FEB 27, 2020
PUC HEARING
EDWARDS vs DUQUESNE LIGHT
DOCKET C-2018-3002741

ALJ 1
COMP A → DO NOT HAVE
COMP B

ALJ JEFF WATSON

Resp E-2 ✓
Resp F-8 ✓
Resp G-7 ✓
Resp G-3 ✓
Resp G-1 ✓
Resp I-1 ✓
Resp H-2 ✓
Resp H-6 ✓
Resp H-1 ✓
Resp B-1 ✓
Resp D-2 ✓
Resp Q ✓
Resp ~~O~~ M-1 ✓
Resp M-2 ✓
Resp O ✓
Resp N ✓

EXHIBIT TRANSMITTAL SHEET

REPORTER:
DYLAN C. DIRENNA

RECEIVED
JUN 10 2020
PA PUBLIC UTILITY COMMISSION
SECRETARY'S BUREAU

Scanned

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

DUQUESNE LIGHT COMPANY
FINAL SMART METER TECHNOLOGY
PROCUREMENT AND INSTALLATION PLAN

Docket Nos. P-2012-___________
M-2009-2123948

Date: June 29, 2012

9626068v1

EXHIBIT B-1

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

Duquesne Light Company ("Duquesne Light" or the "Company") filed its Initial Smart Meter Procurement and Installation Plan ("Initial Smart Meter Plan") with the Pennsylvania Public Utility Commission ("Commission") on August 14, 2009. As part of the Initial filing, Duquesne Light received Commission approval to upgrade its customer information system and install a meter data management system. This project is known as the FOCUS Project. The new and replacement systems under the FOCUS Project are necessary in order for Duquesne Light to provide smart meter technology to customers. In addition, Duquesne Light received Commission approval to further develop a Final Smart Meter Procurement and Installation Plan to be filed with the Commission by December 31, 2011 ("Final Smart Meter Plan" or "Plan"). This date was subsequently extended to June 30, 2012 upon the request of the Company.

This filing constitutes Duquesne Light's Final Smart Meter Plan. Below, Duquesne Light has:

(1) Explained the steps that it has taken to develop this Plan during the Grace Period;

(2) Provided an overview of the FOCUS Project;

(3) Explained the Company's Advanced Metering Infrastructure ("AMI") Project which includes smart meters, the Local Area Network ("LAN"), the Wide Area Network ("WAN") and the Head End Collection Engine;

(4) Explained its plans for IT systems;

(5) Described the AMI system capabilities;

(6) Explained its proposed deployment schedule;

(7) Summarized the Smart Meter Program costs and cost recovery mechanism;

(8) Explained the Company's Customer Education and Acceptance Strategy; and

(9) Explained the Company's Risk Mitigation Strategies.

As explained herein, Duquesne Light's Final Smart Meter Plan will meet all of the requirements of Act 129, the additional requirements set forth in the *Implementation Order* and provides smart meter technology to customers in a cost-effective manner. *Smart Meter Procurement and Installation*, Docket. No. M-2009-2092655, *Implementation Order* entered June 24, 2009 ("*Implementation Order*").

Under Duquesne Light's Final Smart Meter Plan, Duquesne Light proposes to install Itron Smart Meters for all customers. The Itron Smart Meters will be connected by a Local Area Network ("LAN") that collects data from the meters and transmits it through a Wide Area Network ("WAN") to a Head End Data Collection Engine. These four components will constitute Duquesne Light's Advanced Metering Infrastructure ("AMI") system. As explained herein, Duquesne Light's AMI system will provide a technology architecture that enables the six minimum capabilities of Act 129 and the nine additional capabilities identified by the Commission in its Smart Meter Implementation Order.

Duquesne Light proposes to deploy Smart Meters to customers over a seven-year period. This includes a two-year ramp up period to allow time for the Company to test its AMI system, followed by a deployment schedule of 9,000 meters per month, with full deployment of smart meters across the Company's service territory by 2020, three years ahead of the statutory time period under Act 129. In addition, Duquesne Light proposes to phase-in meter functionalities from 2013-2017. The phase-in approach will allow the market for many of the advanced smart meter capabilities to become more mature over time.

Duquesne Light estimates that the total cost of its Smart Meter Program will be approximately $238 million. This includes costs for both the FOCUS and AMI projects within the Smart Meter Program. In its Initial Smart Meter Filing, Duquesne Light estimated that its Smart Meter Program could cost between $152 million and $262 million to implement. Duquesne Light's current estimate of its Smart Meter Program cost is within the range originally identified by the Company and is $24 million lower than the high end of its original estimate.

In the Company's Initial Smart Meter filing, the Commission approved, with certain modifications, Duquesne Light's request to recover its smart meter costs through a fully recoverable Smart Meter Charge ("SMC"). In this proceeding, Duquesne Light is proposing to continue to recover its smart meter costs through its Commission-approved SMC.

In addition, Duquesne Light is proposing a detailed, comprehensive Customer Education and Acceptance ("CEA") strategy to educate customers, stakeholder groups and employees about the Company's Smart Meter Program and its benefits. Duquesne Light is basing its CEA strategy on successful programs used by other utilities across the country. Duquesne Light believes that its CEA strategy is a vital component of its Final Smart Meter Plan.

As with all large, multi-year, multi-million dollar technology projects, the Company recognizes the multitude of risks inherent in a Smart Meter Program of this magnitude. Therefore, Duquesne Light has developed a broad set of risk mitigation strategies to minimize any potential negative impact of these risks on the program.

II. BACKGROUND

Duquesne Light is a public utility as that term is defined under Section 102 of the Public Utility Code, 66 Pa. C.S. § 102, certificated by the Commission to provide electric service in the City of Pittsburgh and in Allegheny and Beaver Counties in Pennsylvania.

On October 15, 2008, Governor Rendell signed into law Act 129 of 2008, which took effect on November 14, 2008 and, *inter alia*, mandated a smart meter procurement and installation program. *See* 66 Pa. C.S. § 2807(f), et seq. ("Act 129"). Act 129 provides, among other things, that each Pennsylvania EDC with at least 100,000 customers is required to provide smart meter technology to customers in accordance with a schedule not to exceed 15 years. Act 129 defines smart meter technology as follows:

> (g) *Definition.* – As used in this section, the term "smart meter technology" means technology, including metering technology and network communications technology capable of bidirectional communication, that records electricity usage on at least an hourly basis, including related electric distribution system upgrades to enable the technology. The technology shall provide customers with direct access to and use of price and consumption information. The technology shall also:
>
> (1) Directly provide customers with information on their hourly consumption.
>
> (2) Enable time-of-use rates and real-time price programs.
>
> (3) Effectively support the automatic control of the customer's electricity consumption by one or more of the following as selected by the customer:
>
> (i) the customer;
>
> (ii) the customer's utility; or
>
> (iii) a third party engaged by the customer or the customer's utility.

66 Pa. C.S. § 2807(g).

The Commission adopted its *Smart Meter Implementation Order* on June 18, 2009, outlining its guidance for an EDC's Smart Meter Procurement and Installation program pursuant to Act 129. The *Implementation Order* established the standards that each plan must meet and provided guidance on the procedures to be followed for submittal, review and approval of all aspects of each smart meter plan. Additionally, upon the recognition that it will take time to fully develop and install the entire smart meter network, the Commission granted a grace period of 30 months following plan approval ("Grace Period") for EDCs to assess needs, select technology, secure vendors, train personnel, install and test support equipment and establish a detailed meter deployment schedule.

In the *Implementation Order*, the Commission identified six minimum functionalities that EDC smart meter systems must provide under Act 129. These six minimum functionalities are:

1. Bidirectional data communications.
2. Reading usage data on at least an hourly basis once per day.
3. Providing customers with direct access to and use of price and consumption information.
4. Providing customers with information on their hourly consumption.
5. Enabling time-of-use ("TOU") rates and real-time price options.
6. Supporting the automatic control of the customers' electric consumption.

Implementation Order, pp. 29-30.

In addition, the Commission stated that each Plan filing should include an analysis of the individual incremental costs for deploying and operating the following nine additional smart meter technology capabilities:

1. Ability to remotely disconnect and reconnect.
2. Ability to provide 15-minute or shorter interval data to customers, EGSs, third-parties and an RTO on a daily basis, consistent with the data availability, transfer and security standards adopted by the RTO.
3. On-board meter storage of meter data that complies with nationally recognized non-proprietary standards such as ANSI C12.19 and C12.22 tables.

4. Open standards and protocols that comply with nationally recognized non-proprietary standards, such as IEEE 802.15.4.

5. Ability to upgrade these minimum capabilities as technology advances and becomes economically feasible.

6. Ability to monitor voltage at each meter and report data in a manner that allows an EDC to react to the information.

7. Ability to remotely reprogram the meter.

8. Ability to communicate outages and restorations.

9. Ability to support net metering of customer-generators.

Implementation Order, p. 30.

In the *Implementation Order*, the Commission further noted that it may waive the additional requirements for an EDC if the requirements are not cost-effective.

On August 14, 2009, Duquesne Light filed its Initial Smart Meter Plan with the Commission. In its Initial Smart Meter Plan, the Company, among other things: (1) provided a description of its current metering system, (2) explained how it would address customer requests for smart meters and installation of smart meters in new construction during the grace period, (3) explained its approach for developing a Final Smart Meter Plan within the 30 month grade period, (4) proposed a milestone and status reporting schedule during the grace period, (5) provided an estimated budget for grace period budget, and (6) proposed a cost recovery mechanism for recovering smart meter costs.

On May 11, 2010, the Commission approved Duquesne Light's Initial Smart Meter Plan, with certain modifications. *Petition of Duquesne Light Company for Approval of Smart Meter Technology Procurement and Installation Plan*, Docket No. M-2009-2123948. In summary, the Commission approved Duquesne Light's proposal to recover its smart meter costs through a reconcilable cost recovery mechanism, and set forth the details of how this mechanism would work. In addition, the Commission approved the Company's proposed smart meter implementation schedule, which the Company explained was subject to change. The

Commission also approved the Company's proposed milestone filing dates, and the Company's proposal to file a Final Smart Meter Plan by December 31, 2011.

On July 1, 2010, the Company filed a Cost Benefit Analysis for the additional smart meter capabilities identified in the *Implementation Order*. Therein, the Company provided a detailed evaluation of the costs to implement each of the nine additional smart meter capabilities identified in the *Implementation Order*, the potential benefits of implementing these additional capabilities and the Company's recommendations regarding whether it should be required to implement these additional capabilities. In the July 1, 2010 filing, Duquesne Light explained that its cost-benefit analysis was a preliminary analysis based upon information that was available at the time. Duquesne Light requested that the Commission defer ruling on whether Duquesne Light should implement the additional smart meter capabilities at that time. Duquesne Light further explained that it would have a better estimate of its smart meter costs at a later time and that the Company would provide a refined project budget and cost estimates in its Final Smart Meter Plan filing.

On December 29, 2010, Duquesne Light filed its Application for Approval of Assessment of Needs, Technology Solutions and Vendor Selection ("Assessment Application"). In summary, in the Assessment Application, Duquesne Light proposed to replace its existing Automated Meter Reading ("AMR") system with a new AMI system that would provide two-way communication between the meter and the Company and would comply with all requirements of Act 129 and the Commission's *Implementation Order*. In the Assessment Application, the Company requested that the Commission issue an order approving: (1) the procedure used to evaluate and select a primary AMI vendor, (2) the Company's Assessment of Needs, (3) the Technology Section of RF mesh and associated findings, (4) the selection of the Company's Primary AMI vendor, (5) updated cost projections for the entire Smart Meter Project and Deployment, and (6) any other approvals that the Commission deemed to be necessary.

On January 31, 2011, the Company filed a Supplement to its Assessment Application. In the Supplement, Duquesne Light identified Itron, Inc. ("Itron") as its recommended primary contractor to design, construct, implement and oversee the Company's Smart Meter program.

The Company explained that it had issued bids for smart meter contractors and received four bids. Itron scored the highest on a technical evaluation of the bids and provided the lowest cost solution of the four bidders. In the Supplement, Duquesne Light requested Commission approval of the initial Assessment Application and Supplement. No party objected to the Company's Assessment Application or its Supplement. The Commission did not issue an Order with respect to the Assessment Application or the Supplement thereto.

On March 31, 2011, the Company filed its Establishment of Network Design for the Duquesne Light Smart Meter Program ("Network Design") with the Commission. Therein, the Company explained that it had conducted a study to review the Company's existing communication infrastructure, review network and communication infrastructure necessary for the AMI and also review available private and public written communications solutions. Specifically, the Company evaluated:

- Operating Frequencies Available in its Service Territory;
- Radio Technologies/Vendors;
- Solution Cost (up front and ongoing)
- Expected capacity, bandwidth, latency and reliability of each option;
- Security provisions (public versus private writers communications); and
- Advantages and disadvantages of available solutions.

The initial Network Design conclusions supported the use of private wireless options as the primary communication methodologies, with public wireless as a backup communication. The Company also noted that further analysis was necessary to finalize the Network Design Study conclusions and that the proposed design was subject to change based on further findings or in the event that other viable technologies would become available.

On June 30, 2011, the Company made an additional milestone filing related to the design, testing and certification of Electronic Data Interchange ("EDI") transactions. Therein, Duquesne Light explained that it would be able to provide customers with direct access to non-validated real time data directly from the smart meter through a residential customer's Home Area Network (HAN).

Validated hourly interval data would be provided through a secure web portal within 24 hours from the completion of the data upload for the entire population of Duquesne Light's smart meters to the MDM systems. Additionally, non-validated, real time data would be provided to third parties through a secure, authenticated connection at the expense of the third party. Validated hourly interval data would be provided to third parties through a standard interface consistent with the North American Energy Standards Board within 24 hours of the completion of the data upload for the entire population of Duquesne Light's smart meters to the MDM systems. Finally, the Company would provide EDI access to smart meter data to authorized commercial operators, such as conservation service providers and electric generation suppliers ("EGS") using the 867 historical interval usage transaction.

On October 6, 2011, the Company filed an Installation, Testing and Rollout of Support Equipment and Software Update filing. The purpose of the October 6 update filing was to outline the equipment testing that the Company planned to conduct prior to deploying AMI meters across its service territory.

On November 2, 2011, the Company filed a status update related to its Establishment of Plans for Installation of Meters and Outside Communications and Training. Therein, the Company provided an overview of its smart meter deployment plan, a high level Smart Meter Program Schedule and Milestones, and an overview of its Staff Training Plan.

On November 18, 2011, the Company filed a status update with respect to its Smart Meter Plan and further requested a six month extension, from December 31, 2011 to June 30, 2012, to file the Company's Final Smart Meter Plan. With respect to the status update, the Company provided a summary of the work that it had done in the previous 18 months. In addition, the Company noted that there were several smart meter issues that it was still reviewing.

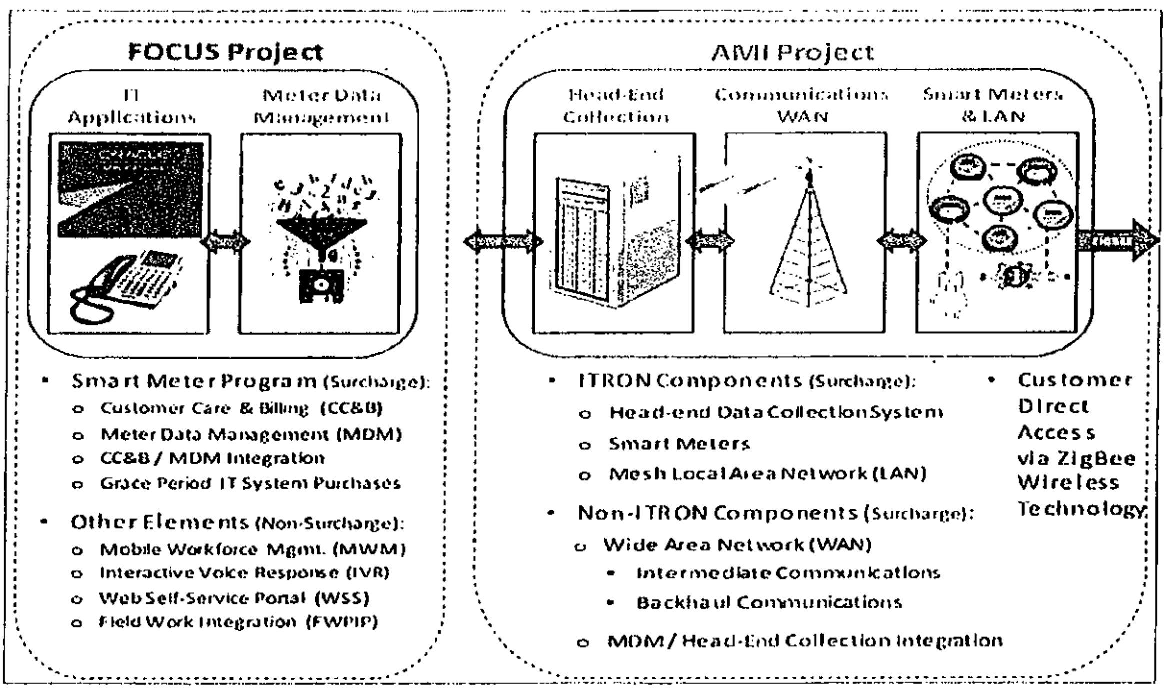
On December 13, 2011, the Commission issued a Secretarial Letter granting the Company's request for an extension, until June 30, 2012, to file its Final Smart Meter Plan. Pursuant to the Commission's December 13, 2011 Secretarial Letter, Duquesne Light hereby files its Final Smart Meter Plan.

III. FINAL SMART METER PLAN

A. INTRODUCTION

Duquesne Light's Smart Meter Program consists of two major projects, FOCUS and AMI. Diagram #1 provides a high-level overview of the scope of Duquesne's Smart Meter Program.

Diagram # 1: Duquesne Smart Meter Program – Two Major Projects



Under the FOCUS project, Duquesne Light is replacing its customer information system with a Customer Care and Billing ("CC&B") system and is implementing a new Meter Data Management ("MDM") system. The Commission approved the upgrade of these Information Technology ("IT") systems in the Company's Initial Smart Meter Plan. The upgrade of these IT systems is necessary in order for Duquesne Light to provide smart meter technology to customers.

Under the AMI project, Duquesne Light will install Itron smart meters, develop necessary communication networks and install a head-end data collection engine for smart meter data. In addition, Duquesne Light will hire a systems integrator to integrate all of the separate components of the Company's Smart Meter Program. This is a critical function in order to ensure seamless operation of the AMI system.

As explained below, Duquesne Light proposes to deploy its AMI System over a seven-year period. The seven-year period includes a two-year ramp up period to allow systems testing before they are implemented on a broader scale. At the end of the two-year ramp up period, the Company proposes a deployment schedule of 9,000 meters per month with full deployment by the end of 2020. In addition, the Company proposes to phase-in AMI functionalities over time to allow the markets for these functionalities to become more mature. The Company's AMI System will meet all of the requirements of Act 129 and provide all of the additional capabilities set forth in the Commission's *Implementation Order*, after all functionalities are phased-in.

The total Smart Meter Program will cost approximately $238 million. The Company has provided additional details regarding these costs herein. In addition, the Company proposes to continue to recover its smart meter costs through its SMC.

These topics are discussed in more detail below.

B. FOCUS PROJECT

In its *Implementation Order*, the Commission recognized that a fully functional smart meter involved more than just the meter hardware attached to the customer's premises. *Implementation Order*, p. 6. Therein, the Commission stated as follows:

> A fully functional smart meter that supports the capabilities required by Act 129 and as outlined below, involves an entire network, to include the meter, two-way communication, computer hardware and software, and trained support personnel.

Consistent with this direction from the Commission, Duquesne Light explained in its Initial Smart Meter filing that it was required to replace its billing, data collection and back-office systems in order to provide smart meter technology to customers. This project is called the FOCUS Project.

The FOCUS project encompasses significant upgrades to the Company's existing IT system architecture in order to provide the back-office foundation necessary to successfully deploy smart meters. Duquesne Light's current customer information system ("CIS") is adequate for sustaining existing business requirements, but is insufficient for meeting Act 129 and the Commission's *Implementation Order* Smart Meter requirements. Functionality enhancements such as TOU rates, real-time price programs, remote disconnect and reconnect, direct access to price and consumption information, and the automatic control of customer's electric consumption cannot be supported without replacing Duquesne Light's existing CIS. Furthermore, Duquesne Light's existing back-office IT architecture is not designed for the proliferation of data inherent in providing hourly or even more granular interval usage information to all of our customers on a daily basis. Therefore, in conjunction with replacing our CIS, Duquesne Light must implement an MDM system as well as integrate this new system with the replacement CIS.

As part of FOCUS project scope within Duquesne Light's Smart Meter Program, the Company is now implementing the Oracle Customer Care and Billing ("CC&B") module within the Utility Application Suite to replace our existing CIS. In addition, Duquesne Light has purchased the Oracle MDM module and is currently implementing this component of the Utility Application Suite as well as integrating it with CC&B as a part of the FOCUS project. The implementation and integration of these two modules provides the necessary IT system foundation components to support the subsequent extension of this architecture for AMI system capabilities. The FOCUS project is an integral part of Duquesne Light's Plan for meeting Act 129 and the Commission's *Implementation Order* requirements.[1]

The FOCUS project started in July 2010 after Commission approval of the Company's Initial Smart Meter Plan and is projected to be completed by the end of the second quarter of 2013. There are five general phases during the FOCUS project lifecycle and timeline is as follows:

---

[1] The FOCUS project also includes several supporting scope components that are not part of Duquesne Light's Smart Meter Program. Some of these more significant components include the implementation of the Oracle Mobile Workforce Management ("MWM") module as well as its integration with CC&B, the replacement of our existing Interactive Voice Response ("IVR") system, and the redesign of our Outage Analysis System ("OAS") and Web Portal ("WSS") to work with CC&B.

- Discovery (Define Scope): July 2010 to November 2010
- Analysis (Gather Requirements): December 2010 to August 2011
- Assembly (Design & Build): August 2011 to May 2012
- Acceptance (Test & Train): June 2012 to March 2013
- Deployment (Go-Live & Support): April 2013 to June 2013

C. AMI PROJECT

1. Introduction

There is a growing demand for sophisticated metering (e.g., net metering), meter data management and price responsive rates as customers have a greater interest in reducing their electric bill. These new demands and requirements cannot be met with Duquesne Light's current meter and system infrastructure.

Pursuant to the milestones detailed in the Company's Initial Smart Meter Plan, Duquesne Light filed an assessment of its AMI technology requirements and potential solutions on December 29, 2010. In this filing, Duquesne Light describes the comprehensive process it undertook with its AMI advisor, SAIC, Inc. ("SAIC") (formerly R. W. Beck), to assess its current AMR technology environment as well as explicitly document the Company's requirements for a future AMI technology environment in the form of a formal Request for Proposal (RFP). The December 2010 filing also described the rigorous RFP process that the Company followed with its AMI advisor to create a short-list of two AMI vendors with similar solutions that best addressed Duquesne Light's needs ranked exclusively on technical merit. In a supplemental filing submitted on January 31, 2011, Duquesne Light advised the Commission concerning the selection of ITRON's OpenWay solution as the most cost effective AMI system for addressing its needs.

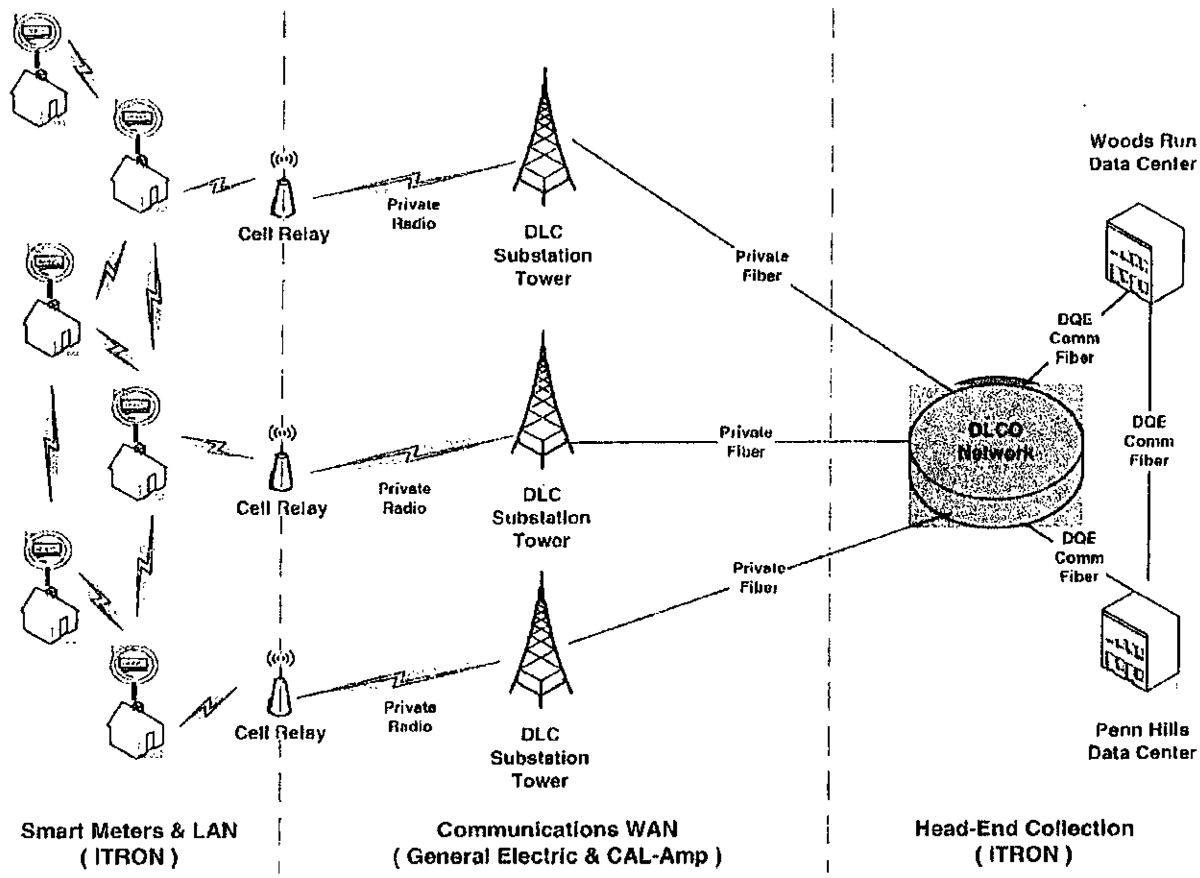
In the first step of defining the AMI project scope, a technology needs assessment was performed to identify the necessary AMI requirements to minimally meet ACT 129 smart meter requirements, as well as the additional requirements outlined in the Commission's *Implementation Order*. The requirements assessment was performed by outlining the current state of Duquesne Light's technology, including AMR and back-office supporting systems, either currently installed, or planned for installation, that would either directly or indirectly integrate with AMI during the Smart Meter deployment phase. By understanding the current environment, AMI requirements could be defined and outlined in a detailed RFP which would ensure that the solutions AMI vendors proposed succinctly addressed Duquesne Light's needs.

Duquesne Light's proposed AMI solution includes four components. These four components are:

- Smart Meters
- Local Area Network
- Wide Area Network
- Head End Data Collection Engine

Diagram 2 below provides an overview of the AMI System Components.

Diagram # 2: Duquesne AMI System Architecture



Duquesne Light plans to replace all existing AMR meters with new smart meters that will provide two-way communication between each customer premise and the utility. All single phase meters will be equipped with ZigBee[2] data channels to enable customers direct access to interval usage data, and provide a platform for future HAN applications. The selected AMI solution is capable of providing interval data for all meters, and single phase meters will be equipped with an internal switch for remote connections and disconnections.

---

[2] ZigBee is a commonly used communication specification for advanced metering systems. ZigBee has the ability to link smart meters with devices such as thermostats, household appliances, HVAC and other equipment that uses electricity.

2. Smart Meters

Duquesne Light proposes to install ITRON smart meters for all customers. The ITRON Smart Meters include the latest advanced metering technology, including bidirectional data communications, ZigBee direct access capabilities and a remote connect/disconnect switch. The ITRON smart meters and related advanced metering infrastructure discussed below will meet all of the six minimum smart meter requirements set forth under Act 129, including:

1. Bidirectional data communications.
2. Reading usage data on at least an hourly basis once per day.
3. Providing customers with direct access to and use of price and consumption information.
4. Providing customers with information on their hourly consumption.
5. Enabling TOU rates and RTP options.
6. Supporting the automatic control of the customers' electric consumption.

In addition, the ITRON Smart Meters and related advanced metering infrastructure will meet all of the nine additional smart meter requirements set forth in the *Implementation Order*, including:

1. Ability to remotely disconnect and reconnect.
2. Ability to provide 15-minute or shorter interval data to customers, EGSs, third-parties and an RTO on a daily basis, consistent with the data availability, transfer and security standards adopted by the RTO.
3. On-board meter storage of meter data that complies with nationally recognized non-proprietary standards such as ANSI C12.19 and C12.22 tables.
4. Open standards and protocols that comply with nationally recognized non-proprietary standards, such as IEEE 802.15.4.
5. Ability to upgrade these minimum capabilities as technology advances and becomes economically feasible.
6. Ability to monitor voltage at each meter and report data in a manner that allows an EDC to react to the information.
7. Ability to remotely reprogram the meter.

8. Ability to communicate outages and restorations.

9. Ability to support net metering of customer-generators.

Further explanation regarding how Duquesne Light's AMI system will meet all of the six minimum smart meter requirements set forth under Act 129 and will meet all of the nine additional smart meter requirements set forth in the *Implementation Order* is provided in Section E below. In addition, the specific technical capabilities of the ITRON smart meters, including the AMI standards supported by the ITRON smart meters are set forth in Appendix A.

3. Mesh or Local Area Network ("LAN")

The LAN consists of the transmission of data between ITRON smart meters and ITRON cell relays. The LAN has the following features:

- An RF mesh based solution that is capable to being Upgraded to an IPv6 based mesh solution
- Bi-directional communication
- Operates in the unlicensed 900 MHz band
- 902-928 MHz Bandwidth (with frequency hopping signaling)
- Supports 142-153 kilobits per second ("kbps") throughput
- Each cell relay supports up to approximately 2,000 meters
- Support of IP and native DNP protocols when running the full IPv6 solution

4. Wide Area Network ("WAN")

The WAN provides data communications between the LAN and the Head-End data collection system. A diagram of the AMI system architecture, including the WAN, is shown on Diagram 2 above.

The solution for the WAN component of the AMI system was determined with the assistance of SAIC. Pursuant to the milestones detailed in the Company's Initial Smart Meter Plan, Duquesne Light filed a preliminary design for the AMI communication network on March 31, 2011. In this preliminary design of the WAN component of the AMI system, Duquesne Light proposed a private radio solution as opposed to a public wireless solution for the intermediate portion of the WAN, which connects the cell relays that are part of ITRON's LAN to existing Duquesne Light owned communication towers. See Diagram # 2. The preliminary design also proposed leveraging the private fiber currently leased by Duquesne Light from DQE Communications that already exists between Duquesne Light's communication towers and data center for the back-haul portion of the WAN. At the time of the March 31, 2011 filing, this preliminary design was determined to be the most cost-effective solution for the WAN component of Duquesne Light's AMI system. The following is a bulleted summary of the Company's preliminary due diligence efforts.

- Engaged SAIC in November 2010 to assist with the AMI Communication Network technology and cost assessment
- Analyzed multiple Private Licensed Wireless (Radio), Private Unlicensed Wireless (Radio) and Public Wireless alternatives for the LAN Cell Relay to Tower communication network
- SAIC recommended a combination of two Private Licensed Wireless solutions (3.65 GHz & 220 MHz) as cost effective alternatives that best met Duquesne Light's technological requirements
- Recognizing the potential unavailability of 220 MHz spectrum in DLC territory, the recommendation also included 900 MHz as a replacement
- It was noted that public wireless could be used as a back-up to the private wireless solution
- Filed preliminary communications network design with PA PUC in March 2011 based on SAIC's recommendation

In requesting and subsequently receiving a six month extension for filing our Final Smart Meter Plan, Duquesne Light committed to performing additional due diligence related to private versus public WAN solutions in light of new information that public carrier price offerings were becoming more cost competitive. After several more months of analysis, Duquesne Light confirmed that a private wireless solution as originally proposed is the best solution because it provides Duquesne Light with more control over the security and reliability of the system as well as strategic opportunities to utilize available bandwidth for other data communication applications including mobile workforce, SCADA, and corporate security. The private wireless solution has more initial costs than a public wireless solution. However, the private wireless solution has considerable annual O&M savings which offset the initial upfront costs over the life of the system. A financial analysis between private versus public networks was too close to conclusively drive the decision of one type over the other.

The following is a bulleted summary of our additional due diligence efforts.

- Met with WAN vendors to determine availability of licensed spectrum in Duquesne territory
- Determined that 220 MHz was not an available spectrum
- Reserved 900 MHz spectrum from Space Data through a 15 month lease with an option to buy upon termination
- Worked with SAIC and ITRON to develop a Propagation study to evaluate coverage capabilities of the 3.65 GHz and 900 MHz Private Licensed Wireless solution
- Finalized capital and on-going O&M cost estimates of private and public solutions based on the propagation study
- Developed a detailed cost comparison between the Private Licensed Wireless solution and the Public Wireless solution
- Determined that the private wireless solution was still the best value for Duquesne Light
- Filed a private wireless solution for the WAN component of our AMI system as part of this Plan

5. Technical Advantages of the New AMI System

There are several distinct technical advantages associated with the proposed AMI system architecture network over the existing AMR system. First and foremost, the existing AMR system architecture only supports a single directional data flow (from meter to head-end data collection engine), whereas the proposed AMI System architecture supports a bi-directional data flow.

Secondly, the existing AMR system LAN solution requires each meter to be in the line of sight of a Cell Control Unit ("CCU") in order to communicate. The new AMI system LAN solution uses mesh network technology which enables meters to communicate to each other. A meter that is not in line of sight of a cell relay communicates its data to a neighboring meter that in turn communicates its data to a neighboring meter and this process continues until the data is consolidated at a meter that does have line of sight to a cell relay. This mesh network technology only requires a portion of the meters to be in the line of sight of a cell relay in order for all meters to be read. Since most meters have several neighboring meters, the mesh network technology also provides redundant paths for communicating data to a cell relay. Therefore, the AMI system solution greatly reduces the amount of LAN components that need to be installed in order to cover all of Duquesne Light's service territory. This will make it more cost effective to read 100% of Duquesne Light's meters at least once daily rather than the 80 to 90% that are being read daily with the AMR system.

Finally, the existing AMR system architecture requires multiple, disparate solutions to communicate with all of Duquesne Light's meters. These solutions differ for all three system components including the type of meter data communications; the WAN communication protocols; and the head-end collection engine applications. The AMI system architecture uses a single type of meter data communications; a common WAN communication protocol and the same head-end data collection engine application to communicate with all of Duquesne Light's meters.

6. Head-End Data Collection Engine

As part of its AMI Project, Duquesne Light must install a Head-End Data Collection Engine. The Head-End Data Collection Engine performs network management and coordinates data collection and operations. The Head-End Data Collection Engine has the following characteristics:

- Collects interval meter usage data for all single phase and three phase meters.
- Support scheduled (automatic) and unscheduled (operator-initiated) meter reads.
- Remotely downloads updates to meter settings, configuration, security settings, and firmware for all AMI devices.
- Obtains meter data, such as register and power status, on demand.
- Communicates with groups of AMI meters and consumer owned control devices to enable load management.

- Collects and reports measurement data, control events, self-test data and alerts, service continuity data and alerts, power quality data and alerts (including tamper), *programming events, configuration settings, etc.*
- Monitors, analyzes, and manages service continuity.
- Supports and reports service continuity and voltage interruptions.
- Supports monitoring, analyses, and management of customers' power quality.
- Supports customer (scheduled and unscheduled) load control functions.
- Provides automatic self-registration of AMI endpoints/meters.
- Supports meter self testing, system performance monitoring and reporting.
- Effectively employs Service Oriented Architecture ("SOA") and/or Enterprise Service Bus ("ESB") technologies for communication among its application modules and for interoperation of its system components with Duquesne's other information systems.

D. IT SYSTEMS

1. Introduction

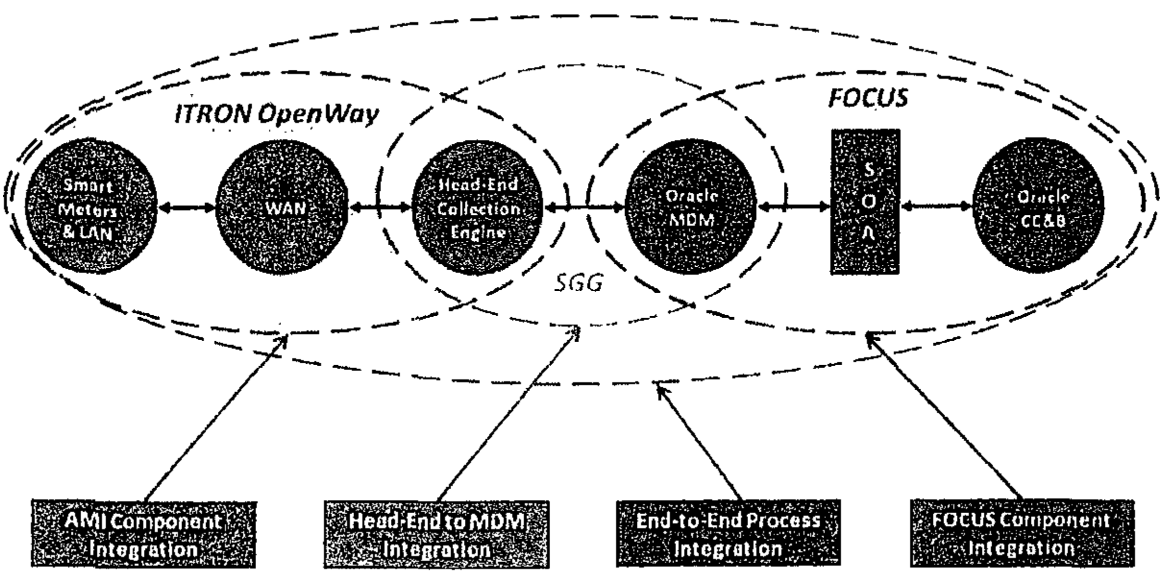
In addition to the AMI Project scope described in the section above, Duquesne Light's Final Smart Meter Plan includes the implementation, ongoing support and multifaceted integration of several IT systems. Some of the more significant of these IT systems such as Oracle's CC&B and MDM will be implemented and integrated as part of the Focus Project but will also require further systems integration and functional enhancements as part of the AMI project.

