW) from the "apparent power" (expressed in kVA). The simple mathematical formula describing this relationship is: $kW = kVA \times PF$.

11. The nameplates for modern alternating current generators directly state the PF they are designed for and, in most cases, the real power expressed in kilowatts.

12. As an example, **Exhibit 3** is a photograph of a nameplate for a 1940's vintage generator originally owned and operated by Niagara Mohawk Power Corporation. The nameplate

indicates 3,500 kVA, PF 0.8, and 2,800 kW, which is confirmed by applying the formula above, 2,800 kW = 3,500 kVA × 0.8 PF.

13. The current standard practice of providing nameplate data that include the PF evolved in the early 20th century, after the introduction of large three-phase, synchronous, alternating current generators.

14. When they were installed in 1897, the Mechanicville Station generators were the only generators supplying electrical power to the greater Capital District area (Albany, Schenectady and Troy). They also supplied all of the power for the motor loads at the GE manufacturing facility in Schenectady and the electric trolley systems in Albany and Troy.

15. The two separate transmission lines, each approximately 20 miles in length, connecting the Mechanicville Station with both Schenectady and Albany-Troy were 3-conductor aerial lines constructed of 3/0 gage wire operating at 12,000 volts. The combined effect of the motor loads and long transmission lengths caused these lines to exhibit considerable electrical inductance.

16. To overcome the significant inductance, and to maximize the real power delivered to both Schenectady and Albany-Troy, it was necessary for the Mechanicville Station generators to provide reactive power (today called vars or kilovars). The contribution of reactive power was necessary to transmit the rated power over the transmission line. This reactive power could only be supplied from the Mechanicville Station 40 Hz generators, which were designed to supply considerable reactive power (today known as "lagging power factor").

17. This compensation allowed the phase angles of the electrical voltage and current to better coincide and thus maximize real power delivery.

18. Since the Mechanicville Station generators were the only generators on the grid until at least 1899 or 1900 they alone were the sole source of reactive power.

19. Steinmetz designed the Mechanicville Station generators purposely to provide the required vars.

20. The measure of the ability of the Mechanicville Station generators to supply vars is now call Power Factor, but in 1897 Steinmetz expressed this as "the cosine of the angle w" or "power factor or f".

21. Steinmetz provides an example in his seminal work "Theory and Calculation of Alternating Current Phenomena," published in January 1897, of the amount and type of power factor or "f" needed to enable a generator to supply a power system.

22. Steinmetz describes a typical "reaction machine," *i.e.,* an alternating current generator capable of providing reactive power vars, as having a power factor "f" of "40%". Today this would be expressed as a PF of 0.4.

23. Standard practice in the last century has been to design three-phase alternating current synchronous generators, those typically used by hydroelectric plants capable of coordinated electrical grid system operation, to have a PF of 0.8. Generally if the generator PF is not explicitly expressed it is understood to be 0.8.

24. In my experience, I have also seen generators with PFs of 0.7 and 0.6 used to supply isolated loads such as the "house generators" used in large hydroelectric stations to supply black-start capability.

25. Providing the capability to supply reactive power (*i.e.,* with a PF less than one), significantly increases the cost of a generator. For that reason many newer grid-connected

generators have PFs of 0.9 or even 0.95. These units are not capable of providing any significant reactive power to the grid.

26. The Niagara Mohawk Power Corporation Operating Manuals and Documents, included with the Mechanicville Station records when AEC took ownership of the plant in 2003, include a summary of generator characteristics for both the 40 Hz and 60 Hz generators.

