
State of Rhode Island Public Utilities Commission

Proceeding to Establish a Pilot Metering Program
for Municipal-Owned Streetlights

Docket No. 4513

Pre-Filed Testimony of

George A. Woodbury

September, 2018

I. Introduction and Qualifications

Q. Please state your name and business address.

A. My name is George Woodbury and my business address is 1052 Johnson Farm Road, Lillington, NC 27546.

Q. By whom are you employed and in what capacity?

A. I am the President of LightSmart Energy Consulting LLC, which is a company I founded in 2001 to assist communities with the acquisition and operation of streetlighting systems.

Q. Please describe your educational background and training.

A. In 1969 I graduated from The United States Military Academy with a Bachelor of Science degree. In 1977 I graduated from the University of Florida with a Masters Degree in Construction Management.

Q. Please describe your professional experience.

A. After a career in the military where I earned the rank of Colonel and commanded engineering and other units, I was the Municipal Utility Director and the Public Works Director for Fort Knox, Kentucky from 1992 to 1995. Fort Knox is the sixth largest city in Kentucky and the Municipal Utility is the largest single customer energy load of Louisville Gas and Electric. During my tenure I instituted demand management programs that reduced our energy costs by 24%. From 1995 to 2000 I was the Director of Public Works in Lexington MA. During that time I authored the legislation in Massachusetts that provided for municipal ownership of street lighting and for municipal aggregation, and played a lead role in the Massachusetts Municipal Association's streetlight maintenance program. From 2000 until the present I have helped 125 communities in eleven states acquire their streetlight systems and implement energy savings. In this capacity I negotiated Purchase and Sale and License Agreements with various utilities. For five years, from 2007 thru 2013, I worked for Republic Electric (now a division of Siemens) as a Municipal Consultant on street lighting matters. Republic Electric is the largest streetlight maintenance company in the country. In this position I was able to gain detailed insights into the maintenance and service requirements of streetlighting systems. Among my current clients is a group of communities in Maine, where I have assisted with the passage of legislation allowing municipal ownership of streetlighting. I have testified numerous times before various utility commissions on streetlighting matters. Today my company has installed over 40,000 complete LED systems with intelligent controls in both Massachusetts and Rhode Island and in the past year we have been responsible for nearly100,000 LED installations internationally. I also serve as a voting member of the American National Standards Institute, ANSI, 136 Outdoor Lighting Committee helping set standards for outdoor lighting and control systems.

Q. What is the purpose of your testimony in this docket?

A. The purpose of this testimony is to review the final streetlight metering pilot report dated November 21, 2017, from Narragansett Electric d/b/ NGRID, and to share my observations based on experience with the implementation of municipal streetlight programs and metering technology.

Q. Please describe the relevant context in which this final metering pilot report is issued?

A. I appreciate the effort put into this document and the level of effort by NGRID in their evaluation. However the final report has several flaws that undermine the value of its conclusions. It has been evident from the onset (Docket 4442) that NGRID objects to the use of these control devices. NGRID's consistent position is that the utility should own the meter as they do for other applications, and since in streetlight controls, the "meter" is merely one of the chips on the circuit board in the controller, that the utility should own the control. This position makes no sense. Controls are specifically allowed under RIGL 39-30, the Municipal Streetlights Investment Act. Moreover, NGrid's ownership of controls bifurcates responsibility for outages and complicates the use of the control network for other municipal purposes. NGRID's position on ownership of the meters has affected their design of the testing. NGRID's context was whether the meters provide highly accurate usage data that can be used for billing purposes. I believe the correct context should be does the control network provide more accurate data than the current unmetered method that National Grid uses for billing purposes and what are the ancillary benefits to the consumer such a system could provide?

Q. Please summarize your concerns about the proposed report.

A. My concerns center on two issues. First and most importantly, National Grid's current billing is highly inaccurate and metered billing should be compared to that as a baseline. Second, the testing protocols NGrid applied from ANSI C12.20 (the recognized current national standard) are not consistent with how the streetlights are used and if they had applied testing protocols that were within the design parameters of the controls NGrid would have reached a different conclusion as to their accuracy. While they claimed to have tested according to ANSI C12.20 standards they did not. ANSI specifically says you should test within the Design operating ranges of the meter, and National Grid did not stay within this range.

Q. What are your concerns about the accuracy of the data used as input for the current formula used in the billing system?

A. Currently streetlights are unmetered. They are billed based on inaccurate and inconsistently applied formula inputs that must be considered the baseline condition against which to evaluate metering accuracy. The variance of these data inputs from utility to utility is not insignificant and is indicative of inaccuracies that distort streetlight billing. As an example, NGRID uses 86 watts for a 70 watt High-Pressure Sodium (HPS,) street light in both Rhode Island and Massachusetts but in their Niagara Mohawk (NY), service territory they assign it an 82 watt usage. NSTAR, formerly Boston Edison and now Eversource assigns 86 watts to a 70 watt HPS fixture in the Commonwealth Electric (CE) Service territory.Operating hours are also inconsistent. NGRID uses 4175 operating hours per year as the basis for its rate calculations in RI and Massachusetts and 4183 hours in New York. In Massachusetts, NSTAR uses 4200.003 hours in the old Boston Electric (BECO) service territory and 4000 hours for the old Commonwealth Electric service territory. BECO does not list the 70-watt fixture in the BECO tariff but by comparison they use 63 watts for a 50w HPS fixture in CE and 58 watts in BECO territory. Western Mass Electric uses 4150 hours and 61 watts for the 50 watt fixture. A 50w HPS fixture on the Cape, next door to Rhode Island is billed at 243.6 kWh per year while in Rhode Island the same fixture is billed for 254.7 kWh or a 4.55% difference.

So we find variation from one utility to the next as to the correct basis of the billing usage and as noted even within NGRID's different service areas we find variation of their calculations which brings to question what is the level of accuracy required. It is very evident that NGRID will tolerate inaccuracies in their billing greater than what they are demanding of the control network. The differences between the utilities even within the same state raises questions as to what is the correct number to use. Utilities can pose plausible arguments to explain what they are doing based on differing equipment, different latitudes, different topographic regions but some of the factors change over the years. As an example the efficiency of the fixtures they buy can change both when new and over time. Clearly a metered result will be an accurate reflection of actual usage that is independent of all of these factors.

Q. What are your concerns about the accuracy of the inventory upon which the formula is applied for the current billing system?

A. National Grid's inventory for streetlight wattage does not match the field conditions. We have completed well over 50 streetlight system audits and it is typical to find numerous lights not working and some lights burning continuously ("day burners"). The number of lights in the field is typically different from the inventory on which the bill is based. The inventory errors typically average 7% across all utilities in my experience over the past 19 years. In Rhode Island our data on 45,169 lights audited shows 4.3% of the lights in the field have higher wattages than indicated on the NGRID inventory data used for billing, 5% that are lower wattages than listed and 9.9% lights not in the field but listed I(and billed) as being there. When this data is translated into the billing information it results in showed a +15.027% error in the billing wattage. An inspection of the 7,700 lights in Brockton (also an NGRID customer) revealed that 359 (4.6%) were not operating.