Much of the systems integration and ongoing support work requires specific expertise and technology skills that are not available within Duquesne Light's existing internal IT staff. Therefore, the Plan supplements Duquesne Light's resources with third party IT vendor delivery and support resources as well as third party Systems Integrator ("SI") resources. Duquesne Light will embark on a formal RFP process to select a qualified SI in the latter half of 2012. Duquesne Light also plans to negotiate a contract with the selected SI that will be executed upon approval of our final Smart Meter Plan.

2. Systems Integration

As shown on Diagram #3 below, Duquesne Light's Smart Meter Program has four levels of complex systems integration that must work both independently as well as in conjunction with each other in order for the entire solution to function properly.

Diagram #3: Duquesne Light Systems Integration



The first level of systems integration is to establish a bidirectional interface between the CC&B and MDM components of the FOCUS project. The integration of these two components is facilitated through Oracle's Services Oriented Architecture ("SOA"). All meter usage data is validated, edited and estimated ("VEE") by the MDM module before it is passed to CC&B on a request basis for billing purposes. This cleansed usage data along with meter events such as tamper notifications is also utilized to support other customer oriented transactions such as high bill complaints, meter inspections and the automated completion of service orders that require a meter read.

The second level of systems integration is to establish a bidirectional interface between the Smart Meters deployed at customer premises and the Head-End Collection Engine installed at Duquesne Light's data center. The integration of these two components is facilitated through the AMI system communication network, which includes the LAN and the WAN. The Smart Meter records interval data on at least an hourly basis which then must be collected from the field at least once daily by the Head-End Collection Engine. The LAN and WAN provide the connectivity necessary to accomplish this automated data collection. This bidirectional interface is also used for collection of meter events and alerts as well as to perform firmware upgrades within the meter.

The third level of systems integration is to establish a bidirectional interface between the Head-End Collection Engine and the MDM module. The integration of these two components is facilitated through Oracle's Smart Grid Gateway ("SGG"). SGG provides standard adapters for data exchange between Head-End Collection Engines from leading AMI vendors and Oracle's MDM module. All requests for meter usage data, events and alerts from Smart Meters are initiated from the MDM module. Therefore, the Head-End Collection Engines receives all of its instructions on what data to collect from the field as well as when to collect this data through the SGG.

The fourth level of systems integration is to establish end-to-end business processes that leverage the bidirectional interfaces between all of the components that were implemented and interfaced in the previous three levels. These end-to-end business processes include base metering functions such as monthly billing; daily displays of usage data on a customer web portal; commissioning and decommissioning of meters; and on-demand meter reads as well as advanced metering functions such as remote connects and disconnects; automated control of electric consumption; and provisioning of HAN devices.

3. Functional Enhancements

There are many functional enhancements to IT systems required to meet the smart meter requirements of ACT 129 and the Implementation Order, which are described in more detail in the AMI System Capabilities section of this plan. In addition, there are other functional enhancements to IT systems that leverage these AMI system capabilities to provide expanded self-service offerings to our customers as well as better information for our customer service representatives. These functional enhancements are described in more detail in the following appendices to this Plan:

- Bill-to-Date & Projected Bill – Appendix B
- Bill Alerts – Appendix C
- Smart Meter Usage Display – Appendix D
- Web Dashboard – Appendix E

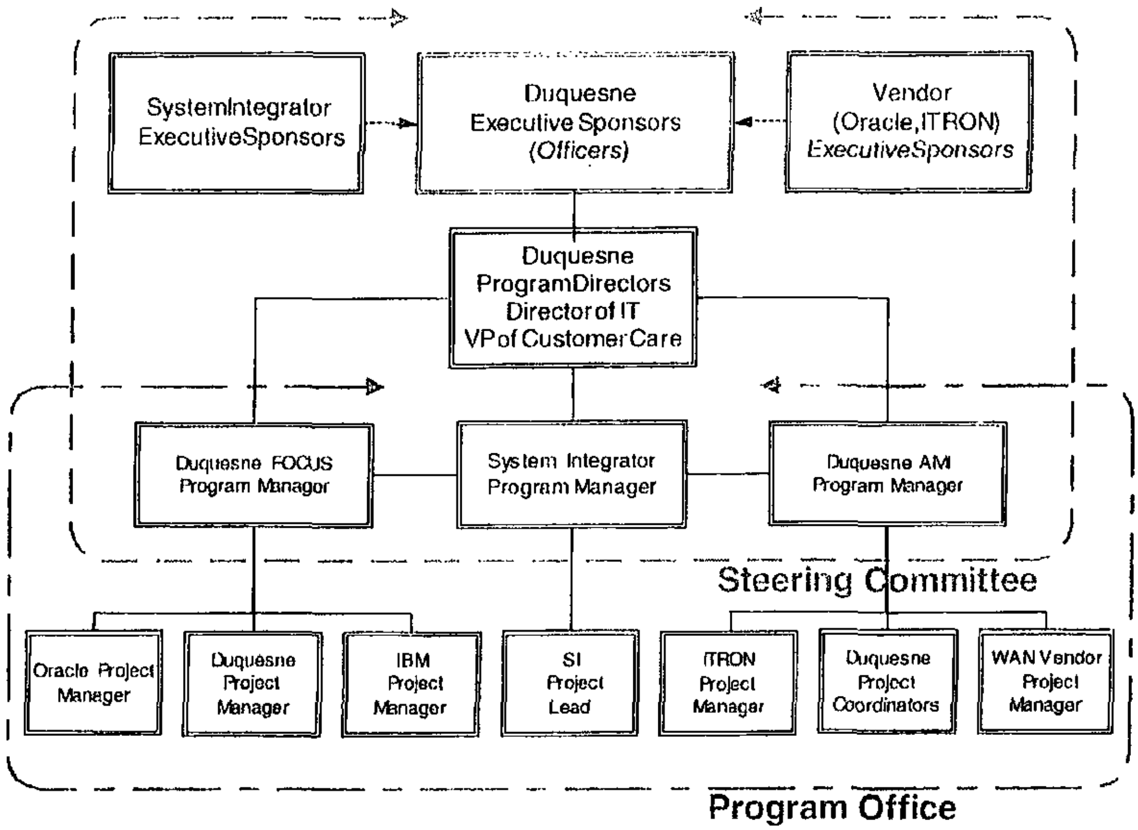
4. Systems Integrator

The complexity of integrating multiple IT systems from multiple vendors across several lines of business such as customer care and metering operations along with deploying all new advanced meters and communication networks requires specific expertise across several technology disciplines that does not exist internally within Duquesne Light. Therefore, Duquesne Light plans to engage a Systems Integrator (SI) to manage the IT systems work effort within the AMI project. The success of the AMI project is highly dependent on engaging an SI that has utility industry experience with both AMI technology projects as well as with Oracle Utility Application Suite implementations. The SI will have ultimate responsibility for the implementation of the remaining three levels of integration (the first level will be complete upon implementation of the FOCUS project) of Duquesne Light's Smart Meter Program. This responsibility includes oversight of the IT system integration and functional enhancement work being performed by other vendors including Oracle and ITRON.

Working with Duquesne Light, one of the initial tasks for the SI will be to finalize the phased implementation approach for the AMI Project. Phased scope definition is established by considering a variety of factors including business criticality and benefit, regulatory mandates, customer needs, overall program risk mitigation, technology availability and delivery, incremental change that users can adapt to and embrace, and other key considerations.

Once the implementation approach and individual phase scopes are confirmed, a detailed project plan will be developed including main tasks, deliverables, milestones and schedule. A Program Management Office (PMO), consisting of Duquesne Light, SI, Oracle, ITRON and other vendor resources will be established to manage and monitor the execution of this plan.

Diagram #4: Duquesne Light Smart Meter Program Management Office



Simply defined, System Integration looks beyond a single, independent system or solution delivery with the knowledge, responsibility, and accountability to validate the enterprise solution delivers as planned and is maintainable and supportable over the useful life of the system. System integration encompasses both business and technical integration of applicable processes. Duquesne Light's Final Smart Meter Plan proposes that the SI will act as an implementation advisor driving day-to-day results by validating constant and consistent alignment of the business vision to the technical solution; managing to an integrated program view vs. individual project views; managing overall program dependencies and interactions between related projects and initiatives; balancing competing interests to provide solutions delivering optimal enterprise results; seeking to eliminate overlap, duplication, and redundancy in program activities; and ensuring individual component applications (new, existing, third party) can support end-to-end business processes. The specific services provided by the SI are detailed in Appendix F to this plan.

5. On-going Support

The IT systems being implemented as part of both the FOCUS project and AMI project require significant ongoing support. Duquesne Light's Final Smart Meter Plan provides for this support through the end of the deployment period in the form of annual maintenance agreements with Oracle and ITRON as well as managed service agreements with a third party IT support vendors.

E. AMI SYSTEM CAPABILITIES

In the Commission's *Implementation Order*, the Commission identified six minimum smart meter capabilities that are required by Act 129. *Implementation Order*, pp. 29-30. The commission directed EDCs to quantify the costs to deploy and operate these six minimum capabilities in EDCs' Smart Meter Plans.

In addition, the Commission listed nine additional capabilities that EDCs were to evaluate. The Commission also directed EDCs to quantify the individual incremental costs for deploying these additional capabilities. The Commission further noted that it may waive these additional capabilities to the extent that an EDC or another party demonstrated that the additional capabilities were not cost-effective.

Duquesne Light addresses each of the minimum and additional capabilities set forth in the *Implementation Order* below.

1. Minimum Capabilities Under Act 129

a. Bidirectional data communications

The Company's existing AMR system provides one-way communication from the meter to the head-end data collection engine hosted at Duquesne Light's data center. The new AMI system will provide two-way communication between the meter and the head-end data collection engine hosted at Duquesne Light's data center.

b. Recording usage data on at least an hourly basis once per day

The Company's existing AMR system records usage data on a daily basis for most of our single-phase meters and on at least an hourly basis for all of our three-phase meters. The new AMI system will have the capability of recording usage data at 5, 10, 15, 30 or 60 minute intervals. The Company's AMI communication network will provide the capability to retrieve this data at least once per day for all meters.

c. Providing customers with direct access to and use of price and consumption information

The Company's existing AMR system does not have any direct access capabilities. The new AMI system will include ZigBee enabled smart meters that under current data communication standards can facilitate direct access from the meter to a customer's HAN device for price and consumption information. Duquesne Light will remotely provision and enable the direct access interface once the customer request for direct access has been authenticated. The customer will be responsible for purchasing and installing their own HAN devices as well as establishing the network connection with the ZigBee interface.

d. Providing customers with information on their hourly consumption

The Company's existing AMR system provides most customers with validated daily consumption information through Duquesne Light's secure customer web portal. The new AMI system will provide all customers with validated hourly consumption information within approximately 24 hours after the data has been collected from all meters through Duquesne Light's secure customer web portal.

e. Enabling time-of-use (TOU) rates and real-time price (RTP) programs

The Company's existing AMR system only supports TOU or hourly rates for customers with three-phase meters. The new AMI system will support TOU rates and RTP programs for all customers. As part of the company's Act 129 Smart Sense pilot, Duquesne Light will develop TOU and/or RTP tariffs for our default service customers with smart meters. Duquesne Light will also be able to support TOU rates and/or RTP programs offered by EGS's for our customers with smart meters that switch to an alternate supplier.

f. Supporting the automatic control of the customer's electric consumption

The Company's existing AMR system cannot support the automatic control of the customer's electric consumption. The new AMI system, with its bidirectional data communication and ZigBee enabled smart meters, can be utilized to support demand response or load limiting programs. Duquesne Light plans to enable third party access to our AMI system for these types of programs through a secure web portal. However, Duquesne Light does not plan to commit to any service level agreements with third parties using our AMI system to facilitate these types of programs.

2. Additional Capabilities under Implementation Order

a. Ability To Remotely Disconnect And Reconnect

Remote disconnect and reconnect functionality allows utilities to turn off or turn on a customer's service at the meter without a physical visit to the premise. This capability is accomplished through additional hardware (a switch) integrated into the meter. This capability is only available for single-phase meters having a 240 volt service with a rating of 200 amps or less.

There are many benefits to implementing the remote disconnect and reconnect functionality. These benefits include improved safety, operational efficiency, revenue collection, employee efficiencies and improved customer experience.

There is an additional cost of approximately $30 per single phase meter to install the switch to enable the remote disconnect/reconnect functionality. In addition, the Company's FOCUS system would require upgrades costing approximately $500,000 to provide this functionality. The expected cost to install this functionality on a system wide basis is approximately $17.5 million.

Duquesne Light believes that the benefits of this functionality support implementation. For these reasons, Duquesne Light proposes to implement the remote connect/disconnect functionality for all single-phase meters.

b. Ability To Provide 15-Minute Or Shorter Interval Data

As previously stated, the Company's Smart Meters will be capable of recording data in 15 minute intervals at no incremental cost as compared to recording usage at hourly intervals. However, the bandwidth of the AMI communication network as well as the storage capacity of the Head End Data Collection Engine and Oracle MDM system would have to be expanded at an incremental cost to accommodate intervals more granular than hourly.

Duquesne Light does not believe these incremental costs are justified at this time since there are no existing requirements for interval data more granular than hourly. However, since expansion of network bandwidth and storage capacity is scalable, the Company proposes implementing an AMI system based on hourly interval data and then expanding it later if future applications require more granular intervals.

c. On-Board Storage Of Meter Data That Complies With Nationally Recognized Non-Proprietary Standards Such As ANSI C12.19 and C12.22 Tables

The ANSI C12.19 standard provides a common data structure for use in transferring data to and from meters. The ANSI C12.22 standard defines how to transmit standardized tables of meter data across wired or wireless networks. This standard uses encryption to enable secure communications, protecting confidentiality and data integrity.

The Company's AMI System will comply with these standards without any additional implementation costs.

d. Open Standards And Protocols That Comply With Nationally Recognized Non-Proprietary Standards, Such As IEEE 802.15.4

IEEE 802.15.4 is a communication standard for low rate wireless personal networks such as ZigBee. ZigBee has the ability to link smart meters with devices such as thermostats, household appliances, HVAC, lighting systems and other household appliances or systems.

The Company's AMI system will comply with the IEEE 802.15.4 standard without any additional implementation costs.

e. Ability To Upgrade Minimum Capabilities As Technology Advances And Becomes Economically Feasible

The capability is whether existing equipment can adopt or be modified to incorporate new capabilities as technology advances. Duquesne Light cannot predict all future needs or technologies. However, the Company is implementing an AMI system that is flexible and expandable. Moreover, Duquesne Light will be able to upgrade the software for its AMI system, including meter firmware and configuration.

f. Ability To Monitor Voltage At Each Meter And Report Data In A Manner That Allows An EDC To React To The Information

The AMI system that Duquesne Light is implementing will provide the capability to monitor voltage at each meter. This monitoring can be accomplished by establishing a register within the Smart Meter for voltage related interval data or by programming the Smart Meter to send an alert if the voltage measurements are outside a normal range.

In order to report voltage data in a manner that allows an EDC to react to the information, an interface needs to be developed between the AMI Head-End Collection Engine and the FOCUS project MDM system. Duquesne Light's approach to developing these type of interfaces is to participate in Oracle's Smart Grid Gateway ("SGG") Customer Validation Program. This program enables Duquesne Light to influence the development of productized integration between ITRON and Oracle applications. At this point in the development cycle, Oracle has not committed to a date for implementing the voltage monitoring interface requirements as part of their SGG roadmap so incremental cost information is unavailable.

In addition to developing the integration between AMI and FOCUS systems, new reporting functionality will need to be developed within the MDM application in order for Duquesne Light to react to the voltage monitoring. At this point in the MDM development roadmap, Oracle has not committed to a date for adding enhanced reporting functionality for voltage monitoring.

Since Oracle has not committed to dates for voltage monitoring capabilities, the incremental cost for developing the required productized integration and reporting functionality is unknown. However, Duquesne Light anticipates that it will implement the voltage monitoring capability, as a supplement to existing power quality systems, once the necessary software becomes available.

g. Ability To Remotely Reprogram The Meter

Firmware within the meter controls all of the functions and capabilities of the meter. Firmware is the software that interfaces the meter's hardware and the network application, enabling the meter to perform its functions. The firmware in the Company's Smart Meters can be reprogrammed remotely through the communications network or at the meter.

There are no additional meter or network costs to be able to remotely program the Smart Meter's firmware.

h. Ability To Communicate Outages And Restorations

The AMI architecture provides the capability to communicate outages and restorations from the Smart Meter to the Head-End Collection system. This communication is based on a "last gasp" alert that the meter sends when it loses power along with a subsequent "first gasp" alert when power is restored. This functionality does not exist in Duquesne Light's existing AMR system.

In order to incorporate AMI outage and restoration alerts into the Company's real-time reliability and customer notification processes, Duquesne Light would need to replace its current Outage Management System ("OMS") as well as develop and maintain a distribution system "Electrical Model". This replacement initiative is not included in the scope of the FOCUS project.

Duquesne Light estimates that the incremental cost to create an Electrical Model are not justified as part of the Company's Final Smart Meter Plan, but will be further evaluated as the AMI system is deployed.

Duquesne Light does plan to implement the capability to communicate outages and restorations from the Smart Meters to the Head-End Collection Engine as part of the AMI project. In addition, Duquesne Light plans to extract the data from the Head-End Collection Engine into an AMI data warehouse on a near real-time basis. The data warehouse will include reporting functionality that provides the Company's Operations Center with the following data:

- Number of customers that are out of power at any given time during an outage event.
- A list of customers that have been restored at any given time during an outage event.
- The length of time between when a customer lost power and when that customer's power was restored.

This reporting functionality in the AMI data warehouse will replace and improve the accuracy of all of the information that the Company's Operations Center currently receives from its existing AMR system. This initiative is estimated to cost approximately $250,000.

i. Ability To Support Net Metering Of Customer Generators

Duquesne Light's Smart Meters will support net metering of customer generators. The ITRON Smart Meters will have multiple channels and bi-directional capability that will allow the Company to measure both the excess energy that is being generated by the customer and also measure energy that is delivered by the Company to the customer. The ITRON Smart Meters come equipped with this capability, and therefore, there are no additional costs to implement this capability.

F. AMI IMPLEMENTATION TIMELINE

1. System Wide Roll-Out

A chart showing the Company's proposed AMI implementation timeline is provided as Appendix G. The timeline includes a smart meter deployment schedule that begins with a 5,000 smart meter acceptance roll out in 2014 followed by ramp up to 90,000 meters by year end 2015.

A full scale deployment of 9,000 meters per month will begin in the first quarter of 2016. The Company anticipates that it will complete full deployment of its smart meters by the end of 2020. In its Initial Smart Meter Filing, Duquesne Light noted that it was premature to develop a final system-wide deployment schedule given the substantial tasks that the Company was undertaking to: (1) assess needs, and (2) select technology, a vendor, software, hardware and other smart meter components. Therefore, the Company noted its intent to meet the 15 year deployment schedule set forth in the Commission's *Implementation Order*. See Duquesne Light Initial Smart Meter Plan, pp. 36-37. The Company did provide an initial estimated date of December 31, 2018 for full system roll out of smart meters. However, the Company explained that this date was not final and that the Company would provide a detailed description of its plans for full system-wide roll out of smart meter technology as part of its Final Smart Meter Plan. See Duquesne Light Initial Smart Meter Plan, p. 37.

In the Commission's Order approving the Company's Smart Meter Plan, the Commission noted that Duquesne Light had provided an approximate date of December 31, 2018 to complete system-wide deployment of smart meters. The Commission further noted that Duquesne Light had explained that the dates were approximate and that it was the Company's intent to meet the 15 year deployment schedule provided by Act 129. *Petition of Duquesne Light Company for Approval of Smart Meter Technology Procurement and Installation Plan*, Docket No. M-2009-2123948, Order entered May 11, 2010, p. 27.

The Company is extending full deployment of smart meters to allow for the two-year ramp-up period described above. This ramp-up period will give the Company time to test systems and functions before implementing technology on a system-wide basis. The Company believes that this is a prudent and reasonable approach and that it will mitigate the risk of technology glitches that could create a negative experience for customers.

In addition to the ramp-up period, Duquesne Light is proposing a phased functional implementation of Smart Meter features starting with the most basic capabilities such as monthly billing from smart meter usage data and ending with the most advanced capabilities such as automatic control of electric consumption. This phased functional implementation is designed to allow the market for many of the advanced smart meter capabilities to become more mature, which will then provide a better definition of the requirements. Requirements that are not fully defined result in rework, which ultimately results in additional costs for customers. Duquesne Light believes that this potential rework and associated costs can be avoided by our proposed phased functional implementation approach.

At the same time, however, the Company anticipates that much of the functionality throughout deployment will be valuable. The Company will integrate available functionality, to the extent it has been fully tested and accepted throughout the process, into business practices where possible. This will allow the Company to take advantage of the benefits early in the process. For example, the Company plans to integrate hourly data into its processes used for daily reconciliation and PJM settlements. Similarly, the Company plans to implement the remote connect / disconnect functionality in select areas as it become available. This extension of the phased-in approach of smart meter functionality throughout the deployment will ensure implementation obstacles are removed throughout the entire process rather than defer until the last stage of deployment. The Company and customers will be able to take advantage of the benefits of AMI as deployed throughout the service area.

The following table provides a high-level overview of Duquesne Light's proposed phased functional implementation approach by requirement.

Duquesne Final SMIP Plan

Type	Requirement	2014	2015	2016	2017
Basic	Commissioning and decommissioning of smart meters in the field	x			
Basic	Collection of usage data for billing and events such as tamper alarms	x			
Basic	Monthly billing from smart meter usage data	x			
Basic	Manual disconnects and reconnects	x			
ACT 129	Bi-directional data communications	x			
ACT 129	Record usage data on at least an hourly basis once per day	x			
ACT 129	Provide direct access to and use of price and consumption information				x
ACT 129	Provide customers with information on their hourly consumption		x		
ACT 129	Enable time-of-use (TOU) rates and real-time price (RTP) programs		x		
ACT 129	Automatic control of the customer's electric consumption				x
PA PUC	Remote disconnects and reconnects			x	
PA PUC	Provide 15-minute or shorter interval data			x	
PA PUC	On-board meter storage that comply with national standards	x			
PA PUC	Open standards and protocols	x			
PA PUC	Upgradable capabilities	x			
PA PUC	Voltage monitoring				x
PA PUC	Remote reprogramming of the meter	x			
PA PUC	Outages and restorations				x
PA PUC	Net metering of customer generators		x		

2. New Construction And Customer Requests

Pursuant to Act 129 and the Commission's *Implementation Order*, EDCs are required to deploy smart meter technology at the end of the 30-month grace period in new construction and upon customer request. As part of Duquesne Light's grace period planning efforts, the Company has designed interim solutions to comply with these deployments outside of the Company's planned smart meter deployment schedule since the AMI project will not start until the Final Smart Meter Plan is approved.

a. New Construction

Duquesne Light installs approximately 2,000 meters annually in new construction sites throughout its service territory. At the end of the grace period, Duquesne Light plans to install ITRON smart meters at all new residential construction sites and communicate with these meters through its existing AMR ITRON Fixed Network system. These meters will be transitioned to the new AMI system at the time that the new communication network is extended to these locations as part of the full deployment schedule. Smart meters that communicate through the AMR system will provide daily reads until they are transitioned to the AMI system at which time they will provide hourly reads and AMI functionality that is available at that time. The transition from the AMR system to the AMI system will be determined by the Duquesne Smart Meter Program full deployment schedule. Duquesne Light will continue to deploy Alpha meters that communicate through its existing AMR ITRON MV-90 system for all new commercial and industrial ("C&I") construction sites until the new communication network is extended to these locations as part of the full deployment schedule.

b. Customer Requests

Since the enactment of Act 129 smart meter legislation in 2008, Duquesne Light has only received a few customer requests for a smart meter. To honor customer requests for direct access to un-validated usage data after the grace period, Duquesne Light plans to install ITRON smart meters that communicate with its existing AMR ITRON Fixed Network system for billing purposes but enable HAN connectivity through ZigBee for direct access purposes. To honor customer requests for next day access to validated hourly usage data through a web portal, Duquesne Light plans to install Alpha meters (currently used on C&I accounts) and communicate with them through its existing AMR ITRON MV-90 system for both billing and next day usage data access purposes. After the Smart Meter Program Final Smart Meter Plan is approved by the Commission, Duquesne Light will purchase, implement and integrate the ITRON Head-End Data Collection Engine with the MDM. Once this work is complete, Duquesne Light will install ITRON smart meters for all customer requests and communicate with them directly via a public cellular network. This solution is projected to be available during the smart meter deployment ramp-up period and will be utilized until the new communication network is extended to these locations as part of the full deployment schedule. Customers that request a smart meter outside of the Company's full deployment schedule will be charged the incremental communication and deployment costs but not the cost for the meter. The Company will develop a fee for this scope and update Rule 14.2 of its tariff.

G. SMART METER PROGRAM COSTS

The total cost of Duquesne's Smart Meter Program is estimated at $238 million spent over an 11 year period beginning in 2010 and ending in 2020. The following table provides a breakdown of the total Smart Meter Program estimated costs by scope component and operating versus capital expenditures.

Cost Estimates ($ millions)	Total
Smart Meter Program Planning	3.0
FOCUS Project	35.0
AMI Project Vendor Components (ITRON)	97.5
AMI Project Communication Network (WAN)	8.0
AMI Project IT Systems including PMO	63.4
AMI Project Customer Acceptance	3.1
AMI Project Contingency	28.0
Total	$238.0

The Smart Meter Program planning costs encompass all of the grace period expenditures necessary to develop the Final Smart Meter Plan. A significant portion of these planning costs are the engagement of third party subject matter expertise such as SAIC, IBM and other consulting resources. These planning costs also include the technology proof of concept with ITRON to prove the viability of the proposed AMI system solution.

The FOCUS Project costs encompass all of the IT system costs necessary to replace Duquesne Light's CIS and implement a new MDM. These IT system costs include software and hardware purchases and maintenance during the grace period; outside services involved in the implementation and integration of CC&B and MDM; and an allocation of other ancillary project expenditures such as facilities, training, organizational change management and installation of supporting IT products.

The AMI Project Vendor Component costs encompass all of the equipment and services being provided by ITRON as described in Section C of this Plan. These cost estimates are based on the contract negotiations that have been conducted to date between Duquesne Light and ITRON. These negotiations are expected to conclude in the third quarter of 2012 with a completed contract that can be executed upon Commission approval of the Company's Final Smart Meter Plan.

The AMI Project WAN costs encompass all of the equipment and services described in Section C.4 of this Plan. These cost estimates are based on analysis, including preliminary propagation studies, conducted by Duquesne Light and ITRON with the assistance of SAIC.

The AMI Project IT Systems costs encompass all of the implementation and integration services described in Section D of this Plan. In some instances where it is cost justified, the third party delivery services may be replaced with the purchase of additional software and hardware products. These cost estimates are based on analysis conducted by Duquesne Light with the assistance of IBM.

The IT Systems costs also encompass the responsibilities of the PMO which includes third party SI resources as well as the following seven Duquesne Light internal resources which are all incremental to the Company's current staffing levels:

- AMI Program Manager (1)

- AMI IT Systems Coordinator and IT Systems Analyst (2)
- AMI Metering Coordinator and Metering Engineer (2)
- AMI Communication Network Coordinator and Telecom Engineer (2)

The AMI Project Customer Acceptance costs encompass all of the work efforts described in Section I of this Plan. These cost estimates are based on analysis conducted by Duquesne Light with the assistance of Customer Performance Group ("CPG").

The AMI Project contingency costs encompass industry standard funding reserves for third party services as well as specific funding reserves for areas of the program where meter deployment, communication protocol, and security appliance decisions still need to be finalized based on emerging or evolving additional information.

A further breakdown of the estimated costs for the FOCUS and AMI projects by year is provided in Appendix H.

H. SMART METER COST RECOVERY

In its Initial Smart Meter Plan the Company proposed to recover its costs to implement smart meter technology via a Section 1307 Smart Meter Charge. By order dated May 11, 2010, the Commission approved Duquesne Light's Initial Plan with certain modifications. In addition, the Commission approved the Company's SMC, with certain modifications, which provides for full and current cost recovery of smart meter costs. The first SMC was implemented effective August 1, 2010.

The SMC uses a formula to calculate the revenue requirement for the quarter for each component. The SMC is updated quarterly, effective January 1, April 1, July 1 and October 1 each year. Common costs are then allocated to the revenue requirement for each meter type based on the number of each type of meter. A description of the SMC is provided in Rider No. 20, Smart Meter Charge, of the Company's retail tariff.

The formula to compute the revenue requirement for single phase, three-phase and common plant each includes four primary components. The first component is the pre-tax return on average projected net plant in-service ("PIS") for the upcoming quarter. Net PIS includes eligible smart meter plant and supporting systems adjusted for accumulated depreciation and accumulated deferred income taxes associated with that plant. The second component of the revenue requirement includes the projected expenses for depreciation, operation and maintenance for the upcoming quarter. The third component is an adjustment to the revenue requirement made for expected operating cost savings, if any, realized by the Company by implementing smart meter technology. The fourth component is a reconciliation adjustment, developed through an annual filing, to reconcile for the actual revenue requirement for the previous reconciliation year versus the billed revenue for the same period.

The revenue billed under the SMC for each quarter of the reconciliation period is compared to the actual revenue requirement calculated for each quarter using actual data for each of the four components of the formula. The over or under collection of revenue is recouped or refunded as appropriate with interest over a one year period beginning on January 1 of the following year. All over and under recovery calculations include interest at the legal rate of 6%.

The Company is proposing to recover the costs for implementing its Final Smart Meter Plan through its existing SMC without modification.

I. CUSTOMER EDUCATION AND ACCEPTANCE STRATEGY

1. Introduction

In early 2011, Duquesne Light engaged Customer Performance Group (CPG) to assist the company with development of a strategy that minimizes the risk of customer resistence to smart meter technology that many utilities throughout the country have previously experienced. CPG has worked with several utilities in California, Nevada and Illinois to successfully deploy smart meters in a manner that increases customer awareness, understanding and confidence with the new AMI technologies. A primary component of the customer confidence model is the communication of AMI technology benefits to customers soon after they receive their new smart meter.

As part of our planning efforts with CPG, we identified several new enhanced products and services such as Bill-to-Date reporting, Usage threshold alerts, Usage graphs, TOU rates, RTP programs and HAN offerings that are all facilitated by leveraging the investment in AMI technologies. Duquesne Light will offer select, cost-effective enhanced products and services for our customers that also provide transactional benefits to the company. These services are signed to increase customer participation and acceptance of smart meter technology. Additionally, The CPG deployment approach also strives to minimize customer inconvenience and provide a neutral, if not positive overall customer experience related to smart meters.

2. Target Audiences

Duquesne Light's three primary target audiences are employees, stakeholders and customers. A description of these three audiences and their relationships to smart meter technology is below:

Audience	Role
Employees	
• Installers	Installers install the smart meters. They have customer contact prior to installation and when the work is completed.
• Field Liaison	The field liaison is a person skilled in energy audits who accompanies the installers to provide door-to-door outreach to customers and troubleshoot customer complaints.
• Call Center	The call center provides customers information and education regarding smart meters and processes customer complaints and claims.
• Other	All other employees serve as ambassadors who can explain the smart meter system to family, friends, and neighbors.
Stakeholders	
• Elected Officials and Staff	Elected officials and their staffs are a source of information about the smart metering system for constituents and a channel for receiving customer complaints.
• Community Leaders	Community leaders include political organizations, special-interest organizations, business organizations, service organizations, faith-based organizations, and schools. They act as third-party communicators to customers.
• Media	Media includes representatives of newspapers, television, and radio who communicate with customers.
• Electric Generation Suppliers (EGS)	EGS's are the retailers who sell the electric commodity to customers and may develop new products and services based upon the smart metering system.
• Curtailment	CSPs provide energy and demand response products to

Service Providers (CSPs)	encourage customers to curtail usage at times of peak load.
• Service Providers	Service providers include contractors, electricians, aggregators, and others who act on behalf of customers and provide information to customers about electric appliances and services.
• Union Leaders	Union leaders are the representatives of DLC employees who *are represented under collective bargaining agreements.* They act as third-party communicators to employees.
Customers	
• Residential	Residential customers include customers who live in single-family and multi-family premises who take service on rates RS, RH, and RA.
• Commercial and Industrial (C&I)	C&I customers include those who take service on rates GS/GM and GMH.

3. 90-60-30 Day Communication Strategy

Duquesne Light's CEA plan focuses on the creation of a neutral-to-positive customer experience. The foundation of this customer experience is the 90-60-30 day strategy. 90-60-30 refers to the number of days prior to installing a smart meter during which specific information, education, and customer experience tactics are implemented.

90 Days. At least 90 days before installing smart meters in a specific community or geography, Duquesne Light will:

1. Establish a website that contains information about the smart meter system.
2. Continue to educate employees about the smart meter system and its deployment.
3. Continue to educate stakeholders about the smart meter system and deployment.

Duquesne Light's approach for employees will be to provide information and education so that all employees can act as advocates for the smart meter system. To achieve this objective, Duquesne Light will use a variety of methods to build employee awareness and understanding. These methods include:

- Town hall meetings
- Training classes
- Internal newsletters
- Office signage
- Employee intranet
- Involving employees in testing smart meter products and services

For front-line employees, Duquesne Light will employ additional educational methods that teach specific skills associated with the employee's job role. This may include advanced training classes for call center representatives, field liaisons, and installers, and daily briefings for field liaisons and installers.

Duquesne Light's approach for stakeholder education will be one of personalized meetings, group presentations, and events (such as stakeholder collaboratives). Duquesne Light will support these activities with collateral materials, props, videos, and demonstrations of smart meter services.

60 Days. Approximately 60 days before deploying smart meters in a specific region, Duquesne Light will conduct outreach events and presentations for both residential and business community members. The media Duquesne Light plans to use for community outreach includes PowerPoint presentations, trade show-style booths, and a mobile display (similar to other mobile smart meter/grid displays used by utilities, such as Oncor's Mobile Experience Center and Reliant Energy's Smart Home Solutions recreational vehicle). The likely venues for these outreach presentations include community groups (Chambers of Commerce, Rotary, citizens' councils, political groups), homeowners' associations, and community events (street fairs, farmers' markets, and athletic events). Content presented during these events will focus on features and benefits, function (how the system works), and confidence (accuracy, security, privacy, health, and value). To increase participation in these community presentations, Duquesne Light may use paid and non-paid media to generate interest and awareness.

30 Days. Thirty days before installing a smart meter at a customer's premises, Duquesne Light will implement a targeted direct media campaign. The first element is a direct mail letter which informs customers of the forthcoming smart meter installation. It also provides the customer information about the function, benefits, and confidence associated with the smart metering system. All communication materials will include Duquesne Light's call center website address and phone number for additional information

Three days before deploying meters at a customer's premises, customers will receive an automated phone call and/or email reminding them of the smart meter installation. This communication will provide customers as precise a time as possible for when the meter will be installed.

At the time of installation, installers will perform the installation according to a customer experience script (knock, explain, install, and leave record of work). A Duquesne Light field liaison will be available to provide immediate, on-call support to customers or, when not otherwise engaged, door-to-door outreach.

Five days after installation Duquesne Light will survey a sample of customers regarding installation satisfaction and their attitudes toward the smart metering system (as compared to the baseline survey).

Thirty five days after installation, customers who have signed up for Duquesne Light's My Account service or otherwise provided Duquesne Light an email address will receive a notification that their smart meter services (bill-to-date, bill alerts, projected bill, and hourly usage data) are now available to them online.

4. Measuring Success

The measure of success for a smart meter deployment project is a neutral-to-positive customer experience. Duquesne Light will measure the success of its customer experience and education efforts through three specific methods.

First, prior to launching the CEA plan, Duquesne Light will conduct focus group tests to ensure that the approach, themes, messages, media, and methods meet customer requirements. Additionally, Duquesne Light will administer a baseline survey that gathers customer attitudes toward the smart meter system prior to implementation. This baseline survey will enable Duquesne Light to then determine the impact of the CEA plan on consumer attitudes.

Second, after implementing the 90-60-30 strategy, Duquesne Light will track the:

- Number of website visits it receives
- Number of calls it receives from customers
- Classification of those calls in appropriate categories such as complaints, claims, high bill, and opt out.

Subsequent analysis of the volume and type of these calls will enable the Duquesne Light to maintain or adjust its customer experience, customer education, and customer support efforts. Additionally, Duquesne Light will collect customer feedback during outreach presentations regarding customer attitudes toward the smart meter system.

Third, five days after the installation of smart meters, Duquesne Light will survey a sample of customers regarding their satisfaction with the installation experience. Analysts will integrate the survey results into a weekly dashboard report for Duquesne Light. This report will guide Duquesne Light in taking appropriate action to correct deficiencies in the customer experience.

J. RISK MITIGATION STRATEGIES

Duquesne's Smart Meter Program is a multi-year, multi-million dollar endeavor that will greatly impact several key stakeholders including our customers and employees. Therefore, a large part of the grace period planning effort has been spent identifying program risks as well as developing strategies for mitigating the impact of these risks. Duquesne's risk mitigation strategies include:

- Engaging Industry Subject Matter Expertise throughout the planning effort
- Commissioning an AMI Technology Proof of Concept (POC)

- Instituting a ramp-up period along with a phased functional implementation within the Smart Meter Program deployment schedule
- Development of a Customer Acceptance Strategy aligned with the PA PUC Retail Market Investigation (RMI) Directives
- Engagement of an experienced Systems Integrator to own the end-to-end integration between the FOCUS and AMI projects

Industry Subject Matter Expertise

As a first step in our Smart Meter Program planning effort, Duquesne issued a Request for Proposal (RFP) in order to obtain the services of a utility industry advisor with extensive planning experience for AMI technology projects. R.W. Beck, Inc. (now SAIC) was selected for this advisory role and assisted Duquesne with our milestone flings as well as with our AMI vendor RFP process and AMI communication network extended analysis. Duquesne has also engaged industry subject matter expertise during our contract negotiations with ITRON. Eckert Seamans is providing external legal counsel while IBM is providing contract assistance from a business risk assessment perspective. IBM was also engaged to provide Duquesne with "lessons learned" from other Smart Meter Programs where they have served as the Systems Integrator as well as to assist Duquesne with developing our systems integration cost estimates for the AMI project. Finally, Customer Performance Group (CPG) is assisting Duquesne with development of a customer acceptance strategy designed to minimize the risk of customer backlash against smart meters that other utilities throughout the country have previously experienced.