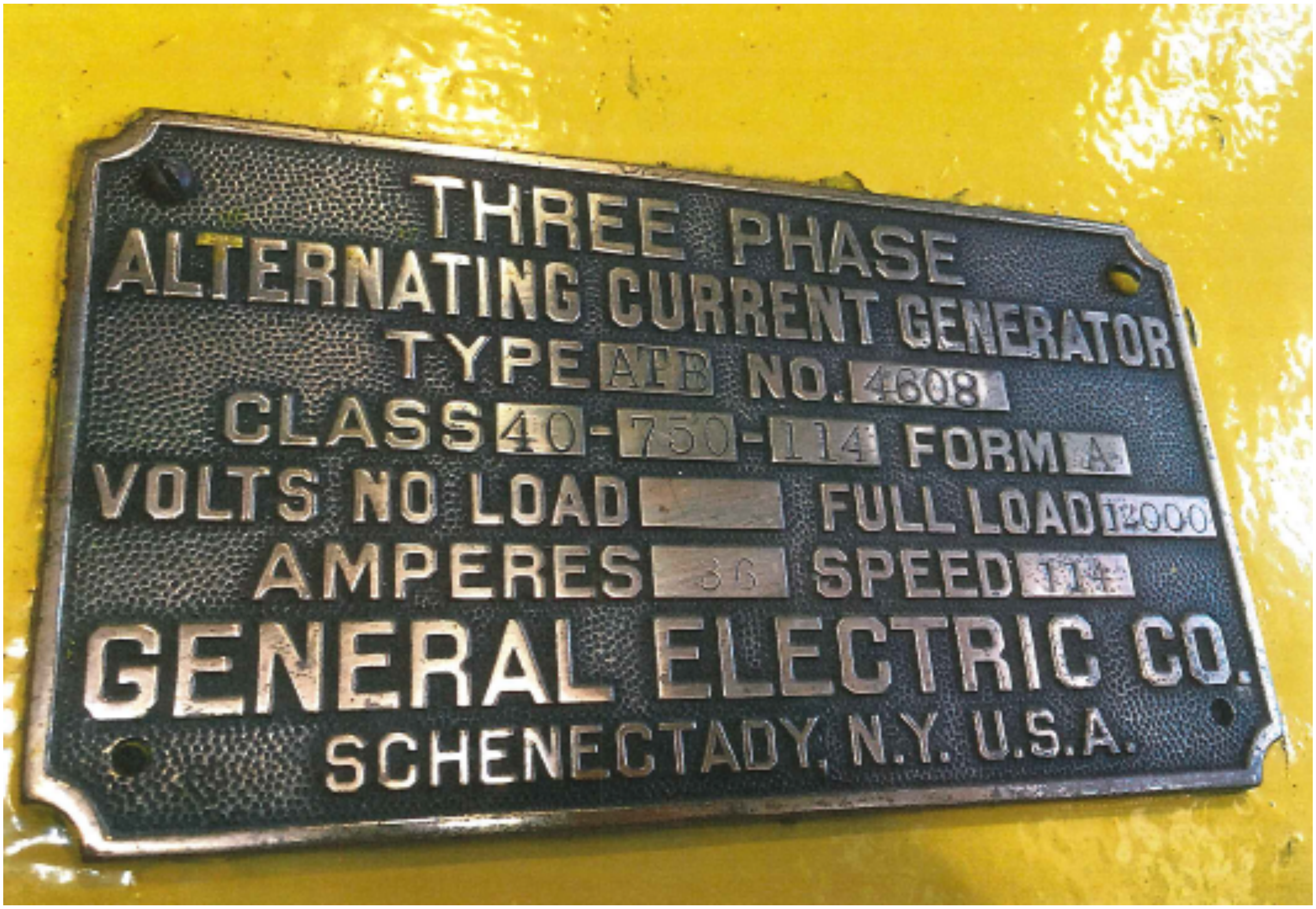
27. A document dated June 15, 1973, **Exhibit 4**, indicates the PF for the 40 Hz units is 0.8 and the kVA is 750. The kilowatt rating of the nameplate capacity therefore is 750 kVA times 0.8 or 600 kW per unit.

28. From this data sheet as well as from the contemporaneous calculations and notes of Charles Proteus Steinmetz, and my understanding of the engineering design of historical power systems, I conclude that each of the six individual generators in the Mechanicville Station has a PF of no more than 0.8 and a corresponding nameplate capacity of no more than 600 kW, and each 40 Hz generator system has a corresponding nameplate capacity of no more than 1,800 kW.

Dated: March 21, 2016

James A. Besha, P.E.