Q. What are your concerns about the accuracy of the formula for the current billing system?

A. NGRID's current street lighting tariff for LED lighting uses a tiered system to determine billing wattage, with each tier being billed at the midpoint wattage and thus ensuring inaccurate billing. There are three 20-watt tiers (0.1-20 billed at 10, 20.1-40 billed at 30, and 40.1-60 billed at 50,) two 40-watt tiers (60.1-100 billed at 80, 100.1-140 billed at 120,) and two 80-watt tiers (140.1-220 billed at 180, 220.1-300 billed at 260). As an example, the 20 to 40 watt billing tier means that LED lights that use either 20.1 watts or 40 watts (or anything between) will be billed as a 30-watt fixture. In Rhode Island, 76,684 of the 98,764 total lights fall in the 20 to 40 watt tier and would be billed at 30 watts. This represents a potential billing error of 51.5% for those fixtures that are operating at 20.1 watts and a 33% error for those at 40 watts. Overall, looking at all fixture wattages and the wattage of the appropriate LED fixture, the errors will range from 13% to 51.5% with the lowest error on the highest wattage lights. Metering will resolve all these estimating errors by billing for actual consumption.

Q. What are your concerns about the testing protocols applied in the report?

A. All electric meters undergo standardized testing under ANSI C12.20-2010. ANSI is currently considering the adoption of testing protocol for streetlight metering controls; the final testing standard that will be used for streetlight control metering chips has not been published yet. C12.20 is the standard applicable to residential and small commercial meters. The accuracy of these meters is tested over a range of loads appropriate for each meter to determine if they meet the required standard over the range. NGRID decided to test the streetlight controls over a range of 1 to 15 amperes (exceeding the design parameters of the meters.) The LED streetlights that will be used in municipal roadway lighting will range from 15 watts to 200 watts. In Rhode Island, the highest wattage deployed has been a few 168 watt floodlights, which draw 1.417 amps at 120 volts based on the DOE approved Independent Test laboratory (ITL)) results. On page 21 of the report, NGRID references discussions they had with Georgia Power (GP) and specifically the Lead Project Engineer who chairs the ANSI Outdoor Lighting Committee. The report states

> "Georgia Power also recognizes the specific non-conformance issues with the meter testing specification in ANSI C12.20, but continues to use the standard until an alternative meter standard is approved for this type of device. Georgia Power indicated that test results and general observations were "fairly accurate" up to 10 amps, with no further details provided. Georgia Power and National Grid agree that meter accuracy should be sustained up to 15 amps in order to accommodate larger electrical loading conditions in the field.

> Georgia Power described its initial observations of meter accuracy at the 15 amp level as "somewhat dismal," with no further details provided."

Despite the conclusion that the testing results would be dismal above 10 amps and the fact that no LED light in service uses more than 2 amps, NGRID chose to test outside the design criteria for these controls. NGRID stated that GP "agrees that meter accuracy should be maintained up to 15 amps" and yet in my conversations with the same individual, that is not his stated position. In an email to me on 9 March he stated they use "the 10 amp test protocols from ANSI 12.20" for NLC's, Networked Lighting Controllers." While there can be some flexibility in determining testing protocols pending publication of the new ANSI standards, there is no justification for NGrid's testing protocols. In their initial proposal they were going to limit their testing to 10 amps (Paragraph 4.1.2) but without stating any justification they changed to using 15 amps. There is no reason to test outside of the design parameters of these NLC's and well outside of their expected application. National Grid knew this testing would be problematic, and still retested at a level they knew would produce "dismal results."

I attach, as **Exhibit A**, a copy of an independent test result for one of the products used by NGRID that underwent independent testing in accordance with the ANSI C12.20 standard and passed without incident all tests. But it should be noted the maximum amperage of their testing was 10 amps which is consistent with the design parameters of the tested device and the ANSI C12.20 standard paragraph 5.5.4.5.s which states "NOTE- Test all conditions within the operating ranges of the meter." It is interesting that this very same company when working for NGRID tested outside of the expected operating ranges of the meter. We can only conclude they were directed to do so by NGRID.

Q. What other issues did you identify in the report that are of concern?

A. NGRID's reporting focuses on very granular issues to undermine results. Even by their own admission, their system of unmetered calculation does not achieve the same standard they are demanding of the street light controls. In the second paragraph of section 7.4, they state "the usage values produced by the unmetered calculated method and the node meter method were generally within one to two kWh of each other per week at the Park and Ride Test site, or a 2-3% variance." This testing addressed only a very small sample of lights known to be functioning. It does not account for the sort of issues we have identified in their inventory nor the frequency of out lights or day burners.

In addition, NGRID discovered that at all but the Park and Ride test site, there were other loads on the meters besides streetlights (last paragraph page 88). And yet there is no evidence to indicate they took action to correct that issue in their data collection. They are using a requirement of one half of a percent as the required level of accuracy, which the independent test results attached indicate (see **Exhibit A**) were met by that particular meter. If they use the ANSI Standard for residential meters by comparison, we would like to see how an approved revenue grade residential meter performs when it is tested outside of its expected operating ranges. NGRID must accept that meter testing protocol must be consistent. It is not appropriate to test one device outside of its operating parameters and not all as part of their acceptance testing.

Q. Are any other utilities using these devices for billing purposes.?

A. Yes. I am aware that these devices are being used in limited applications by Pacific Gas and Electric. Overseas the utility in Oslo is using these devices for measuring energy consumption on 250,000 street lights (see https://www1.nyc.gov/assets/globalpartners/downloads/pdf/Oslo_Climate%20Change_Streetlights.pdf). It is my understanding that Georgia Power, a subsidiary of Southern Electric Company, is also using these on a limited basis for billing and is looking to expand this program.

Q. What do you think the issues of concern would be with streetlight controls used for billing purposes and are their solutions for these issues?

A. I believe the controls are much more accurate than the current unmetered method and open the possibility for the communities to better manage their energy usage and costs. I think the only real issue is control units that are off line and not reporting. These devices do provide a "last gasp" report if they lose power but is also possible that they are functioning but simply lost communications. The responsibility for repairing the light and restoring communications falls on the community. The solution is simple in that for non-reporting units a simple mathematical calculation could be used, much as is being done now, to take the known usage data from that light and extrapolate it to the monthly usage for billing purposes or the known wattage of the light and calculate identically as is currently being done. It should be noted that control systems record usage data per light, so recent history can be used to report usage in a way far more accurate than the current unmetered rate.

Q. How does the cost benefit analysis mandated from Docket 4600 apply to this streetlight metering proceeding?

A. The Commission has been clear that the goals, principles, and framework from Docket 4600 must be applied to cases that affect National Grid's electric rates. Any proponent of a rate, rate design, or program proposal with associated cost recovery must meet the same standards. The Commission has directed the utility and its opponents to reference the goals, principles, and framework.

Q. How does streetlight metering meet the goals set out by stakeholders in Docket 4600 and adopted by the Commission's guidance?

A. Streetlight metering will strengthen our economy by optimizing the benefits of a modern grid and achieving appropriate rate design structures as I have discussed above. It will also help address the challenge of climate change and other pollution by giving municipalities every accurate monetary incentive to use streetlights efficiently and thereby conserve energy and mitigate emissions. Lighting can be fine-tuned on a light-by-light or street-by-street basis so safe and adequate lighting is used and the community pays for only what is used. Metering facilitates customer investment in facilities that provide recognizable net benefits because municipal investment in modern control systems makes much more financial and operational sense if metering is allowed.