AMI Technology Proof of Concept

In the latter half of 2011, Duquesne entered into a one year contract with ITRON to conduct an AMI Technology Proof of Concept (POC). This POC enables Duquesne to test the various components of the AMI System outlined in section IV of this plan. The POC is designed to validate the following data.

- Meter configurations/settings
- Captured interval data using ITRON AMI Service Test

- Captured event messages/alerts/alarms in the ITRON OpenWay Collection Engine
- Firmware download using the ITRON OpenWay Collection Engine
- On demand reads; remote disconnects and reconnects using ITRON AMI Service Test

In addition to testing the ITRON OpenWay components of Duquesne's proposed AMI System, this POC will also test various AMI communication network solutions. The scope of the POC is 36 residential meters and 16 commercial meters. These meters are installed in a dual-socket environment so that the customer's existing meter is still used for production billing purposes. The POC local area network (LAN) consists of four cell collectors and two range extenders. The POC wide area network (WAN) utilizes various private wireless solutions for intermediate transmittal to Duquesne owned communication towers as well as public wireless solutions for direct connect functionality. As part of the POC, Duquesne is also performing laboratory tests on several Home Area Network (HAN) devices. These devices include:

- Two Smart Thermostats
- Two In-Home Displays (IHDs)
- Two Load Control Devices

Ramp-up Period and Phased Functional Implementation

In order to minimize the risk of any potential unforeseen technology glitches having a mass negative impact on our customers, Duquesne is proposing a ramp-up period for Smart Meter deployments. This period will begin with a 5,000 smart meter acceptance roll-out in the latter half of 2014 followed by a gradual build-up to a full deployment of 9,000 meters per month by the end of 2015. In addition to the ramp-up period, Duquesne is proposing a phased functional implementation of Smart Meter features starting with the most basic capabilities such as monthly billing from smart meter usage data and ending with the most advanced capabilities such as support for Home Area Networks. This phased functional implementation is designed to allow the market for many of the advanced smart meter capabilities to become more mature, which will then provide a better definition of the requirements.

Customer Acceptance Strategy

In early 2011, Duquesne engaged Customer Performance Group (CPG) to assist the company with development of a strategy that minimizes the risk of customer backlash against smart meters that many utilities throughout the country have previously experienced. CPG has worked with several utilities in California, Nevada and Illinois to successfully deploy smart meters in a manner that increases customer awareness, understanding and confidence with the new AMI technologies. Duquesne Light's Customer Acceptance Strategy is explained in more detail in Section I above.

System Integrator

As explained in Section D above, Duquesne's Smart Meter Program has four levels of complex systems integration that must work both independently as well as in conjunction with each other in order for the entire solution to function properly. The Company believes that the success of our AMI project is highly dependent on engaging an SI that has utility industry experience with both AMI technology projects as well as with Oracle Utility Application Suite implementations.

IV. CONCLUSION

As explained herein, during the Grace Period, Duquesne Light has been implementing billing system and information technology changes that are necessary to provide customers with Smart Meter Technology. In addition, Duquesne Light has been carefully and thoroughly investigating ways to meet the Act 129 Smart Meter Technology requirements. Duquesne Light's Final Smart Meter Plan will provide all of the smart meter capabilities required under Act 129 and the Commission's *Implementation Order* to customers in a cost-effective manner.

RULES AND REGULATIONS - (Continued)

INSTALLATION OF SERVICE - (Continued)

8. **NONSTANDARD SERVICE** The Company reserves the right to require a customer or applicant for service to pay the cost, including the related income tax, of any special installation necessary to meet the unusual requirements of the customer or applicant for service, including, but not limited to: **(C)**

(1) service at other than standard voltages, **(C)**

(2) service for intermittent, unbalanced or fluctuating loads, which, in the Company's sole judgement, would not generate sufficient revenue to recover the installation costs of the required facilities, **(C)**

(3) service for loads that will be continuous but that will generate minimal usage, and which, in the Company's sole judgement, would not generate sufficient revenue to recover the installation costs of the required facilities, **(C)**

(4) service for loads that will require provision of closer voltage regulation than required by standard service, **(C)**

(5) redundant service requested by the customer and not required by the Company, and **(C)**

(6) service routings or configurations that deviate from the Company's standard construction standards described in the Company's "Electric Service Installation Rules," or that would otherwise necessitate significant construction of new Company facilities. **(C)**

The customer or applicant shall pay all costs to the Company of performing environmental assessments, including, but not limited to, the cost of consultants utilized by the Company, the cost of removal and disposal of contamination, waste or hazardous materials or dealing with other adverse environmental conditions associated with either the initial installation, modification, repair, maintenance or removal of service facilities. **(C)**

The Company may decline to provide Nonstandard Service where, in the Company's sole judgment, it would not be commercially, operationally, and/or technically reasonable to provide such service. **(C)**

9. **RELOCATIONS OF FACILITIES**

A. Pole Removal or Relocation for Residential Customers

When requested by a residential property owner who is not otherwise entitled to receive condemnation damages to cover the cost of the pole removal or relocation or who is not requesting a pole removal or relocation as the result of damages caused by the intentional or negligent conduct of any party, the Company will when it is practicable, subject to the execution and receipt of required easements, licenses or municipal permits, remove or relocate a pole or poles and associated attachments, upon receipt, in advance, of the Company's estimated contractor or direct labor and direct material costs associated with the particular pole removal or relocation, less any maintenance expenses avoided as a result of the pole removal or relocation.

For purposes of this Rule, the following definitions are applicable:

(1) **Contractor costs** - Amount paid by the utility to a contractor for work performed on a pole removal or relocation.

EXHIBIT
02/27/2020
Respondent D-2
C-2018-3002741

(C)

(C) – Indicates Change

EXHIBIT D-2

RULES AND REGULATIONS - (Continued)

INSTALLATION OF SERVICE - (Continued)

9. RELOCATIONS OF FACILITIES – (Continued)

A. Pole Removal or Relocation for Residential Customers – (Continued)

(2) **Direct labor costs** - Includes pay and expenses of public utility employees directly attributable to work performed on pole removals or relocations. Excludes payroll taxes, workmen's compensation, similar items of expense and construction overhead costs.

(3) **Direct materials costs** - Includes the purchase price of materials used in performing a pole removal or relocation and excludes the related stores expenses. Proper allowance shall be made for unused materials, and materials recovered from temporary structures, and for discounts allowed and realized in purchase of materials.

(4) **Income tax** - Federal and State tax relating to the tax liability of contributions in aid-of-construction.

B. **Meter Relocation for all Customers** (C)

Pursuant to Act 129 of 2008; the Commission's Smart Meter Procurement and Installation Implementation Order entered June 24, 2009, at Docket No. M-2009-2092655; and Duquesne Light's Smart Meter Procurement and Installation Plan, approved in relevant part by Order entered April 7, 2017, at Docket No. P-2015-2497267; smart meter(s) conforming to Company standards must be installed at each metered service premises. Customers may not decline smart meter installation for any reason. Instead, as their sole remedy, customers may designate an alternative location on the premises for the smart meter. The Company shall relocate the smart meter to such alternative location where (i) the relocation (including associated customer service equipment) conforms to the Company's "Electric Service Installation Rules" (see Rule No. 6) and the National Electric Safety Code, as determined by the Company in its sole judgment; (ii) the relocation can be readily, safely, and reliably interconnected to the Company's facilities, as determined by the Company in its sole judgment; (iii) the customer provides any easements, permits, or other governmental or third-party approvals the Company deems necessary to accommodate such relocation; and (iv) the Company receives, in advance, payment for the Company's estimated total direct and indirect costs including the related income tax of such relocation. (C)

C. **Other Company Facilities for all Customers** (C)

When requested or required by the action of a customer or a third party, relocation of Company facilities, except those covered under Section A of this Rule, will be performed by the Company upon receipt, in advance, of the Company's estimated total direct and indirect costs including the related income tax of such relocations from the customer or such third party. The Company may waive charges under this rule if, in the Company's judgment, the location of the Company's existing supply line and/or service line on the customer's property restricts the growth of the customer's operations and the potential increase in the Company's revenues.

(C) – Indicates Change

3835 Acorn Street
Pittsburgh, PA 15207

February 19, 2019

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street, 2nd Floor
Harrisburg, PA 17120

Re: Miranda Grace Edwards v. Duquesne Light Company
Docket No. C-2018-3002741

Dear Secretary Chiavetta:

Enclosed for filing with the Commission is my Certificate of Service indicating that my Answers to Interrogatories and Request for Production of Documents, Set I, (Questions #2, 4, 6, 16, 18, 27, and 29) were emailed to Counsel for Duquesne Light Company on this day in the matter referenced above.

Please feel free to contact me if you have any questions.

Sincerely,

M. Grace Edwards
Complainant
msea.mdew@gmail.com

Attachment

Cc: Jeffrey A. Watson, ALJ (Cover Letter and Certificate only)
Per Certificate of Service

EXHIBIT 02/27/2020 Respondent E-2 C-2018-3002741

EXHIBIT E-2

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

MIRANDA GRACE EDWARDS, Complainant, vs. DUQUESNE LIGHT COMPANY, Respondent.	No. C-2018-3002741 **Responses to Respondent's**

FIRST SET OF DISCOVERY REQUESTS

Filed by Miranda Grace Edwards

msea.mdew@gmail.com
3835 Acorn Street
Pittsburgh, PA 15207

COMPLAINANT'S RESPONSES TO RESPONDENT'S FIRST SET OF DISCOVERY REQUESTS

TO: RESPONDENT'S GENERAL COUNSEL, SHANE MILLER, ESQUIRE

THESE PAGES CONSTITUTE THE FILING OF MY WRITTEN RESPONSE TO THE FIRST SET OF DISCOVERY REQUESTS SERVED ON ME BY RESPONDENT DUQUESNE LIGHT COMPANY. THESE HAVE BEEN SUBMITTED TO YOU PER THE SPECIFIED DEADLINE OF FEBRUARY 19, 2019.

Mg

Miranda Grace Edwards

February 19, 2019

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

MIRANDA GRACE EDWARDS, Complainant, vs. DUQUESNE LIGHT COMPANY, Respondent.	No. C-2018-3002741

RESPONSES TO RESPONDENT'S FIRST SET OF DISCOVERY REQUESTS

AND NOW comes Complainant Miranda Grace Edwards ("I") and hereby files this, my Responses to Respondent's First Set of Discovery Requests.

2. Produce all Documents, including but not limited to hospital and/or medical records or studies, that relate to Your answer to Discovery Request No. 1.

ANSWER:

In Discovery Request No. 1, Duquesne Light Company Counsel (DLC) asked me to "state all facts that support [my] claim that Duquesne Light's installation of a Smart Meter at the Property will negatively affect [my] health." In his January 28, 2019 interim order, ALJ Watson noted that in my response to DLC's motion to compel, I averred that "[I am] not claiming to be highly sensitive to radio frequency radiation from smart meters or to be a member of an especially vulnerable group. In addition, [I am] not claiming to have suffered from any health effects from a smart meter as a smart meter has not been installed on [my] property." ALJ Watson then stated, "If Complainant is not claiming that the installation of a smart meter at the property *will* negatively affect her health she can indicate that in her response and therefore would not be requested to provide the requested hospital or medical records requested in Discovery Request No. 2. If Complainant is making that claim the requested records are a proper discovery request." (emphasis added)

I have attached documents that by no means represent "all" information related to my answer to Discovery Request No. 1; however, they do support my claim. I have not included personal hospital or medical records, because these are still irrelevant. As I mentioned in my response to DLC's motion to compel, as far as I am currently aware nothing exists in my hospital or medical records that would demonstrate DLC's installation of a smart meter at my residence has already harmed my health (because a smart meter has not yet been installed) or is certain to harm my health in the future (because I have not been diagnosed with, nor am I claiming to have, a condition that makes me highly sensitive to radio frequency radiation or a member of an especially vulnerable group). I am not planning to enter my personal medical hospital records into evidence, nor am I planning to introduce testimony from doctors who have treated me. Therefore, there is no reason for me to provide this information.

I have not included the personal hospital or medical records of others who have made credible claims that smart meters have harmed their health because such records constitute confidential information about utility customers who are not parties to this litigation. DLC has some of these documents in its possession.

Furthermore, DLC's Discovery Request No. 1 mischaracterizes my "claim" that "Duquesne Light's installation of a Smart Meter at the Property **will** negatively affect [my] health." (emphasis added) I checked my original complaint again, and I never asserted that DLC's smart meter **will** harm my health. Asking me to support such a definitive claim calls for speculation. I stated my desire to avoid potential health effects, and I have seen enough evidence to convince me that legitimate concerns exist regarding those potential health effects. Microwave radiation, such as produced by the smart meter DLC intends to install on your meter socket without my consent, have been shown to produce cancers in rats and ill health effects in human beings who have smart meters on their residences. Cell phones have been shown to produce cancers in humans after many years of holding the phone close to the head. Cell towers and Wi-Fi in places of business have been shown to cause ill health effects and are banned in many public schools and other settings around the world.

Neither DLC nor the PA PUC has a right to violate the PA PUC Title 66, Section 1501 specification that "Every public utility shall furnish and maintain adequate, efficient, **safe,** and reasonable service and facilities ..." (emphasis added)

4. Produce all Documents that relate to Your answer to Discovery Request No. 3.

ANSWER:

In Discovery Request No. 3, DLC asked me to "state all facts that support [my] claim that Duquesne Light's installation of a Smart Meter at the Property will infringe upon [my] privacy and/or violate [my] rights under the Fourth Amendment to the United States Constitution." ALJ Watson's October 24, 2018 interim order dismissed my claim that DLC has violated my rights under the Fourth Amendment to the United States Constitution.

DLC customers' right to privacy is not limited to their Fourth Amendment rights. Privacy issues are also safety and security issues. Smart meters transmit wireless signals that may be intercepted by unauthorized and unknown parties. Those signals can be used to monitor behavior and occupancy and they can be used by criminals to aid criminal activity against the occupants of a dwelling.

DLC admits in its own Privacy Policy (https://www.duquesnelight.com/customer-support/policies-forms/privacy-policy) that "no set of controls can provide absolute security;" however, unauthorized intruders cannot access information that is not collected. I am seeking the ability to protect myself from such unauthorized intruders by using a more reliable method than even the best encryption process. DLC's Smart Meter Plan constitutes an inherent privacy and security downgrade from my preferred method of not supplying the information at all. DLC is capable of providing electricity without collecting this information. And since DLC has already admitted it cannot "provide absolute security" for the information it collects, I aver that DLC's intention to forcibly downgrade my privacy as a DLC customer violates PA PUC Title 66, Section 1501 specification that "Every public utility shall furnish and maintain adequate, efficient, **safe,** and reasonable service and facilities ..." (emphasis added)

By way of further response, I have attached documents that by no means represent "all" information related to my answer to Discovery Request No. 3; however, they do support my claim.

6. Produce all Documents that relate to Your answer to Discovery Request No. 5.

ANSWER:

In Discovery Request No. 5, DLC asked me to "state all facts that support [my] claim that Duquesne Light's installation of a Smart Meter at the Property poses a potential fire hazard."

I have attached documents that by no means represent "all" information related to my answer to Discovery Request No. 5; however, they do support my claim. Additional evidence that smart meters have caused house fires, including court records and news stories, is publicly available and can be accessed by DLC without my intervention.

16. Identify the type (with make and model) of all devices, appliances, and equipment used in Your home or by You in Your daily life that produce radio frequency or low frequency fields, including, but not limited to, cell phones, microwave ovens, wireless internet, and Wi-Fi routers.

ANSWER:
Providing this detailed information about wireless products used in my home may compromise my privacy and security. Please sign the attached Stipulated Protective Agreement and I will provide the information as specified in the interim order of January 28, 2019.

18. Produce all documents, including, but not limited to, user manuals and instructional materials, relating to each device identified in response to Discovery Request No. 16.

ANSWER:

See answer to Discovery Request No. 16. By way of further response, once DLC signs the Agreement named in Discovery Request No. 16, DLC will have access to the make and model of any wireless devices used in my home, and can freely access any user manuals/instructional materials that are available online to anyone.

27. Identify all medical conditions that make You vulnerable to, or that would be aggravated by, proximity to an Itron SK9AMI7 HW 3.1 OpenWay CENTRON Singlephase Smart Meter.

ANSWER:

See answer to Discovery Request No. 2. By way of further response, I am not claiming to have existing, diagnosed medical conditions that make me especially vulnerable to harm from an Itron SK9AMI7 HW 3.1 OpenWay CENTRON Singlephase Smart Meter. However, I should not be forced to have already suffered damage to my health in order to have the opportunity to challenge the installation of a smart meter at my home.

28. Produce all Documents, including but not limited to hospital and/or medical records and studies, demonstrating that You suffer from the medical condition(s) identified in Your response to Discovery Request No. 27.

ANSWER:

See answers to Discovery Requests No. 2 and No. 27.

29. Produce all Documents, including but not limited to hospital and/or medical records and studies, demonstrating the relationship between the medical condition(s) identified in Your response to Discovery Request No. 27 and Your proximity to an Itron SK9AMI7 HW 3.1 OpenWay CENTRON Singlephase Smart Meter.

ANSWER:

See answers to Discovery Requests No. 2 and No. 27.

Respectfully submitted,

Miranda Grace Edwards
February 19, 2019

EXHIBIT E-2

1.36 Verification

Verification

I, Miranda Grace Edwards, hereby state that the facts above set forth are true (or are true and correct to the best of my knowledge, information and belief) and that I expect to be able to prove the same at a hearing held in this matter. I understand that the statements herein are made subject to the penalties of 18 Pa. C.S. section 4904 (relating to unsworn falsification to authorities).

2-19-19
Date

MMG
Signature

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

MIRANDA GRACE EDWARDS, Complainant, vs. DUQUESNE LIGHT COMPANY, Respondent.	No. C-2018-3002741

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a true copy of my Answers to Interrogatories and Request for Production of Documents, Set I, (Questions #2, 4, 6, 16, 18, 27, and 29) in the above matter to Counsel for Duquesne Light Company in the manner listed below in accordance with the requirements of 52 PA. Code § 1.54 (relating to service by a participant):

VIA EMAIL

Shane Miller, Esquire
1500 One PPG Place
Pittsburgh, PA 15222
smiller@tuckerlaw.com

Counsel for Respondent, Duquesne Light Company

Dated this 19th day of February, 2019

Miranda Grace Edwards
msea.mdew@gmail.com
3835 Acorn Street
Pittsburgh, PA 15207

EXHIBIT E-2

RF Safety Compliance of OpenWay Smart Meters

January 2018

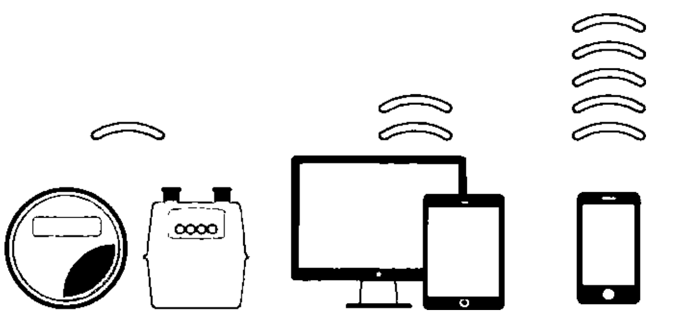
WHITE PAPER

EXECUTIVE SUMMARY

As a world-leading technology and services company that manufactures products that utilize wireless communications, Itron is committed to delivering safe products that meet or exceed all applicable safety standards. With that, we are also committed to providing accurate and complete product safety information to our utility customers and the customers they serve.

To this end, and to supplement the FCC and Health Canada certifications for the meters, Itron recently completed a detailed study of radio frequency (RF) transmissions and duty cycles for OpenWay® CENTRON® smart meters operating under the OpenWay CG-Mesh Internet Protocol Version 6 network. For this study, Itron utilized data from an OpenWay system operated by BC Hydro in British Columbia, Canada.

Results from the study show the RF wireless communication from the OpenWay meters meet all applicable safety standards established by government agencies, such as Health Canada and the Federal Communications Commission (FCC) in the U.S. In fact, the RF exposure to people from OpenWay meters amounts to a fraction of the maximum permissible exposure levels and safety standards set by these agencies. The study shows that the duty cycle – the total time meters are transmitting in a given 24-hour period – on average was about three minutes per day. That translates into a duty cycle of 0.21 percent. This means the OpenWay meters, on average, are not transmitting radio signals for 99.79 percent of a typical day. In addition, these meters utilize very low-power transmissions and typically operate at a significant distance away from people, especially compared to other common wireless devices such as cell phones. In conclusion, the exposure from OpenWay smart meters is negligible in comparison to other common wireless devices encountered every day.



WHY SMART METERS?

Utilities across the U.S. and Canada have been replacing old-style electromechanical meters with digital communicating smart meters for the past decade. Industry research groups estimate that today approximately 50 percent of the 180 million electricity meters in the U.S. and Canada are now smart, with the vast majority of those smart meters – approximately 95 percent or more – using RF wireless communication to send data back to the utility. Installation of digital smart meters continues to accelerate and it is estimated that by 2020, virtually all electricity meters in the U.S. and Canada will be smart.

Utilities, with the approval of regulatory bodies, are replacing their old meters with new smart meters for several reasons as smart meters deliver a variety of benefits both to utilities and consumers. Key among those benefits is the automation of meter data collection, which helps utilities control operating costs while improving operational efficiencies and customer service. Smart meters can also signal when there is a power outage so utilities can detect outages and restore power to customers in a timely manner. Smart meters also enable utilities to deliver a variety of new services and programs, such as providing real-time energy usage information to customers to help them reduce energy usage and control their monthly bill. In a time when adoption of new technologies, such as customer-owned solar, electric vehicles and energy storage, is accelerating, smart meters provide vital measurement, sensing and communications capabilities to help ensure the reliability and stability of the power grid.

WHAT IS OPENWAY AND HOW DOES IT WORK?

OpenWay is a smart metering network from Itron that utilizes IPv6 standards and architecture developed jointly by Itron and Cisco, the world's leading network technology provider. The network comprises Itron OpenWay CENTRON smart meters installed at homes and business, Cisco network routers that are typically installed on utility power poles to route the data received from nearby meters back to the utility, and software to collect and process the data from the meters so it can be made available to generate customer bills and support other utility operations.

The OpenWay smart meters and OpenWay CG-Mesh IPv6 network use RF wireless communications and operate in the Industrial, Scientific and Medical (ISM) bands at frequencies from 902 MHz to 928 MHz. This is the same portion of the RF spectrum utilized by other devices such as garage door openers and baby monitors. Regulatory agencies, such as the FCC and Health Canada, have established specific limits and standards for the wireless transmissions of all these devices to ensure they do not pose a danger to public health and do not interfere with one another. The OpenWay meters and network have been tested and certified by independent third-party labs, validating that they comply with all applicable safety standards from these and other standards organizations.

The OpenWay CG-Mesh IPv6 network is a mesh network, which is a type of network topology in which devices or nodes (in this case meters) transmit their own data and can also serve as a communication relay for other nodes in the network. Routers are used to provide the best and most efficient data path for effective and reliable communication back to the utility. In the event of a hardware failure in the network, many routes are available to continue the network communication process. This enables the network to be self-forming and self-healing to continue operating when a node breaks down or when a connection becomes unreliable due to changing environmental conditions. As a result, the network has higher reliability because there is often more than one path between a source and a destination in the network. In addition to transmitting electricity consumption and event data (e.g. outage detection, voltage alarms, meter tamper alerts), the network also transmits data to ensure efficient, reliable and secure operation of the network, including connectivity status, device management and network security.

RF COMMUNICATION AND PUBLIC HEALTH

Radio frequency (RF) energy is all around us. RF plays a critical role in the communications systems that we depend on every day, such as police and fire radio systems and pagers, radio and television broadcasts and cellular telephones. Many of the conveniences we've grown accustomed to in our homes, such as cordless phones and wireless internet (Wi-Fi), utilize radio frequency communications.

Since 1996, the FCC in the U.S. has required all wireless communications devices sold in the United States meet minimum guidelines for safe human exposure to radio frequency emissions. Health Canada has established similar requirements and regulations for RF devices sold in Canada. In addition, federal health and safety agencies, including the EPA, FDA, National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA), consistently monitor and regulate RF safety. The research and recommendations from these public health organizations are factored into FCC regulations regarding RF exposure. Through the course of this research, the FCC has concluded that "currently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses."

Itron's products are stringently evaluated for RF safety and meet all FCC, Health Canada, and Institute of Electrical and Electronic Engineers (IEEE) standards. We consistently evaluate key factors for exposure risk, including the total duration of the transmission (duty cycle), the power output and the distance from the public. These key factors ensure that Itron OpenWay meter represent exposure levels which are not only well below the legal limits, but, minimal when compared to other devices people use every day.

» **Limited time on the air:** Itron electric smart meters and associated communication modules transmit for very short intervals (typically totaling about three minutes per day) and thus have a very low duty cycle. The resulting RF exposure levels amount to a fraction of the limits specified by regulatory agencies, including the FCC and Industry Canada.

» **Low power:** Itron electric smart meters and associated communication modules are low power; transmitting at one watt or less, well within the regulatory and safety limits.

» **Limited proximity to humans:** Itron electric smart meters and associated communication modules are typically installed outside the home. Since RF energy falls off very quickly with distance, smart meters typically represents much lower exposure than other RF devices located within the home. More specifically, the RF exposure decreases exponentially with distance – at twice the distance, the exposure level is reduced to a quarter of the original.

STUDY METHODOLOGY

This study took place in the summer of 2015 and used the Cisco network management system to pull operational data and statistics from a total of 12,969 OpenWay smart meters operating in the BC Hydro service territory. Each meter or node in the network delivers all transmission statistics to the Cisco system as part of its standard status reporting. The meter population selected for the study was randomized to ensure a representative cross section of deployed meters in differing service environments and operational scenarios within the network. This approach was taken because duty cycles for individual meters will vary to some degree depending on where they are situated in the topology of the mesh network. In addition to sending their own data (typically one to three times a day), meters will also relay data from other meters in the mesh network.

SUMMARY OF DUTY CYCLE DATA, SUMMER 2015 BC HYDRO

	Daily Transmission Time *(min)*	Duty Cycle Per Interval *(% Time Transmitting)*
Mean/Average	2.99	0.21
Median	2.43	0.19
Mimimum	0.03	0.003
Maximum	115.2	7.99

RESULTS

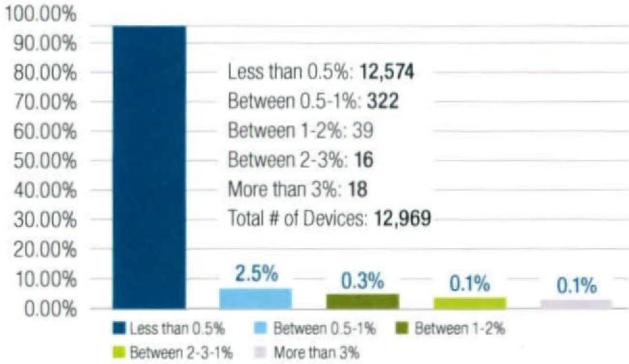
The analysis of this representative meter population operating in the field at BC hydro showed that the average duty cycle for the meters was 2.99 minutes. That figure translates into a duty cycle of 0.21 percent. This also means that, on average, OpenWay meters are not transmitting or emitting RF signals for 99.79 percent of a typical 24-hour period. That means that the vast majority of the meters are not transmitting for 23 hours and 56 minutes in a typical day.

VARIATIONS IN DUTY CYCLE

As previously mentioned, the mesh network topology relies on meters in certain areas of the network to act as pathways for data from other meters during the journey back to the router and the utility. For this reason, duty cycles will vary to some degree among meters depending on their position in the network and how many other meters' data they may be transmitting back to the network router.

Typically, meters located closer to the network routers tend to have higher duty cycles than meters located further from the router. Despite these dynamics, duty cycles remain consistently lower for the vast majority of meters throughout the network. For this representative field study of 12,969 meters, 99.5% of the meters have duty cycles of less than 1% with 97% having duty cycles of less than 0.5%. The meters with duty cycles greater than 3% totaled only eighteen meters or roughly 0.1% of the population.

DUTY CYCLE RANGES (% DAILY TIME TRANSMITTING)



COMPARISON TO LIMITS

The FCC and Health Canada requirements account for the duty cycle of the devices when determining the level of exposure. The table below compares the OpenWay meter power density to the FCC and Health Canada Maximum Permissible Exposure limits with the Average (0.21%) and Majority (0.5%) field duty cycles from this study.

IVP6 OPENWAY METERS AND FEDERAL COMMUNICATIONS COMMISSION (FCC) EXPOSURE LIMITS

	RF MESH: Duty Cycle	RF MESH: Transmission time per day	RF MESH: Power Density*	FCC LIMIT	RF MESH: Percent of limit
Mean	0.21%	3 min.	0.0005 mW/cm²	0.61 mW/cm²	0.08%
Majority	0.5%	7.2 min.	0.00114 mW/cm²	0.61 mW/cm²	0.18%

*At 0.2 meter distance

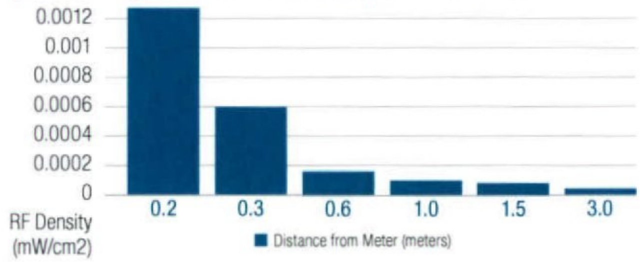
IVP6 OPENWAY METERS AND HEALTH CANADA (HC) EXPOSURE LIMITS

	RF MESH: Duty Cycle	RF MESH: Transmission time per day	RF MESH: Power Density*	HC LIMIT**	RF MESH: Percent of limit
Mean	0.21%	3 min.	0.0005 mW/cm²	0.28 mW/cm²	0.17%
Majority	0.5%	7.2 min.	0.00114 mW/cm²	0.28 mW/cm²	0.41%

*At 0.2 meter distance

**Health Canada Safety Code 6 (2015) Limit for 900MHz

POWER DENSITY OF TYPICAL METER (MAJORITY, <0.5% DUTY CYCLE) BY DISTANCE



OPENWAY RIVA DUTY CYCLES

Itron's new generation technology, OpenWay Riva, is based on the current routing protocols and introduces new communications capabilities such as integrated RF, Powerline Carrier and Wi-Fi communications on the same device, as well as multiple modulations for RF and PLC comms. Like all Itron radio products, the new OpenWay Riva devices are fully compliant with all applicable regulatory standards and safety requirements. Some of these advancements, such as higher data rates using faster modulations and the use of PLC communications are expected to reduce RF duty cycles, while additional coordination traffic on the network to manage these new communication capabilities is expected to add to the device transmit times. These changes are also expected to better balance the network traffic distribution between meters closer to the router and those further from the router.

Based on our lab testing of OpenWay Riva devices thus far, our expectation is that the RF duty cycles for OpenWay Riva technology will be comparable to OpenWay CG-Mesh technology, with no significant changes. The Wi-Fi interface replaces the current 2.4GHz ZigBee radios and will be used only occasionally for field access. 2018 will bring our first significant deployments of OpenWay Riva technology in the field, and will provide Itron the opportunity to analyze duty cycles at scale under realistic operating conditions.

CONCLUSION

The results of the latest duty cycle analysis show that the RF power densities for OpenWay smart meters operating under the OpenWay CG-Mesh IPv6 network amount to only a small fraction of the MPE limits set forth by both Health Canada and FCC. Itron will continue to monitor the regulatory standards and research related to RF exposure to ensure that its products are in compliance with all applicable safety standards and legal requirements.

CORPORATE HQ

2111 North Molter Road
Liberty Lake, WA 99019 USA

Phone: 1.800.635.5461
Fax: 1.509.891.3355

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Itron, Inc. - Oconee

ANSI Qualification Report for the

CENTRON® OpenWay® Hardware 3.1 Single Phase Meters

1S Remote Disconnect
2S Remote Disconnect
2S Standard
12S Remote Disconnect

Document Title: CENOPENWAYHW31SPAUG2011

Document Version 1

August 23, 2011

Wayne Thomas
R&D Manager - Product Services

EXHIBIT
02/27/2020
RESPONDENT G-1
C-2018-3002741

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Contents

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Version History

Version	Date	Reason
1	23-Aug-2011	• Original release of document.

Itron

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Purpose
This document contains a summary of all ANSI qualification tests completed for the Single Phase CENTRON OpenWay Hardware 3.1 ANSI Forms shown below.

1S Remote Disconnect
2S Remote Disconnect
2S Standard (Does not have Remote Disconnect Switch)
12 Remote Disconnect

The qualification plans followed ANSI C12.1-2008, *Code for Electricity Metering*, and ANSI C12.20-2010, *American National Standard for Electricity Meters 0.2 and 0.5 Accuracy Classes.* The meters are considered accuracy class 0.2 devices.

The meters are manufactured by:

Itron, Inc.
313 North Highway 11
West Union, South Carolina 29696

References - Standards
All tests are performed in accordance with the following standards and / or specifications.

ANSI C12.1 (2008) *Code for Electricity Metering*

ANSI C12.20 (2010) *American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Class*

SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Adequacy of Testing Laboratory
The tests are conducted by personnel who have been trained in and have a thorough and practical knowledge of the meters under test. They are knowledgeable about all test requirements, including testing procedures. Devices used for checking compliance have traceability to the National Institute of Standards and Technology (NIST).

Equipment Verification
Test equipment used during a test shall be checked daily for proper operation to the applicable standard before and after testing. Test procedures contain sections for recording this information.

Meter Failure Definitions
A meter and option board combination shall be designated as failed if any of the following events occur.

- Failure of the meter to perform all of the specified functions.
- Failure of the meter to meet the technical performance specifications included in this Specification.
- Signs of physical damage or performance degradation as a result of the test procedure, including effects, which could shorten the service life of the meter.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

- The occurrence of unexpected change of state, loss of data, or other unacceptable mode of operation for the meter as a consequence of a test procedure.
- Failure of any Option module to operate as designed.

The meters were programmed for the following Configuration Options:

Items on the Display of Meter
kWh (delivered)
kWh (received)
Max kWh (delivered)
Meter Time
Meter Date
Time on Battery
Number of Power Outages

Other Programmable Requirements
Demand Interval Length = 5 minutes
Interval Data Recording:
2 Channels, Channel 1 = Wh (delivered), Channel 2 = Wh (received)
Recording Length = 5 minutes

The meters were also programmed to have the ZigBee, and LAN radios working and connected to the Collection Engine.

Prior to and after testing a particular meter an accuracy check was made at Max Amps, Full Load, Light Load and Power Factor. Meter accuracy must be within the accuracy class of the meter.

The values shown in the Configuration Options were monitored before and after the test to make sure no corruption of values had occurred.

ANSI Test Sequence
The tests shown in the following table were ran in the sequence shown, using the same meters, if so indicated in this report.

