Control Number: 49795

Item Number: 113

Addendum StartPage: 0

DOCKET NO. 49795
SOAH DOCKET NO. 473-20-1118

COMPLAINT OF PETTY GROUP, LLP AGAINST RIO GRANDE ELECTRIC COOPERATIVE, INC.	§ § §	**BEFORE THE STATE OFFICE OF ADMINSTRATIVE HEARINGS**

DIRECT TESTIMONY AND EXHIBITS

OF

DAVID MUELLER P.E.

ON BEHALF OF

RIO GRANDE ELECTRIC COOPERATIVE, INC.

May 11, 2020

1B

DIRECT TESTIMONY OF DAVID MUELLER, P.E.
ON BEHALF OF
RIO GRANDE ELECTRIC COOPERATIVE, INC.

I. PROFESSIONAL TRAINING AND EXPERIENCE

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is David Mueller. I am employed by EnerNex. My business address is 620 Mabry Hood Road, Suite 300, Knoxville, TN 37932.

Q. WHAT IS YOUR PRESENT POSITION?

A. I am the Director of Energy Systems Studies.

Q. PLEASE STATE YOUR EDUCATIONAL BACKGROUND AND PROFESSIONAL EXPERIENCE.

A. I have 35 years of experience as an electrical engineer, 30 years working with electrical power quality and harmonics issues. I obtained my BSEE from the University of Cincinnati in 1982 and a Master of Electrical Power Engineering Degree from RPI in 1990. I am registered as a Professional Engineer in my home state of Ohio.

I participate as a voting working group member of the IEEE Standard 519-2014 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems. This is the main document used by utilities in their evaluation of issues caused by nonlinear loads on power systems. This effort supports my practice as a consultant for electric utilities, industrial plants, data centers, and large commercial office clients on the identification and solution of power system harmonics problems.

My job functions are to provide expert consulting to clients on power quality issues, and to also manage a power system studies group that performs dozens of harmonics and other studies annually. I also have conducted advanced seminars on Power Systems Harmonics.

II. INTRODUCTION

Q. WHAT TYPE OF PROBLEMS DO HARMONICS CAUSE ON POWER SYSTEMS?

A. There are actual problems caused by harmonics, and there are often perceived issues that are caused by other factors. The most common actual problems are the overheating and failure of power factor capacitor units that participate in resonance phenomena. The heating of wires, transformers, and motors are other problems encountered. In industrial plants, the combination of large motor drives with power factor capacitors is the most common issue. In commercial facilities, issues with single phase loads on shared neutral conductors and transformer heating are the most common concerns.

But power systems are quite robust, and our electric utility distribution systems largely handle nonlinear (harmonics producing) loads without concern. System damping, load diversity and cancellation mean that most problems only occur due to resonance.

Q. WHAT DO YOU MEAN BY PERCEIVED PROBLEMS?

A. Harmonics are often blamed for equipment failures when the actual cause is unknown. This is because harmonics are "invisible," they require special meters to record the levels of harmonics, and so it is not possible to pin down the actual cause of equipment failures.

Most electronic equipment will operate in the presence of very high harmonic levels without any detrimental impacts.

Q. WHAT PROBLEMS ARE INTRODUCED BY ELECTRONIC MOTOR DRIVES?

A. Electronic motor drives, where the motor speed is controlled, present a nonlinear characteristic where they are a source of harmonic currents. They introduce harmonics, a form of electrical pollution onto power systems, that is a concern when they are present in large enough units or numbers, or when there is a resonance that magnifies their impacts.

Q. ARE MOTOR DRIVES IMPACTED BY HARMONICS FROM OTHER SOURCES?

A. No, generally not. The most common type of motor drive rectifies the input ac power to dc power. This process of rectification involves semiconductor switches, smoothing inductors, and dc bus capacitance – which result in any harmonics present on the input ac line to be "cleaned up." This means that the output of this drive to the motor is not impacted by input line harmonics.

Motor drives are impacted by other power disturbances, particularly transient overvoltage surges caused by lightning. These disturbances cause the drive to trip, or may cause the input power electronic devices to fail.

III. RGEC RESPONSE TO HARMONICS

Q. WHAT IS YOUR EVALUATION OF THE RIO GRANDE ELECTRIC RESPONSE TO THE HARMONIC ISSUES THAT WERE EXPERIENCED AT THE PETTY RANCH?