Streetlight metering allows both the customer and the utility to be more accurately compensated for benefits provided and charged for services and costs incurred. Finally, streetlight metering will better align utility, customer and policy objectives through rate design, cost recovery and incentives for optimized operation of state's streetlight systems across the state.

Q. How would streetlight metering serve the ratemaking principles set out in Docket 4600 and the Commission's guidance?

A. The Commission's approval of streetlight metering will serve those ratemaking principles very well. It will enable and enhance safe, reliable, affordable and environmentally responsible electric service by improving operational capacity and accurately tying billing to electricity actually used. Metering enhances economic efficiency by ensuring that municipalities are accurately charged and rewarded for their streetlight operating practices. The price signals sent by metering will better reflect long-term marginal costs, and the records of time-of-day usage can be helpful going forward. Further, because the control systems centralize and aggregate usage data, the performance of a town, a neighborhood, or a street can be segregated, analyzed, and the utilized for planning and system weakness identification.

Metering more accurately accounts for externalities that are not adequately addressed by existing rate structures by much more closely and accurately aligning billing with the capacity to achieve operational efficiency savings. Records light-by-light show actual voltage levels, interruptions, etc. Metering will better enable municipal streetlight customers to manage their costs through operational efficiency by, as one example, directly accounting for savings from strategies like dimming and dark-nighting (turning off lights). Metering will also allow the utility to achieve fair recovery of its costs and provide for greater revenue stability by guarantying that municipalities do not game the current estimating process to undercompensate the utility for their actual electric load. Streetlight metering would provide a much more transparent and understandable billing methodology than currently exists, as described above. Metering will enable municipalities to better control their energy burden, passing those benefits along to low income residents through budgeting and tax benefits. Streetlight metering is entirely consistent with well-established Rhode Island energy policies, including but not limited to, environmental, climate (Resilient Rhode Island Act), energy diversity, competition, innovation, power/data security, and least cost procurement. Finally, streetlight metering encourages appropriate investment in the evolution of our future energy system, providing proper incentives for the installation of control systems that will integrate effectively with the automated metering infrastructure to be studied and implemented pursuant to the settlement of the power sector transformation proceedings in National Grid's recent rate case, Dockets 4770 and 4780. The ubiquitous nature of streetlights and the availability of a communication platform also opens up the opportunity to use this platform to support other municipal operations to better enhance services to their citizens.

Q. How should streetlight metering be analyzed under the benefit cost framework from Docket 4600, as adopted in the PUC's guidance?

A. The municipalities are frustrated that National Grid has ignored the application of Docket 4600 to this (and other) proceedings recently brought before the Commission. A robust analysis of all costs and benefits is technically complex work that requires application of resources that the utility may be uniquely equipped to provide and that the municipalities cannot fully afford. Yet, as the Commission noted in its guidance, failure to account for all costs and benefits of energy decisions leaves Rhode Island unequipped and unable to achieve least cost and best value procurement. The municipalities ask the Commission to consider the practicalities of how docket 4600 can best be applied in proceedings like this one that produce decisions critically important to the future of Rhode Island's energy system. Meanwhile, I will do my best to consider the costs and benefits of streetlight metering as effectively and efficiently as I can pursuant to the Commission's approved guidance and framework. Efficiency requires that I only address those criteria that are applicable (at least by my analysis.). Some benefits warrant repeating because they may impact more than one receptor/beneficiary (power sector, customer and/or society), and sometimes in different ways.

It is also very important to understand that the evolution of roadway lighting technology. LED technology can be turned on and off instantly and can be dimmed, leading to the development of intelligent streetlight controls that take the place of the conventional photocell. These controls allow for communication with the streetlight and establish a communication network across all of the streetlights. In addition to facilitating municipality's ability to manage the energy usage of their streetlights more cost effectively, this communication platform is now being integrated into other municipal operations to enhance the services to the citizens and provide for better traffic management, more prudent use of energy resources, greater public safety and other potential service enhancements. Streetlights with intelligent controls provide a wide range of benefits, so streetlights are becoming much more than just roadway lighting and must be viewed in the context of the totality of their potential contribution to the goals set under 4600. Streetlight communication platforms can potentially support parking solutions that provide information to drivers where available parking is and the associated fees. Studies have shown that as much as 30% of traffic congestion in downtown areas is caused by people looking for parking. Reduction in this congestion provides for less fuel use, less air pollution, lee frustration and a better shopping experience that in turn increases economic activity. Streetlight communication platforms can support localized traffic management and assist with synchronization of traffic signals to improve traffic flow using real time information gathered over the streetlight network. So we can see that we have to view streetlights from a very different perspective given their future potential benefits to society beyond just lighting the roadways.

Q. How does streetlight metering relate to the power system level costs and benefits?

A. Streetlight metering can be expected to generate great net value at the power system level. More municipalities will fund the installation of modern, sophisticated control mechanisms if they are authorized to reap the many benefits of metered billing.

Streetlight metering will inherently benefit the operating value of energy provided or saved since metering functionality and analysis of power flows is an essential component of tracking and optimizing time- and location-specific marginal pricing (an evident impact the municipalities do not have the resources to fully study and quantify). Metering will allow for the development and implementation of dynamic retail pricing necessary to offset retail supplier risk premium (an evident impact the municipalities do not have the resources to fully study and quantify). Metering allows better calibration of actual demand as is needed to accurately inform forward commitment and capacity value and to minimize the cost of ancillary services (an evident impact the municipalities do not have the resources to fully study and quantify). There will surely be some added billing administration costs, but any such increases are consistent with the automated metering functionality studied and ultimately to be implemented as resolved by the docket 4600 stakeholders and the settlement of the power sector transformation element of National Grid's recent rate case (dockets 4770 and 4780). Therefore, such costs should not be considered incremental or specific to streetlight metering. Metering will better enable the regional system operator to track actual load requirements and evaluate, plan and anticipate the capacity to avoid transmission system investments (an evident impact the municipalities do not have the resources to fully study and quantify). Streetlight controls, which are economically facilitated by the allowance of metering, provide great benefit to utility system operations by enhancing operational flexibility and the potential to respond to system disruptions (e.g., immediate load curtailment if/as needed). In addition this system can provide the utility information as to areas without power, with voltage issues or with other system challenges. Unlike electric meters, the streetlight controls include a GPS component and therefore can provide a map of outage areas assisting the utility with directing resources. Metering can also enhance the value of other distributed resources like solar power by more accurately compensating municipalities for dimming and dark-lighting practices that will reduce demand on off-peak, stand-by generation (an evident impact the municipalities do not have the resources to fully study and quantify). Metering promises to mitigate uncertainty associated with municipal modernization decisions by ensuring that municipalities are properly rewarded for their investment in streetlight control systems (including ___ municipalities that have already made that investment to install controls on _____ streetlights in Rhode Island). More efficient operation of streetlights, a foreseeable result of metering, will significantly reduce streetlight electric load and the greenhouse gas and criteria air pollutant compliance costs associated with our region's dominate source of electricity, natural gas fired power plants (another analysis the municipalities do not have the resources to fully study and quantify). Streetlight metering also actually provides positive impacts beyond the electrical system by bringing down gas peak load requirements during winter evenings when the demand for both gas-fired electricity and heat is at its peak (another analysis the municipalities do not have the resources to fully study and quantify). Metering can be expected to reduce distribution system capacity costs by reducing load anticipated for circuit requirements on winter weeknights when people come home from work (another analysis the municipalities do not have the resources to fully study and quantify). Metering will help facilitate the implementation of distribution locational marginal pricing by helping to analyze circuit specific distribution system planning thereby also enhancing the safety, reliability and performance of the distribution system (another analysis the municipalities do not have the resources to fully study and quantify). Metering and control systems will contribute to improved customer voltages and power quality because they are on the same distribution lines as the residential customers and report information continuously as well as retain historic information about power quality. The streetlight metering is embedded in the intelligent control so that we can control the light's power consumption and help address system loads during emergencies.