Sequence	Test Requirement
1	ANSI C12.1-2008 Section 4.7.3.1 Insulation
2	ANSI C12.1-2008 Section 4.7.3.2 Voltage Interruptions Test
3	ANSI C12.1-2008 Section 4.7.3.3 Effect of High Voltage Line Surges Ring Wave
4	ANSI C12.1-2008 Section 4.7.3.3 Effect of High Voltage Line Surges Combination Wave
5	ANSI C12.1-2008 Section 4.7.3.11 Fast Transient/Burst
6	ANSI C12.1-2008 Section 4.7.3.11a Effect of Electrical Oscillatory SWC
7	ANSI C12.1-2008 Section 4.7.3.14 Effect of Electrostatic Discharge
8	ANSI C12.1-2008 Section 4.7.3.16 Effect of Operating Temperature
9	ANSI C12.1-2008 Section 4.7.3.17 Effect of Relative Humidity

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Section 1 Meter Information

Hardware Qualification Meters

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes
303 923 347	1S	200	120		
303 922 215	2S	200	240	Yes	
303 922 993	12S	200	120	Yes	Yes
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes
303 923 348	1S	200	120		
303 923 437	1S	200	120	Yes	

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 922 213	2S	200	240	Yes	
303 923 426	2S	200	240		
303 922 994	12S	200	120	Yes	Yes
303 923 384	12S	200	120		Yes
303 923 443	1S	200	120		
303 923 006	12S	200	120		Yes
304 150 723	1S	200	120	Yes	
304 150 717	12S	200	120	Yes	Yes

Form	Metrology PWB Assembly	Metrology Etch and Drill	Communications Module PWB Assembly	Communications Module Etch and Drill	Register PWB Assembly	Register Etch and Drill
1S – Class 200 RDS	443591-006	443590-005	443915-001	443914-004	443970-001	443969-003
2S – Class 200 RDS	443591-005	443590-005	443915-001	443914-004	443970-001	443969-003
2S – Class 200	443591-007	443590-005	443915-001	443914-004	443970-002	443969-003
12S – Class 200 RDS	443984-001	443983-002	443915-001	443914-004	443970-001	443969-003

Firmware Revisions:
Date: Initial Qualification

Register Firmware Version: 3.007.073
Communications Module Firmware Version: 0.013.013

Form	Metrology Firmware Revision
1S – Class 200 RDS	66
2S – Class 200 RDS	66
2S – Class 200	66
12S – Class 200 RDS	66 for U2 0.1.1 for U6

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

List of Test Equipment for Section 1 Testing

Equipment Type	Manufacturer	Model Number	Serial Number	Last Calibration Date	Calibration Due Date
Line Cycle Dropout	HAEFELY	PLINE 1610	151020	March 8, 2011	March 8, 2012
ESD Gun	Schaffner	NSG435	4777	July 8, 2010	July 31, 2011
Oscilloscope	Agilent	DSO6052A	MY44002373	July 7, 2010	July 31, 2011
Fast Transient Generator	Schaffner	NSG 2025	19876	July 9, 2010	July 31, 2011
Fast Transient Coupler	Schaffner	CDN 300	1219004	July 9, 2010	July 31, 2011
Meter Test System	WECO	2300	4581	February 2, 2011	August 2, 2011
Meter Test System	WECO	2300	2434	February 17, 2011	August 17, 2011
Hi Pot Tester	ROD-L	MI50AC	20656	July 7, 2010	July 31, 2011
Watt Hour Standard	Radian	RD-21-332	202154	August 27, 2010	August 27, 2011
Voltmeter	Fluke	8506A	4655002	July 7, 2010	July 31, 2011
Voltmeter	HP	34401A	3146A56993	July 7, 2010	July 31, 2011
Oscillatory Waveform Control Module	HAEFELY	PSURGE 8000	153829	March 29, 2011	March 29, 2012
Oscillatory Waveform Generator	HAEFELY	PIM 150	153950	March 29, 2011	March 29, 2012
Standards Bench	Itron	None	8590A	October 1, 2010	October 1, 2011
Temperature Chamber	Associated Environmental Systems	SD-305	7399	July 7, 2010	July 31, 2011
Salt Fog Chamber	Associated Environmental Systems	MX-9216	7685	NCR	Use pH meter
pH Meter	Orion	250A	011685	NCR	pH meter is checked before each use by using Standard Calibration Solutions
Xenon Test Chamber	Q-Sun	Xe-3-S	06-3275-26-X-X3S	December 22, 2010	December 22, 2011
Oscilloscope	Agilent	DSO6052A	MY44007036	July 8, 2010	July 31, 2011
Thermometer	Fluke	52 II	87840034	July 7, 2010	July 31, 2011
Thermometer	Fluke	52 II	75160013	July 9, 2010	July 31, 2011
AC Amp Meter	Fluke	31	760642410	July 7, 2010	July 31, 2011
AC Amp Meter	Fluke	31	70518359	July 7, 2010	July 31, 2011
Counter	Agilent	53131A	3416AD7452	July 8, 2010	July 31, 2011
Standard	Radian	RM-10-02	8199	May 18, 2011	May 18, 2012
Standard	Radian	RM-10-08	7483	March 16, 2011	March 16, 2012
Oscilloscope	HP	54510A	3022A01883	July 8, 2010	July 31, 2011
Power Analyzer	RFL	636	171	July 8, 2010	July 31, 2011
Standard	Radian	RM-15-14	500768	December 9, 2010	December 9, 2011
Temperature/Humidity Chamber	Cincinnati Sub-Zero	ZHS-32-2-2-H/WC	Z0344017	July 7, 2010	July 31, 2011
KeyTek ECAT Surge System					
Combination Waveform Generator	KeyTek	E501B	1008193	August 26, 2010	August 26, 2011
Ring Wave Generator	KeyTek	E503	9509479	June 11, 2010	June 11, 2011
Coupler	KeyTek	E4553KV	503214	May 20, 2010	May 20, 2011
Differential High Voltage Probe	KeyTek	IL-2	0710196	November 19, 2010	November 19, 2011
RFI Test System					
GTEM	ETS-LINDGREN	5407	00107106	NCR	
Amplifier	IDI	SCCX500	P1271-0511	NCR	
Amplifier	OPHIR	5127	1001 "X1"	NCR	
Amplifier	OPHIR	5163	1005 "B"	NCR	
Amplifier	CPI	PA00	0103096200	NCR	
Power Head	Amplifier Research	PH 2004	311870	July 8, 2010	July 31, 2011

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Equipment Type	Manufacturer	Model Number	Serial Number	Last Calibration Date	Calibration Due Date
Power Head	Amplifier Research	PH 2000	311214	July 8, 2010	July 31, 2011
Power Meter	Amplifier Research	PM 2002	311644	July 8, 2010	July 31, 2011
RF Divider	Amplifier Research	DC 7440A	310592	July 8, 2010	July 31, 2011
RF Divider	Amplifier Research	DC 2600A	311326	July 8, 2010	July 31, 2011
RF Divider	Amplifier Research	DC 7144A	311376	July 8, 2010	July 31, 2011
RF Divider	Amplifier Research	DC 6180A	311270	July 8, 2010	July 31, 2011
Signal Generator	ROHDE SCHWARZ	SML03	102435	July 8, 2010	July 31, 2011
Signal Generator	ROHDE SCHWARZ	SMR40	SC1006	July 8, 2010	July 31, 2011
E Field Probe	ETS-LINDGREN	HI-005	0002367	February 16, 2011	February 16, 2012
E Field Probe	HOLADAY	HI-4422	00023882	October 15, 2010	October 15, 2011
E Field Probe	HOLADAY	HI-4450	00022136	August 19, 2010	August 19, 2011

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Section 2 Meter Information

Register board firmware as well as the Communications module firmware was changed.

Hardware Qualification Meters

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Form	Metrology PWB Assembly	Metrology Etch and Drill	Communications Module PWB Assembly	Communications Module Etch and Drill	Register PWB Assembly	Register Etch and Drill
1S – Class 200 RDS	443591-006	443590-005	443915-001	443914-004	443970-001	443969-003
2S – Class 200 RDS	443591-005	443590-005	443915-001	443914-004	443970-001	443969-003
2S – Class 200	443591-007	443590-005	443915-001	443914-004	443970-002	443969-003
12S – Class 200 RDS	443984-001	443983-002	443915-001	443914-004	443970-001	443969-003

Firmware Revisions:
Date: Regression testing started on July 20, 2011.

Register Firmware Version: 3.008.062
Communications Module Firmware Version: 0.013.058

Form	Metrology Firmware Revision
1S – Class 200 RDS	66
2S – Class 200 RDS	66
2S – Class 200	66
12S – Class 200 RDS	66 for U2 0.1.1 for U6

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

List of Test Equipment for Section 2 Testing

Our annual calibration for some of our test equipment occurred in July. Below is the new calibration information for equipment used in Section 2 Testing.

Equipment Type	Manufacturer	Model Number	Serial Number	Last Calibration Date	Calibration Due Date
Line Cycle Dropout	HAEFELY	PLINE 1610	151020	March 8, 2011	March 8, 2012
ESD Gun	Schaffner	NSG435	4777	July 12, 2011	July 31, 2012
Oscilloscope	Agilent	DSO6052A	MY44002373	July 12, 2011	July 31, 2012
Fast Transient Generator	Schaffner	NSG 2025	19876	July 13, 2011	July 31, 2012
Fast Transient Coupler	Schaffner	CDN 300	1219004	July 13, 2011	July 31, 2012
Meter Test System	WECO	2300	4581	February 2, 2011	August 2, 2011
Meter Test System	WECO	2300	2434	February 17, 2011	August 17, 2011
Hi Pot Tester	ROD-L	MI50AC	20656	July 12, 2011	July 31, 2012
Watt Hour Standard	Radian	RD-21-332	202154	August 27, 2010	August 27, 2011
Voltmeter	Fluke	8506A	4655002	July 12, 2011	July 31, 2012
Voltmeter	HP	34401A	3146A56993	July 12, 2011	July 31, 2012
Oscillatory Waveform Control Module	HAEFELY	PSURGE 8000	153829	March 29, 2011	March 29, 2012
Oscillatory Waveform Generator	HAEFELY	PIM 150	153950	March 29, 2011	March 29, 2012
Oscilloscope	Agilent	DSO6052A	MY44007036	July 12, 2011	July 31, 2012
AC Amp Meter	Fluke	31	70518359	July 12, 2011	July 31, 2012
KeyTek ECAT Surge System	KeyTek				
Combination Waveform Generator	KeyTek	E501B	1008193	August 26, 2010	August 26, 2011
*Ring Wave Generator	KeyTek	E503	9509479	June 11, 2010	June 11, 2011
*Coupler	KeyTek	E4553KV	503214	May 20, 2010	May 20, 2011
Differential High Voltage Probe	KeyTek	1L-2	0710196	November 19, 2010	November 19, 2011

* = KeyTek could not get to our facility to calibrate the Ring Wave Generator nor the Coupler. Testing completed in this section was after the Calibration Due Date for these two pieces of equipment. We used our KeyTek Differential High Voltage Probe to take pictures of the waveforms on a calibrated scope. We used these results to certify the waveform still met the requirements of the standard.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Section 1 - Tests Results

All tests were made at 23° C ±2° C, rated voltage ±1%, rated frequency ±1 Hz, test amps ±1%, and unity power factor 0° ±2°, unless otherwise indicated in a specific test.

Internal Influences

No Load

Testing for this requirement was conducted on April 27, 2011.

Reference: ANSI C12.1-2008 Section 4.7.2.1

Purpose:
This test is to verify no accumulation of Energy output of the test LED during a no load condition.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:
The meter voltage inputs were energized, and all current inputs were in an open circuit condition. The meter shall not complete one equivalent revolution (one pulse at the programmed Kh value) within 10 minutes and no additional pulses in the next 20 minutes.

Results:
All units passed this test requirement.

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Starting Load

Testing for this requirement was conducted on April 26, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.2

Purpose:

Starting load is verification that the meter will measure energy at a certain minimum load current. The registration accuracy is not specified by ANSI.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

Each meter was operated at the input current shown in the ANSI Start Load Table. The current inputs were wired in series for these tests. Percent Registration was obtained on each unit.

ANSI Start Load Table

Meter Class	Current (Amps)
200	0.100

Results:

Serial Number	Percent Registration at Start Load Current
303 923 433	99.858
303 922 210	100.856
303 923 422	101.036
303 922 990	99.775

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Load Performance

Testing for this requirement started on April 26, 2011 and concluded on May 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.3

Purpose:

The purpose of this test will be to verify the meter accuracy for Watt-hours over certain test points as indicated in the table.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

Tests were run to determine the percent registration of the meters under test. Test conditions are dependent on the meter class being tested as indicated in the tables. The meters were allowed a 10 minute warm-up time before the first point, and each point was applied for a minimum of 10 seconds before the registration measurement was taken.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 433 - Watt Hour

Condition	Class 200 (Amps)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference (±) Percent
1	2	100.002	-0.005	0.4
2	3	100.000	-0.007	0.2
3	6	99.987	-0.020	0.2
4	20	100.013	0.006	0.2
5	30	100.007	Reference	Reference
6	60	99.968	-0.039	0.2
7	100	99.945	-0.062	0.2
8	150	99.930	-0.077	0.2
9	180	99.913	-0.094	0.2
10	200	99.886	-0.121	0.2
11				

S/N 303 922 210 - Watt Hour

Condition	Class 200 (Amps)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference (±) Percent
1	2	100.041	0.068	0.4
2	3	100.006	0.033	0.2
3	6	99.976	0.003	0.2
4	20	99.989	0.016	0.2
5	30	99.973	Reference	Reference
6	60	99.932	-0.041	0.2
7	100	99.871	-0.102	0.2
8	150	99.925	-0.048	0.2
9	180	99.818	-0.155	0.2
10	200	99.785	-0.188	0.2
11				

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 422 - Watt Hour

Condition	Class 200 (Amps)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference (+) Percent
1	2	100.023	0.052	0.4
2	3	99.943	-0.028	0.2
3	6	99.985	0.014	0.2
4	20	99.981	0.010	0.2
5	30	99.971	Reference	Reference
6	60	99.941	-0.030	0.2
7	100	99.942	-0.029	0.2
8	150	99.928	-0.043	0.2
9	180	99.950	-0.021	0.2
10	200	99.957	-0.014	0.2
11				

S/N 303 922 990 - Watt Hour

Condition	Class 200 (Amps)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference (+) Percent
1	2	99.946	-0.060	0.4
2	3	99.901	-0.105	0.2
3	6	99.917	-0.089	0.2
4	20	100.022	0.016	0.2
5	30	100.006	Reference	Reference
6	60	99.949	-0.057	0.2
7	100	99.910	-0.096	0.2
8	150	99.885	-0.121	0.2
9	180	99.877	-0.129	0.2
10	200	99.903	-0.103	0.2
11				

All units passed this test requirement.

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Enhanced Current Range Performance

Testing for this requirement started on June 8, 2011 and concluded on June 15, 2011.

Purpose:

This test will determine the meters performance for Watt-hour accuracy over an extended current range. This is not covered by ANSI standards and this data is provided for informational purposes only.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

Watt-hour accuracy was determined at Unity, 0.5 Lag and 0.5 Lead for the following current values.

Class 200 Test Current
200
210
220
230
240

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 435 – Watt Hour

Test Current	Registration Unity	Registration 0.5 Lag	Registration 0.5 Lead
200	99.856	99.747	99.890
210	99.799	99.685	99.863
220	99.748	99.606	99.821
230	99.720	99.636	99.771
240	99.673	99.534	99.709

S/N 303 922 212 – Watt Hour

Test Current	Registration Unity	Registration 0.5 Lag	Registration 0.5 Lead
200	99.968	99.982	99.811
210	99.999	99.894	99.983
220	99.978	99.941	99.900
230	99.985	99.981	100.005
240	99.898	99.986	99.898

S/N 303 923 424 – Watt Hour

Test Current	Registration Unity	Registration 0.5 Lag	Registration 0.5 Lead
200	99.937	99.780	99.762
210	100.040	100.032	99.929
220	99.979	99.872	99.925
230	99.930	99.864	99.838
240	99.913	99.870	99.857

S/N 303 922 992 – Watt Hour

Test Current	Registration Unity	Registration 0.5 Lag	Registration 0.5 Lead
200	99.736	99.636	99.668
210	99.924	99.643	99.716
220	99.807	99.684	99.657
230	99.727	99.633	99.646
240	99.618	99.538	99.586

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Variation of Power Factor

Testing for this requirement started on April 26, 2011 and concluded on May 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.4

Purpose:

This test will verify the Watt Hour accuracy performance of each element of the meter in regard to power factor influence.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

Each element of a multi-element meter shall be tested as a single-element meter, except that all voltage circuits shall be in parallel. Compliance is determined by the maximum percent deviation given in the table for a particular meter type.

Test Conditions Single Element Meters

Condition	Class 200 (Amps)	Power Factor
Reference for Conditions 1	3	1.0
1	6	0.5 lag
Reference for Conditions 2	100	1.0
2	100	0.5 lag
Reference for Conditions 3	200	1.0
3	200	0.5 lag

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Test Conditions Two Element Meters

Condition	Class 200 (Amps)	Power Factor
Reference for Conditions 1 and 2	6	1.0
1	6	.866 lead
2	12	.5 lag
Reference for Condition 3	30	1.0
3	30	.866 lead
Reference for Conditions 4 and 5	100	1.0
4	100	.866 lead
5	100	.5 lag
Reference for Conditions 6 and 7	200	1.0
6	200	.866 lead
7	200	.5 lag

Results:

S/N 303 923 433 - Watt Hour

Test Condition	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
Reference for Conditions 1	99.941	Reference	Reference
1	99.947	0.006	0.5
Reference for Condition 2	99.943	Reference	Reference
2	99.985	0.042	0.3
Reference for Condition 3	99.899	Reference	Reference
3	99.920	0.021	0.3

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 210 - Watt Hour

Test Condition	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
Reference for Conditions 1	99.953	Reference	Reference
1	99.995	0.042	0.5
Reference for Condition 2	99.828	Reference	Reference
2	99.839	0.011	0.3
Reference for Condition 3	99.792	Reference	Reference
3	99.768	-0.024	0.3

S/N 303 923 422 - Watt Hour

Test Condition	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
Reference for Conditions 1	99.996	Reference	Reference
1	99.982	-0.014	0.5
Reference for Condition 2	99.900	Reference	Reference
2	99.950	0.050	0.3
Reference for Condition 3	99.907	Reference	Reference
3	99.930	0.023	0.3

S/N 303 922 990 - Watt Hour
Element 1

Test Condition	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
Reference for Conditions 1 & 2	100.025	Reference	Reference
1	100.115	0.090	0.5
2	99.997	-0.028	0.5
Reference for Condition 3	100.066	Reference	Reference
3	100.110	0.044	0.3
Reference for Condition 4 & 5	99.941	Reference	Reference
4	99.974	0.033	0.3
5	99.890	-0.051	0.3
Reference for Condition 6 & 7	99.914	Reference	Reference
6	99.926	0.007	0.3
7	99.841	0.073	0.3

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Element 2

Test Condition	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
Reference for Conditions 1 & 2	100.002	Reference	Reference
1	100.019	0.017	0.5
2	100.005	0.003	0.5
Reference for Condition 3	100.020	Reference	Reference
3	99.990	-0.030	0.3
Reference for Condition 4 & 5	99.889	Reference	Reference
4	99.869	-0.020	0.3
5	99.919	0.030	0.3
Reference for Condition 6 & 7	99.942	Reference	Reference
6	99.869	-0.073	0.3
7	99.913	-0.029	0.3

All units passed this test requirement.

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Variation of Voltage

Testing for this requirement started on April 26, 2011 and concluded on May 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.5

Purpose:

This test will verify the performance of the meter for Watt-hour accuracy at various input voltages. Accuracy will be checked against the Reference Conditions.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The meter was tested for percent registration at the current and voltage values as shown in the Results Tables shown below.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 433 - Watt Hour

Current	Condition	Tested At Voltage	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
3	Reference performance 100% of calibration voltage for conditions 1 and 2	120 V	99.949	Reference	Reference
3	1 – Itron	80% LRV 96 Volts	99.942	-0.047	0.1
3	1	90% LRV 108 Volts	99.967	-0.022	0.1
3	2	110% HRV 132 Volts	99.974	-0.015	0.1
3	2 - Itron	120% HRV 144 Volts	99.980	-0.009	0.1
30	Reference performance 100% of calibration voltage for conditions 3 and 4	120 Volts	99.989	Reference	Reference
30	3 – Itron	80% LRV 96 Volts	100.003	0.014	0.1
30	3	90% LRV 108 Volts	99.993	0.004	0.1
30	4	110% HRV 132 Volts	99.998	0.009	0.1
30	4 - Itron	120% HRV 144 Volts	100.001	0.012	0.1

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 210 - Watt Hour

Current	Condition	Tested At Voltage	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
3	Reference performance 100% of calibration voltage for conditions 1 and 2	240 V	99.949	Reference	Reference
3	1 – Itron	80% LRV 192 Volts	99.972	0.023	0.1
3	1	90% LRV 216 Volts	99.980	0.031	0.1
3	2	110% HRV 264 Volts	100.005	0.056	0.1
3	2 - Itron	120% HRV 288 Volts	100.014	0.065	0.1
30	Reference performance 100% of calibration voltage for conditions 3 and 4	240 V	99.961	Reference	Reference
30	3 – Itron	80% LRV 192 Volts	99.954	-0.007	0.1
30	3	90% LRV 216 Volts	99.955	-0.006	0.1
30	4	110% HRV 264 Volts	99.973	0.012	0.1
30	4 - Itron	120% HRV 288 Volts	99.976	0.015	0.1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 422 - Watt Hour

Current	Condition	Tested At Voltage	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
3	Reference performance 100% of calibration voltage for conditions 1 and 2	240 V	99.993	Reference	Reference
3	1 – Itron	80% LRV 192 Volts	99.996	0.003	0.1
3	1	90% LRV 216 Volts	99.999	0.006	0.1
3	2	110% HRV 264 Volts	100.003	0.010	0.1
3	2 - Itron	120% HRV 288 Volts	100.009	0.016	0.1
30	Reference performance 100% of calibration voltage for conditions 3 and 4	240 V	99.976	Reference	Reference
30	3 – Itron	80% LRV 192 Volts	99.961	-0.015	0.1
30	3	90% LRV 216 Volts	99.975	-0.001	0.1
30	4	110% HRV 264 Volts	99.984	0.008	0.1
30	4 - Itron	120% HRV 288 Volts	99.993	0.017	0.1

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 990 - Watt Hour

Current	Condition	Tested At Voltage	Percent Registration	Error Relative to Reference	ANSI C12.20 Limits ± Percent
3	Reference performance 100% of calibration voltage for conditions 1 and 2	120 V	99.933	Reference	Reference
3	1 – Itron	80% LRV 96 Volts	99.948	0.015	0.1
3	1	90% LRV 108 Volts	99.947	0.014	0.1
3	2	110% HRV 132 Volts	99.958	0.025	0.1
3	2 - Itron	120% HRV 144 Volts	99.948	0.015	0.1
30	Reference performance 100% of calibration voltage for conditions 3 and 4	120 Volts	99.982	Reference	Reference
30	3 – Itron	80% LRV 96 Volts	99.982	0.000	0.1
30	3	90% LRV 108 Volts	99.979	-0.003	0.1
30	4	110% HRV 132 Volts	99.982	0.000	0.1
30	4 - Itron	120% HRV 144 Volts	99.980	-0.002	0.1

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Variation of Frequency

Testing for this requirement started on April 26, 2011 and concluded on May 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.6

Purpose:

This test is a verification of Watt-hour accuracy under various input frequencies.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The registration tests were ran at the current and frequencies shown and in the order shown. The meter was allowed a 10 minute warm-up time before the first point, and each point will be applied for a minimum of 10 seconds before the registration measurement was taken. Compliance is determined by the deviation from the reference point.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 433 - Watt Hour

Condition	Class 200 Input Current (Amps)	Frequency (Hz)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference ± Percent
Reference for Conditions 1 and 2	3	60	99.989	Reference	Reference
1	3	57	99.993	0.004	0.1
2	3	63	99.987	-0.002	0.1
Reference for Conditions 3 and 4	30	60	100.007	Reference	Reference
3	30	57	100.005	-0.002	0.1
4	30	63	100.001	-0.006	0.1

S/N 303 922 210 - Watt Hour

Condition	Class 200 Input Current (Amps)	Frequency (Hz)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference ± Percent
Reference for Conditions 1 and 2	3	60	100.044	Reference	Reference
1	3	57	100.042	-0.002	0.1
2	3	63	100.039	-0.005	0.1
Reference for Conditions 3 and 4	30	60	99.986	Reference	Reference
3	30	57	99.977	-0.009	0.1
4	30	63	99.978	-0.008	0.1

EXHIBIT G-1

Electric / Gas / Water
information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 422 - Watt Hour

Condition	Class 200 Input Current (Amps)	Frequency (Hz)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference ± Percent
Reference for Conditions 1 and 2	3	60	100.015	Reference	Reference
1	3	57	100.025	0.010	0.1
2	3	63	100.021	0.006	0.1
Reference for Conditions 3 and 4	30	60	99.980	Reference	Reference
3	30	57	99.987	0.007	0.1
4	30	63	99.985	0.005	0.1

S/N 303 922 990 - Watt Hour

Condition	Class 200 Input Current (Amps)	Frequency (Hz)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference ± Percent
Reference for Conditions 1 and 2	3	60	99.978	Reference	Reference
1	3	57	99.973	-0.005	0.1
2	3	63	99.963	-0.015	0.1
Reference for Conditions 3 and 4	30	60	99.983	Reference	Reference
3	30	57	99.993	0.010	0.1
4	30	63	99.985	0.002	0.1

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Equality of Current Circuits

Testing for this requirement started on April 26, 2011 and concluded on May 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.7

Purpose:

This test will determine the equivalence of each current circuit within the meter at various current points.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 922 990	12S	200	120	Yes	Yes

Procedure:

Percent registration was taken at reference conditions with all current elements active. Then each current circuit was tested individually, at twice load current, and checked for deviation from Reference point.

Results:

S/N 303 922 990 – Watt Hour

Condition	Connection of Current Circuits	Class 200 Input Current (Amps)	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation From Reference ± Percent
Reference for Conditions 5 and 6	All Circuits	3	99.973	Reference	Reference
5	Circuit A	6	100.062	0.089	0.3
6	Circuit B	6	100.008	0.035	0.3
Reference for Conditions 8 and 9	All Circuits	30	99.987	Reference	Reference
8	Circuit A	30	100.037	0.050	0.3
9	Circuit B	30	99.997	0.010	0.3

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Internal Meter Losses

Testing for this requirement was conducted on May 11, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.8

Purpose:

This test determines the internal meter losses for current and voltage circuits. These losses are used to determine the "Watt and VA Load" a meter places on the input power system.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Note: With the Register board attached to the meter, with the RF radios active, the Watt loss readings will be around 6 to 7 Watts during the "Discovery Period". This period is when the meter powers up and attempts to find the network. Once the network has been found the Watt loss readings are as shown in the table.

Procedure/Results:

The loss in each voltage and current circuit of a meter was tested to the values shown in the tables.

Current Circuits VA Limits

Class 200 Specification Limit
1.0 VA

Potential Circuit Watt and VA Limits

ANSI Watt Specification Limit	ANSI VA Specification Limit
5	20

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 435 FM 1S

Parameter	Meter Value	ANSI Specification
Watt Loss Potential Circuit A	2.686	5
VA Loss Potential Circuit A	6.999	20
VA Loss Current Circuit A	0.593	1
VA Loss Current Circuit C	0.585	1

S/N 303 922 212 FM 2S

Parameter	Meter Value	ANSI Specification
Watt Loss Potential Circuit A	3.203	5
VA Loss Potential Circuit A	11.892	20
VA Loss Current Circuit A	0.418	1
VA Loss Current Circuit C	0.361	1

S/N 303 923 424 FM 2S

Parameter	Meter Value	ANSI Specification
Watt Loss Potential Circuit A	3.241	5
VA Loss Potential Circuit A	12.017	20
VA Loss Current Circuit A	0.367	1
VA Loss Current Circuit C	0.303	1

S/N 303 922 992 FM 12S

Parameter	Meter Value	ANSI Specification
Watt Loss Potential Circuit A	2.831	5
VA Loss Potential Circuit A	7.393	20
Watt Loss Potential Circuit C	0.055	5
VA Loss Potential Circuit C	0.110	20
VA Loss Current Circuit A	0.392	1
VA Loss Current Circuit C	0.351	1

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Temperature Rise

Testing for this requirement started on June 29, 2011 and concluded on July 30, 2011.

Reference: ANSI C12.1-2008 Section 4.7.2.9

Purpose:

The purpose of this test is to determine the temperature rise of any current carrying part within the meter under maximum amp conditions.

Units Included in this Test:

Serial Number	Form	Class	Remote Disconnect	Link
304 150 723	1S	200	Yes	
303 922 215	2S	200	Yes	
304 150 717	12S	200	Yes	Yes

Procedure:

The test was made with the specified current applied to all current circuits in series. The temperature rise of any of the current carrying parts of the meter, tested under specified conditions, shall not exceed 55° C. All tests shall be performed in a room essentially free from drafts with the meter cover in place. The meter shall be mounted in a conventional manner and on a suitably rated meter mounting as shown in the table. Not less than 4 feet (8 feet jumper between terminals) of stranded, insulated copper conductor shall be connected to the line and load current terminals of the meter or socket. All openings shall be closed with suitable material to prevent drafts that could cool the meter socket or meter itself. The conductor size, and test current, shall be as shown in the Test Parameters table. The meter shall be subjected to the current values shown in the table until the temperature of the test point has stabilized.

Readings should be taken after 1 hour has elapsed from start of test, then readings are taken every 5 minutes until the readings do not deviate more than 1° C, over a 15 minute period. The stabilized point has been reached and final data can be recorded.

The temperature rise shall be considered the difference in degrees Celsius between the stabilized temperature and ambient (room) temperature.

Temperature rise will be measured using thermocouples soldered as close as possible to the center of all current elements used by the meter form under test.

A temperature-rise test shall be conducted on the simulated meter by applying the test current to all jumper bars in series until the temperature as indicated by the temperature detector has stabilized. This temperature

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

shall then be recorded and the simulated metering device replaced by the metering device to be tested. When the temperatures of the metering device current circuits have stabilized, the temperatures shall be measured and the empirical temperature-rise values of the meter device current circuits shall be calculated as follows:

Empirical temperature rise = $\theta_m - (\theta_s - 55°C)$

Where:

θ_m= Measured final temperature rise of current circuit of metering device under test

θ_s= Measured final temperature rise of current circuit of simulated meter jumper bar for the same current phase

Test Parameters

Meter Class	Wire Size (AWG Copper)	Current (Amps)	Socket Rating (Amps)
200	4/0	200	200

Test on Simulated Meter for the 2S RDS

Test Start Time: 10:30:00 June 29, 2011

Temperature of Current Coils – Simulated Meter

Delta from Start	Time of Reading	Left Current Coil	Right Current Coil	Ambient Temperature
2 hours 30 minutes	13:00:00	85.2	88.9	23.2
2 hours 45 minutes	13:15:00	84.5	88.2	22.0
3 hours	13:30:00	84.4	87.9	22.2
3 hours 15 minutes	13:45:00	84.0	87.7	22.5
3 hours 30 minutes	14:00:00	83.8	87.5	22.8
3 hours 45 minutes	14:15:00	84.6	88.2	22.7

Final Readings after Stabilization – Simulated Meter

	Left Current Coil	Right Current Coil
Temperature, Room	22.7	22.7
Temperature, Meter	84.6	88.2
Temperature, Rise θ_s	61.9	65.5

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Test on Simulated Meter for the 1S RDS and 12S RDS

Test Start Time: 13:30:00 July 20, 2011

Temperature of Current Coils – Simulated Meter

Delta from Start	Time of Reading	Left Current Coil	Right Current Coil	Ambient Temperature
1 hour 15 minutes	14:46	80.4	77.0	21.3
1 hour 30 minutes	15:00	81.3	78.4	21.2
1 hour 45 minutes	15:15	81.9	79.2	21.3
2 hours	15:30	81.9	79.9	21.3
2 hours 15 minutes	15:45	81.9	80.9	23.2
2 hours 30 minutes	16:00	82.0	81.1	23.0
2 hours 45 minutes	16:15	82.2	81.3	23.0

Final Readings after Stabilization – Simulated Meter

	Left Current Coil	Right Current Coil
Temperature, Room	23.0	23.0
Temperature, Meter	82.2	81.3
Temperature, Rise θ_s	59.2	58.3

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Test on Subject Meter S/N 303 922 215 FM 2S RDS Class 200

Test Start Time: 13:30 June 29, 2011

Temperature of Current Coils – Subject Meter

Delta from Start	Time of Reading	Left Current Coil	Right Current Coil	Ambient Temperature
1 hour	14:30	72.9	74.6	22.0
1 hour 15 minutes	14:45	72.7	74.4	22.1
1 hour 30 minutes	15:00	73.0	74.7	22.0
1 hour 45 minutes	15:15	73.0	74.8	22.1
2 hours	15:30	73.2	74.7	22.0
2 hours 15 minutes	15:45	73.4	74.8	22.0
2 hour 30 minutes	16:00	73.6	75.1	21.9
2 hours 45 minutes	16:15	73.3	74.8	21.9

Final Readings after Stabilization – Subject Meter

	Left Current Coil	Right Current Coil
Temperature, Room	21.9	21.9
Temperature, Meter	73.3	74.8
Temperature, Rise = θ_m	51.4	52.9
Empirical temperature rise	44.5	42.4

Empirical temperature rise = $\theta_m - (\theta_s - 55^\circ C)$

The maximum empirical temperature rise allowed by ANSI is 55° C unless suitable insulation is used.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Test on Subject Meter S/N 304 150 723 FM 1S RDS Class 200

Test Start Time: 13:45:00 July 29, 2011

Temperature of Current Coils – Subject Meter

Delta from Start	Time of Reading	Left Current Coil	Right Current Coil	Ambient Temperature
15 minutes	14:00	59.6	57.1	20.8
30 minutes	14:15	64.6	62.6	20.9
45 minutes	14:30	68.1	65.8	20.9
1 hour	14:45	71.6	68.0	20.9
1 hour 15 minutes	15:00	73.5	69.2	20.6
1 hour 30 minutes	15:15	74.7	69.8	20.7
1 hour 45 minutes	15:30	75.4	70.2	20.7
2 hours	15:45	75.5	70.1	20.7
2 hours 15 minutes	16:00	76.2	70.6	20.6
2 hour 30 minutes	16:15	76.3	70.8	20.8
2 hours 45 minutes	16:30	76.9	70.5	20.6

Final Readings after Stabilization – Subject Meter

	Left Current Coil	Right Current Coil
Temperature, Room	20.6	20.6
Temperature, Meter	76.9	70.5
Temperature, Rise = θ_m	56.3	49.9
Empirical temperature rise	52.1	46.6

Empirical temperature rise = θ_m - (θ_s - 55° C)

The maximum empirical temperature rise allowed by ANSI is 55° C unless suitable insulation is used.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Test on Subject Meter S/N 304 150 717 FM 12S RDS Class 200

Test Start Time: 16:30:00 July 29, 2011

Temperature of Current Coils – Subject Meter

Delta from Start	Time of Reading	Left Current Coil	Right Current Coil	Ambient Temperature
30 minutes	17:00	73.8	73.2	20.9
45 minutes	17:15	75.0	73.9	20.7
1 hour	17:30	75.7	74.3	20.5
1 hour 15 minutes	17:45	75.6	74.2	20.7
1 hour 30 minutes	18:00	76.1	74.8	20.8
1 hour 45 minutes	18:15	76.4	75.0	20.6
2 hours	18:30	76.4	75.1	20.6

Final Readings after Stabilization – Subject Meter

	Left Current Coil	Right Current Coil
Temperature, Room	20.6	20.6
Temperature, Meter	76.4	75.1
Temperature, Rise = θ_m	55.8	54.5
Empirical temperature rise	51.6	51.2

Empirical temperature rise = $\theta_m - (\theta_s - 55^\circ C)$

The maximum empirical temperature rise allowed by ANSI is 55° C unless suitable insulation is used.

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Internal Heating

Testing for this requirement started on June 6, 2011 and concluded on June 10, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.11

Purpose:

This test will verify the accuracy of the meter under the influence of internal heating. Internal heating can be caused by electronic circuits, voltage and current measurement instrumentation and current carrying conductors.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The meter was mounted in a conventional manner on a suitably rated meter mounting and wired with not less than four foot of conductor (eight feet between terminals) of a size adequate for the load range of the meter. All openings around the conductors and any other openings were closed to prevent drafts. The currents shown in the table were applied in the order shown. The time duration was observed before the percent registration measurement was taken. Compliance is determined by the deviation from the reference conditions.

Results:

See following tables for detailed findings.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 433

Condition	Amps	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation Allowed ± Percent
Reference for Conditions 1, 2, and 7	200	99.910	Reference	Reference
Reference for Conditions 3, and 5	3	99.873	Reference	Reference
Reference for Conditions 4, and 6	30	99.968	Reference	Reference
1 0.5 hours after application of load	200	99.672	-0.338	0.4
2 One hour after application of load	200	99.654	-0.356	0.4
3 Immediately following test for condition 2	3	99.831	-0.042	0.4
4 Immediately following test for condition 3	30	99.915	-0.053	0.4
5 Two hours after test for condition 4 with meter at no load current during the two hour interval	3	99.907	0.034	0.4
6 Immediately following test for condition 5	30	100.001	0.033	0.4
7 Immediately following test for condition 6	200	99.966	0.056	0.4

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 210

Condition	Amps	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation Allowed ± Percent
Reference for Conditions 1, 2, and 7	200	99.896	Reference	Reference
Reference for Conditions 3, and 5	3	99.963	Reference	Reference
Reference for Conditions 4, and 6	30	99.988	Reference	Reference
1 0.5 hours after application of load	200	99.671	-0.225	0.4
2 One hour after application of load	200	99.643	-0.253	0.4
3 Immediately following test for condition 2	3	99.908	-0.055	0.4
4 Immediately following test for condition 3	30	99.976	-0.012	0.4
5 Two hours after test for condition 4 with meter at no load current during the two hour interval	3	100.051	0.088	0.4
6 Immediately following test for condition 5	30	100.068	0.080	0.4
7 Immediately following test for condition 6	200	99.934	0.038	0.4

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 422

Condition	Amps	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation Allowed ± Percent
Reference for Conditions 1, 2, and 7	200	100.101	Reference	Reference
Reference for Conditions 3, and 5	3	100.062	Reference	Reference
Reference for Conditions 4, and 6	30	100.101	Reference	Reference
1 0.5 hours after application of load	200	99.927	-0.174	0.4
2 One hour after application of load	200	99.900	-0.201	0.4
3 Immediately following test for condition 2	3	100.196	0.134	0.4
4 Immediately following test for condition 3	30	100.243	0.142	0.4
5 Two hours after test for condition 4 with meter at no load current during the two hour interval	3	100.165	0.103	0.4
6 Immediately following test for condition 5	30	100.165	0.064	0.4
7 Immediately following test for condition 6	200	100.137	0.036	0.4

EXHIBIT G-1

Itron

Electric / Gas / Water
information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 990

Condition	Amps	Percent Registration	Deviation From Reference	ANSI C12.20 Maximum Deviation Allowed ± Percent
Reference for Conditions 1, 2, and 7	200	99.892	Reference	Reference
Reference for Conditions 3, and 5	3	99.847	Reference	Reference
Reference for Conditions 4, and 6	30	99.943	Reference	Reference
1 0.5 hours after application of load	200	99.746	-0.146	0.4
2 One hour after application of load	200	99.769	-0.123	0.4
3 Immediately following test for condition 2	3	99.926	0.079	0.4
4 Immediately following test for condition 3	30	100.017	0.074	0.4
5 Two hours after test for condition 4 with meter at no load current during the two hour interval	3	99.982	0.135	0.4
6 Immediately following test for condition 5	30	100.076	0.133	0.4
7 Immediately following test for condition 6	200	100.056	0.164	0.4

All units passed this test requirement.

Electric / Gas / Water
information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Stability of Performance

Testing for this requirement started on June 20, 2011 and concluded on July 4, 2011.

Reference: ANSI C12.20-2010 Section 5.5.4.13

Purpose:

Determines the ability of the metering device to maintain accuracy within certain limits over a period of time as defined in the standard.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

The metering device shall be operated continuously. The percentage registration shall be determined at 10% of test amperes at the start of the test and at 10 successive intervals at least 24 hours apart within a period of 2 weeks. The change in percentage registration from performance at the start of the test shall not exceed 1% on any subsequent test.