A. First, I would put this into context that it is an uncommon situation for electric utilities to have harmonics problems on their systems. When I have taught advanced harmonic courses to electric utilities, I'll often ask for a show of hands those that have experienced these issues, and most have not. This is in accordance with the fact that most power systems are able to absorb a normal level of nonlinear loads. However, what the RGEC has experienced is a rather unique set of circumstances where large motor drives are being installed by their members, and eventually it becomes "too much" when the recommended limits for harmonics are finally exceeded.

Also, the normal metering equipment of the utility company does not usually have much capacity to monitor harmonics, and so special recording equipment is necessary. The utility must rely upon "complaints" – that is observations from customers that there are relatively high levels of harmonics on the system. And so there is a significant "ramp up" just to get started to address the problem.

Then, once having started, there is the issue of what is causing it – where is it coming from? Harmonic sources that are distributed on a long feeder have to be located. The location effort involves obtaining and installing special monitors at various customer locations. Often the initial setup of the monitors will need to be refined. Eventually a good set of measurements for a week long profile will be obtained. Then those measurements data are downloaded by computer and analyzed to determine what do they represent. Then the process goes to the next location. Weeks turn into months, due to the need to monitor at multiple locations, and to analyze the results. Then, a difficult determination needs to be made regarding which of the customers are causing the problem? If it is one large customer, then the finding can be fairly clear, but when it is more than one customer

causing the problem, then the participation of each customer toward causing the overall problem is far from clear.

The IEEE Standard 519 recommendations provide strict limits that attempt to ensure that if all of the customers meet these limits, then there should only be harmonic problems when there is resonance (caused by capacitor units, etc.). However, if one customer is exceeding these limits, it doesn't necessarily mean that customer will cause a problem. The general case is that it will not. So establishing which customers on the utility feeder are causing the actual harmonic voltage levels is quite difficult.

Finally, those customers with high harmonic currents causing the harmonic voltages need to be informed about the situation, and then given time to respond. Customer mitigation in the form or harmonic filters might involve equipment lead times of several weeks, where the overall procurement and installation may take months. Disconnect of customers is absolutely "last resort," and very rarely employed by electric utilities.

Given all that needs to be done, I think it is reasonable that it would take RGEC longer than a year to evaluate these concerns. I worked with Guadalupe Valley Electric Cooperative (GVEC) who is also in Texas on a very similar situation. Their process of identifying the harmonics problem, working with customers to resolve the problem, also spanned a couple of years before the problems were addressed by their customers.

Q. WHAT IS YOUR EVALUATION OF THE RGEC DETERMINATION OF THE "PCC" ACCORDING TO THE IEEE 519 STANDARD?

A. The point of common coupling, "PCC," is defined at that connection (voltage level) where other customers are or could be connected. Many utilities will reasonably assume that is the metering point, because that is the point where the customer is getting supplied from,

and it might be reasonable to assume that future customers might also be connected at that location. So this determination can be interpreted differently by various people, where each viewpoint is reasonable according to the standard.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes it does.

EnerNex

A CESI Company

David Mueller, PE

Director, Energy System Studies

Background

David Mueller joined EnerNex in January 2012. David is a broadly experienced electric power engineering consultant who delivers value to clients through troubleshooting of electrical problems, power system engineering analysis and expert technical seminars. He performs consulting projects through careful evaluation of client's needs by developing project proposals and careful execution of engineering analysis. David is an accomplished speaker on technical subjects and is known nationally for his seminars on electrical power quality. He has an uncanny ability to explain complex technical subjects to both technical and non-technical audiences.

From 1990-2012, while at Electrotek Concepts, David managed the power systems engineering consulting group that performs investigations for electric utilities, large industrial concerns and commercial end-users. He also authored a 1,200 page training manual on power quality and many other technical papers and articles.

Masters of Electric Power Engineering, Rensselaer Polytechnic Institute
B.S.E.E., University of Cincinnati

Registered Professional Electrical Engineer, Ohio

- IEEE Power Engineering Society, Member
- IEEE Power Quality Solutions Working Group, Chairman
- IEEE Wind Power Plant Collector Working Group, Member
- NRECA Power Quality Subcommittee, Member

Wind and Solar Plant Interconnections Studies

Mr. Mueller directs the group that has performed electrical grid interconnection studies and power flow analysis for over 15 GW of wind power plants, and over 2 GW of solar power plants. Issues studied include harmonics, transients, and power flow issues.