Q. How does streetlight metering relate to the customer level costs and benefits?

A. Streetlight metering also promises to produce major net benefits at the customer level. It will enhance "prosumer benefits" by appropriately rewarding municipalities for their investment in streetlight system improvements, not only improving their capacity to control and improve their energy use profile but also making significant positive contributions to quality of life in communities, like for example, enhanced safety protocol (incident specific lighting control). Energy and quality of life will be improved by such measures as, for example, turning off lights at night in a quiet cul-de-sac, but having a motion detector deployed so if a pedestrian, bicycle, or vehicle enters the area, the lights come on for, perhaps, 30 minutes. This level of control technology is available now, but there is economic disincentive for municipalities to invest in it without metering. Metering will greatly improve the municipality's ability to fine-tune brightness (wattage) levels and save non-energy costs, including principally reducing load requirements for natural gas at peak times for consumption (winter evenings). Metering will encourage municipalities to purchase their streetlights and convert to LED lighting which greatly reduces maintenance costs with direct budgeting and tax benefits to all residents, including low-income residents, and reduce stray light emissions that can impair sleep habits and public health. Metering enhances customer choice and flexibility by better enabling municipal customers to realize the benefits of streetlight investment and conversion to LEDs and controls. It will provide noncustomer benefits (and thus enhance equity) by properly incentivizing efficiency and control measures that substantially reduce load and energy costs during periods of peak consumption, thereby reducing the costs of electric service for all ratepayers (another evident impact the municipalities do not have the resources to fully analyze and quantify).

Q. How does streetlight metering relate to the societal level costs and benefits?

A. Streetlight metering will also provide very significant net benefit at the societal level. First, as previously noted, metering will properly incentivize streetlight operating efficiency and reduce demand for electricity, mitigating the externality costs of greenhouse gases and criteria air pollutants (the framework properly notes that reduced greenhouse gas compliance costs are a power system level impact and reduced externality costs – like mitigated climate change – are realized at the societal level). The reduced load requirements that will result from streetlight metering will provide community conservation benefits by reducing the need for electric infrastructure that negatively impacts community conservation values. The allowance of metering will produce great economic development value by enabling municipalities to monetize their investment in their streetlight systems, conversion to LEDs and installation of control systems resulting in job production and reduced operating costs (eg, energy consumption and streetlight maintenance costs) that frees up resources for more productive economic activity. The Commission's approval of streetlight metering will have major information and knowledge spillover benefits by encouraging municipalities to lead in the implementation of modernized metering and control technology that provides important data and experience for the anticipated implementation of automated metering in Rhode Island (per the settlement of Dockets 4770 and 4780). As previously discussed, metering should be expected to benefit municipal budgeting and reduce the tax burden for low-income residents. Streetlight metering and intelligent controls contribute to ancillary uses of the communication platform. Today we are on the forefront of the added benefits these control systems (that include the meterology). By analogy it is like the first flip cell phones that would keep you address book. Today they are used for so much more. It started with a wireless communication platform and the ingenuity of the American industry. Streetlights are now entering this arena and will be a key component of the future Smart Cities and the Internet of Things.

Q. What are your conclusions?

A. We currently bill streetlights on inaccurate inventories with fixed and inaccurate assumptions about energy consumption and operation. Communities are now switching to LED technology and NGRID has introduced even greater inaccuracies in their billing through their LED tariff design. Metering also allows communities the flexibility to increase and decrease light levels and be billed accordingly. Communities can select LED lights that have the capability to be much brighter than their nominal operating levels and during an emergency or special events or as may be needed they can brighten these lights and then later dim them. Likewise they can use the controls to dim the lights or even turn some off when not needed or after hours. Cities and Towns that have much higher traffic and pedestrian levels during certain seasons can adjust their lighting in accordance with the IESNA RP-8 guidelines who recommend higher lighting levels when pedestrian activities are higher. Absent the ability to use these control meters, communities are unfairly billed for the maximum possible wattage of the fixture even though it is normally operated at much lower wattages. Allowing the use of the meters makes the control device more economical because NGRID only allows dimmingon set schedules and creates obstacles to altering the schedules for special events. Providence has been dimming nearly 50% for 6 hours per night since September 2016, but did not receive the full benefit of their dimming schedule for almost two years now. Should communities wait for two years to see tariffs that allow their desired operations? The new dimming formula (up to 6-hours at a 50 percent dim rate, per the settlement in docket 4770) assumes streetlights come on at full power and then dims later, which in many of our communities is not true. Meteredcontrols will allow mu nicipalities to turn on the light at any set level less than full power, then dim further late at night or temporary shut offs and relightingat set levels until dawn. We have specified lights that are internally dimmed in order to capture long-term billing savings, even though these same specifications mean a reduction in the energy efficiency incentive payments. Control-based meter savings would make the controls more cost effective and enhance the application of Smart City concepts to improve public safety and the services cities and towns can provide their citizens. The meters in these control devices allow the customer this flexibility and ensure that NGRID is able to be properly compensated — neither the community nor the utility will be over compensated as is the current system. The most important question that remains unaddressed by NGrid's final report is whether metering is more accurate than their existing billing methodology. . NGRID's NGRID's report (7.4 pg 87) states that,

"However, when properly specified, manufactured, and operated, the nodes' performance was reasonable in metering the energy consumption of the designated loads or street lights as compared with the existing unmetered analytical calculation."

NGRID admits that metered control systems work.

It is important to put all of this into perspective. In 2017 Narragansett Electric reported 2,698,285 MWH in sales (See FERC Form 1) of which 6,054 were for street lighting or .2244% of their sales. Streetlighting represents two tenths of a percent of National Grid's sales but it is one of the larger utility bills for every Rhode Island city and town. NGRID has demonstrated that that they are willing to accept significant billing inaccuracies by their own tariff design, and yet their demands for higher accuracy of the control metering includes an accuracy tolerance of a half percent or better even at operating loads well above the design loads. Metering allows for substantially more accurate billing and communities gain greater flexibility to control one of their larger electric bills while enhancing public safety by allowing immediate adjustments to address issues. Metering also allows the utility to validate a community's actual use of electricity at these fixtures. Other utilities (Georgia Power for example) are using these devices for billing purposes so the claim that his cannot be done is much more a reflection of NGRID's position than reality.

Streetlight metering will clearly provide net value to our power system, all ratepayers and to our society, according to the cost benefit analysis stakeholders developed in docket 4600 and the Commission has adopted and mandated. While municipalities do not have the means to provide all of the modeling and analysis necessary to fully quantify the net benefits, it is evident that metering provides substantial value to all three identified receptors. Moreover, Commission approval of streetlight metering is consistent with the goals and ratemaking principals set out and approved in docket 4600.

Rhode Island's cities and towns have invested millions of dollars to gain the reporting and operational advantages of these control systems, using all their capacity to finally achieve accurate and transparent streetlight billing. It is time to approve metering now.