Results:

See following tables for our test results.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 435 - Watt Hour

Date of Reading	Percent Registration	Difference from Reference	ANSI Specification Deviation from Reference ± Percent
20-Jun-2011	100.020	Reference	Reference
21-Jun-2011	99.962	-0.058	0.2
22-Jun-2011	100.072	0.052	0.2
23-Jun-2011	100.055	0.035	0.2
24-Jun-2011	100.084	0.064	0.2
27-Jun-2011	100.081	0.061	0.2
28-Jun-2011	100.107	0.087	0.2
29-Jun-2011	100.105	0.085	0.2
30-Jun-2011	100.121	0.101	0.2
01-Jul-2011	100.076	0.056	0.2
04-Jul-2011	100.077	0.057	0.2

S/N 303 922 212 - Watt Hour

Date of Reading	Percent Registration	Difference from Reference	ANSI Specification Deviation from Reference ± Percent
20-Jun-2011	100.030	Reference	Reference
21-Jun-2011	99.971	-0.059	0.2
22-Jun-2011	99.989	-0.041	0.2
23-Jun-2011	99.974	-0.056	0.2
24-Jun-2011	99.966	-0.064	0.2
27-Jun-2011	99.952	-0.078	0.2
28-Jun-2011	99.950	-0.080	0.2
29-Jun-2011	99.928	-0.102	0.2
30-Jun-2011	99.887	-0.153	0.2
01-Jul-2011	99.878	-0.152	0.2
04-Jul-2011	99.870	-0.160	0.2

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 424 - Watt Hour

Date of Reading	Percent Registration	Difference from Reference	ANSI Specification Deviation from Reference ± Percent
20-Jun-2011	100.056	Reference	Reference
21-Jun-2011	100.179	0.123	0.2
22-Jun-2011	100.121	0.065	0.2
23-Jun-2011	100.120	0.064	0.2
24-Jun-2011	100.176	0.120	0.2
27-Jun-2011	100.132	0.076	0.2
28-Jun-2011	100.098	0.042	0.2
29-Jun-2011	100.155	0.099	0.2
30-Jun-2011	100.214	0.158	0.2
01-Jul-2011	100.217	0.161	0.2
04-Jul-2011	100.189	0.133	0.2

S/N 303 922 992 - Watt Hour

Date of Reading	Percent Registration	Difference from Reference	ANSI Specification Deviation from Reference ± Percent
20-Jun-2011	100.112	Reference	Reference
21-Jun-2011	100.052	-0.060	0.2
22-Jun-2011	100.160	0.048	0.2
23-Jun-2011	100.145	0.033	0.2
24-Jun-2011	100.157	0.045	0.2
27-Jun-2011	100.185	0.073	0.2
28-Jun-2011	100.220	0.108	0.2
29-Jun-2011	100.211	0.099	0.2
30-Jun-2011	100.212	0.100	0.2
01-Jul-2011	100.176	0.064	0.2
04-Jul-2011	100.168	0.056	0.2

All units passed this test requirement.

External Influences

Insulation

Testing for this requirement was conducted on April 25, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.1

Test 1 in the ANSI Test Sequence.

Purpose:

To verify that adequate insulation exists to withstand a minimum sinusoidal RMS voltage of 2.5 kV between accessible parts of the meter and all current carrying lines.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

All voltage and current lines were tested. The test level was 2500 volts, AC, 60 Hz for a duration of one minute. The trip current, which is the level in which a failure will be indicated, was set to 1.0 mA for all test points.

Results:

All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Voltage Interruption Test

Testing for this requirement was conducted on April 26, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.2

Test 2 in the ANSI Test Sequence.

Purpose:

This test is to verify proper operation of the meter after the application of a series of voltage interruptions.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure 1: 0.5 to 6.0 Cycle Interruption – Itron Requirement

The meter input voltage was terminated into a short-circuit for the Test Points shown. For each test point, the interruption was applied 1 time. A one minute wait state was observed between each Test Point.

Test Points: 0.5 to 6.0 cycles, incrementing by 0.5 cycles, for a total of 12 tests.

Procedure 2: 6.0 Cycle Interruption - Ten Times – ANSI Requirement

The meter input voltage was terminated into a short-circuit for the Test Point shown. The interruption was applied 10 times within a 10 second period.

Test Point: 6.0 cycles

For all procedures, the meter may recognize the interruptions as an outage and will properly save any volatile data. After the completion of the interruptions, the meter will operate with no abnormalities.

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges - 100 kHz Ring Waveform – Itron Procedure

Testing for this requirement started on April 28, 2011 and concluded on May 5, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.3.1

Test 3 in the ANSI Test Sequence.

Purpose:

This test is a check for proper operation after the application of a series of high voltage and current waveforms, 0.5 mS, 100 kHz ringing waveform as described in ANSI C62.45-1992.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

Each coupling was surged at 6 kV and -6 kV from 0 to 360°, every 15°, for each test point shown in the Coupling Arrangement tables. A wait time of 1 minute was observed between each application of the surge to allow for component cooling. The polarity side of the current circuits were connected to the line and the non-polarity side open circuited.

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2
L1 to PE
L2 to PE

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1 to L2
L1 to N
L2 to N
L1 to PE
L2 to PE
N to PE

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges - Combination Waveform - Itron Procedure

Testing for this requirement started on May 2, 2011 and concluded on May 6, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.3.2

Test 4 in the ANSI Test Sequence.

Purpose:

The metering device shall meet the AC Line Surge Requirements of ANSI/IEEE C62.41 for a Category A and B location. The required waveform is the 1.2/50 microsecond - 8/20 microsecond Combination Wave. A peak current of 3000 amps is available during the surge.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

Each coupling was surged at 6 kV and -6 kV from 0 to 360°, every 15°, for each test point shown in the Coupling Arrangement tables. A wait time of 3 minutes was observed between each application of the surge to allow for component cooling. The polarity side of the current circuits were connected to the line and the non-polarity side open circuited.

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2
L1 to PE
L2 to PE

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1 to L2
L1 to N
L2 to N
L1 to PE
L2 to PE
N to PE

Results:

All units passed this test requirement.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges Combination Waveform - Southern California Edison Procedure

Testing for this requirement started on April 28, 2011 and concluded on May 3, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

The metering device shall meet the AC Line Surge Requirements of ANSI/IEEE C62.41 for a Category A and B location. The required waveform is the 1.2/50 microsecond - 8/20 microsecond Combination Wave. A peak current of 3000 amps is available during the surge.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

The Southern California Edison procedure is broken down into 3 voltages as shown below:

4 kV Test

Peak voltage was set to 4 kV and the surge applied from 0° to 360°, every 10°, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

5 kV Test

Peak voltage was set to 5 kV and the surge applied from 0° to 180°, every 15°, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

6 kV Test

Peak voltage was set to 6 kV and the surge applied from 0° to 180°, every 15°, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1, L2 to N

Results:

All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges 100 kHz Ring Waveform - Southern California Edison Procedure

Testing for this requirement started on April 28, 2011 and concluded on May 3, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

This test is a check for proper operation after the application of a series of high voltage and current waveforms, 0.5 mS, 100 kHz ringing waveform as described in ANSI C62.45-1992.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

The Southern California Edison procedure is broken down into 3 voltages as shown below:

4 kV Test

Peak voltage was set to 4 kV and the surge applied from 0^{O} to 360^{O}, every 10^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

5 kV Test

Peak voltage was set to 5 kV and the surge applied from 0^{O} to 180^{O}, every 15^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

6 kV Test

Peak voltage was set to 6 kV and the surge applied from 0^{O} to 180^{O}, every 15^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1, L2 to N

Results:
All units passed this test requirement.

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of External Magnetic Field

Testing for this requirement started on April 28, 2011 and concluded on May 2, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.4 and ANSI C12.20-2010 Section 5.5.5.5

Purpose:

To verify meter integrity during the application of a magnetic field. The external magnetic field is to be *generated by a 100 ampere-turn current, in phase with the meter voltage. The loop is based on a* straight, rigid conductor six feet long, with the connecting leads arranged to form a square with six foot sides. The meters are placed in test conditions shown.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Test Points

Meter Class	Current (Amps)
200	3

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Procedure:

Condition 1:

Behind the test board in a horizontal position and parallel to the back of the meter. The middle of the conductor shall be ten inches directly behind and on a level with the center of the meter. The loop shall be in a horizontal plane perpendicular to the test board.

Condition 2:

Directly behind the center line of the meter in a vertical position. The middle of the conductor shall be ten inches directly behind and on a level with the center of the meter. The loop shall be in a vertical plane perpendicular to the test board.

Condition 3:

Vertically at the same distance in front of the test board as the center of the meter. The middle of the conductor shall be on the same level with the center of the meter and ten inches to the right or left. The loop shall be in a vertical plane parallel to the test board.

Condition 4:

Vertically at the same distance in front of the test board as the center of the meter. The middle of the conductor shall be on the same level with the center of the meter and ten inches from the center of the meter. The meter should be turned to the left. The loop shall be in a vertical plane parallel to the test board

Condition 5:

Horizontally at the same distance in front of the test board as the center of the meter. The middle of the conductor shall be on the same level with the center of the meter and ten inches from the center of the meter. The meter should be turned to the right. The loop shall be in a horizontal plane perpendicular to the test board.

Condition 6:

Horizontally at the same distance in front of the test board as the center of the meter. The middle of the conductor shall be on the same level with the center of the meter and ten inches from the center of the meter. The meter should be turned to the left. The loop shall be in a horizontal plane perpendicular to the test board.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results

S/N 303 923 433 – Watt Hour

Condition	Percent Registration	Deviation from Reference	ANSI Maximum Deviation from Reference Performance + Percent
Reference for Conditions 1, 2, 3, 4, 5 and 6	99.867	Reference	Reference
1	99.691	-0.176	1
2	99.248	-0.619	1
3	99.018	-0.849	1
4	100.732	0.865	1
5	99.752	-0.115	1
6	99.598	-0.269	1

S/N 303 922 210 – Watt Hour

Condition	Percent Registration	Deviation from Reference	ANSI Maximum Deviation from Reference Performance + Percent
Reference for Conditions 1, 2, 3, 4, 5 and 6	99.875	Reference	Reference
1	99.775	-0.100	1
2	99.635	-0.234	1
3	100.718	0.843	1
4	99.009	-0.833	1
5	99.740	-0.135	1
6	99.688	0.187	1

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 422– Watt Hour

Condition	Percent Registration	Deviation from Reference	ANSI Maximum Deviation from Reference Performance + Percent
Reference for Conditions 1, 2, 3, 4, 5 and 6	99.961	Reference	Reference
1	99.898	-0.063	1
2	100.178	0.217	1
3	99.053	-0.908	1
4	100.773	0.812	1
5	99.849	-0.112	1
6	100.057	0.096	1

S/N 303 922 990 – Watt Hour

Condition	Percent Registration	Deviation from Reference	ANSI Maximum Deviation from Reference Performance + Percent
Reference for Conditions 1, 2, 3, 4, 5 and 6	99.890	Reference	Reference
1	100.102	0.212	1
2	99.318	-0.572	1
3	100.548	0.658	1
4	98.979	-0.911	1
5	100.126	0.236	1
6	100.122	0.232	1

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Variation of Ambient Temperature

Testing for this requirement started on June 8, 2011 and concluded on June 15, 2011.

Reference: ANSI C12.20-2010 Section 5.5.5.6

Purpose:

This test will determine the meters performance for Watt-hour accuracy under various temperature, current levels and power factor conditions.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

Itron has adjusted the temperature test points from 50° C to 85° C for the upper point and from -20° C to -40° C for the lower point. Per ANSI standard, *when the actual temperature difference between two tests differs from the nominal temperature difference specified for the two tests, the deviation shall be adjusted proportionally*. Since we are testing 35° higher on the upper end, and 20° lower on the lower end, we have adjusted the allowable variation that is specified by ANSI to cover our wider temperature range.

Reference conditions at 25° C were taken first at the current, and power factor indicated for the class of meter under test. The meters were energized with potential only for a minimum of two hours before the first test condition. The meters were ran at each reference condition for at least one hour before the registration measurement was taken.

The test chamber was set to 85° C and the meters were ran with potential only for a minimum of two hours. The meters were then ran at each condition for at least one hour before the registration measurement was taken.

The test chamber was set to -40° C and the meters were ran with potential only for a minimum of two hours. The meters were then ran at each condition for at least one hour before the registration measurement was taken.

Itron

Electric / Gas / Water
Information collection analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 435 – Watt Hour

Condition	Current	Power Factor	Temperature °C	Percent Registration	Deviation from Reference	ANSI C12.20 Maximum Deviation from Reference + Percent
Reference for Conditions 1 and 7	3	1.0	25	99.850	Reference	Reference
Reference for Conditions 2 and 8	30	1.0	25	99.920	Reference	Reference
Reference for Conditions 3 and 9	100	1.0	25	99.911	Reference	Reference
Reference for Conditions 4 and 10	6	0.5 lag	25	99.878	Reference	Reference
Reference for Conditions 5 and 11	30	0.5 lag	25	99.798	Reference	Reference
Reference for Conditions 6 and 12	100	0.5 lag	25	99.873	Reference	Reference
1	3	1.0	85	99.654	-0.196	0.7
2	30	1.0	85	99.655	-0.264	0.7
3	100	1.0	85	99.599	-0.313	0.7
4	6	0.5 lag	85	99.503	-0.375	1.2
5	30	0.5 lag	85	99.487	-0.310	1.2
6	100	0.5 lag	85	99.522	-0.352	1.2
7	3	1.0	-40	99.917	0.068	0.7
8	30	1.0	-40	100.043	0.123	0.7
9	100	1.0	-40	100.062	0.150	0.7
10	6	0.5 lag	-40	100.094	0.216	1.3
11	30	0.5 lag	-40	100.110	0.313	1.3
12	100	0.5 lag	-40	100.097	0.224	1.3

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 212 – Watt Hour

Condition	Current	Power Factor	Temperature °C	Percent Registration	Deviation from Reference	ANSI C12.20 Maximum Deviation from Reference ± Percent
Reference for Conditions 1 and 7	3	1.0	25	99.991	Reference	Reference
Reference for Conditions 2 and 8	30	1.0	25	100.030	Reference	Reference
Reference for Conditions 3 and 9	100	1.0	25	99.973	Reference	Reference
Reference for Conditions 4 and 10	6	0.5 lag	25	100.003	Reference	Reference
Reference for Conditions 5 and 11	30	0.5 lag	25	100.025	Reference	Reference
Reference for Conditions 6 and 12	100	0.5 lag	25	100.040	Reference	Reference
1	3	1.0	85	100.071	0.080	0.7
2	30	1.0	85	100.099	0.069	0.7
3	100	1.0	85	100.050	0.077	0.7
4	6	0.5 lag	85	100.202	0.199	1.2
5	30	0.5 lag	85	100.191	0.165	1.2
6	100	0.5 lag	85	100.147	0.107	1.2
7	3	1.0	-40	99.901	-0.089	0.7
8	30	1.0	-40	99.984	-0.046	0.7
9	100	1.0	-40	99.990	0.016	0.7
10	6	0.5 lag	-40	99.846	-0.157	1.3
11	30	0.5 lag	-40	99.912	-0.114	1.3
12	100	0.5 lag	-40	99.895	-0.145	1.3

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 424 – Watt Hour

Condition	Current	Power Factor	Temperature °C	Percent Registration	Deviation from Reference	ANSI C12.20 Maximum Deviation from Reference ± Percent
Reference for Conditions 1 and 7	3	1.0	25	100.024	Reference	Reference
Reference for Conditions 2 and 8	30	1.0	25	100.056	Reference	Reference
Reference for Conditions 3 and 9	100	1.0	25	100.058	Reference	Reference
Reference for Conditions 4 and 10	6	0.5 lag	25	100.016	Reference	Reference
Reference for Conditions 5 and 11	30	0.5 lag	25	100.027	Reference	Reference
Reference for Conditions 6 and 12	100	0.5 lag	25	100.022	Reference	Reference
1	3	1.0	85	99.910	-0.144	0.7
2	30	1.0	85	99.921	-0.136	0.7
3	100	1.0	85	99.866	-0.192	0.7
4	6	0.5 lag	85	99.973	-0.043	1.2
5	30	0.5 lag	85	99.979	-0.048	1.2
6	100	0.5 lag	85	99.904	-0.119	1.2
7	3	1.0	-40	100.028	0.004	0.7
8	30	1.0	-40	100.126	0.069	0.7
9	100	1.0	-40	100.128	0.070	0.7
10	6	0.5 lag	-40	99.941	-0.075	1.3
11	30	0.5 lag	-40	100.038	0.011	1.3
12	100	0.5 lag	-40	99.972	-0.051	1.3

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 992 – Watt Hour

Condition	Current	Power Factor	Temperature °C	Percent Registration	Deviation from Reference	ANSI C12.20 Maximum Deviation from Reference + Percent
Reference for Conditions 1 and 7	3	1.0	25	99.895	Reference	Reference
Reference for Conditions 2 and 8	30	1.0	25	100.012	Reference	Reference
Reference for Conditions 3 and 9	100	1.0	25	100.028	Reference	Reference
Reference for Conditions 4 and 10	6	0.5 lag	25	99.911	Reference	Reference
Reference for Conditions 5 and 11	30	0.5 lag	25	99.995	Reference	Reference
Reference. for Conditions 6 and 12	100	0.5 lag	25	99.997	Reference	Reference
1	3	1.0	85	99.932	0.037	0.7
2	30	1.0	85	100.040	0.028	0.7
3	100	1.0	85	99.991	-0.037	0.7
4	6	0.5 lag	85	100.021	0.110	1.2
5	30	0.5 lag	85	100.122	0.126	1.2
6	100	0.5 lag	85	100.016	0.019	1.2
7	3	1.0	-40	99.755	-0.140	0.7
8	30	1.0	-40	99.978	-0.034	0.7
9	100	1.0	-40	99.965	-0.064	0.7
10	6	0.5 lag	-40	99.704	-0.206	1.3
11	30	0.5 lag	-40	99.789	-0.206	1.3
12	100	0.5 lag	-40	99.851	-0.145	1.3

All units passed this test requirement

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Temporary Overloads – Effect on Accuracy

Testing for this requirement was conducted on May 24, 2011.

Reference: ANSI C12.20-2010 Section 5.5.5.7

Purpose:

To verify the watt-hour accuracy does not change by more that the specified percent after the application of the overload to the current conductors of the meter.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

This test will subject a self-contained meter to a short-circuit current of 7000 Amps peak, 60 Hz for not more that 0.1 seconds. For this test, all current circuits of the meter shall be connected in series. The effect of short-circuit current on the performance of a meter shall not exceed that as specified in the table.

Accuracy Test Conditions

Condition	Class 200 (Amps)	Maximum Deviation from Reference ±Percent
Reference Performance for Condition 1	30	Reference
Reference Performance for Condition 2	3	Reference
1	30	0.1
2	3	0.1

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 433 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance for Condition 1	99.965	Reference	Reference
Reference Performance for Condition 2	99.913	Reference	Reference
1	99.965	0.000	0.1
2	99.927	0.014	0.1

S/N 303 922 210 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance for Condition 1	99.943	Reference	Reference
Reference Performance for Condition 2	99.940	Reference	Reference
1	99.941	-0.002	0.1
2	99.947	0.007	0.1

S/N 303 923 422 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance for Condition 1	99.964	Reference	Reference
Reference Performance for Condition 2	99.938	Reference	Reference
1	99.959	-0.005	0.1
2	99.940	0.002	0.1

EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 990 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance for Condition 1	99.942	Reference	Reference
Reference Performance for Condition 2	99.865	Reference	Reference
1	99.927	-0.015	0.1
2	99.840	-0.025	0.1

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Temporary Overloads – Effect on Mechanical Structure and Insulation

Testing for this requirement was conducted on June 2, 2011.

Reference: ANSI C12.20-2010 Section 5.5.5.7.2

Purpose:

To verify that the meter's mechanical structure or insulation level is not adversely affected by the application of a symmetrical fault current.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The meter shall withstand for a duration of four cycles, a 60 Hz symmetrical fault current as shown in the table without damage to the mechanical structure or reduction of the insulation level.

Class 200 (Amps RMS)
12000

Results:

An Insulation test was ran after the test to check for any loss of insulation performance. No abnormalities were noted.

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Current Surge in Ground Conductor

Testing for this requirement was conducted on May 18, 2011.

Reference: ANSI C12.20-2010 Section 5.5.5.8

Purpose:

To verify the watt-hour accuracy does not change by more that the specified percent after the application of the current surge in the ground conductor.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The meter shall be subjected to one transient surge of 20,000 Amps (20 x 50 uS) of either polarity through a conductor placed vertically 1.5 inches behind the flat portion of the base of the meter with a socket in place. The effect of the surge upon the performance of the meter shall not exceed that specified in the table.

Test Points

Condition	Class 200 (Amps)	Maximum Deviation from Reference ±Percent
Reference Performance	30	Reference
1	30	0.1

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 433 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance	99.987	Reference	Reference
1	99.972	-0.015	0.1

S/N 303 922 210 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance	99.970	Reference	Reference
1	99.966	-0.004	0.1

S/N 303 923 422 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance	99.997	Reference	Reference
1	99.981	-0.016	0.1

S/N 303 922 990 – Watt Hour

Condition	Percent Registration	Deviation from Reference	Maximum Deviation from Reference ±Percent
Reference Performance	99.972	Reference	Reference
1	99.944	-0.028	0.1

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Voltage Variation – Secondary Time Base

Testing for this requirement started on August 11, 2011 and concluded on August 12, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.9

Purpose: To verity real time clock accuracy, while on battery carry-over over at ±5% of nominal battery voltage.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

With the battery disconnected for a minimum of 6 hours and an auxiliary dc power supply connected to the battery carryover circuit, the accuracy of the secondary time base shall be within ±0.02 with a voltage variation of ±5% of nominal battery voltage.

Nominal Battery Voltage: 3.60 Volts
95% Test Point = 3.42 Volts
105% Test Point = 3.78 Volts

95% Test Point Results

Outage Length = 22260 seconds.
0.02% Accuracy = 4 seconds.

Readings After 95% Test Point

Serial Number	Delta Time on Battery Carry-Over
303 923 435	0
303 922 212	0
303 923 424	0
303 922 992	0

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

105% Test Point Results

Outage Length = 53880 seconds.
0.02% Accuracy = 10 seconds.

Readings After 105% Test Point

Serial Number	Delta Time on Battery Carry-Over
303 923 435	-2
303 922 212	-2
303 923 424	-3
303 922 992	-3

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Electrical Fast Transient

Testing for this requirement started on May 4, 2011 and concluded on May 6, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.11

Test 5 in the ANSI Test Sequence.

Purpose:

To verify meter integrity after the application of this fast transient waveform. The waveform is described in IEC 61000-4-4 (2004-07).

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

The meter voltage and current inputs were tested to ±5000 volts. The waveform was applied to all voltage and current inputs for a duration of 60 seconds. The Burst Frequency was 5 kHz. This signal was applied as shown in the following tables.

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to PE
L2 to PE

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1, L2 to PE
N to PE

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Electrical Fast Transient Test - Southern California Edison Procedure

Testing for this requirement was conducted on May 4, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

To verify meter integrity after the application of this fast transient waveform. The waveform is described in IEC 61000-4-4 (2004-07).

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

The meter voltage and current inputs were tested to ±4400 volts. The waveform was applied to all voltage and current inputs for a duration of 25 seconds, two times. The burst frequency was 400 kHz.

Configuration for the KeyTek ECAT system are shown in the following table for FM 1S, 2S and 12S meters.

Parameter	Setting	Additional 1	Additional 2
Voltage	4400	Mode = List	Polarity = Alt 1 each polarity
Duration	100	Mode = Fixed	Units = Pulses
Frequency	400 kHz	Mode = Fixed	
Phase	0 degrees	Mode = Fixed	Sync = Line
Coupling		Mode = List	
Coupling List			
1	L1+		
2	L3+		
3	N+		
4	L1+, L3+		
5	L1+, N+		

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Parameter	Setting	Additional 1	Additional 2
6	L3+, N+		
7	L1+, L3+, N+		
General Notes			
Test Duration	25 Seconds		
Wait Time	5 Seconds		
Repeat	2		

Results:

All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Electrical Oscillatory SWC

Testing for this requirement started on May 6, 2011 and concluded on May 9, 2011.

Reference : ANSI C12.1-2008 Section 4.7.3.11a

Purpose:

To verify meter integrity after the application of this SWC waveform.

Test 6 in the ANSI Test Sequence

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

This test subjects the power inputs of the metering device to repetitive bursts damped oscillatory waves with an initial crest of 2.5 kV for a duration of 2 minutes. The test shall be conducted utilizing the test equipment configurations and test conditions specified in IEEE C37.90.1-2002. The application points shall be Current and Voltage inputs for this particular meter.

Results:

All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Radio Frequency Interference

Testing for this requirement was conducted between May 16, 2011 and June 7, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.12

Purpose:

This test will subject the meter to a range of radio frequencies to check for any abnormal interference.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 348	1S	200	120		
303 923 437	1S	200	120	Yes	
303 922 213	2S	200	240	Yes	
303 923 426	2S	200	240		
303 922 994	12S	200	120	Yes	Yes
303 923 384	12S	200	120		Yes

Procedure:

The test sample was subjected to a linearly polarized wave of both vertical and horizontal polarization over the frequency and field strength ranges as shown in the following table.

Frequency Range	Field Strength
200 kHz to 10 GHz	15 V/m, ±5 V/m

Procedure:

The test sample was subjected to both vertical and horizontal polarized continuous wave signals over a frequency range of 200 kHz- 10 GHz with a field strength of 15 ±5 V/m. The field was generated by a linearly polarized antenna positioned vertically and again with the antenna positioned horizontally.

The test fixture was composed of a minimum amount of metal (or other EMI reflecting or absorbing material) capable of shielding or otherwise distorting the field in the vicinity of the test sample. The fixture allowed the test sample to be oriented in each of 10 orientations to allow both horizontal and vertical irradiation of the front, left side, right side, top, and bottom of the test sample.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Below 1 GHz, the signal was 90% amplitude modulated with a 1.0 kHz sine wave. A continuous wave signal is used above 1 GHz. Beginning at 200 kHz, the scan rate will double the frequency no faster than every 200 seconds (0.005 octaves/second) through 10 GHz.

In each orientation, the fixture placed the test sample in a test volume in which the field strength remained within acceptable test limits. Our field strength was held closer to the 20 V/m level.

Results:

No abnormalities were noted while the meters were subjected to the RF fields. No extra energy accumulation or memory loss was noted. The meters performed successfully in accuracy testing after the Radio Frequency Interference test.

See file 11-0606 RFI HW 3.1 Single Phase 1S 2S 12S.pdf for additional information.

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Conducted and Radiated Emissions – FCC Part 15

Testing for this requirement was conducted April 21, 2011 thru April 26, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.13

Purpose:

The purpose of the test is to show compliance to the Code of Federal Regulations (CFR) 47, Part 15—Radio Frequency Devices, Subparts A - General and B - Unintentional Radiators issued by the Federal Communications Commission for Class B emissions limits.

Procedure:

The meter will be classified as a Class B computing device for this test. The test shall be conducted with all cables connected, with all options and accessories specified, in a configuration closely resembling typical field in-service connections.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 922 213	2S	200	240	Yes	
303 923 443	1S	200	120		
303 923 006	12S	200	120		Yes

Testing for this requirement was conducted at:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518

Results:

See file 11-0134 C14 11 B Conducted and Radiated HW 3.1 Single Phase 1S 2S 12S.pdf for additional information from ACS.

All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Electrostatic Discharge - ESD

Testing for this requirement started on May 6, 2011 and concluded on May 9, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.14

Test 7 in the ANSI Test Sequence.

Purpose:

This test confirms the meters ability to withstand the application of a series of electrostatic discharges.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

This test was carried out according to IEC 61000-4-2 (2001), *Electrostatic Discharge Requirements*, under the following conditions:

Test Severity Level = 4
Test Voltage = 15 kV
Number of Discharges at each test Point = 10

The discharge was applied to all surfaces accessible with the meter installed in a typical field installation. The ESD applications did not change any programmable variable or register value within the meter. The meter was subjected to 10 discharges of 15,000 volts to the following locations:

- Meter Cover
- Socket Box Enclosure (12 discharges, one at each hour on the clock)
- Optical Port Ring
- Relay/Demand Reset Switch

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Electrostatic Discharge - ESD Southern California Edison Procedure

Testing for this requirement was conducted on May 4, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

This test confirms the meters ability to withstand the application of a series of electrostatic discharges.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 435	1S	200	120	Yes	
303 922 212	2S	200	240	Yes	
303 923 424	2S	200	240		
303 922 992	12S	200	120	Yes	Yes

Procedure:

This test was carried out according to IEC 61000-4-2 (2001), *Electrostatic Discharge Requirements*, under the following conditions:

Test Voltage = 10 kV (Through Air Discharge Method)
Test Voltage = 15 kV (Through Air Discharge Method using 0.5 inch spacer)

Number of Discharges at each test Point = 10 (5 Positive & 5 Negative)

The discharge was applied to all surfaces accessible with the meter installed in a typical field installation. The ESD applications did not change any programmable variable or register value within the meter.

- Meter Cover
- Socket Box Enclosure
- Optical Port Ring
- Relay Reset Switch

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Operating Temperature

Testing for this requirement started on May 20, 2011 and concluded on May 27, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.16

Test 8 in the ANSI Test Sequence.

Purpose:

To subject the meter to a series of temperature cycles covering the operating range of the meter. The operating and storage range of the meter are the same.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

The meters, with their outer covers removed, were cycled every 24 hours to the following profile. The cycle was repeated six times for a total of seven days of temperature cycling between 85° C and -40° C. Daily checks were made on the units for energy accumulation. On two of the days power was removed from the units. At the conclusion of the test proper operation of the meter was checked. A control meter was outside the test chamber and was used for comparison purposes.

Parameter	Time (Hours)
25° C ramp to 85° C	3.25
Soak at 85° C	10.75
Ramp from 85° C to -40° C	5.25
Soak at -40° C	2.75
Ramp from -40° C to 25° C	2

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

Final Readings

Serial Number	Delta kWh	Calculated kWh using Control Meter as Reference	% Difference
303 923 434	455396	454318	0.237
303 922 211	471356	470516	0.179
303 923 423	471345	470516	0.176
303 922 991	454360	454666	0.067

Clock Accuracy During 48 Hour Outage
Outage Length = 172800 seconds.
Specification of ±0.02% = ±34.56 seconds

Serial Number	Time Change During 48 Hours on Battery Carry Over (Seconds)
303 923 434	16
303 922 211	14
303 923 423	16
303 922 991	16

All energy readings were within acceptable limits as compared to the Control Unit and all information was maintained during the two day power outage. Clock accuracy on battery carryover was within the ±0.02% requirement.

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Relative Humidity

Testing for this requirement started on May 31, 2011 and concluded on June 1, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.17

Test 9 in the ANSI Test Sequence.

Purpose:

To subject the meter to a high temperature and humidity cycle. Our meter covers are removed for this test which places the meters in a more hostile environment.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

The meters, with their outer covers removed, were subjected to the humidity profile as shown below. A control meter was outside the test chamber and was used for comparison purposes.

Profile:

1. Initial Point = 20° C, at 65 to 70 percent Relative Humidity (RH)
2. The temperature will be increased in a linear fashion to 85° C in approximately 3.25 hours. The humidity during this time will be maintained at approximately 70 percent.
3. During the next 1.0 hour, the temperature will be maintained at 85° C and the humidity will increase to 95 percent in a linear fashion.
4. The meters are at the soak condition and will stay at this condition for approximately 18 hours.
5. At the end of the soak time, the temperature will be decreased to 80° C and the humidity will be decreased to 75 percent in approximately 15 minutes.
6. For the next 3.0 hours the temperature will be decreased to 20° C while the humidity is maintained at 75 percent.
7. At this time the temperature and humidity will be held at 20° C, 75 percent for approximately 2 hours.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

Final Readings

Serial Number	Delta kWh	Calculated kWh using Control Meter as Reference	% Difference
303 923 434	74965	74460	0.678
303 922 211	97421	96864	0.575
303 923 423	97111	96864	0.255
303 922 991	74512	74429	0.112

All energy readings were within acceptable limits as compared to the Control Unit.

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Temperature Extremes Testing

Reference: Internal Itron Requirement

Purpose:

This test is designed to check the performance of the meter, including all option boards at the temperature extremes of -40° C and 85° C.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 434	1S	200	120	Yes	
303 922 211	2S	200	240	Yes	
303 923 423	2S	200	240		
303 922 991	12S	200	120	Yes	Yes

Procedure:

The meters, with their outer covers removed, were subjected to the following testing profile:

- Meter was connected to rated voltage and had Test Amps applied during this test.
- Ramp temperature chamber from 23° C to 85° C in approximately 1 hour. Soak at this temperature for at least 2 hours. During the soak time proper operation of the meter along with any option boards were verified. RFLAN and ZigBee operation was also included.
- The meter was then given a power outage towards the end of the soak time. Power shall be removed for 10 minutes then reapplied. Proper operation of the meter was verified once power was applied.
- Ramp temperature chamber from 85° C to -40° C in approximately 2 hours. Soak at this temperature for at least 2 hours. During the soak time proper operation of the meter along with any option boards were verified. RFLAN and ZigBee operation was also included.
- The meter was then given a power outage towards the end of the soak time. Power shall be removed for 10 minutes then reapplied. Proper operation of the meter was verified once power was applied.

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Mechanical Shock

Testing for this requirement was conducted between May 25, 2011 and May 27, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.18

Purpose:

This test shall determine the adequacy of the meter to withstand, during shipping or service, conditions involving relatively infrequent non-repetitive shocks.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes

Testing for this requirement was conducted at the following laboratory:

QUALTEST, INC.
5325 Old Winter Garden Road
Orlando, FL 32811-1520

Procedure:

The test shall be conducted as described in IEC 60068-2-27 based on the following conditions:

* The meter device shall be non-operating and shall be without packaging.
* The meter device shall be rigidly mounted to a test fixture and the reference point for the control accelerometer shall be attached to the test fixture.
* Half sine pulse applied 3 times in each direction, for each of the 3 mutually perpendicular axes, for a total of 18 shocks.
* Peak acceleration shall be 15g (150 m/s^2) with a duration of 11 ms with a corresponding velocity change of 1.0 m/s.

The test meter shall be verified before and after this test requirement for proper operation, including mechanical inspection and accuracy performance.

EXHIBIT G-1

Electric / Gas / Water
information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 436

Test Condition	Before Test	After Test	Difference
FL % Registration	99.960	100.010	0.050
LL % Registration	100.020	99.938	-0.082
PF % Registration	99.940	100.022	0.082

S/N 303 922 214

Test Condition	Before Test	After Test	Difference
FL % Registration	99.926	99.911	-0.015
LL % Registration	99.930	99.906	-0.024
PF % Registration	99.976	99.921	-0.055

S/N 303 923 383

Test Condition	Before Test	After Test	Difference
FL % Registration	99.990	99.938	-0.052
LL % Registration	99.950	99.901	-0.049
PF % Registration	100.010	99.963	-0.047

QUALTEST has issued a report of their work. The report can be found in file JN07658RPT ITRON, Inc.pdf.

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Transportation Drop - International Safe Transit Association

Testing for this requirement was conducted on April 25, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.19

Purpose:

This test shall determine the adequacy of the shipping container to protect the meter during transit after a series of drop tests as prescribed by the International Safe Transit Association.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The test will follow the latest release of the International Safe Transit Association Test Procedure 1A, Performance Test for Individual Packages-Products Weighing 150 lbs, or less under Drop Test.

Each meter in the test was verified to operate properly before the test and a percent registration check and other programmable functional checks will be performed. At the conclusion of the tests, a mechanical inspection was made and the electrical checks were again verified.

The metering device was in its intended final packaging. We tested a 4-Pack for this requirement.

The metering device was exposed to ten drops to a concrete floor in accordance with ASTM D775 method A.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

Units were tested in the shipping package shown below according to the procedures in the ISTA standard. Mechanical inspection after the tests showed that no damage was done to any of the meters. Example registration results are shown in the following table.

Change in Percent Registration

Serial Number	Full Load	Light Load	Power Factor
303 923 433	-0.019	-0.029	-0.018
303 922 210	-0.043	-0.035	-0.039
303 923 422	-0.005	-0.011	-0.003
303 922 990	0.010	0.035	0.061

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Mechanical Vibration

Testing for this requirement was conducted between May 25, 2011 and May 27, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.20

Purpose:

This test shall determine the adequacy of the meter to withstand, during shipping or in service, conditions involving vibration of a harmonic pattern generated primarily by rotating, pulsating, or oscillating forces.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes

Testing for this requirement was conducted at the following laboratory:

QUALTEST, INC.
5325 Old Winter Garden Road
Orlando, FL 32811-1520

Procedure:

The test shall be conducted as described in IEC 60068-2-6 based on the following conditions:

- The meter device shall be non-operating and rigidly mounted to a test fixture and the reference point for the control accelerometer shall be attached to the test fixture.
- The test shall be run over a frequency range of 10-350 Hz, with a sweep time of one octave per minute at 0.5 g (5m/s2) in each of 3 mutually perpendicular axes.
- The sweep time shall be 30 minutes in each axis.

The test meter shall be verified before and after this test requirement for proper operation, including mechanical inspection and accuracy performance.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

S/N 303 923 436

Test Condition	Before Test	After Test	Difference
FL % Registration	99.960	100.010	0.050
LL % Registration	100.020	99.938	-0.082
PF % Registration	99.940	100.022	0.082

S/N 303 922 214

Test Condition	Before Test	After Test	Difference
FL % Registration	99.926	99.911	-0.015
LL % Registration	99.930	99.906	-0.024
PF % Registration	99.976	99.921	-0.055

S/N 303 923 383

Test Condition	Before Test	After Test	Difference
FL % Registration	99.990	99.938	-0.052
LL % Registration	99.950	99.901	-0.049
PF % Registration	100.010	99.963	-0.047

QUALTEST has issued a report of their work. The report can be found in file JN07658RPT ITRON, Inc.pdf.