IEEE Wind and Solar Plants Collector Systems Working Group

Mr. Mueller has been a member of the IEEE Wind and Solar Plants Collector Systems WG, authoring a paper on Harmonic Studies for Wind Plants.

Super Bowl XLVIII Power System Resiliency (MetLife Stadium, New Jersey)

Evaluation of the utility supply network, the local distribution system, the stadium complex, and various power system upgrades and contingency plans.

EnerNex
A CESI Company

620 Mabry Hood Road, Suite 300, Knoxville, TN 37932 T: +1 865.218.4600 info@enernex.com E enernex.com

Cape Wind Offshore Wind Farm Harmonics Study, NSTAR

David analyzed the concerns for connecting offshore wind turbines to the 115 kV transmission system. Built an electrical model and ran simulations of the potential harmonics interactions. Reviewed system background power quality levels and provided recommendations of the applicable standards and guidelines. Campus Microgrid Evaluation, ARUP

David created simulations of a large campus microgrid during islanded mode, evaluating the frequency response and other power quality concerns associated with the inverter based equipment of PV cells, fuel cells, and a battery energy storage system.

Electrotek Concepts Inc. (1990 – 2012)

David managed the power systems engineering consulting group that performs investigations for electric utilities, large industrial concerns and commercial end-users. His responsibilities included consulting activities for national and international clients, research work and developing and presenting seminars. He is considered an expert in all aspects of electric power quality.

David consulted on a variety of electric utility company management and technical issues, including power quality program development, building relationships with key customers, utility system performance, capacitor switching transients, harmonics issues and customer equipment sensitivity to power disturbances.

- "Power Quality Standards for Utility Wind and Solar Power Plants," David Mueller and E. H. Camm, IEEE T&D Show 2012.
- "Harmonics and Resonance Issues in Wind Power Plants," with the Wind Plant Collector System Design WG, IEEE PES General Meeting 2011.
- "Power Quality Considerations of Wind Power Plants," David Mueller, 2010 Georgia Tech Fault Disturbance Analysis Conference.
- "Detecting and Diagnosing Power Problems in Datacenters," David Mueller, World Energy Engineering Conference 2008.
- "Common Power Quality Waveform Signatures using IEEE COMTRADE and PQDIF," Tom Grebe and David Mueller, 2007 Georgia Tech Fault Disturbance Analysis Conference.
- "Case Studies of Harmonic Problems, Analysis, and Solutions on Transmission Systems,"
- David Mueller, Electrical Power Quality and Utilisation (EPQU 2007) Congress.
- "Case Histories of Harmonic Simulation Studies," David Mueller, PQ Synergy 2006.
- "Power Quality Solutions and Energy Savings," Dan Carnovale, David Mueller, Power Systems World 2005.
- "Connecting a Windfarm to the HV Grid with Underground Transmission Cable," David Mueller, AWEA Windpower 2005 AWEA.