Metering may need to be phased in because NGRID may not be ready to receive automated data and the necessary adjustments to the meter data management system to accommodate the data. One way to do this is to utilize the software's greatest strength and aggregate streetlight usage not by light, but by municipality, and to provide town-wide reports monthly to NGRID that show what kWh are used and changes in any operating parameters. NGRID can then update its systems relatively easily until the more automated system can be implemented. There is no need to create a separate account for each metering control as NGRID has stated. These systems are far more accurate than the existing unmetered rate, and their usage can and should be authorized immediately.

ORIGINATING GROUP:	ORIGIN DATE:	REVISION DATE:	NO. OF SHEETS:
TESCO ENGINEERING	**22-Mar-2018**	**-**	**20**

Final Test Report
for

SELC
Power Behind Light

Photocell Node C12.20 Accuracy Testing
Project 8218
Accuracy Class 0.5%

APPROVED: Originator: John Williams	DATE: 22-Mar-18
APPROVED: Project Mgr.: John Williams	DATE: 22-Mar-18

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1 Purpose

TESCO has been contracted by SELC to conduct ANSI C12.1/C12.20 Accuracy Testing on their Photocell Metering Devices (referred to as "nodes" within this report). According to the manufacturer (and per their UL/CSA certification listing via Intertek), the nodes tested are representative of the class referred to by SELC as "8S Series Photocells". SELC states that all models across their product line use the same control board with same metrological components and hardware.

This report details all test equipment and procedures used, and results obtained, throughout the project.

2 Definitions, Acronyms and Abbreviations

Abbreviation	Definition
A	Amperes
AC	Alternating Current
AAC	Amperes AC
ANSI	American National Standards Institute
DPT	Digital Power Technologies (Power Supply Manufacturer)
Hz	Hertz, unit of frequency
IEC	International Electrotechnical Commission
Kh	Node pulse constant (Wh/pulse)
KV	Kilovolt
mA	Milliamp
MTB	TESCO Node Test Board
MQB	TESCO Node Qualification Board
PF	Power Factor
T_a	Test Amperes
THD	Total Harmonic Distortion
T_v	Test volts
V	Volt
VT	Voltage Transformer
W	Watts
Wh	Watt-hour

3 Test Equipment information

3.1 TESCO Node Test Board (MTB)

The TESCO MTB is a four socket unit capable of simultaneously testing 4 nodes. It is ANSI C12.20 compliant and uses a NIST traceable 3 phase reference standard.

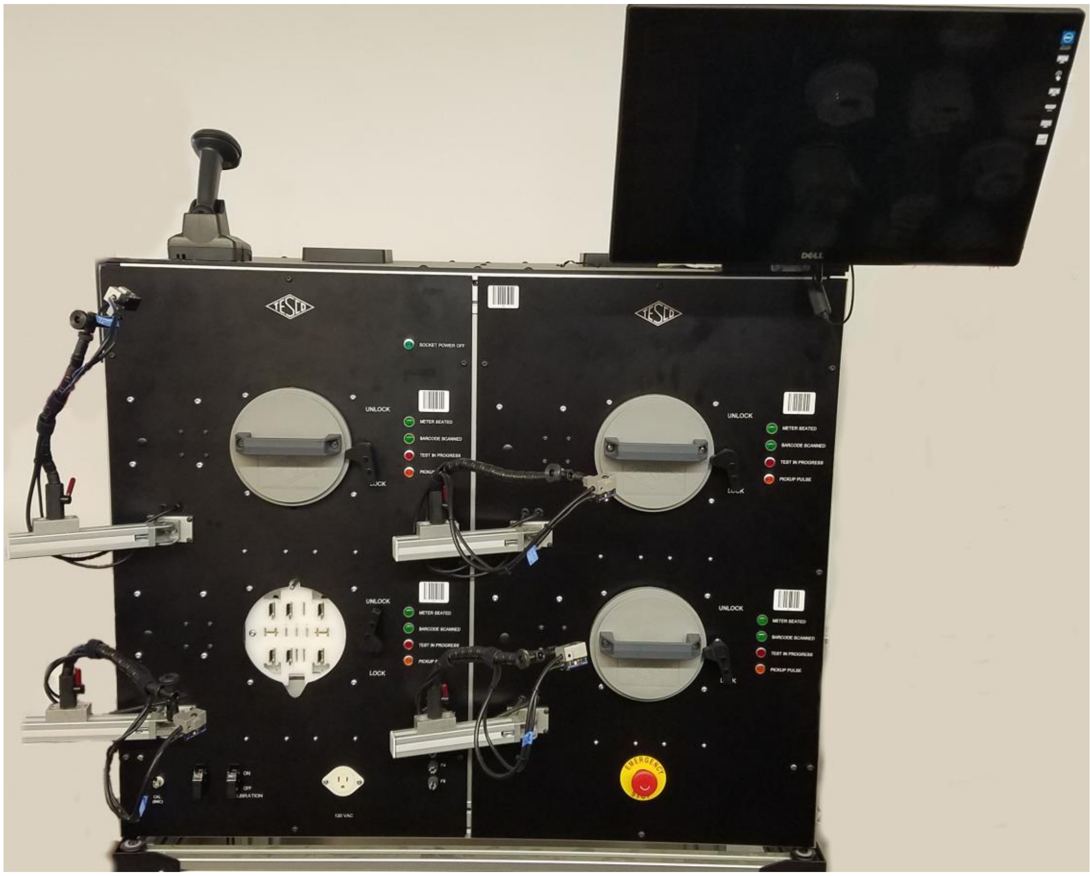
3.1.1 Main Components

a. Digital Power Supply - DPT 024 Series 3 phase source.

- Voltage Set point accuracy - 0.5%
- Current Set point Accuracy - 0.5%
- THD <0.5% Linear load
- Frequency Accuracy - +/-0.02Hz
- Phase Resolution - 0.01 degree

b. Internal Reference Standard - Radian RD-31-221

- .02% accuracy class
- Serial Number 300250
- Calibration date: 06/15/17 (due 6/14/18)



4 Test Data

4.1 TESCO Test #1 – No Load

4.1.1 ANSI Test #1, ANSI C12.20 Section 5.5.4.2

4.1.2 ANSI Description - The metering device with the voltage circuit(s) energized and current circuit(s) open shall not make one complete revolution of the rotor or more than on equivalent revolution in watthours within 10 minutes and no additional equivalent complete revolutions of the rotor in the next 20 minutes.

4.1.3 Test method used - Power only the voltage circuit of the node. Verify there is not an accumulation of more than 1 optical pulse in the next 10 minutes. After the 10 minutes have elapsed, verify there is not an accumulation of more than 1 additional optical pulse in the following 20 minutes.