All units passed this test requirement.

Itron

Electric / Gas / Water
information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Transportation Vibration - International Safe Transit Association

Testing for this requirement was conducted on April 25, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.21

Purpose:

The metering device, packaged in its intended final packing container shall pass the test requirements described in the International Safe Transit Association, Pre-Shipment Test Procedures, Test B.1, Vibration.

Units Included in this test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 433	1S	200	120	Yes	
303 922 210	2S	200	240	Yes	
303 923 422	2S	200	240		
303 922 990	12S	200	120	Yes	Yes

Procedure:

The test followed the latest release of the International Safe Transit Association Test Procedure 1A, Performance Test for Individual Packages-Products Weighing 150 lbs, or less under Vibration Test. This test exposes the metering device, packaged for shipment, to transportation vibration, for approximately one hour, and is in accordance with ASTM D999.

Each meter in the test was verified to operate properly before the test and a percent registration check and other programmable functional checks will be performed. At the conclusion of the tests, a mechanical inspection was made and the electrical checks were again verified.

The metering device was in its intended final packaging. We tested a 4-Pack for this requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Results:

Units were tested in 4-pack shipping containers according to the procedures in the ISTA standard. Mechanical inspection after the tests showed that no damage was done to any of the meters. Example registration results are shown in the following table.

Change in Percent Registration

Serial Number	Full Load	Light Load	Power Factor
303 923 433	-0.014	0.002	-0.003
303 922 210	0.024	0.017	0.007
303 923 422	0.015	0.015	0.005
303 922 990	-0.013	0.007	0.077

All units passed this test requirement.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Weather Simulation

Testing for this requirement started on June 8, 2011 and concluded on June 27, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.22

Purpose:

This test will determine the ability of the meter, when used in a normal field installation, to withstand ultra violet/fresh water spray environments as defined by the Standard. The meters will be designed for outdoor installations.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes

Procedure:

This test is intended for devices used in outdoor applications.

The meter shall be exposed to a series of 2 hour weathering cycles for a total of 14 days in accordance with Exposure condition 1 of Table X3.1 of the 1998 edition of ASTM G155.

- Each 2 hour cycle shall consist of 102 minutes of light exposure followed by 18 minutes of both light and water spray.
  - The light source shall be a xenon-arc lamp utilizing borosilicate glass inner and outer optical filters to simulate the spectral power distribution of natural daylight. The irradiance measured at 340 nm shall be maintained at 0.35 W/ throughout the test. During the light-only portion of the cycle, the black panel temperature shall be maintained at 63° C.
  - The water spray shall be applied to the metering devices under test using spray nozzles adjusted so that the water is sprayed onto the surfaces of the test samples that are normally exposed to the weather.

Results:

After this test, covers, terminal covers were readily removable. There was no progressive corrosion or electrolytic action that would adversely affect the function of any part of the apparatus. There was no evidence of deleterious discoloration or fading of finishes or materials.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Weather Simulation Chamber

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 436 After Weather Simulation Cycle

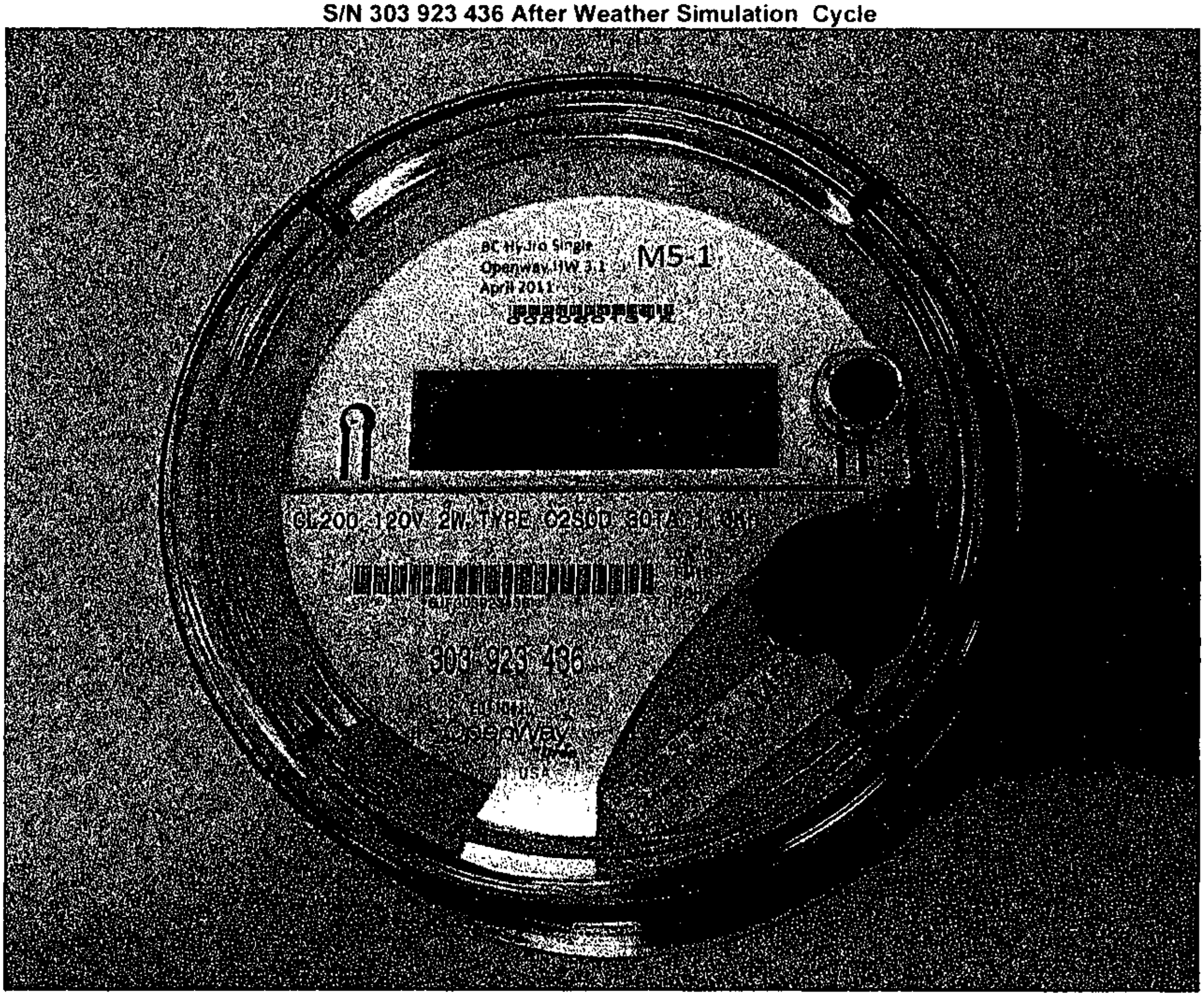


EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 214 After Weather Simulation Cycle

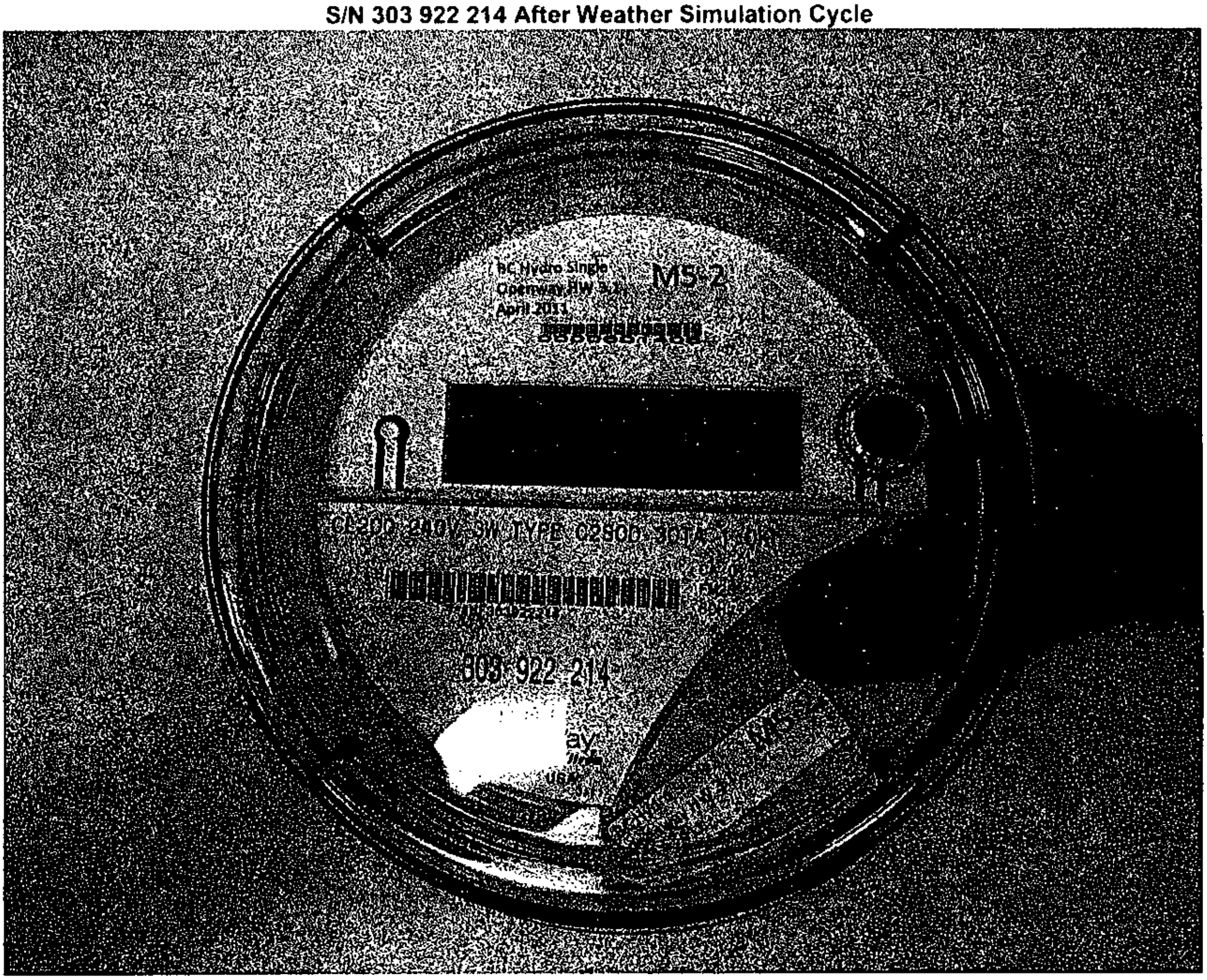
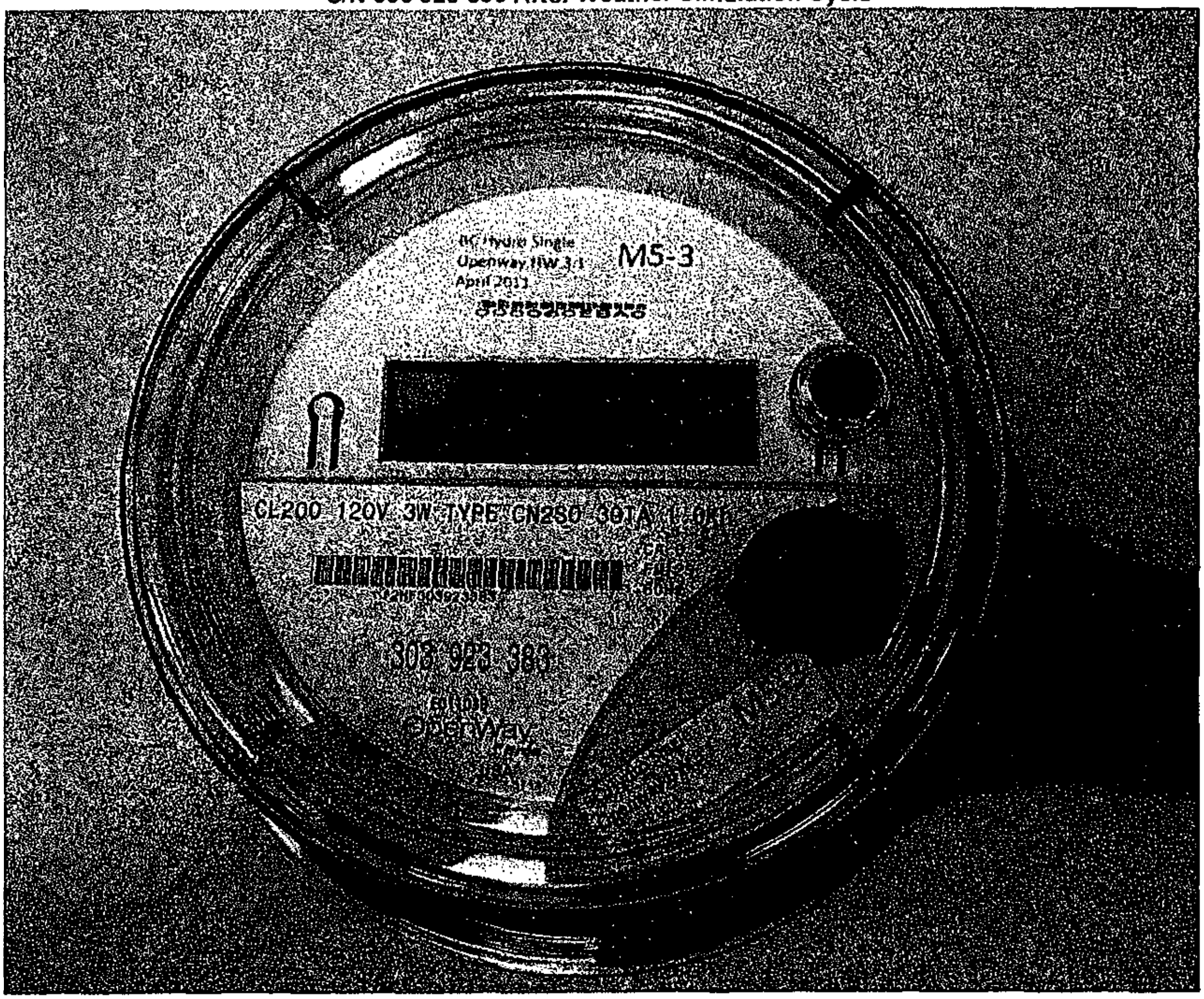


EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 383 After Weather Simulation Cycle



All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Salt (Fog) Spray

Testing for this requirement was started on July 19, 2011 and concluded on July 21, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.23

Purpose:

This test will determine the ability of the meter, when used in a normal field installation, to withstand salt-spray environments as defined by the Standard. The meters will be designed for outdoor installations.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes

Procedure:

The meter shall be mounted in its normal operating position in a salt-spray chamber and subjected to a 25 hour salt-spray in accordance with the current edition of ASTM B117.

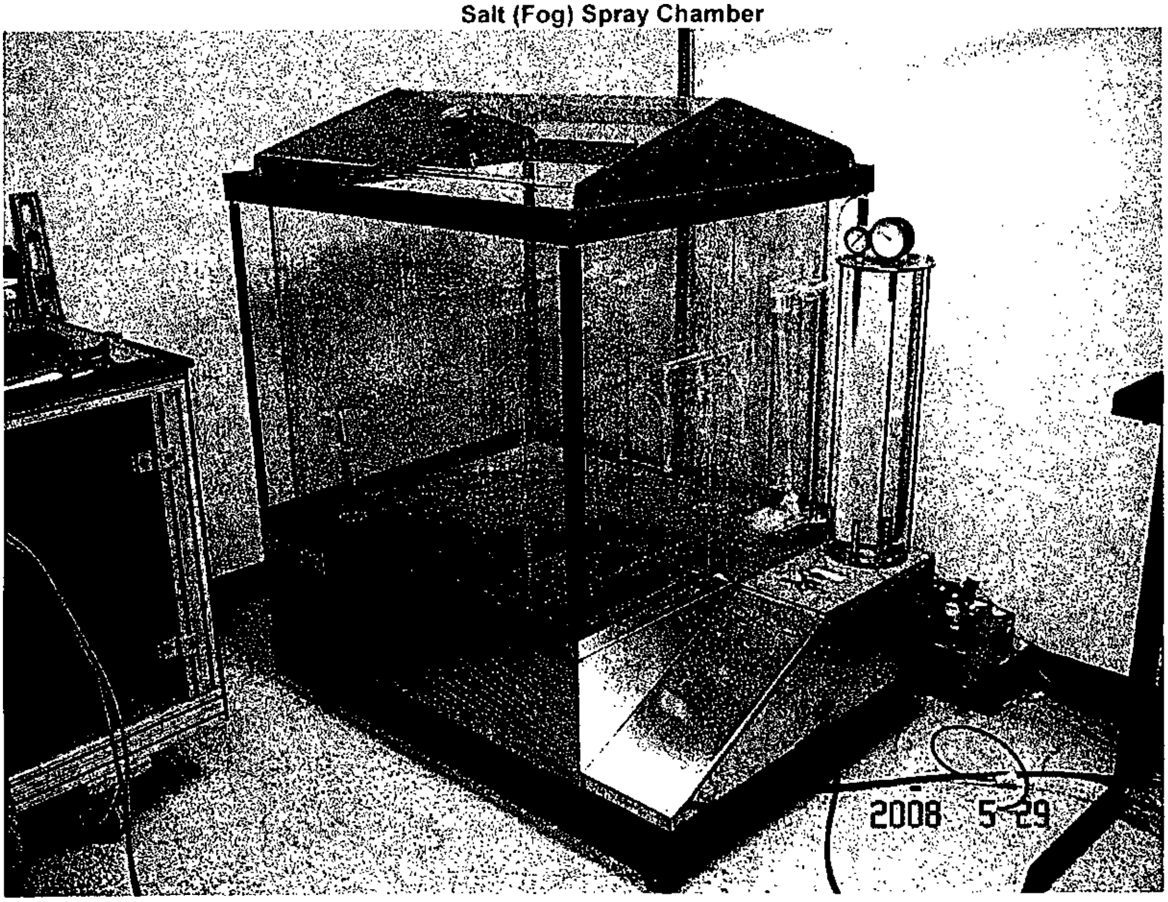
Results:

After this test, all outer meter covers, and terminal covers shall be readily removable. There shall be no progressive corrosion or electrolytic action that will adversely affect the functioning of any part of the apparatus.

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Salt (Fog) Spray Chamber



Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Meters in Salt Fog Chamber

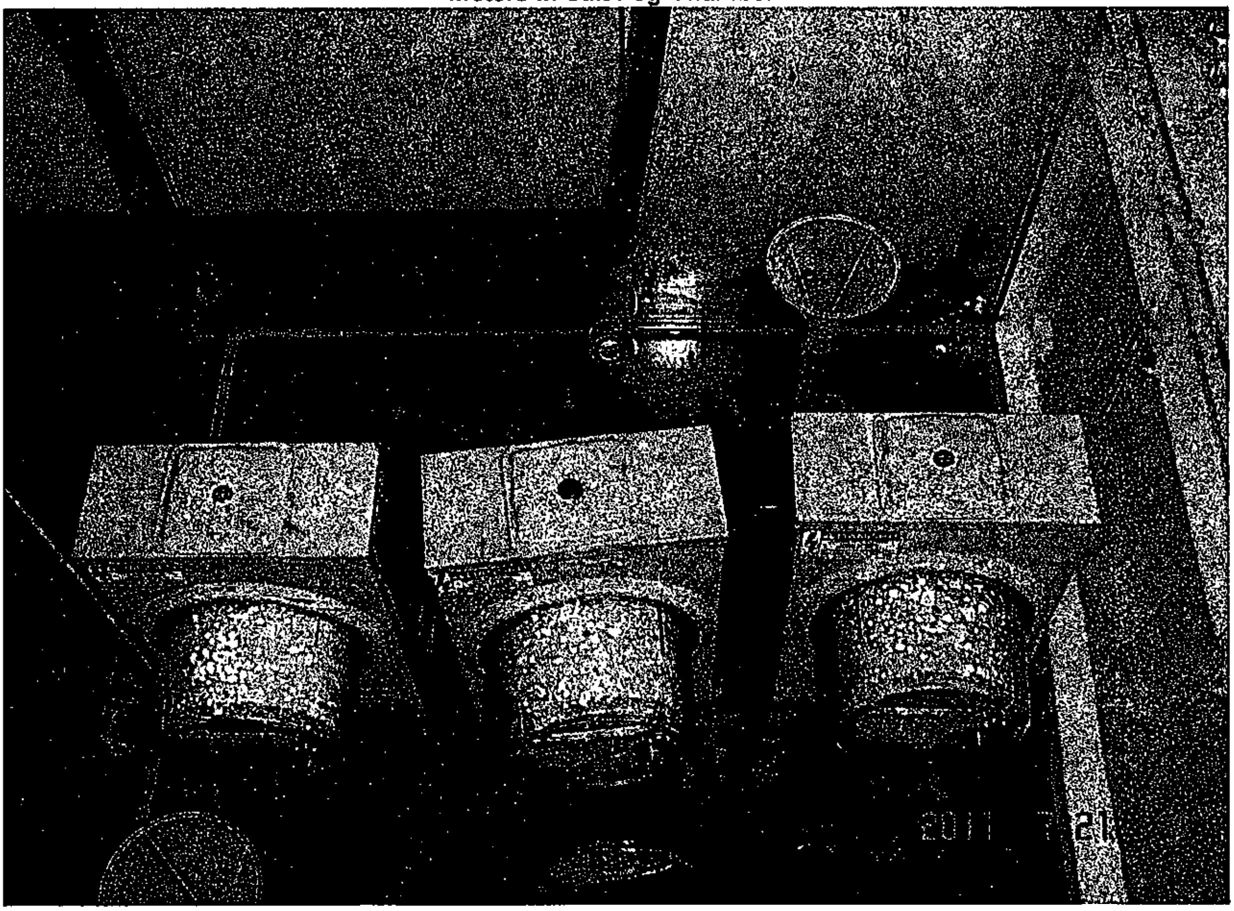


EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

M5-1 S/N 303 923 436 After Salt Fog Cycle

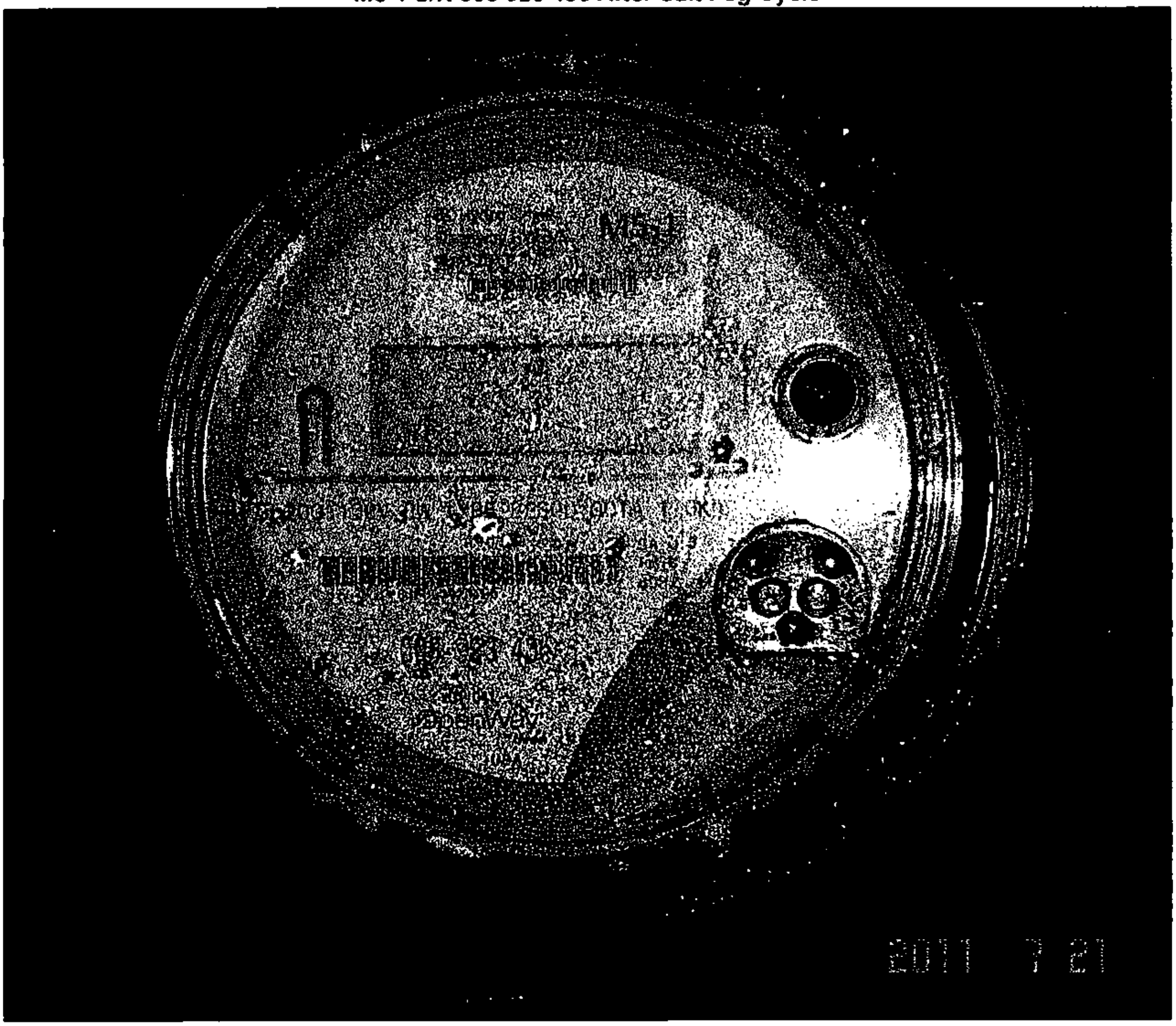
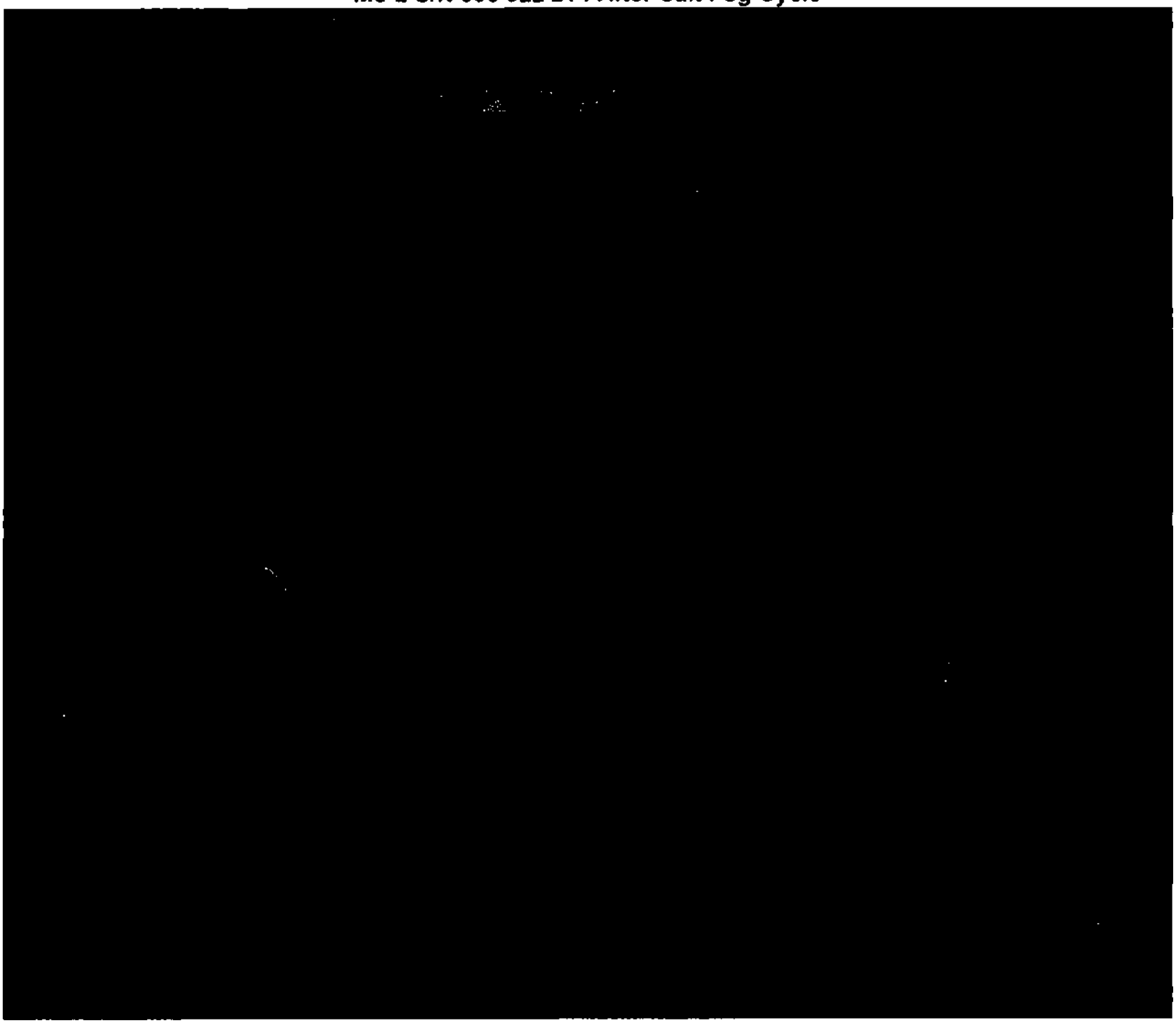


EXHIBIT G-1

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

M5-2 S/N 303 922 214 After Salt Fog Cycle



313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

M5-3 S/N 303 923 383 After Salt Fog Cycle

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Raintightness

Testing for this requirement was conducted on June 28, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.24

Purpose:

This test will determine the ability of the meter, when used in a normal field installation, to withstand wet weather environments as defined by the Standard. The meters will be designed for outdoor installations.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
303 923 436	1S	200	120	Yes	
303 922 214	2S	200	240	Yes	
303 923 383	12S	200	120		Yes

Procedure:

When mounted in its normal operating position in or on a meter mounting intended for outdoor installation a metering device shall pass the test described in UL 50, "Rain Test" under the Performance section of the UL standard. Meter tested as a type 3R device.

The water-spray-test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 30.1. Spray heads are to be constructed in accordance with the details shown in Figure 30.2. The enclosure is to be set up as in a normal installation with conduit connections – without pipe compound – if so intended. The enclosure is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the enclosure. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each spray head. The enclosure is to be exposed to the water spray for 1 hour.

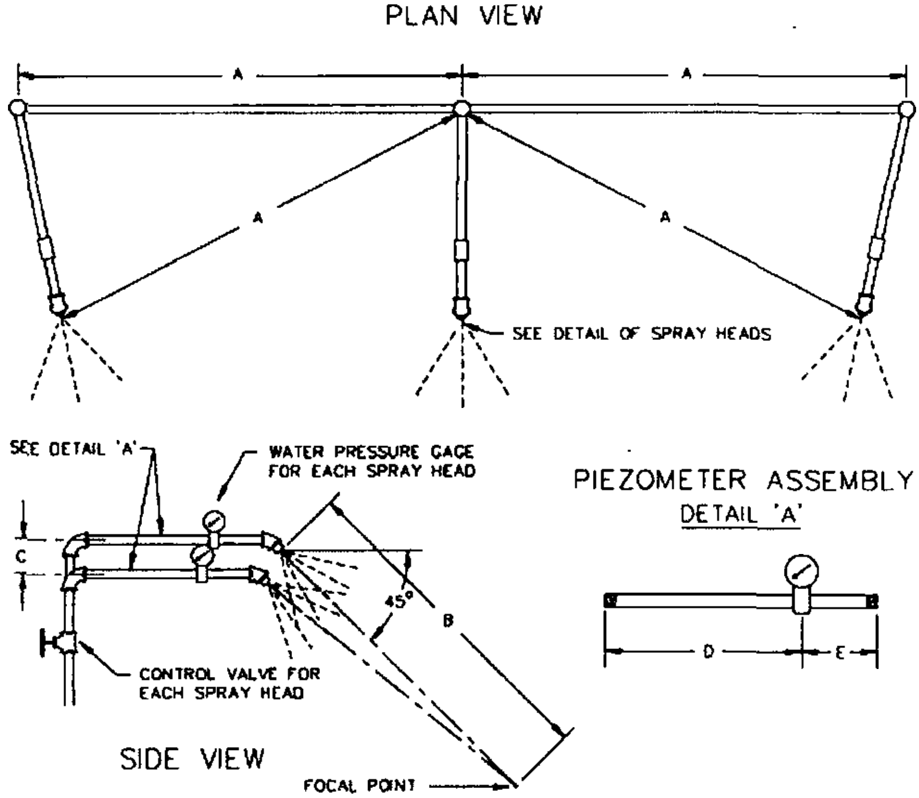
EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Figure 30.1
Rain-test spray-head piping



Item	mm	inch
A	710	28
B	1400	55
C	55	2-1/4
D	230	9
E	75	3

Results:

EXHIBIT G-1

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Raintightness Setup

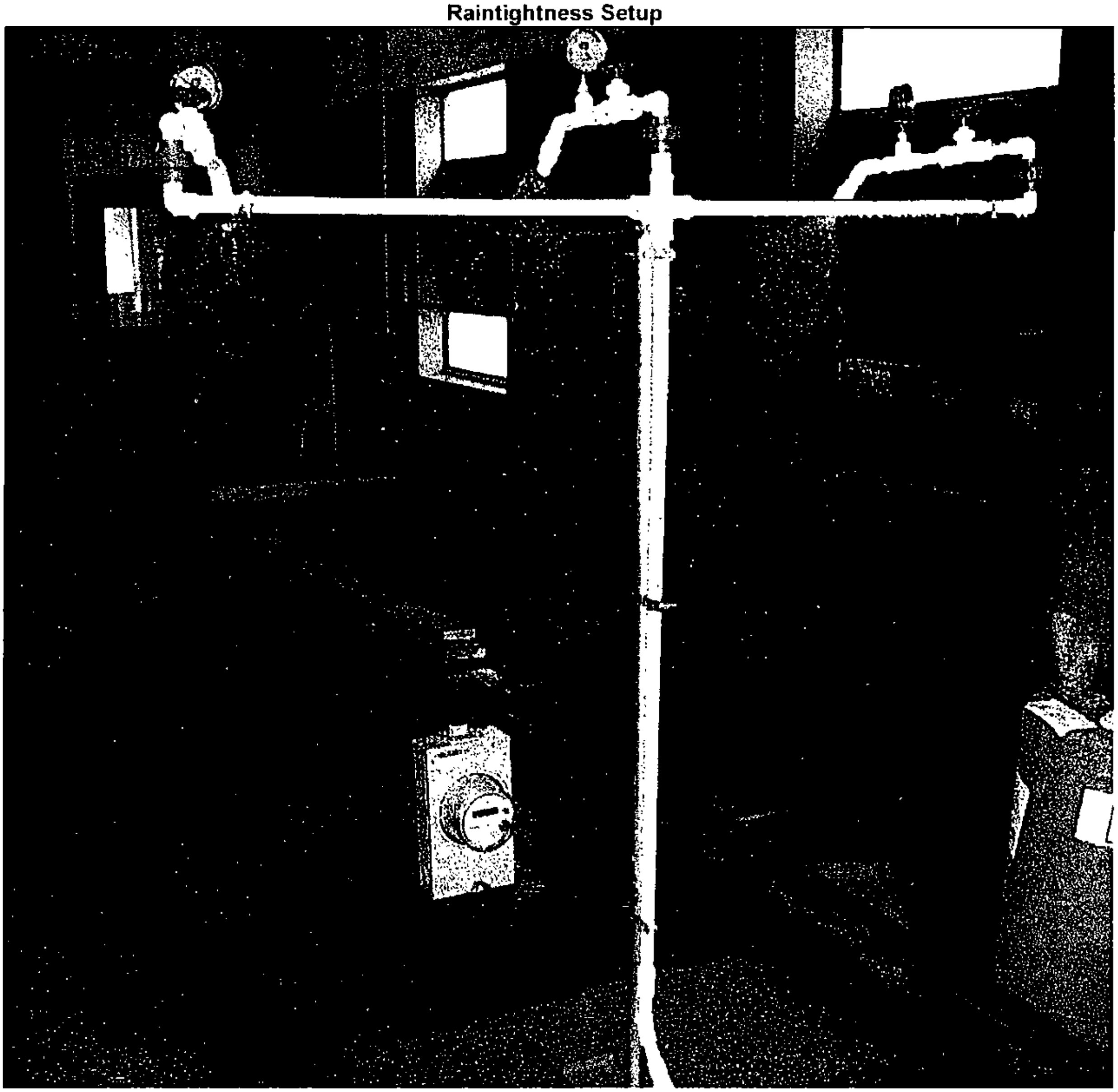


EXHIBIT G-1

S/N 303 923 436 After Raintightness Test

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 922 214 After Raintightness Test