EXHIBIT 1


THREE PHASE
ALTERNATING CURRENT GENERATOR
TYPE ATB NO. 4608
CLASS 40-750-114 FORM A
VOLTS NO LOAD FULL LOAD 12000
AMPERES 36 SPEED 114
GENERAL ELECTRIC CO.
SCHENECTADY, N.Y. U.S.A.

GO-424-a 500 9-23-14

EXHIBIT 2

NOMENCLATURE INSTRUCTIONS No. 1076

E312.1

SUPERSEDING Eng. Brief 10855-H DATE Jan.29,1915.

SUBJECT ALTERNATING CURRENT GENERATORS AND SYNCHRONOUS MOTORS.

Alternating Current Generators and Synchronous Motors are identified as follows:

Type - Class - Form - Volts.

TYPE:

Type Letters are two or three in number as follows:

(First)	A	Alternating Current Generator.
	I	Induction Generator.
(Second)	M	Monocyclic
	S	Single phase
	Q	Two phase
	T	Three phase
	H	Six phase
	D	Twelve phase
(Third)	B	Revolving Field
	I	Squirrel cage winding in pole faces
	C	Inductor Alternator

CLASS:

Type letters are followed by (first) numerals to indicate number of poles, (second) numerals to indicate capacity in Kv-a and (third) numerals to indicate synchronous speed in R.P.M. (In some ratings the letter "B" is placed after the second group of numerals to indicate certain characteristics).

FORM:

Class rating is followed by a Form Letter or letters to indicate different mechanical constructions.

COPIES TO: Broderick, Humpf, B.T.H., Testing Dept. #11, Inspection Dept.(5), Reist, Holcombe, Eden, Lynn(10).

VOLTS:

Form Letters are followed by numerals to indicate voltage of circuit on which the machine operates.

Examples: ATB 12 - 150 - 600 - B - 5000
ATB 12 - 150B- 600 - B - 5000

FORM LETTERS ASSIGNED:

A	No particular significance
B	Belt driven
C	For Motor-Generator Sets (when on common base)
D	Compensated
E	Engine Driven (Non Flywheel type) without base or bearings.
F	Engine Driven (Flywheel type) without base or bearings.
G	Self excited
GT	Geared to Steam Turbine
H	Column 2 rating (Superseded)
HT	Direct connected to Horizontal Steam Turbine.
M	Machine with rating radically different from standard practice.
N	Machine when "M" was not available because used on another one of same rating.
P	Belt driven (Pulley) different design but same rating as Form B.
S	Shaft driven.
T	Direct connected to Vertical Steam Turbine.
V	Vertical Shaft (Not Steam Turbine)
PB	Belt driven (Built at Fort Wayne)
RC	Direct coupled (Built at Fort Wayne)
RE	Engine driven (Built at Fort Wayne)

SIGNED: M. P. Rice.

EXHIBIT 3


GENERAL ELECTRIC
ALTERNATING CURRENT GENERATOR
NO. 65394 TYPE ATB-20 KVA 3500 RPM 360
FORM A VOLTS 2400 AMP ARM. 843 P F 8 KW 2800
PHASE 3 CY 60 EXC VOLTS 125 AMP FLD 125 FRAME
3500 KVA CONT 80 C ARM. BY 60 C FIELD BY
C THERMOMETER C RESISTANCE
CAUTION! BEFORE INSTALLING OR OPERATING READ INSTRUCTIONS
SCHENECTADY, N.Y., MADE IN U.S.A.

DO NOT REMOVE FROM DESK. 6/15/93
[signature]

EXHIBIT 4

Mechanicville Hydro

Generator

No. 32311
Type ATB
Class-40-750-114 Form A

Cycles – 40
Volts – 12,000
Amps – 36
Speed – 114
KW – 750 @ .80 P.F.
Pole Pieces – 40
Coils – 60
Head – 18 ft.
Slots – 120

Frequency Changer

Synchronous Motor

No. 1560084
Type- ATI-8-2650M Form C
KVA – 600
Cycles – 40
Amps – 139
Volts – 11,000
Speed – 600
P.F. – .85
H.P. – 2800

A.C. Generator

No. 1560085
Type-ATI-12-2500M-600 Form C
Amps – 628
Speed – 600
KW – 2000
Volts Full Load – 2300
P.F. .8