4.1.4 Data (Results)

MAC ID	Tv	Ta	Start Time	End Time	Pass/Fail	Observations
0013500500216E12	120	0	14:31	15:05	Pass	No pulses detected
00135005002343D0	120	0	14:31	15:05	Pass	No pulses detected
0013500500246222	120	0	13:15	14:20	Pass	No pulses detected
0013500500214FED	120	0	14:31	15:05	Pass	No pulses detected
001350050024D83C	120	0	14:31	15:05	Pass	No pulses detected
00135005002D1143	120	0	17:16	17:46	Pass	No pulses detected
001350050021D0C5	120	0	17:16	17:46	Pass	No pulses detected
00135005002D0904	120	0	13:15	14:20	Pass	No pulses detected
00135005002CED48	120	0	13:15	14:20	Pass	No pulses detected
001350050023CA78	120	0	13:15	14:20	Pass	No pulses detected

4.1.5 Conclusion – All nodes tested passed without incident.

4.2 TESCO Test #2 - Starting Load

4.2.1 ANSI Test #2, ANSI C12.20 Section 5.5.4.2

4.2.2 ANSI Description - The metering device shall operate continuously with a load current as specified in Table 7. The lowest rated voltage value shall be used for wide voltage ranging metering devices.

Table 7 – Starting load test

Current Class	Current in Amperes		
	0.5 Accuracy Class	0.2 Accuracy Class	0.1 Accuracy Class
2	0.001	0.001	0.001
10	0.01	0.01	0.01
20	0.01	0.01	0.01
100	0.05	0.05	0.05
200	0.10	0.10	0.10
320	0.16	0.16	0.16

4.2.3 Test method used - The node shall be operating at specified operational voltage and shall operate properly with the specified starting current from Table 7 of the referenced ANSI C12.20 section once applied.

4.2.4 Data (Results)

MAC ID	Tv	Freq	Ta	Power Factor	# of Pulses	Registration	Error	Result
0013500500216E12	120	60	0.01	1.00	1	100.00%	0.00%	Pass
00135005002343D0	120	60	0.01	1.00	1	100.00%	0.00%	Pass
0013500500246222	120	60	0.01	1.00	1	100.00%	0.00%	Pass
0013500500214FED	120	60	0.01	1.00	1	100.00%	0.00%	Pass
001350050024D83C	120	60	0.01	1.00	1	100.00%	0.00%	Pass
00135005002D1143	120	60	0.01	1.00	1	100.00%	0.00%	Pass
001350050021D0C5	120	60	0.01	1.00	1	100.00%	0.00%	Pass
00135005002D0904	120	60	0.01	1.00	1	100.00%	0.00%	Pass
00135005002CED48	120	60	0.01	1.00	1	100.00%	0.00%	Pass
001350050023CA78	120	60	0.01	1.00	1	100.00%	0.00%	Pass

4.2.5 Conclusion – All nodes tested passed by operating continuously throughout the duration of the test.

4.3 TESCO Test #3 – Load Performance

4.3.1 ANSI Test #3, ANSI C12.20 Section 5.5.4.3

4.3.2 ANSI Description – The performance of the metering device shall not deviate from the reference registration by an amount exceeding the maximum deviation specified in Table 8, except that the tests for conditions (9) through (11) shall be omitted for two-element four-wire wye metering devices.

Table 8 – Load performance test

Condition	Current in Amperes						Maximum Deviation in Percent from Reference Performance		
	Current Class						Accuracy Class		
	2	**10**	**20**	**100**	**200**	**320**	**0.5**	**0.2**	**0.1**
(1)	0.015	0.15	0.15	1	2	3	±1.0	±0.4	±0.2
(2)	0.025	0.25	0.25	1.5	3	5	±0.5	±0.2	±0.1
(3)	0.05	0.50	0.5	3	6	10	±0.5	±0.2	±0.1
(4)	0.15	1.5	1.5	10	20	30	±0.5	±0.2	±0.1
(5)	0.25	2.5	2.5	15	30	50	Reference[1]	Reference[1]	Reference[1]
(6)	0.5	--	5	30	60	75	±0.5	±0.2	±0.1
(7)	1	5	10	50	100	100	±0.5	±0.2	±0.1
(8)	1.5	7.5	15	75	150	150	±0.5	±0.2	±0.1
(9)	1.8	--	18	90	180	250	±0.5	±0.2	±0.1
(10)	--	10	--	100	200	300	±0.5	±0.2	±0.1
(11)	2	--	20	--	--	320	±0.5	±0.2	±0.1

4.3.3 Test method used – Configure the MTB to power the node as described in all applicable conditions listed in Table 8 for Current Class 10. Electronically record the accuracy reading for each condition listed. Once all applicable points have been evaluated, verify that each point does not deviate from its Reference condition by more than the specified value.

4.3.4 Data (Results)

MAC ID	Test Amps	Test Condition	Value	Allowable Deviation	Result
0013500500216E12	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.06%	+/- .5%	Pass
	2.5	5	-0.08%	+/- .2% (Reference)	Pass
	5	7	-0.10%	+/- .5%	Pass
	7.5	8	-0.12%	+/- .5%	Pass
	10	10	-0.12%	+/- .5%	Pass
00135005002343D0	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.08%	+/- .5%	Pass
	2.5	5	-0.08%	+/- .2% (Reference)	Pass
	5	7	-0.08%	+/- .5%	Pass
	7.5	8	-0.08%	+/- .5%	Pass
	10	10	-0.08%	+/- .5%	Pass

MAC ID	Test Amps	Test Condition	Value	Allowable Deviation	Result
0013500500246222	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.06%	+/- .5%	Pass
	2.5	5	-0.08%	+/- .2% (Reference)	Pass
	5	7	-0.10%	+/- .5%	Pass
	7.5	8	-0.12%	+/- .5%	Pass
	10	10	-0.12%	+/- .5%	Pass
0013500500214FED	.15	1	-0.10%	+/- 1.0%	Pass
	.25	2	-0.10%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.08%	+/- .5%	Pass
	2.5	5	-0.10%	+/- .2% (Reference)	Pass
	5	7	-0.12%	+/- .5%	Pass
	7.5	8	-0.14%	+/- .5%	Pass
	10	10	-0.16%	+/- .5%	Pass
001350050024D83C	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.08%	+/- .5%	Pass
	2.5	5	-0.08%	+/- .2% (Reference)	Pass
	5	7	-0.06%	+/- .5%	Pass
	7.5	8	-0.06%	+/- .5%	Pass
	10	10	-0.06%	+/- .5%	Pass
00135005002D1143	.15	1	-0.10%	+/- 1.0%	Pass
	.25	2	-0.10%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.06%	+/- .5%	Pass
	2.5	5	-0.06%	+/- .2% (Reference)	Pass
	5	7	-0.06%	+/- .5%	Pass
	7.5	8	-0.06%	+/- .5%	Pass
	10	10	-0.06%	+/- .5%	Pass
001350050021D0C5	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	0.00%	+/- .5%	Pass
	1.5	4	0.00%	+/- .5%	Pass
	2.5	5	0.00%	+/- .2% (Reference)	Pass
	5	7	0.00%	+/- .5%	Pass
	7.5	8	0.00%	+/- .5%	Pass
	10	10	0.00%	+/- .5%	Pass

MAC ID	Test Amps	Test Condition	Value	Allowable Deviation	Result
00135005002D0904	.15	1	-0.10%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.10%	+/- .5%	Pass
	2.5	5	-0.12%	+/- .2% (Reference)	Pass
	5	7	-0.12%	+/- .5%	Pass
	7.5	8	-0.10%	+/- .5%	Pass
	10	10	-0.10%	+/- .5%	Pass
00135005002CED48	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	-0.10%	+/- .5%	Pass
	1.5	4	-0.06%	+/- .5%	Pass
	2.5	5	-0.08%	+/- .2% (Reference)	Pass
	5	7	-0.08%	+/- .5%	Pass
	7.5	8	-0.08%	+/- .5%	Pass
	10	10	-0.08%	+/- .5%	Pass
001350050023CA78	.15	1	0.00%	+/- 1.0%	Pass
	.25	2	0.00%	+/- .5%	Pass
	.5	3	0.00%	+/- .5%	Pass
	1.5	4	0.00%	+/- .5%	Pass
	2.5	5	-0.02%	+/- .2% (Reference)	Pass
	5	7	-0.02%	+/- .5%	Pass
	7.5	8	0.00%	+/- .5%	Pass
	10	10	0.00%	+/- .5%	Pass

4.3.5 Conclusion – All nodes tested passed without incident.

4.4 TESCO Test #4 – Effect of Variation of Power Factor

4.4.1 ANSI Test #4, ANSI C12.20 Section 5.5.4.4

4.4.2 ANSI Description - Each element of a multi-element metering device shall be tested as a single-element metering device except that all circuits shall be effectively in parallel.