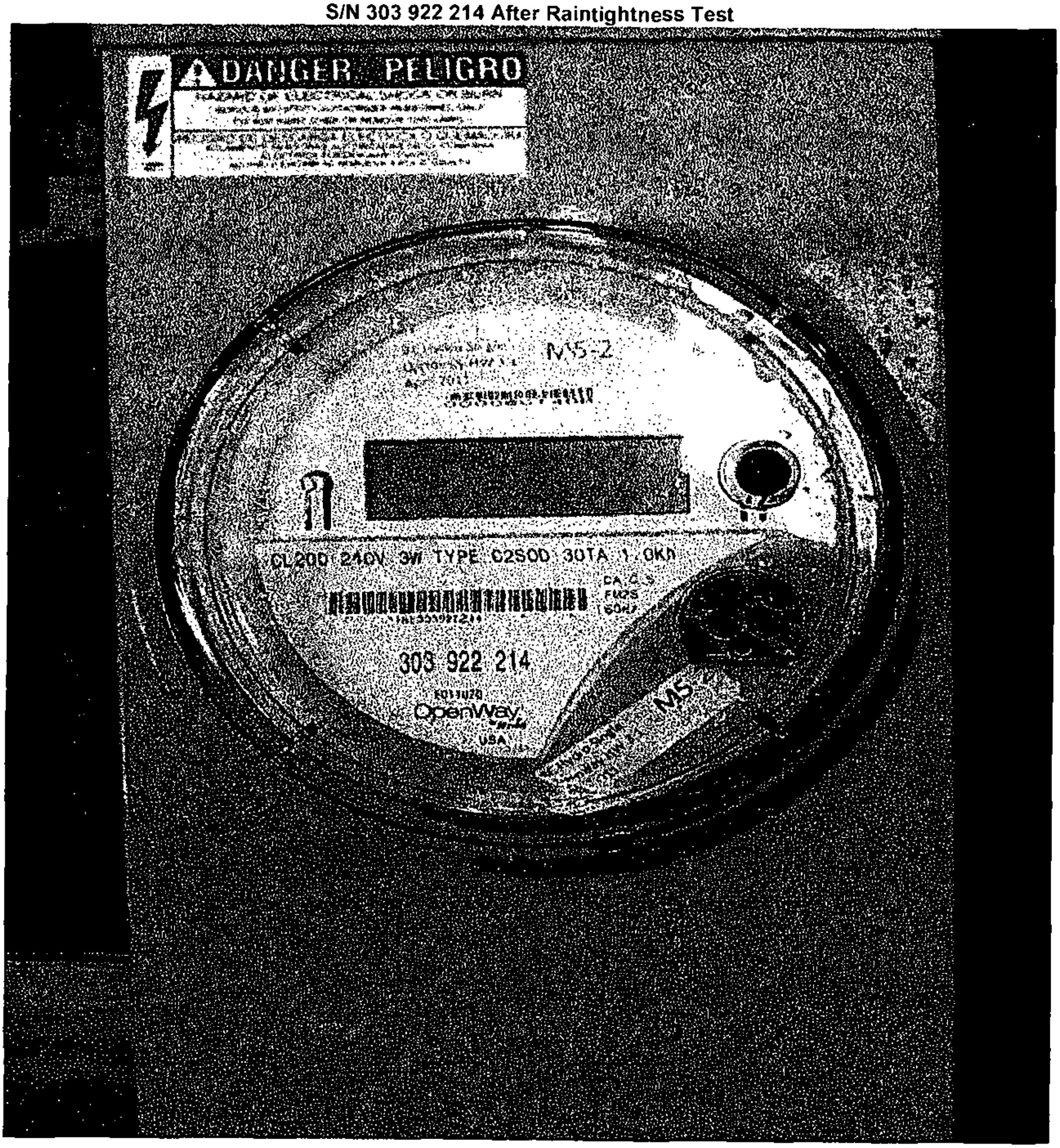


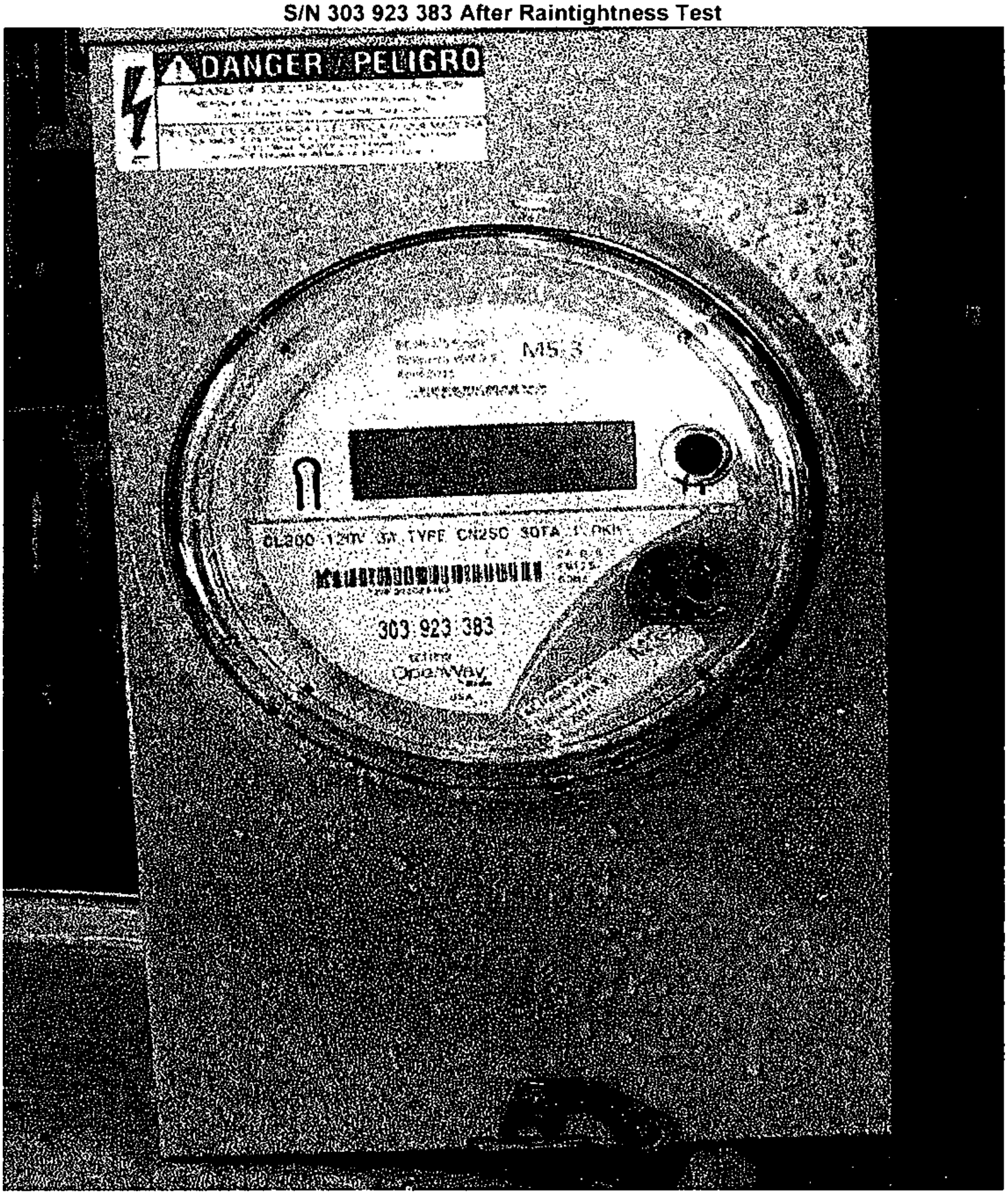
EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

S/N 303 923 383 After Raintightness Test



At the conclusion of this test no water was visible inside the meter enclosures.

All units passed this test requirement.

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

FCC and Industry Canada Radio Certification Reports

Part 15 Subpart C of the FCC's Code of Federal Regulations and Industry Canada's Radio Standards Specification RSS-210 for Certification of a single limited modular approval.

Testing for these certifications was conducted at:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518

The following files contain the reports for FCC and Industry Canada Radio Certifications for the LAN and ZigBee radios.

AMI7 RF Exposure.pdf - RF Exposure report from ACS

AMI7 RFLAN.pdf- Certification report from ACS for the 900 MHz LAN radio

AMI7 Zigbee.pdf- Certification report from ACS for the 2.4 GHz ZigBee radio

EXHIBIT G-1

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Section 2 - Tests Results

Insulation

Testing for this requirement started on July 20, 2011 and concluded on July 21, 2011.

Reference: ANSI C12.1-2008 Section 4.7.3.1

Purpose:

To verify that adequate insulation exists to withstand a minimum sinusoidal RMS voltage of 2.5 kV between accessible parts of the meter and all current carrying lines.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

All voltage and current lines were tested. The test level was 2500 volts, AC, 60 Hz for a duration of one minute. The trip current, which is the level in which a failure will be indicated, was set to 1.0 mA for all test points.

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges Combination Waveform - Southern California Edison Procedure

Testing for this requirement was conducted on July 25, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

The metering device shall meet the AC Line Surge Requirements of ANSI/IEEE C62.41 for a Category A and B location. The required waveform is the 1.2/50 microsecond - 8/20 microsecond Combination Wave. A peak current of 3000 amps is available during the surge.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

The Southern California Edison procedure is broken down into 3 voltages as shown below:

4 kV Test

Peak voltage was set to 4 kV and the surge applied from 0^{o} to 360^{o}, every 10^{o}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

5 kV Test

Peak voltage was set to 5 kV and the surge applied from 0^{o} to 180^{o}, every 15^{o}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

6 kV Test

Peak voltage was set to 6 kV and the surge applied from 0^{o} to 180^{o}, every 15^{o}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1, L2 to N

Results:
All units passed this test requirement.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of High Voltage Line Surges 100 kHz Ring Waveform - Southern California Edison Procedure

Testing for this requirement started on July 23, 2011 and concluded on July 24, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

This test is a check for proper operation after the application of a series of high voltage and current waveforms, 0.5 mS, 100 kHz ringing waveform as described in ANSI C62.45-1992.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

The Southern California Edison procedure is broken down into 3 voltages as shown below:

4 kV Test

Peak voltage was set to 4 kV and the surge applied from 0^{O} to 360^{O}, every 10^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

5 kV Test

Peak voltage was set to 5 kV and the surge applied from 0^{O} to 180^{O}, every 15^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

6 kV Test

Peak voltage was set to 6 kV and the surge applied from 0^{O} to 180^{O}, every 15^{O}, at each of the coupling arrangements shown in the table. Wait time between surges was 15 seconds.

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Coupling Arrangement FM 1S and 2S

Surge Applied
L1, L2 to PE
L1 to L2

Coupling Arrangement FM 12S

Surge Applied
L1, L2, & N to PE
L1, L2 to N

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Electrical Fast Transient Test - Southern California Edison Procedure

Testing for this requirement was conducted on July 27, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

To verify meter integrity after the application of this fast transient waveform. The waveform is described in IEC 61000-4-4 (2004-07).

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

The meter voltage and current inputs were tested to ±4400 volts. The waveform was applied to all voltage and current inputs for a duration of 25 seconds, two times. The burst frequency was 400 kHz.

Configuration for the KeyTek ECAT system are shown in the following table for FM 1S, 2S and 12S meters.

Parameter	Setting	Additional 1	Additional 2
Voltage	4400	Mode = List	Polarity = Alt 1 each polarity
Duration	100	Mode = Fixed	Units = Pulses
Frequency	400 kHz	Mode = Fixed	
Phase	0 degrees	Mode = Fixed	Sync = Line
Coupling		Mode = List	
Coupling List			
1	L1+		
2	L3+		
3	N+		
4	L1+, L3+		
5	L1+, N+		

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Electrical Oscillatory SWC

Testing for this requirement was conducted on July 25, 2011.

Reference : ANSI C12.1-2008 Section 4.7.3.11a

Purpose:

To verify meter integrity after the application of this SWC waveform.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

This test subjects the power inputs of the metering device to repetitive bursts damped oscillatory waves with an initial crest of 2.5 kV for a duration of 2 minutes. The test shall be conducted utilizing the test equipment configurations and test conditions specified in IEEE C37.90.1-2002. The application points shall be Current and Voltage inputs for this particular meter.

Results:

All units passed this test requirement.

Itron

Electric / Gas / Water
Information collection, analysis and application

313 North Highway 11
West Union, SC 29696
(864) 638-8300
www.itron.com

Effect of Electrostatic Discharge - ESD Southern California Edison Procedure

Testing for this requirement was conducted on July 27, 2011.

Reference: SCE Laboratory Testing Procedures for Metering Device Evaluation, Revision 2, dated May 31, 2006

Purpose:

This test confirms the meters ability to withstand the application of a series of electrostatic discharges.

Units Included in this Test:

Serial Number	Form	Class	Test at Voltage	Remote Disconnect	Link
304150724	1S	200	120	Yes	
304150711	2S	200	240	Yes	
304150719	2S	200	240		
304150718	12S	200	120	Yes	Yes

Procedure:

This test was carried out according to IEC 61000-4-2 (2001), *Electrostatic Discharge Requirements*, under the following conditions:

Test Voltage = 10 kV (Through Air Discharge Method)
Test Voltage = 15 kV (Through Air Discharge Method using 0.5 inch spacer)

Number of Discharges at each test Point = 10 (5 Positive & 5 Negative)

The discharge was applied to all surfaces accessible with the meter installed in a typical field installation. The ESD applications did not change any programmable variable or register value within the meter.

- Meter Cover
- Socket Box Enclosure
- Optical Port Ring
- Relay Reset Switch

Results:

All units passed this test requirement.

NOTICE OF COMPLETION
AND
AUTHORIZATION TO APPLY THE UL MARK

05/30/2015

Itron Inc
Mr. LARRY O'DELL
313 N Highway 11
West Union Sc 29696-2706, Us

Our Reference:	File E470764, Vol. 1	Project Number	4786755348
Your Reference:	74131		
Project Scope:	Quote for UL2735- Safety; UL Listing for Centron OpenWay and C12.19 Series Meters		

Dear Mr. LARRY O'DELL:

Congratulations! UL's investigation of your product(s) has been completed under the above Reference Number and the product was determined to comply with the applicable requirements. This letter temporarily supplements the UL Follow-Up Services Procedure and serves as authorization to apply the UL Mark at authorized factories under UL's Follow-Up Service Program. To provide your manufacturer(s) with the intended authorization to use the UL Mark, you must send a copy of this notice to each manufacturing location currently authorized under File E470764, Vol. 1 and *including any special instructions as indicated in the addendum to this letter.*

Records in the Follow-Up Services Procedure covering the product are now being prepared and will be sent in the near future. Until then, this letter authorizes application of the UL Mark for 90 days from the date indicated above.

Additional requirements related to your responsibilities as the Applicant can be found in the document "Applicant responsibilities related to Early Authorizations" that can be found at the following web-site: http://www.ul.com/EAResponsibilities

Any information and documentation provided to you involving UL Mark services are provided on behalf of UL LLC (UL) or any authorized licensee of UL.

We are excited you are now able to apply the UL Mark to your products and appreciate your business. Feel free to contact me or any of our Customer Service representatives if you have any questions.

Very truly yours,

John H. Wellhouse II
919-549-1466
Senior Project Engineer
John.H.WellhouseII@ul.com

Reviewed by:

Bruce A. Mahrenholz
847-664-3009
CPO Director
Bruce.A.Mahrenholz@ul.com

NBKB07F-59EAC3

EXHIBIT
02/27/2020
Respondent G-3
C-2018-3002741
PENGAD 800-631-6989

This is an electronically generated letter. Signatures are not required for this document to be valid.

IPI ADDENDUM

NOTICE OF COMPLETION
AND
AUTHORIZATION TO APPLY THE UL MARK

Our Reference:	File E470764, Vol. 1	Project Number	4786755348
Your Reference:	74131		
Project Scope:	Quote for UL2735- Safety; UL Listing for Centron OpenWay and C12.19 Series Meters		

This addendum covers products manufactured at the following location:

ITRON INC
MR. LARRY O'DELL
313 N HIGHWAY 11
WEST UNION , SC 29696-2706
US
Subscriber #: 133768001
Party Site #: 549004

Before you may begin shipping product with the UL Mark at the above manufacturing locations, an Initial Production Inspection (IPI) must be successfully performed by a UL representative at the location.

The IPI is intended to confirm that your manufacturing location is capable of producing a product in accordance with UL's requirements. **YOU MAY NOT SHIP PRODUCTS WITH THE UL MARK UNTIL THE IPI HAS BEEN COMPLETED AND UL HAS FOUND THE PRODUCTS AT THE FACTORY TO COMPLY WITH OUR REQUIREMENTS**. Once the IPI has been successfully completed, you will be granted authorization to ship products bearing the UL Mark.

Instructions for the IPI will be sent to our inspection center nearest to you. The Inspection Center will contact you shortly to make arrangements for the IPI.

TCB **GRANT OF EQUIPMENT AUTHORIZATION** **TCB**

Certification
Issued Under the Authority of the
Federal Communications Commission
By:

TUV SUD America Inc.
10 Centennial Drive
Peabody, MA 01960

Date of Grant: 05/06/2011

Application Dated: 05/05/2011

Itron, Inc.
313 North Highway 11
West Union, SC 29696

Attention: Lee Littlejohn , Compliance Engineer

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER: SK9AMI7
Name of Grantee: Itron, Inc.
Equipment Class: **Part 15 Spread Spectrum Transmitter**
Notes: **AMI7 Module**
Modular Type: **Limited Single Modular**

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequency Tolerance	Emission Designator
	15C	902.25 - 927.75	0.684		
	15C	909.6 - 921.8	0.689		

Limited Modular Approval. Power listed is conducted. This device must be professionally installed and is limited to installation for mobile and fixed applications only. This grant is valid only when the device is installed by the grantee or contractors employed by the grantee who are instructed to ensure that the end-user has no manual instructions to remove or install the device. The transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. Installers and end-users must be provided with transmitter operation conditions for satisfying RF exposure compliance.

EXHIBIT AQ
02/27/2020
RESPONDENT G-7
C-2018-3002741
PENGAD 800-631-6989

TCB **GRANT OF EQUIPMENT AUTHORIZATION** **TCB**

Certification
Issued Under the Authority of the
Federal Communications Commission
By:

TUV SUD America Inc.
10 Centennial Drive
Peabody, MA 01960

Date of Grant: 05/06/2011

Application Dated: 05/05/2011

Itron, Inc.
313 North Highway 11
West Union, SC 29696

Attention: Lee Littlejohn , Compliance Engineer

NOT TRANSFERABLE

EQUIPMENT AUTHORIZATION is hereby issued to the named GRANTEE, and is VALID ONLY for the equipment identified hereon for use under the Commission's Rules and Regulations listed below.

FCC IDENTIFIER: SK9AMI7
Name of Grantee: Itron, Inc.
Equipment Class: **Digital Transmission System**
Notes: **AMI7 Module**
Modular Type: **Limited Single Modular**

Grant Notes	FCC Rule Parts	Frequency Range (MHZ)	Output Watts	Frequency Tolerance	Emission Designator
	15C	2405.0 - 2475.0	0.065		

Limited Modular Approval. Power listed is conducted. This device must be professionally installed and is limited to installation for mobile and fixed applications only. This grant is valid only when the device is installed by the grantee or contractors employed by the grantee who are instructed to ensure that the end-user has no manual instructions to remove or install the device. The transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. Installers and end-users must be provided with transmitter operation conditions for satisfying RF exposure compliance. Device must transmit with a source-based-time-averaged duty cycle not to exceed 27%.

Effective Date: January 17, 2019

Duquesne Light Company (DLC) values its customers and takes seriously its responsibility to protect its customer data. This Privacy Policy applies directly to DLC and its employees, and also sets forth DLC's expectations with respect to its business partners, agents, contractors, and affiliates.

DLC has developed this Privacy Policy to help its customers understand how it accesses, collects, stores, uses, and discloses Customer Information, including personally identifiable information (PII) and consumer-specific energy usage data (CEUD), collectively referred to as Customer Information.

For these purposes, PII is defined as information which, by itself, identifies a specific person or provides sufficient information to contact a person. CEUD is information about a customer's energy usage when associated with any information that can reasonably be used to identify the customer. CEUD is collected by DLC's metering system and through customers' participation in energy efficiency programs, renewable energy programs, and demand side management.

DLC collects and retains Customer Information that is reasonably necessary for DLC to service its customers, effectively manage its business operations, and meet its regulatory and compliance obligations.

As required by the Pennsylvania Public Utility Commission (PAPUC), DLC provides Customer Information to third party electricity suppliers to enable them to offer DLC customers electricity at competitive rates.

Unless otherwise prohibited by law, DLC may share Customer Information with third parties with whom it has a business relationship, such as affiliate companies, business partners, and contractors, or when that information is reasonably necessary for DLC business operations, such as:

- Answering a customer inquiry, including through an agent, attorney or legislative representative
- Providing or supporting a requested product or service
- Fulfilling the operational needs of the electrical system or grid
- Providing services as required by state or federal law or as authorized, ordered, or directed by the PAPUC or by other regulatory entities
- Providing or billing for electrical service, including the collection of payment
- Investigating, resolving and managing legal claims
- Responding to PAPUC questions or concerns Planning, operating, and evaluating special programs, such as energy conservation, demand response, energy efficiency, or customer assistance

Nothing in this Privacy Policy shall limit the rights of any customer under the PAPUC, or other applicable regulations to restrict the release of Customer Information. DLC does not sell or rent Customer Information to third parties that do not have a business relationship with DLC. However, if DLC reaches an agreement in principle to sell its assets as part of a merger or acquisition, DLC may provide Customer

Information to the other parties in the transaction, including prior to the closing of the transaction. Such Customer Information also may form part of the business assets that are subject to the sale or merger. In that circumstance, this Privacy Policy would still apply to Customer Information unless notice of a changed Privacy Policy is provided by the purchaser and, to the extent that consent is required for a new proposed use, appropriate consent is given. Customer Information may also be transferred as part of corporate reorganization.

DLC may collect and maintain information pertaining to children under the age of 13 when required for customer assistance programs or other business purposes; however, such information is not knowingly collected from minors directly.

DLC may disclose Customer Information when required by law or to comply with a judicial proceeding, a subpoena, a court order or other legal process. DLC also may disclose Customer Information when reasonably necessary to comply with an order or direction from the PAPUC. DLC will disclose customer information with an authorization or request from the customer.

DLC has implemented administrative, technical, and physical safeguards, as well as third party management controls and limitations on data shared, designed to protect Customer Information from unauthorized access, use, modification, or disclosure. While no set of controls can provide absolute security, these measures reflect the value that DLC places on Customer Information. DLC will retain Customer Information for as long as is reasonably necessary to meet its business needs and regulatory and compliance obligations.

AGGREGATE AND PUBLIC INFORMATION

DLC may aggregate multiple customers' CEUD in various formats so that individual customer's CEUD remains anonymous. Similarly, DLC maintains certain non-privileged, publicly available information about its customer base. This information may include general characteristics of the DLC customers' total load and generation mix as well as general information regarding rates and customer participation in various programs.

This aggregated information and public information relates to electricity usage of groups of customers or broad categories of customers (e.g. industrial business, residential, etc.). The information is collected from a sufficiently large group of customers so as to make it highly improbable that the third party receiving such information could deduce the identities and/or electricity usage of individual customers.

DLC uses this information for various purposes, including analyzing rates and rate structures, evaluating energy usage demand needs, and determining potential changes within a geographic area. This aggregated and public information is not considered Customer Information and is not covered by this Privacy Policy.

INFORMATION ABOUT THE DLC WEBSITE AND MOBILE APPLICATION

DLC automatically collects certain information from visitors to the DLC website and users of the DLC mobile application, including browser information, domain names, the date and time a visitor accesses the website or mobile application, information viewed while visiting the website or mobile application, carrier providers, a unique device identifier (a string of alphanumeric characters (similar to a serial number) used to uniquely identify and distinguish each mobile phone or other wireless communications

EXHIBIT I-1

device.), geo-location information (if allowed by the user), the types of mobile devices accessing the mobile application, and the types of operating systems accessing the mobile applications. This information is used for statistical purposes, to measure the use of the website or mobile application, to improve its content and DLC's customer service, and to diagnose and correct technical problems. Some DLC website pages may use "cookies." A cookie is a piece of data stored on a visitor's computer that helps DLC improve access to the site and make it more user friendly and customize information. If desired, visitors should follow their browser's instructions to delete and/or block cookies.

DLC also may administer surveys from the DLC website or mobile application to gather information about its customers and their use of energy or related products and services, or to obtain customer views on other matters to help DLC provide better customer service. Participation in these surveys is voluntary.

The DLC website and mobile application may contain links to other websites or mobile applications that may be of interest or benefit to its customers and others. DLC is not responsible for the content or privacy practices of these other websites or mobile applications.

Accessing DLC mobile application using biometric authentication tools.

Customers may choose to access their DLC mobile application account using Face ID or Touch ID (Apple), Trusted Face or Fingerprint (Android), or other biometric authentication tools available to them through their mobile device. Currently, the DLC mobile application is available for download in the Apple App Store and Google Play store and is designed to work with Apple's Face ID and Touch ID, as well Android's Trusted Face and Fingerprint biometric authentication tools ("Biometric Authentication Tools"). Customers can access their DLC account through the DLC mobile application using the Biometric Identification Tools if (i) their mobile device supports the Biometric Authentication Tools, and (ii) they enable the Biometric Authentication Tools functionality on their mobile device and confirm that they want to use the Biometric Authentication Tools to sign into their DLC account through the DLC mobile application.

Face ID and Touch ID are authentication tools provided by Apple and are governed by Apple's policies related to their use. Apple's policies and information concerning Face ID can be accessed here, and Apple's policies and information concerning Touch ID can be accessed here. Similarly, Trusted Face and Fingerprint are authentication tools offered on many Android mobile devices and are governed by Android's security best practices and policies, accessible here.

DLC has no control over the Biometric Authentication Tools and does not have access to any customer biometric data that may be retained by such tools. DLC is not responsible for any issues arising from a customer's decision to use the Biometric Authentication Tools to access his or her DLC account, and DLC shall not be liable for any unauthorized access to or unauthorized use of a customer's biometric data or other Customer Information that is caused by a customer's use of the Biometric Authentication Tools.

CHANGES AND INFORMATION

DLC regularly reviews its policies and will notify customers of any changes to this Privacy Policy through updates on the DLC website or mobile application.

EXHIBIT I-1

For questions, concerns or more information about DLC's Privacy Policy or Customer Information, please contact a DLC Customer Service Representative:

By Telephone: 412-393-7100 press option 3-1-1

By Email: privacy@duqlight.com

By Mail: **Duquesne Light Company**
Customer Service Representative – Privacy Maildrop 6-1
411 Seventh Avenue
Pittsburgh, PA 15219

EXHIBIT I-1

Exponent®

Health Sciences Practice

Report of Gabor Mezei, M.D., Ph.D.

Re: Miranda Grace Edwards v. Duquesne Light Company, Pennsylvania Public Utility Commission Docket Number C-2018-3002741

EXHIBIT H-1

Report of Gabor Mezei, M.D., Ph.D.

Re: Miranda Grace Edwards v. Duquesne Light Company, Pennsylvania Public Utility Commission Docket Number C-2018-3002741

Prepared for

Duquesne Light Company
411 7th Avenue
Pittsburgh, PA 15219

Prepared by

Gabor Mezei, M.D., Ph.D.
Exponent, Inc.
149 Commonwealth Drive
Menlo Park, CA 94025

February 4, 2020

1902236.000 - 0218

EXHIBIT H-1

Contents

Acronyms and Abbreviations

°C	Degrees Celsius
AAEM	American Academy of Environmental Medicine
AGNIR	Advisory Group on Non-ionising Radiation
AMI	Advanced metering infrastructure
AMR	Automated meter reading
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
BIR	BioInitiative Report
BIWG	BioInitiative Working Group
CCST	California Council on Science and Technology
CDMA	Code Division Multiple Access
EMF	Electromagnetic fields
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FCC	Federal Communications Commission
FDA	Food and Drug Administration
GHz	Gigahertz
GSM	Global System for Mobile Communication
IARC	International Agency for Research on Cancer
ICES	International Committee on Electromagnetic Safety
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronic Engineers
IEI-EMF	Idiopathic environmental intolerance attributed to EMF
kHz	Kilohertz

MHz	Megahertz
mW/cm^2	Milliwatts per square centimeter
MPE	Maximum permissible exposure
NCRP	National Council for Radiation Protection
NTP	National Toxicology Program
PUC	Public Utilities Commission
SAR	Specific absorption rate
RF	Radiofrequency fields
UCLA	University of California in Los Angeles
WHO	World Health Organization
W/kg	Watts per kilogram
W/m^2	Watts per square meter

Summary of Opinions in the *Edwards* Matter

Based on my knowledge and familiarity with the relevant scientific literature, including the relevant weight-of-evidence reviews conducted by a number of international multidisciplinary expert panels, and the case materials presented to me in relation to the Complaint filed with the Pennsylvania Public Utility Commission against Duquesne Light Company on behalf of Miranda Grace Edwards (*Edwards* matter), my opinions are as follows:

1. A causal relationship is not established between environmental exposure to radiofrequency (RF) fields, including RF fields specifically from smart meters owned and operated by Duquesne Light Company, and adverse human health effects, including cancer or non-cancer health outcomes, as claimed in the Complaint and other submissions by the Complainant.

2. Exposure to RF fields estimated in the Edwards residence as a result of the operation of smart meters or from other common sources found within or outside a typical residence does not have any proven adverse effect on health.

3. The materials included in the Complaint or other submissions by Ms. Edwards do not provide a basis to reach a valid scientific conclusion that low-level RF exposure, including the RF fields associated with the operation of smart meters, causes or contributes to the development of any adverse health effects, including cancer and non-cancer health outcomes.

4. Scientific research does not support the claim that exposure to RF fields from smart meters has any proven adverse effect on health, thus, there is no support to the claim that RF fields from smart meters would adversely affect the health of Ms. Edwards, or others at the Edwards residence.

My opinions are expressed herein to a reasonable degree of scientific and medical certainty. I reserve the right to revise my opinions as more information becomes available.

Introduction and Purpose

On June 14, 2018, a Complaint was filed in the *Edwards* matter. Among other complaints, Ms. Edwards alleges health effects from exposure to RF electromagnetic fields (EMF) from smart meters.

The Counsel for Duquesne Light Company has asked me to evaluate case documents and the relevant scientific literature in relation to the *Edwards* matter. I was specifically asked to provide an overview of the scientific evidence on potential health effects of RF fields, evaluate whether exposure to RF fields from the smart meters owned and operated by Duquesne Light Company near the Edwards residence presents any health risk to Ms. Edwards or others, and provide a scientific evaluation of documents and other information submitted in this matter. This report summarizes my findings and opinions based on my professional qualifications, work experience, knowledge of the scientific literature on RF exposure assessment, epidemiology related to RF exposure and related scientific fields, and the case documents I have reviewed in this matter. The specific materials I received from Duquesne Light Company in this matter, and which I reviewed, are:

1. The Formal Complaint and Amended Complaint;
2. Duquesne Light Company's Answer and New Matter to Complaint and Amended Complaint;
3. Responses and various documents produced by Ms. Edwards in response to the Answer and New matter, and discovery requests;
4. Duquesne Light Company's Responses and Supplementary Responses to Complainant's Interrogatories; and
5. The Report of Benjamin Cotts, Ph.D., P.E., in the *Edwards* matter.

My opinions are expressed herein to a reasonable degree of scientific and medical certainty. I reserve the right to revise my opinions as more information becomes available.

Background and Qualifications

I am a medical doctor and an epidemiologist with over 25 years of experience in health research including the conduct of epidemiologic studies of both clinical outcomes and environmental and occupational health issues. I have considerable experience in conducting and evaluating epidemiologic studies and complex health assessments and exposure characterization studies related to power-frequency and RF EMF. I am a Senior Managing Scientist in the Health Sciences practice of Exponent, a scientific and engineering firm headquartered in Menlo Park, California.

Prior to joining Exponent, I was responsible for leading a multidisciplinary scientific health research program at the Electric Power Research Institute (EPRI), a not-for-profit independent research organization. The research program's scientific work addressed potential human health effects associated with residential and occupational exposure to power-frequency and RF EMF. I have submitted expert testimony on EMF and health, and have appeared as an EMF health expert before the Alberta Utilities Commission, the Connecticut Siting Council, the Kentucky Public Service Commission, the Virginia State Corporation Commission, and the *An Bord Pleanála* (the Planning and Development Board of Ireland). I also served as a consulting expert to the staff of the California Public Utilities Commission, California Assemblyman Jared Huffman, and members and staff of the California Council on Science and Technology (CCST) during the preparation of the CCST report "*Health Impact of Radiofrequency Exposure from Smart Meters*" published in April 2011, and to the Joint Committee for Transport and Communications of the Parliament of Ireland. I was invited by the National Research Council to provide peer-review of the National Academy's Committee report titled "*Identification of Research Needs Relating to the Potential Biological or Adverse Health Effects of Wireless Communication Devices*" published in 2008.

Previous to employment at EPRI, I worked as an epidemiologist at the Toronto Western Hospital, University of Toronto, and as a practicing physician and epidemiologist at the National Institute for Dermatology in Budapest, Hungary. I trained as a medical doctor (M.D.) at the Semmelweis University of Medicine in Budapest, Hungary, and as an epidemiologist (Ph.D.) at the School of Public Health of the University of California in Los Angeles (UCLA). I lectured at the UCLA School of Public Health, at Stanford University, and at the Electrotechnical Committee of the Hungarian Academy of Sciences, and I served as an affiliate associate professor in the Department of Environmental and Occupational Health Sciences of the University of Washington in Seattle, as a visiting scientist at the Hungarian National Research Institute for Radiobiology and Radiohygiene, and as an Associate Editor for the *Journal of Exposure Science and Environmental Epidemiology*. I was the recipient of Fogarty and Fulbright Fellowships. I am an author or co-author of over 60 scientific publications and book chapters on topics related to epidemiology of a wide range of environmental and occupational exposures (with a focus on exposure to EMF, including RF fields) and chronic diseases. A copy of my curriculum vitae is provided in Appendix A.

Allegations of Health Effects in the *Edwards* Matter

Allegations of Health Effects

According to the Complaint and other submissions in this matter, Ms. Edwards does not claim to have suffered from any health effects as a result of exposure to RF fields from smart meters or from other sources of RF fields. In addition, Ms. Edwards does not claim to have any existing, diagnosed medical conditions that makes her vulnerable to any potential harm from RF fields.

In the Complaint and additional submissions in this matter, Ms. Edwards expresses general health concerns in association with smart meters. In support of these general health claims, she states, "[h]ealth effects are also well documented in multiple complaints filed with the PA PUC [Pennsylvania Public Utilities Commission]"; "[m]icrowave radiation ... have been shown to produce cancers in rats and ill health effects in human beings"; and that smart meters "present a credible threat of harm" to her health, for which no evidence is adduced. In support of her opinion that adverse health effects are caused by exposure to low-level RF fields, Ms. Edwards specifically references the classification of RF fields by the International Agency for Research on Cancer (IARC) in 2011, and a 2014 fact sheet from the World Health Organization (WHO) on mobile phones. She also states, "[o]ther groups have documented harmful effects," and provides a list of various organizations, such as the BioInitiative Working Group (BIWG), and the American Academy of Environmental Medicine (AAEM), to support her view. None of the publications included or referenced in Ms. Edwards's submissions, individually or in combination, provide sufficient evidence to conclude that environmental exposure to RF at the levels generated by smart meters causes or contributes to any adverse health effects.

Below I provide an overall evaluation of the Complaint and address the specific health-related allegations made by Ms. Edwards in relation to RF fields and smart meters. In support of my opinions and conclusions, I also describe the well-established scientific methods of weight-of-evidence assessments, provide an overview of health risk assessments of RF exposure conducted using the weight-of-evidence method by reputable health, scientific, and government agencies, briefly review relevant scientifically-established exposure limits, and provide a brief review of key scientific research relevant to RF exposure and health.

Evaluation of the Complaint

The materials submitted by Ms. Edwards in support of her allegations of health effects in association with RF exposure from smart meters, considered either separately or in combination, fail to establish any cause-and-effect relationship between RF exposure at levels below scientifically-based exposure limits and adverse health effects. The documents referenced or submitted by Ms. Edwards can be broadly grouped into the following categories, which I evaluate below:

1. **References to non-peer reviewed documents.**

   I will not further consider these non-peer reviewed documents; these sources do not provide information that may serve as the basis of any valid scientific conclusion. Valid scientific conclusions about causality rely on systematic weight-of-evidence evaluations of research on health and exposures to RF that meet the minimum scientific criteria to have been published in peer-reviewed journals.

2. **Reference to "well documented" health effects and "credible threat of harm" are not documented in peer-reviewed scientific and medical publications.**

   Without proper identification of specific scientific publications, I am unable to evaluate the specific basis of Ms. Edwards's allegations. I will note, however, that valid scientific conclusions can only be drawn following an assessment of the *entire* body of available scientific literature, as discussed in more detail in my report below. A specific study or selected set of publications cherry-picked from the literature cannot form the basis of any valid scientific conclusion. The available body of scientific evidence published in the peer-reviewed scientific literature has been considered in the weight-of-evidence assessments and systematic reviews conducted by national and international expert panels (e.g., the IARC, which is the specialized cancer agency of the WHO; the Health Protection Agency[HPA] of the United Kingdom; and the Scientific Committee on Emerging and Newly-identified Health Risks [SCENIHR] of the European Commission). These health risk assessments, after consideration of the available evidence, did not conclude that the evidence overall confirms the existence of any adverse health effects from RF exposure.

3. **Reference to weight-of-evidence evaluations (e.g., the IARC evaluation of RF exposure).**

   Weight-of-evidence evaluations conducted by multidisciplinary panels on behalf of national and international health and scientific agencies (e.g., IARC, HPA, and SCENIHR), after properly considering the available body of scientific literature, did not conclude that there are any confirmed adverse health effects of low-level RF exposure, and provide no support to Ms. Edwards's allegations of health effects. The Complaint and the additional submissions, in general, disregard these weight-of-evidence conclusions about the lack of established adverse health effects, and disregard that the conclusions of these agencies were based on a thorough review of an extensive body of scientific literature that has accumulated over decades as a result of worldwide research efforts.

4. **Reference to evaluations by organizations that were *__not__* based on a proper weight-of-evidence evaluation of the available scientific literature (e.g., the BioInitiative Report [BIR]).**

   As discussed in more detail in my report below, "alternative views" most notably expressed by the BIWG in the BIR, were not reached using valid scientific methods. A number of scientific and government agencies strongly criticized the BIR for the lack of a scientific weight-of-evidence approach (e.g., EMF-NET, 2007; HCN, 2008; ACRBR, 2008; COMAR, 2009). The main limitations of the BIR and similar conclusions include the selective referencing of studies believed by the contributors to support their preconceived conclusions, systematic disregard of studies not in support of their opinion (including the laboratory animal studies not demonstrating an association), and the heavy reliance on *in vitro* studies [i.e., laboratory studies of cells and tissue]. The Internet site that posted the BIR is not sponsored by any professional scientific society, and the BIR has not been subjected to peer review by other scientists as would have occurred if the document had been submitted to a peer-reviewed scientific journal for publication.