- "Optimizing the Reactive Power Compensation at a Large Windfarm," David Mueller, AWEA Windpower 2005 AWEA.
- "Sawing Into Voltage Sag Problems at a Lumber Mill Operation: Taking Actions on Both Sides of the Meter," David Mueller, Mike Bares, Ronny Wilson, PQA 2004.
- "Understanding the Harmonics from Multiple DC Drives," David Mueller, Power Quality October 2003 NXTbook.
- "Persuading Customers to Solve Voltage Sag Problems," David Mueller, Charlotte Otero-Goodwin, E-Source Publication PQ-12, December 2002.
- "Evaluating Power Quality Solutions with the PQDS Economic Assessment Module," Bill Roettger, David Mueller, Sid Bhatt, Marek Waclawiak, PQA 1999.
- "Using Web-based Power Quality Monitoring for Problem Solving and Improving Customer Relations," Sandy Smith and David Mueller, Latin American Power Conference, Miami 1999.
- "Designing Harmonic Filters for ASDs to Comply with New IEEE-519 Harmonic Limits," David Mueller, Mark McGranaghan, IEEE Transactions on Industry Applications, Vol. 35, No. 2, March/April 1999.
- "Detecting, Identifying, and Solving Power Quality Problems," Power Systems World, San Jose 1998.
- "Priming the Pump for Different Grades of Power Quality," PowerValue Magazine, Nov/Dec 1998.
- "EPRI PQ Toolbox / EPRI PQ Pager "Demonstration of State of the Art Power Quality Progducts," Dr. S. Bhatt, D. Mueller, A Khan, G. Rauch, W. Winnerling, ERPI PQA 1997 Europe.
- Electrical Power Systems Quality, McGraw-Hill 1996. contributing Author.
- "Developing Power Quality Programs for the 21st Century," Seminario Brasileiro da Qualidade de Energia Electrica. Uberlandia Brazil 1996.
- The East Midlands Electricity Power Quality Training Manual, 1996 (editor and chief author), a 10 volume exhaustive reference on power quality analysis and case histories.
- "Affects of Voltage Sags in Process Industry Applications," D. Mueller, M. McGranaghan Dranetz-BMI, 1996.
- "Building a Power Quality Programme at a Privitised Electric Utility," Primer Seminario Latinoamericano Sobre la Calidad de la Potencia Electrica, Bogota Columbia 1995.
- "Using Computers for PQ Investigations," Primer Seminario Latinoamericano Sobre la Calidad de la Potencia Electrica, Bogota Columbia 1995.
- "IEEE-519 and Other International Harmonics Standards," Primer Seminario Latinoamericano Sobre la Calidad de la Potencia Electrica. Bogota Columbia 1995.
- "Electric Utilities Assistance to Industrial Customers to Improve Power Quality," IBERDROLA Seguridad Y Calidad Del Suministro Electrico Conference, Bilbao Spain 1995.
- "Transient Voltages at an Industrial Facility Caused by Utility Capacitor Switching," Steve Conrad, Mark McGranaghan, David Mueller, and others, PQA 95 International Conference on Power Quality.

- "Electric Utilities Implement Power Quality Programs," Electric Light & Power Vol. 73, Number 1, January 1994.
- "Voltage Sag Analysis Case Studies," J. Lamoree, D. Mueller, P. Vinett, W. Jones and M. Samotyj, IEEE Transactions on Industry Applications, Vol 30, No. 4, July 1994.
- "A Major UK Distribution Power Quality Survey," E. Delaney, D. Mueller, N. Foster, 29th Utilities Power Engineering Conference, Galway Ireland 1994.
- "Both Sides of the Meter: An Electric Utilities Response to Customer Power Quality Concerns," N. Foster, E. Delaney, D. Mueller, PQA 94: Third International Conference on Power Quality, Amsterdam 1994.
- "Monitoring Power Quality in the UK," D. Mueller, E. Delaney, N. Foster, PQA 94: Third International Conference on Power Quality, Amsterdam 1994.
- "Voltage Sag Analysis Case Studies," Jeff Lamoree, David Mueller and others, IEEE Transactions on Industry Applications, Vol. 30, No. 4, July/August 1994, pgs. 1083-1089.
- "Voltage Sags in Industrial Systems," Mark McGranaghan, David Mueller, Marek Samotyj, IEEE Transactions on Industry Applications, Vol. 29, No. 2, March/April 1993.
- "Interface Between an AC Power Supply and a Steel Plant DC Arc Furnace with Thyyristor Controlled Static Vars Compensation," Le Tang and David Mueller, First European Conference on Power Systems Transients, Lisbon 1993.
- "Analysis of DC Arc Furnace Operation and Flicker Caused by 187 Hz Voltage Distortion", Le Tang, David Mueller and others, IEEE PES 1993 Summer Meeting.
- "Chip Maker, Utility Track Costly Power Sags," David Mueller, William Jones and others, Electrical World, January 1993.
- "An Optimized Approach Toward Designing for Harmonics in Commercial Power Systems," David R. Mueller, Rory Dwyer, PCIM/Power Quality 1992 Conference.
- "Inside Intel, Monitoring Power Quality, Manufacturing i486 Microprocessors," William Jones, David Mueller and others, PQA'92, Atlanta.
- "Selection of Transformers for Commercial Buildings," Rory Dwyer, David Mueller, IEEE Industry Applications Society 1992 Conference.
- "Cable Derating for Harmonic Currents," The Resonant, Vol. 2, No. 1, Summer 1992.
- "Power Quality Considerations for Automotive Plants," EPRI Technical Publications.
- "Application Considerations for Uninterruptible Power Supplies," prepared for EPRI Technical Publications.
- "Protecting Sensitive Loads in Industrial Plants," David Mueller, prepared for EPRI Technical Publications.
- "Transformer Rating and Harmonic Loads," The Resonant, Vol. 1, No. 4, Winter 1991.