4.4.3 Single-element nodes – The effect of variation of power factor upon performance of the metering device shall not exceed the maximum deviation specified in Table 9.

Table 9 – Effect of variation of power factor for single-element meters

Condition	Current in Amperes							Maximum Deviation in Percent from Reference Performance		
	Current Class						Power Factor	Accuracy Class		
	2	10	20	100	200	320		0.5	0.2	0.1
Reference performance for condition (1)	0.05	0.25	0.5	1.5	3	5	1.0	Reference	Reference	Reference
Condition (1)	0.1	0.5	1	3	6	10	0.5 lag	±1.0	±0.5	±0.25
Reference performance for condition (2)	1	5	10	50	100	150	1.0	Reference	Reference	Reference
Condition (2)	1	5	10	50	100	150	0.5 lag	±0.6	±0.3	±0.15
Reference performance for condition (3)	2	10	20	100	200	320	1.0	Reference	Reference	Reference
Condition (3)	2	10	20	100	200	320	0.5 lag	±0.6	±0.3	±0.15

4.4.4 Test method used – Configure the MTB to power the node as described in all applicable conditions listed in Table 9 for Current Class 10. Electronically record the accuracy reading for each condition listed. Once all applicable points have been evaluated, verify that each point does not deviate from its Reference condition by more than the specified value.

4.4.5 Data (Results)

MAC ID	Test Amps	Test Condition	Power Factor	Value	Allowable Deviation	Result
0013500500216E12	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.20%	+/- 1.0%	Pass
	5	2	1.0	-0.10%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.20%	+/- .6%	Pass
	10	2	1.0	-0.12%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.18%	+/- .6%	Pass
00135005002343D0	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.20%	+/- 1.0%	Pass
	5	2	1.0	-0.08%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.16%	+/- .6%	Pass
	10	2	1.0	-0.08%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.12%	+/- .6%	Pass
0013500500246222	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.30%	+/- 1.0%	Pass
	5	2	1.0	-0.10%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.18%	+/- .6%	Pass
	10	2	1.0	-0.12%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.08%	+/- .6%	Pass

MAC ID	Test Amps	Test Condition	Power Factor	Value	Allowable Deviation	Result
001350050O214FED	.25	1	1.0	-0.10%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.10%	+/- 1.0%	Pass
	5	2	1.0	-0.12%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.06%	+/- .6%	Pass
	10	2	1.0	-0.16%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	-0.04%	+/- .6%	Pass
001350050024D83C	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.20%	+/- 1.0%	Pass
	5	2	1.0	-0.06%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.18%	+/- .6%	Pass
	10	2	1.0	-0.06%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.18%	+/- .6%	Pass
00135005002D1143	.25	1	1.0	-0.10%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.10%	+/- 1.0%	Pass
	5	2	1.0	-0.06%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.12%	+/- .6%	Pass
	10	2	1.0	-0.06%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.12%	+/- .6%	Pass
001350050021D0C5	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.10%	+/- 1.0%	Pass
	5	2	1.0	0.00%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.06%	+/- .6%	Pass
	10	2	1.0	0.00%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.06%	+/- .6%	Pass
00135005002D0904	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.10%	+/- 1.0%	Pass
	5	2	1.0	-0.12%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.12%	+/- .6%	Pass
	10	2	1.0	-0.10%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.08%	+/- .6%	Pass
00135005002CED48	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.20%	+/- 1.0%	Pass
	5	2	1.0	-0.08%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.14%	+/- .6%	Pass
	10	2	1.0	-0.08%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.10%	+/- .6%	Pass
001350050023CA78	.25	1	1.0	0.00%	+/- .2% (Reference)	Pass
	.5	1	0.5 Lag	0.30%	+/- 1.0%	Pass
	5	2	1.0	-0.02%	+/- .2% (Reference)	Pass
	5	2	0.5 Lag	0.30%	+/- .6%	Pass
	10	2	1.0	0.00%	+/- .2% (Reference)	Pass
	10	3	0.5 Lag	0.28%	+/- .6%	Pass

4.4.6 Conclusion – All nodes tested passed without incident.

4.5 TESCO Test #5 – Effect of variation of voltage on the metering device

4.5.1 ANSI Test #5, ANSI C12.20 Section 5.5.4.5.

4.5.2 ANSI Description – The effect of voltage upon the performance of the metering device shall not exceed the maximum deviation specified in Table 12.

Table 12 – Effect of variation of voltage

Condition	Current in Amperes						Maximum Deviation in Percent from Reference Performance		
	Current Class						Accuracy Class		
	2	10	20	100	200	320	0.5	0.2	0.1
Reference performance 100% of calibration voltage for condition (1) and (2)	0.025	0.25	0.25	1.5	3	5	Reference	Reference	Reference
Condition (1) 90% of calibration voltage	0.025	0.25	0.25	1.5	3	5	±0.2	±0.1	±0.05
Condition (2) 110% of calibration voltage	0.025	0.25	0.25	1.5	3	5	±0.2	±0.1	±0.05
Reference performance 100% of calibration voltage for conditions (3) and (4)	0.25	2.5	2.5	15	30	50	Reference	Reference	Reference
Condition (3) 90% of calibration voltage	0.25	2.5	2.5	15	30	50	±0.2	±0.1	±0.05
Condition (4) 110% of calibration voltage	0.25	2.5	2.5	15	30	50	±0.2	±0.1	±0.05

4.5.3 Test method used – Configure the MTB to power the node as described in all applicable conditions listed in Table 12 for Current Class 10. Electronically record the accuracy reading for each condition listed. Once all applicable points have been evaluated, verify that each point does not deviate from its Reference condition by more than the specified value.

4.5.4 Data (Results)

MAC ID	Test Volts	Test Amps	Test Condition	Value	Allowable Deviation	Result
0013500500216E12	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	-0.10%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.06%	+/- .2%	Pass
	132	2.5	4	-0.04%	+/- .2%	Pass
00135005002343D0	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	-0.10%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.08%	+/- .2%	Pass
	132	2.5	4	-0.04%	+/- .2%	Pass
0013500500246222	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.02%	+/- .2%	Pass
	132	2.5	4	0.00%	+/- .2%	Pass
0013500500214FED	120	.25	1	-0.10%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	-0.10%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.10%	+/- .2%	Pass
	132	2.5	4	-0.08%	+/- .2%	Pass
001350050024D83C	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	-0.10%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.08%	+/- .2%	Pass
	132	2.5	4	-0.04%	+/- .2%	Pass
00135005002D1143	120	.25	1	-0.10%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	-0.10%	+/- .2%	Pass
	120	2.5	3	-0.06%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.08%	+/- .2%	Pass
	132	2.5	4	-0.06%	+/- .2%	Pass

MAC ID	Test Volts	Test Amps	Test Condition	Value	Allowable Deviation	Result
001350050021D0C5	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	0.00%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.02%	+/- .2%	Pass
	132	2.5	4	-0.02%	+/- .2%	Pass
00135005002D0904	120	.25	1	-0.10%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	-0.12%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.04%	+/- .2%	Pass
	132	2.5	4	-0.04%	+/- .2%	Pass
00135005002CED48	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.02%	+/- .2%	Pass
	132	2.5	4	-0.02%	+/- .2%	Pass
001350050023CA78	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.10%	+/- .2%	Pass
	120	2.5	3	-0.02%	+/- .2% (Reference)	Pass
	108	2.5	3	0.06%	+/- .2%	Pass
	132	2.5	4	0.06%	+/- .2%	Pass

4.5.5 Conclusion – All nodes tested passed without incident.

4.6 TESCO Test #6 – Effect of variation of frequency

4.6.1 ANSI Test #6, ANSI C12.20 Section 5.5.4.6

4.6.2 ANSI Description – The effect of the variation of frequency upon the registration of a metering device shall not exceed the maximum deviation specified in Table 14.

Table 14 – Effects of variation of frequency

	Current in Amperes						Percent Of Rated Frequency	Max. Deviation in % from Reference Performance		
	Current Class							Accuracy Class		
Condition	**2**	**10**	**20**	**100**	**200**	**320**		**0.5**	**0.2**	**0.1**
Reference for conditions (1) & (2)	0.025	0.25	0.25	1.5	3	5	100	Reference	Reference	Reference
Condition (1)	0.025	0.25	0.25	1.5	3	5	98	±0.2	±0.1	±0.05
Condition (2)	0.025	0.25	0.25	1.5	3	5	102	±0.2	±0.1	±0.05
Reference for conditions (3) & (4)	0.25	2.5	2.5	15	30	50	100	Reference	Reference	Reference
Condition (3)	0.25	2.5	2.5	15	30	50	98	±0.2	±0.1	±0.05
Condition (4)	0.25	2.5	2.5	15	30	50	102	±0.2	±0.1	±0.05

4.6.3 Test method used – Configure the MTB to power the node as described in all applicable conditions listed in Table 14 for Current Class 10. Electronically record the accuracy reading for each condition listed. Once all applicable points have been evaluated, verify that each point does not deviate from its Reference condition by more than the specified value.

4.6.4 Data (Results)

MAC ID	Test Amps	Frequency	Test Condition	Value	Allowable Deviation	Result
0013500500216E12	.25	60	1	0.00%	+/- .2% (Reference)	Pass
	.25	58.8	1	-0.10%	+/- .2%	Pass
	.25	61.2	2	-0.10%	+/- .2%	Pass
	2.5	60	3	-0.06%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.06%	+/- .2%	Pass
	2.5	61.2	4	-0.04%	+/- .2%	Pass
00135005002343D0	.25	60	1	0.00%	+/- .2% (Reference)	Pass
	.25	58.8	1	-0.10%	+/- .2%	Pass
	.25	61.2	2	-0.10%	+/- .2%	Pass
	2.5	60	3	-0.08%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.08%	+/- .2%	Pass
	2.5	61.2	4	-0.06%	+/- .2%	Pass
0013500500246222	.25	60	1	0.00%	+/- .2% (Reference)	Pass
	.25	58.8	1	0.00%	+/- .2%	Pass
	.25	61.2	2	0.00%	+/- .2%	Pass
	2.5	60	3	-0.08%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.04%	+/- .2%	Pass
	2.5	61.2	4	-0.04%	+/- .2%	Pass
0013500500214FED	.25	60	1	-0.10%	+/- .2% (Reference)	Pass
	.25	58.8	1	-0.10%	+/- .2%	Pass
	.25	61.2	2	-0.10%	+/- .2%	Pass
	2.5	60	3	-0.08%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.10%	+/- .2%	Pass
	2.5	61.2	4	-0.08%	+/- .2%	Pass
001350050024D83C	.25	60	1	0.00%	+/- .2% (Reference)	Pass
	.25	58.8	1	-0.10%	+/- .2%	Pass
	.25	61.2	2	-0.10%	+/- .2%	Pass
	2.5	60	3	-0.08%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.06%	+/- .2%	Pass
	2.5	61.2	4	-0.06%	+/- .2%	Pass
00135005002D1143	.25	60	1	-0.10%	+/- .2% (Reference)	Pass
	.25	58.8	1	-0.10%	+/- .2%	Pass
	.25	61.2	2	-0.10%	+/- .2%	Pass
	2.5	60	3	-0.06%	+/- .2% (Reference)	Pass
	2.5	58.8	3	-0.08%	+/- .2%	Pass
	2.5	61.2	4	-0.06%	+/- .2%	Pass

MAC ID	Test Amps	Frequency	Test Condition	Value	Allowable Deviation	Result
001350050021D0C5	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	0.00%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.02%	+/- .2%	Pass
	132	2.5	4	-0.02%	+/- .2%	Pass
00135005002D0904	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	-0.10%	+/- .2%	Pass
	132	.25	2	-0.10%	+/- .2%	Pass
	120	2.5	3	-0.12%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.06%	+/- .2%	Pass
	132	2.5	4	-0.06%	+/- .2%	Pass
00135005002CED48	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.00%	+/- .2%	Pass
	120	2.5	3	-0.08%	+/- .2% (Reference)	Pass
	108	2.5	3	-0.02%	+/- .2%	Pass
	132	2.5	4	-0.02%	+/- .2%	Pass
001350050023CA78	120	.25	1	0.00%	+/- .2% (Reference)	Pass
	108	.25	1	0.00%	+/- .2%	Pass
	132	.25	2	0.04%	+/- .2%	Pass
	120	2.5	3	-0.02%	+/- .2% (Reference)	Pass
	108	2.5	3	0.04%	+/- .2%	Pass
	132	2.5	4	-0.10%	+/- .2%	Pass

4.6.5 Conclusion – All nodes tested passed without incident.

5 Conclusions

5.1 Summary of Data

In all tests and under each of the prescribed conditions, all of the nodes tested passed without exception.

5.2 Summary of Observations.

Throughout the testing, TESCO documented whatever observations we felt pertinent to the purpose of this testing. In all of the testing done, however, the nodes performed well enough to be considered without notable additional observations.

6 Revision Record

REV	REVISION DESCRIPTION:	APPR:	REL:
-	Final Release	JFW	3/22/10

7 Appendices (supplied electronically with this report)

7.1 MTB Calibration report (CalibrationReport TESCO MTB.xlsx)

7.2 MTB Internal Reference Standard Calibration Certificate (Calibration Certificate SN 300250.pdf)

7.3 MTB Reference Standard Calibration Certificate (Calibration Certificate SN 208231.pdf)

7.4 Raw Test Data (SELC Node Testing Data.xlsx)

7.5 TESCO ISO Certificate (Advent Design 110415 Cert ISO 90012008 05.16-09.18 – elec.pdf)