In her submissions, Ms. Edwards expressed general health concerns in relation to exposure to RF fields. As discussed above, the weight-of-evidence reviews of the scientific literature did not conclude that RF fields at levels below scientifically-established guideline values cause or exacerbate any adverse health effects.

Scientific Review Process

In this section, I provide an overview of the well-established and generally-accepted scientific methods (i.e., the weight-of-evidence evaluation), which is used by reputable national and international health and scientific agencies for human health risk assessment. Types of health studies that are evaluated as part of risk assessments are also discussed.

Scientists around the world have conducted a large amount of scientific research and published their results on the potential health effects of RF fields over the past several decades in peer-reviewed scientific publications. The published peer-reviewed scholarly manuscripts published as part of this extensive research effort report on the results of these studies, which were conducted by a wide variety of scientists in related, but diverse, scientific disciplines. The WHO commented on this large body of research on electromagnetic fields, stating "[d]espite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals."[1] The WHO's website cites their position: "[b]ased on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields."[2]

Although much of the scientific research on electromagnetic fields and health and other scientific and health topics has been conducted by reputable scientists and laboratories, there is a large variability in the quality of scientific research, and the various types of scientific studies have varying strengths and limitations. Since it is difficult for an individual to synthesize all of this research, to impartially assess the quality of the research, and to recognize and weed out the unscientific and low-quality research results and publications, standard scientific methods have been developed by scientists to evaluate evidence to determine whether there is a cause-and-effect relationship between an exposure (e.g., RF fields) and adverse health outcomes. This

---

1 http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

2 Ibid.

section provides an overview of the well-established and generally accepted scientific review process.

The standard scientific method used by scientists to evaluate scientific research as it relates to potential adverse health outcomes is a health risk assessment, which includes a weight-of-evidence review of relevant scientific studies. Typically, multidisciplinary expert panels are convened by both national and international health and scientific agencies to conduct weight-of-evidence evaluations of the literature to arrive at a valid conclusion. It is important to note that no single study or limited group of studies can provide sufficient evidence to draw a scientific conclusion on a potential cause-and-effect relationship; the totality of the evidence needs to be considered.

Sources of Scientific Evidence for a Weight-of-Evidence Review

A systematic search of the scientific literature will identify relevant research studies to be considered in a weight-of-evidence review. Review panels typically consider the three main types of scientific studies: epidemiologic studies of human populations; experimental laboratory studies of animals or humans (*in vivo* studies); and laboratory studies of cells and tissues (*in vitro* studies). Epidemiologic, *in vivo*, and *in vitro* studies provide different but complementary information and since each type of study has particular strengths and limitations, a valid risk assessment will consider all three types of studies together.

Epidemiologic studies are classified as non-experimental because they observe human populations in their natural environment and scientists do not control the factors that influence study subjects' activity, nor can they control exposure to the agent of interest. The goal of an epidemiologic study is to measure statistical associations between exposure to a particular agent and health conditions. The two most commonly employed types of epidemiologic approaches are case-control and cohort studies. Case-control studies compare the occurrence of exposure among persons with a particular disease (cases) to that among persons who do not have that disease (controls). One of the measures of statistical association in case-control studies is an odds ratio.[3] Cohort studies follow a specific group of individuals over time, often in an occupational setting, who at the start of the study do not have the disease of interest. Scientists compare the frequency of disease occurrence among those who experience exposure to a particular agent to the frequency of disease occurrence among those members of the cohort who are not exposed to that same agent. Commonly used measures of an association in a cohort study are the relative risk and risk ratio.[4]

The limitations of epidemiologic studies include the scientist's inability to control exposure in the population, as already noted. This, among other drawbacks, may result in confounding in a study. Confounding, which is a key concept in epidemiology, refers to, in the simplest terms, confusion of effects. Confounding occurs when the apparent effect of one exposure on disease risk is distorted by or mixed with the effect of another exposure (i.e., the effect of a confounder). Confounding may result in overestimation or underestimation of the potential effect of an exposure on disease risk. Statistical techniques, such as stratification and co-variate adjustment, are available to adjust for the potential effects of known and measured confounders; however, residual confounding may remain even after adjustment, when the confounder is, for example, misclassified or crudely measured.

In addition, the methods used to select or recruit study subjects can result in selection and participation bias if those who are selected or recruited have inherently different characteristics than those who are not selected or choose not to participate. Scientists have developed methods to reduce the effect of these and other limitations, and epidemiologic studies typically provide the most weight in the studies considered in a weight-of-evidence review because they study humans, the species of interest in a human health risk assessment.

In vivo studies of laboratory animals typically study the effects of the agent of interest at high levels of exposure and often for durations that span the animals' lifetimes. These studies compare the rate and severity of symptoms and disease in exposed animals compared to un-

---

3 An odds ratio is a measure of a statistical association between exposure and outcome in case-control studies and is calculated as the ratio of the odds of being exposed among the cases and the odds of being exposed among the controls.

4 Relative risk and risk ratio are measures of a statistical association between exposure and disease in a cohort study and are calculated as the ratio of the risk of diseases among the exposed and the risk of disease among the unexposed.

exposed animals. One of the benefits of the *in vivo* animal study is that scientists can control and accurately measure exposure and other environmental factors that may influence disease development and exposure levels can be greater than that experienced by humans. A major limitation of *in vivo* animal studies is that the findings in animal studies may not be directly extrapolated to humans due to differences in physiology, metabolism, size, and longevity. Experimental studies are also conducted involving humans, but these studies typically contribute to an understanding of short-term effects, not long-term effects. In addition, ethical considerations prevent testing of known toxic or carcinogenic agents on humans.

In vitro studies of cells and tissues in the laboratory examine whether exposure results in certain biological changes. These observations can expand scientists' understanding of biophysical mechanisms that may lead to disease processes. Since the response of cells and tissues *in vitro* to a particular exposure may be very different than the response in intact organisms (i.e., living animals or humans), and may not directly predict adverse health effects, (e.g., AGNIR, 2012), the conclusions drawn from *in vitro* studies are extremely limited. Therefore, they receive less weight when considered in a weight-of-evidence review.

Weight-of-Evidence Review

After studies are systematically identified in the scientific literature, the strengths and weaknesses of each study are individually assessed and rated (i.e., given more or less weight) according to its overall quality. The quality of studies, among other factors, is determined by considering the number of study subjects, the design of the study, the methods used to collect data, the analysis of that data, and the potential for confounding, various biases, and random errors.

The next step in a weight-of-evidence review is to consider the totality of the evidence. The generally accepted guidance scientists use to weigh epidemiologic evidence includes the nine criteria outlined by Sir Austin Bradford Hill in his now seminal manuscript published in 1965. The nine criteria used to assess causality include strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. Hill recommended that these guidelines should be applied when a chance association (i.e., caused by systematic error, such as confounding, bias, classification error, or random variability) could be ruled out with reasonable certainty, and cautioned that none of these criteria represent "hard-and-fast rules" and none of these criteria are "*sine qua non*" of causality (Hill, 1965). The more the epidemiologic evidence meets these guidelines, the more persuasive the evidence is for a potential causal relationship.

Scientists use similar guidance to weigh *in vivo* studies, including, among other criteria, whether a sufficient number of animals and exposure levels were included in the study; whether the assignment of the animals to various exposure groups was random; whether the outcome assessment and statistical analyses were conducted in a blinded manner;[5] whether health effects can be consistently demonstrated by two or more independent laboratories and in two or more species; and whether health effects can be demonstrated under different laboratory protocols. Similar guidelines are also outlined in a joint publication by the Federal Judicial Center and the National Research Council, *Reference Manual on Scientific Evidence* (FJC-NRC, 2011).

Weight-of-Evidence Evaluation of Carcinogenicity

IARC, the cancer research agency of the WHO, is one of the leading international organizations for cancer risk assessment. In its risk assessments, which are published as Monographs, the IARC primarily considers epidemiologic and *in vivo* animal studies, and evaluates *in vitro* studies to provide supplemental evidence on potential biophysical mechanisms (classified as strong, moderate, or weak) that lead to disease processes. The IARC has classified the overall evidence for carcinogenicity for over 1,000 chemicals, physical agents, biological agents, and industrial processes and exposure scenarios based on comprehensive reviews of epidemiologic and *in vivo* animal studies into one of three categories, defined as follows.

- **Sufficient evidence**: A causal relationship can be established between exposure and cancer. This determination is based on the overall epidemiologic evidence in which positive relationships have been observed between the exposure and cancer in studies in

[5] Blinding in a study means that the investigators are not aware whether the animals were exposed or not exposed during the experiment and when the data are assessed. In a human experimental study, double-blinding means that neither the study participants nor the investigators are aware of participants' exposure status during the study. The lack of blinding may lead to human error or bias in a study.

which chance, bias, and confounding could be ruled out with reasonable confidence and on overall *in vivo* evidence in which increased incidence of cancer was observed in high quality laboratory animal studies in at least two species or from two independent laboratories.

- **Limited evidence:** A credible positive association is observed in epidemiologic studies, but chance, confounding, or bias could not be excluded as explanations for that association, and if *in vivo* studies result in an association, but the association is limited to one experiment or there are unresolved questions about study design features.
- **Inadequate evidence**: Epidemiologic studies are of insufficient quality, consistency, or statistical power, and *in vivo* studies have major qualitative or quantitative limitations or lack of data.

Based on the above risk assessment evaluation of human and animal evidence, the IARC places each agent or exposure it examines into one of five Groups:

- Group 1: Carcinogenic to humans;
- Group 2A: Probably carcinogenic to humans;
- Group 2B: Possibly carcinogenic to humans;
- Group 3: Non-classifiable as to carcinogenicity to humans; and,
- Group 4: Probably not carcinogenic to humans.

Group 2B, possibly carcinogenic to humans, denotes substances and exposures for which there is limited evidence in epidemiologic studies and limited or inadequate evidence in *in vivo* studies. The IARC has reviewed over 1,000 substances and exposure circumstances to evaluate their potential carcinogenicity and classified them as follows: Group 1, 120 agents; Group 2A, 83 agents; Group 2B, 314 agents; Group 3, 500 agents, Group 4, 1 agent. About 80% of the IARC's classifications fall into the possibly carcinogenic or non-classifiable category.[6] Since it is impossible in science to prove the absence of an effect, the IARC has classified only one substance (caprolactam) in Group 4, which illustrates the conservative nature of the IARC's risk evaluation process and the difficulty in proving the absence of an effect beyond all doubt.

[6] http://monographs.iarc.fr/ENG/Classification/ (Last accessed on January 9, 2020).

Research for only about 20% of the substances examined by the IARC showed a clear-cut carcinogenic risk (Group 1, ~10%) or probable carcinogenic risk (Group 2A, ~8%); most agents were categorized in either Group 2B as possible carcinogenic risks or Group 3 as unable to be classified

Recent Key Reviews of RF Health Studies

In this section, I provide a summary of key recent reviews of the scientific literature on RF exposure and potential health effects. None of the comprehensive reviews that applied the scientific weight-of-evidence process concluded that the scientific evidence confirms the existence of any health effect of low-level RF exposure, including the RF fields associated with the operation of smart meters.

Numerous international and national governmental, health, and scientific agencies have conducted thorough weight-of-evidence reviews of the available scientific literature to evaluate whether exposure to RF fields may result in potential adverse health effects. To account for the large volume and complexity of available scientific information, these reviews were performed by panels assembled and appointed by these agencies, representing multiple scientific disciplines (e.g., epidemiology, toxicology, exposure assessment) with relevance to research areas related to RF fields and potential health effects. These weight-of-evidence evaluations represent scientifically-based consensus opinions that provide guidance for governmental and standards-setting agencies to establish exposure limits or regulations to protect the health and safety of the public, and guide future scientific research by identifying potential research gaps and priorities.

In the past several years, a number of major scientific reviews have evaluated the weight of evidence regarding RF and health including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2009, the Advisory Group on Non-ionising Radiation (AGNIR) for the HPA in 2012, the IARC in 2013, and the European Commission's SCENIHR in 2015, which I briefly review below. These reviews conducted proper weight-of-evidence evaluations of the scientific evidence and from those evaluations concluded that there is not sufficient evidence to conclude that exposure to low-level RF fields (i.e., below currently existing, scientifically-based exposure guidelines) causes any adverse health effects, including cancer among children or adults, adverse nervous system effects, immunological effects, cognitive effects, cardiovascular effects, reproductive effects, developmental effects, self-reported symptoms (including tinnitus), or hypersensitivity to RF fields. Additional agency reviews on exposure to RF fields and health, all expressing similar conclusions (i.e., lack of established health effects of RF exposure at levels below scientifically-established guideline values), are listed in Appendix B.

International Commission on Non-Ionizing Radiation Protection (2009)

ICNIRP is the preeminent independent, non-governmental scientific organization for setting guidelines to protect the public from potential harmful effects of exposure to EMF, including RF fields, and it is the formally recognized organization for providing guidance on standards for non-ionizing radiation exposure for the WHO. ICNIRP systematically reviewed the available scientific evidence on exposure to high-frequency EMF and health, including numerical dosimetry, measurements, *in vitro* and *in vivo* biological laboratory studies, and epidemiologic studies. With respect to laboratory studies, ICNIRP concluded that while there are well-understood effects of RF exposure through tissue heating, the overall evidence from experimental studies does not provide consistent support for carcinogenic effects of RF exposure at non-thermal levels.[7] ICNIRP described that there is some evidence of small changes in brain activity, but these do not represent any adverse effects.[8] ICNIRP further concluded, "[w]hilst it is in principle impossible to disprove the possible existence of non-thermal interactions, the plausibility of various non-thermal mechanisms that have been proposed is very low." ICNIRP also concluded that the "evidence from double-blind provocation studies suggests that subjective symptoms, such as headaches, that have been identified by some individuals as associated with RF exposure, whilst real enough to the individuals concerned, are not causally related to EMF exposure." With respect to epidemiologic studies, ICNIRP concluded that results of available and reviewed epidemiologic studies provide no consistent or convincing evidence of a causal relationship between RF exposure and any adverse health effect.

---

[7] ICNIRP subsequently reviewed recent studies of chronic exposure of mice and rats to RF and commented that the recent "findings does not provide evidence that radiofrequency EMF is carcinogenic" (ICNIRP, 2018). ICNIRP's comments are also discussed in a subsequent section.

[8] Normal physiological changes (e.g., constriction of pupils or changes in brain activity) may occur as a result of everyday environmental stimuli, such as light and sound. These physiological changes, however, cannot be considered adverse effects.

Health Protection Agency (2012)

The independent AGNIR of the HPA (now part of Public Health England), the United Kingdom's primary governmental authority on public health protection, conducted its systematic review of the *in vitro*, *in vivo* animal, experimental human, and epidemiologic literature in 2012. With respect to *in vitro* and *in vivo* animal studies, AGNIR concluded that these studies provided no consistent evidence of adverse health effects of RF exposure at levels below those that produce heating. With respect to human experimental studies of acute effects of RF exposure below guideline levels, AGNIR concluded that the evidence suggests that such exposure "does not cause acute symptoms in humans, and that people, including those who report being sensitive to RF fields, cannot detect the presence of RF fields. Similarly, well-conducted studies do not suggest that exposure to RF fields gives rise to acute cognitive effects." While their review identified some scientific evidence that RF-field exposure may affect a person's brain activity, they cautioned that "the size of these reported effects is often small relative to normal physiological changes, and it is unclear whether they have any implications for health."

AGNIR found that epidemiologic studies of long-term exposure to RF fields below established guidelines provides no substantial evidence of effects, particularly those studies of cardiovascular morbidity, reproductive function, and non-cancer mortality, although they note that the literature "has been very limited." They similarly concluded that studies examining cancer risk in relation to occupational RF exposure and residential proximity to RF transmitters suffer from methodological limitations and provide no evidence for a causal relationship between exposure to RF fields and any adverse health effects. Finally, they conclude that the overall evidence from epidemiologic studies of mobile phone use and cancer risk "does not suggest that use of mobile telephones causes brain tumours or any other type of cancer," but they qualify this assessment by noting that "[t]he data, however, are essentially restricted to periods of less than 15 years from first exposure."

Overall, they concluded "... although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guidance levels causes health effects in adults or children."

International Agency for Research on Cancer (2013)

In 2013, the IARC reviewed the scientific literature to evaluate potential carcinogenic effects of RF fields with a particular focus on exposures produced by close proximity to RF sources, such as from mobile phones. The IARC expert working group classified RF fields as possibly carcinogenic (Group 2B) based on "limited evidence" for carcinogenicity of RF fields in relation to glioma and acoustic neuroma from mobile phone epidemiologic studies, and on "limited evidence" from experimental animal studies. The IARC concluded that results from epidemiologic studies of mobile phones and all other types of cancer, and from epidemiologic studies of occupational and environmental exposure to RF provided no clear indication of an association between RF exposure and cancer development. The IARC Group 2B classification does not imply that a cause-and-effect relationship is established between exposure and cancer. To the contrary, it means that artifacts, such as chance, confounding, and bias cannot be ruled out with scientific certainty as an explanation for the limited statistical association reported in some of the studies, because of the limitations of those studies.

Scientific Committee on Emerging and Newly Emerging Health Risks (2015)

SCENIHR is made up of independent scientific experts assembled to provide advice on public health and risk assessments to the Department of Health and Consumer Protection of the European Commission. SCENIHR provides opinions on emerging or newly-identified health and environmental risks and on broad, complex, or multidisciplinary issues requiring a comprehensive assessment of risks to consumer safety or public health and related issues not covered by other community risk assessment bodies. The mandate of SCENIHR includes the evaluation of potential health effects of EMF, including RF fields. SCENIHR's most recent report was issued in 2015.

With respect to epidemiologic studies of cancer, SCENIHR concluded the following:

> Overall, the epidemiological studies on mobile phone RF EMF exposure do not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region. Some studies raised

> questions regarding an increased risk of glioma and acoustic neuroma in heavy users of mobile phones. The results of cohort and incidence time trend studies do not support an increased risk for glioma while the possibility of an association with acoustic neuroma remains open. Epidemiological studies do not indicate increased risk for other malignant diseases, including childhood cancer.

With respect to potential effects of RF exposure on brain physiology, SCENIHR noted that while some studies indicated that RF may affect brain activity, "the relevance of the small physiological changes remains unclear and mechanistic explanation is still lacking." They note, however, that "overall, there is a lack of evidence that mobile phone RF EMF affects cognitive functions in humans."

With respect to "symptoms that are attributed by some people to various RF EMF exposure," SCENIHR concluded that, based on available evidence, "RF EMF exposure is not causally linked to these symptoms." SCENIHR further concluded that evidence does not show a consistent association between RF exposure and neurological diseases, reproductive and developmental effects, and male fertility.

Reviews of Smart Meter RF Fields and Health

In this section, I provide a brief overview of evaluations conducted by various state and national government agencies in the United States and other countries specifically on potential health effects in relation to RF fields from smart meters. These evaluations concluded that there are no established health effects in relation to smart meter RF fields.

In response to public concern about potential health effects related to RF emissions from smart meters, several states in the United States have formally assessed the scientific evidence on smart meters and health effects and issued their reports or statements with their conclusions and opinions.

A review conducted in Maine by the Maine Center for Disease Control in 2010 concluded in their summary statement that "our review of these agency assessments and studies do not indicate any consistent or convincing evidence to support a concern for health effects related to the use of radio frequency in the range of frequencies and power used by smart meters. They also do not indicate an association of EMF exposure and symptoms that have been described as electromagnetic sensitivity" (MCDC, 2010).

In California, the state assembly commissioned the CCST to perform an independent study to inform the debate among policy makers and the general public about the potential risk of adverse health effects due to RF field emissions from smart meters. The CCST's report concluded that "[t]he current FCC [Federal Communications Commission] standard provides an adequate factor of safety against know thermally induced health impacts of existing common household electronic devices and smart meters." They further conclude that scientific studies have neither identified nor confirmed any negative health effects from RF emissions produced by smart meters and other common electronic devices (CCST, 2011).

The Colorado Department of Public Health and the Environment issued a fact sheet in 2012, which concluded that "Smart Meters are unlikely to cause health effects because … [t]o date, research does not suggest any consistent evidence of adverse health effects of RF emissions produced by Smart Meters or other common household electronic devices" (CDPHE, 2012).

The Michigan Public Service Commission issued a report in 2012 concluding that "[a]fter careful review of the available literature and studies, the Staff has determined that the health risk from the installation and operation of metering systems using radio transmitters is insignificant" (MPSC, 2012).

The Oregon Health Authority concluded in 2012 that "[b]ased on our review of these reports, evidence from the scientific literature and consultations with radiation experts, we conclude at this time that the implementation of smart meters will not adversely impact public health" (OHA, 2012).

The Public Utility Commission of Texas concluded in 2012 that "the large body of scientific research reveals no definite or proven biological effects from exposure to low-level RF signals. Further, Staff found no credible evidence to suggest that advanced meters emit harmful amounts of EMF" (PUCT, 2012). An order of the Public Utility Commission of Texas in 2013 similarly stated that "[t]he commission evaluated health, privacy, and operational concerns against advanced meters and concluded that the concerns are unwarranted" (PUCT, 2013).

The Arizona Department of Health Services conducted a study of smart meters that included measurements of RF signals at a random selection of single-family residences and apartment complexes within the state. The average and peak levels of RF were measured at 1 foot in front of meters three times during the day. All measurements were found to comply with FCC standards. A search and review of the literature on potential effects of RF on health was performed which led the Department of Health to conclude that "[e]xposure to electric meters (AMI [advanced metering infrastructure] and AMR [automated meter reading]) is not likely to harm the health of the public" (ADHS, 2014).

A review of scientific and public health agency perspectives on RF fields related to smart meters commissioned by the Vermont Department of Health and the Vermont Public Service Department in 2014 concluded that "[b]ased on the substantial collective scientific evidence, the consensus of scientific and health agencies continues to conclude that current regulatory standards for RF from smart meters are sufficient to protect public health" (VDH/VPSD, 2014).

The legislature of North Carolina asked the Division of Public Health to perform an evaluation of existing information on RF and health related to smart meters. The team from the Division concluded the following:

> Radiofrequency waves have demonstrated subtle biological effects on certain cellular systems; however there is no conclusive evidence that these changes have clinical significance ... Major reviews by various governmental organizations, both U.S. and global, have not found sufficient evidence that non-thermal effects of radiofrequency waves are a significant risk to humans … accepted criteria to justify the application of the Precautionary Principle are not met for RF exposures from smart meters (NCDHHS, 2015).

A fact sheet issued by Health Canada in 2011 states that based on its review "Health Canada has concluded that exposure to RF energy from smart meters does not pose a public health risk" (Health Canada, 2011). A similar fact sheet issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) in 2015 concluded that "there is no established scientific evidence that the low level RF EME exposure from smart meters causes any health effects including symptoms of ill health communicated by some people" (ARPANSA, 2015). More recently, Public Health England in the United Kingdom concluded that "[t]he evidence to date suggests exposures to the radio waves produced by smart meters do not pose a risk to health" (Public Health England, 2017).

RF Exposure Standards and Guidelines

Current scientifically-derived RF exposure guidelines are based on avoiding the risk to health that results from localized temperature increases in tissues and from physiological stress due to excessive whole-body heat load. No properly conducted weight-of-evidence review of the relevant scientific literature has confirmed the existence of any adverse health effects at non-thermal exposure levels. A whole-body averaged energy absorption rate or specific absorption rate (SAR) of 4 watts per kilogram (W/kg) of body mass is required to result in an increase of 1 degree Celsius (°C) in the tissue temperature that may be associated with behavioral disruption. With the application of safety factors of 10 and 50 for occupational and public exposures, respectively, limits are derived on the strength of external RF fields.

Federal Communications Commission

In the United States, the FCC is the government agency responsible for regulating RF-generating devices. Their regulations specify the limit on the maximum permissible exposure (MPE) level to RF of varying frequencies, from 300 kilohertz (kHz) to 100 Gigahertz (GHz) (47 CFR §1.1310). The FCC based their standards on the work of organizations such as the U.S. National Council for Radiation Protection (NCRP) and the Institute of Electrical and Electronic Engineers (IEEE).

The FCC established limits for exposure to RF (FCC, 1997) based on the recommendations of the NCRP and IEEE, as well as the U.S. National Institute for Occupational Safety and Health, the Occupational Safety and Health Administration, the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). The FCC's MPE limits are set to protect against effects from RF exposure that can induce electric fields and currents in body tissues and cause tissue heating. Exposure, in the frequency range relevant to smart meters, is described in terms of power density, and measured in watts per square meter (W/m^2), or milliwatts per square centimeter (mW/cm^2). These units may be used to directly compare to either calculated or measured levels of RF. The FCC's MPE limits are evaluated in terms of 30-minute, time-averaged values as averaged over the body dimensions. The reference levels set by ICNIRP and the IEEE's International Committee on Electromagnetic Safety (ICES) are comparable to the

FCC limits for frequencies that are typically used in smart meter communication systems (i.e., frequencies of 900 megahertz [MHz] and 2.4 GHz) (IEEE, 2005; ICNIRP, 1998).

On August 8, 2019, the Chairman of the FCC announced that, "following more than six years of public input and review," the FCC would propose to maintain its existing RF exposure limits. The FCC press release announcing the decision stated, "[t]he FCC sets radiofrequency limits in close consultation with the FDA and other health agencies" (FCC, 2019). The FCC press release also quoted the Director of the FDA's Center for Devices and Radiological Health concluding, "[t]he available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits" and "[n]o changes to the current standards are warranted at this time."

Alternative Views

In this section, I provide specific examples of views that are not based on valid scientific methods to assess the available evidence, which thus arrive at invalid conclusions regarding the existence of health effects in relation to low-level RF exposure. Such views and conclusions are contrary to conclusions of properly conducted weight-of-evidence reviews (e.g., reviews by IARC, HPA, and SCENIHR).

As discussed above, none of the scientific reviews by government or scientific agencies that were properly conducted using standard scientific methods concluded that the evidence confirms the existence of any adverse health consequences in association with exposure to low-level RF fields in our daily environments.

Alternative views, such as that put forward by the BIWG in their 2007 BIR and their 2012 update, are not based on proper and rigorous evaluation of the scientific evidence. The BIWG report suffers from several deficiencies: 1) the report was authored by a self-organized group of individuals from academic institutions and public interest groups, and not under the auspices of any recognized scientific organization; 2) the conclusions expressed in the individual chapters of the document did not represent consensus opinions, rather they were the opinions of the individual contributors; 3) the authors did not follow a weight-evidence approach, and selectively reported on studies that, in their opinions, showed some effect and supported their views; 4) the authors mostly disregarded studies that did not show an effect, including the entire body of literature on long-term animal bioassays; and 5) the authors did not thoroughly assess the quality of studies they evaluated. These deficiencies likely explain why the BIWG's conclusions are completely inconsistent with conclusions of other risk assessments that followed the generally-accepted scientific methods of weight-of-evidence evaluations.

Several scientific and governmental agencies strongly criticized the BIWG report. The Australian Centre for Radiofrequency Bioeffects Research wrote, "[a]s it stands it [the BIWG 2007 report] merely provides a set of views that are not consistent with the consensus of science, and it does not provide an analysis that is rigorous-enough to raise doubts about the scientific consensus" (ACRBR, 2008). The EMF-NET Steering Committee of the European

Commission opined the report was "written in an alarmist and emotive language and the arguments have no scientific support from well-conducted EMF research" and "[t]here is a lack of balance in the report; no mention is made in fact of reports that do not concur with authors' statements and conclusions" (EMF-NET, 2007). The Health Council of the Netherlands also questioned the authors' motivation noting "[u]pfront, therefore, the reason for writing the report was not to give an objective analysis of the current state of science that would subsequently lead to recommendations. Instead, the aim was to present information to demonstrate why current standards are inadequate" (HCN, 2008). All of these agencies concurred that BIWG did not follow the methods of a standard weight-of-evidence review and, for this reason, its conclusions and recommendations were not convincing. Over time, despite adding more text to this online document, the absence of a rigorous scientific method for evaluating research studies has not changed.

Similar alternative statements expressing concern about health effects related to exposure to RF fields from smart meters were offered by, for example, the AAEM and a scientist from the Santa Cruz County Health Services Agency. These alternative statements also appear to have been based on evaluations that did not follow well-established methods for weight-of-evidence assessments of the available scientific literature.

Specifically, there is no indication that any of the AAEM proclamations or opinions were based on a weight-of-evidence evaluation or a similar comprehensive and systematic review of the scientific literature. The AAEM documents merely pronounce opinions espoused by several members and make recommendations without providing a scientifically-valid support for their conclusions. None of the medical conditions listed in the AAEM documents were found to be causally related to low-level EMF by organizations that conducted a weight-of-evidence evaluation of the scientific literature (e.g., WHO, SCENIHR). The AAEM documents only list a few selected references in support for their positions. As discussed in more detail above, a few cherry-picked references cannot form the basis of a valid scientific conclusion. The references cited by the AAEM were available for review by organizations that conducted weight-of-evidence reviews (e.g., SCENIHR) that reached conclusions contrary to the conclusions of AAEM. In addition, many of the references cited in the AAEM documents are not specifically relevant for the frequency range used by smart meters. Criticisms of the AAEM opinions were also expressed by other organizations, such as EPRI and the Lawrence Berkeley National Laboratory (EPRI, 2012; LBNL, 2012). It is also noteworthy that AAEM is not listed as a medical specialty board recognized by the American Board of Medical Specialties.[9]

9 https://www.abms.org/member-boards/

RF Health Research

In this section, I provide a brief overview of the relevant scientific research conducted in the past several decades on low-level RF exposure and health. For a detailed and comprehensive discussion of the relevant scientific literature, I refer to the reviews and weight-of-evidence assessments conducted by ICNIRP, HPA, IARC, and SCENIHR, as described above. Overall, none of the comprehensive evaluations conducted by these agencies concluded that the evidence confirms the existence of any adverse health effects in relation to RF exposure below currently existing exposure guidelines. The current scientific consensus as exemplified by the conclusion of the WHO is that the "current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields." Results of more recent studies published after the completion of the above-mentioned weight-of-evidence evaluations have not changed the overall conclusions expressed in these evaluations. Below I provide a brief overview of the key lines of scientific evidence related to exposure to RF fields and potential health effects.

Epidemiologic Studies of RF and Cancer

Epidemiologic studies examining potential effects of RF fields on human health outcomes can be broadly grouped into three categories: studies of occupational or military exposures to RF; studies of environmental exposure to RF (i.e., RF sources of fixed locations, such as radio and television transmitters and mobile phone base stations); and studies of personal exposure to cordless and mobile phones. In addition to these analytical epidemiologic studies, descriptive epidemiologic studies monitoring incidence trends of brain cancer are also used to assess the potential impact of mobile phone use on brain cancer development.

Epidemiologic studies of occupational and military exposures include cohort studies that follow well-defined populations exposed to RF from radar in military settings (e.g., Garland et al., 1990; Szmigielski, 1996; Szmigielski et al., 2001; Groves et al., 2002) or in the police force (e.g., Finkelstein, 1998), from use of amateur radio among operators (e.g., Milham, 1985), and from various sources in industrial settings (e.g., Armstrong et al., 1994; Morgan et al., 2000). Case-control studies of various cancer types have also assessed the potential relationship between sources of occupational exposure to RF and cancer, and estimated exposure based on occupation or job category, used as a proxy for potential exposure to RF fields (e.g., Stang et al., 2001; Berg et al., 2006; Karipidis et al., 2007a, 2007b; Vila et al., 2018). While some earlier studies reported statistically significant associations between these proxy exposure measures and cancer, most recent studies have not consistently reported a risk of any type of cancer in association with occupational RF exposure.

Earlier studies of environmental RF exposures mostly consisted of studies with ecologic design or geographical correlations that compared cancer rates calculated for geographic areas (e.g., at various distances from an antennae), but did not directly assess exposure of individuals (e.g., Hocking et al., 1996; Dolk et al., 1997a, 1997b; McKenzie et al., 1998; Cooper et al., 2001; Michelozzi et al., 2002; Park et al, 2004). Distance is another proxy exposure measurement used by scientists in the absence of direct measurements or modeled calculations of RF exposure; the interpretation of these results is constrained because not all people in an area have the same exposure, and it does not consider exposure from other RF sources. In addition, distance has limited accuracy because it does not consider characteristics of the source, topography, or the built environment that may also affect levels of RF fields. More recent studies of environmental RF exposure using case-control or cohort designs have improved exposure assessment and estimated RF exposure on the individual level, but none of these studies found any consistent, statistically significant positive association between total RF exposure and risk of childhood leukemia or brain cancer (Ha et al., 2007, 2008; Merzenich et al., 2008; Li et al., 2012; Hauri et al., 2014). Another study that estimated maternal exposure to RF from mobile phone base stations and the risk of cancer in their children also found no association with childhood leukemia/lymphoma or brain cancer (Elliott et al., 2010).

Cohort studies of mobile phone users with large sample sizes (Schüz et al., 2006; Frei et al., 2011; Benson et al., 2013a, 2013b) reported no associations with any types of cancer, including cancer of the head and neck, leukemia, and lymphoma. Some of these studies relied on mobile phone subscription records from mobile phone companies to determine use and estimate exposure (Schüz et al., 2006; Frei et al., 2011), which may result in exposure misclassification due to people sharing phones, using more than one phone, using company phones, and switching carriers.

A large number of case-control studies also have been conducted to assess mobile phone use and development of brain tumors. Most of these studies relied on self-reported mobile phone use to determine exposure, potentially resulting in well-documented recall bias and non-differential and differential exposure misclassification (e.g., Vrijheid et al., 2009; Toledano et al., 2018). Early case-control studies reported no association between mobile phone use and brain cancer, however, these studies included relatively short time periods of exposure (Muscat et al., 2000; Inskip et al., 2001).

Most of the more recent case-control mobile phone epidemiologic studies belong to one of two sets of studies: the multinational, comprehensive studies conducted by the INTERPHONE Study Group and the series of case-control studies conducted by a research group in Sweden. The INTERPHONE Study Group is comprised of a consortium of 16 research groups in 13 countries in Europe, Asia, North America, and Australia/New Zealand (Cardis et al., 2007, 2011; Interphone Study Group, 2010, 2011). The majority of studies by the INTERPHONE Study Group—both studies conducted in individual countries and pooled-analyses of data from several countries—show no significant positive association between self-reported mobile phone use and risk of glioma, meningioma, and acoustic neuroma. The pooled analysis found that those who had ever been a regular mobile phone user were associated with a significantly lower risk of glioma and meningioma, although this association was possibly due to selection bias, that is, greater participation among controls who had ever used mobile phones compared to those who had not (Interphone Study Group, 2010; Cardis et al., 2011). A significant risk increase was observed in the highest of 10 categories of cumulative call time when all the data were combined in one analysis; however, the authors noted that there were implausible values of reported use in those highest categories, and they could not rule out chance or reporting bias as an explanation for the findings (Interphone Study Group, 2010, 2011).

Hardell and colleagues in Sweden conducted another series of case-control studies of malignant and benign brain tumors (e.g., Hardell et al., 1999, 2013). While all these studies reported a significant positive association between mobile phone use and risk of brain tumors, with evidence of a positive exposure-response trend and especially with longer latency, concerns about selection bias, recall bias, interviewer bias, and multiple hypothesis testing, along with unclear exposure definitions and study inclusion criteria, limit the strength of the authors' conclusions. The higher odd ratios reported in these studies are not consistent with results from other epidemiologic studies, including those from the Swedish INTERPHONE group (Lonn et al., 2005).

More recently Olsson et al. (2019) examined cell phone use prior to diagnosis and survival in 806 glioma patients after diagnosis in Denmark, Finland, and Sweden. The authors reported no indication of reduced survival among glioblastoma patients in association with various measures of mobile phone use; in fact, all statistically significant associations suggested better survival for mobile phone users (Olsson et al., 2019).

There is little epidemiologic evidence regarding mobile phone use and risk of brain tumors in children. One case-control study of children and adolescents (aged 7–19 years) reported no exposure-response relationship between the amount of mobile phone use and risk of brain tumors. In addition, the study did not detect an increased risk of brain tumors in those brain areas that received the highest amount of exposure (Aydin et al., 2011). Similarly, there are few case-control studies of mobile phone use and the risk of parotid and salivary gland tumors, leukemia, non-Hodgkin lymphoma, uveal melanoma, testicular cancer, and intratemporal facial nerve tumor. Existing studies on these outcomes do not reveal a consistent or convincing positive association and have the same general limitations as other case-control studies.

Because RF exposure from mobile phones has been hypothesized to affect primarily the development of brain cancer and because mobile phone use has dramatically increased in the past couple of decades in all modern societies, incidence trends of brain cancer have been examined in several countries in recent years. These studies, however, reported no observable increase brain cancer incidence during a period of substantial increase in mobile phone use (e.g., Cook et al., 2003; Röösli et al., 2007; Deltour et al., 2009; Inskip et al., 2010; de Vocht et al., 2011; Aydin et al., 2012; Shibui, 2012; McKean-Cowdin et al., 2013; Karipidis et al., 2018; Natukka et al., 2019; Nilsson et al., 2019; Röösli et al., 2019). While some studies reported an increase in the rate of glioblastoma multiforme (i.e., high-grade brain tumors), they also reported a corresponding decrease in other types of brain tumors, a pattern that more likely was produced by a shift in tumor classification, and improvements in diagnostic technology over time rather than mobile phone use (e.g., Philips et al., 2018; de Vocht, 2019).

Laboratory Animal Studies of RF and Cancer

A review of experimental studies of RF exposures in rats and mice between 1982 and 2011 was reported by the IARC in 2013. The conclusion was that, in aggregate, the studies provided "limited evidence in experimental animals for the carcinogenicity of radiofrequency radiation." No rationale as to how the studies were rated or evaluated was provided. An updated review of these and some newer studies and analyses prompted SCENIHR (2015) to conclude "[o]verall, because a considerable number of well-performed studies using a wide variety of animal models have been mostly negative in outcome, the animal studies are considered to provide strong evidence for the absence of an effect." The studies reviewed by these agencies applied exposures with SARs below 8 mW/kg, but several involved exposures to SARs at much higher levels between 2-5 W/kg.

The SCENIHR (2015) review also commented on the study by the U.S. National Toxicology Program (NTP) then underway, and stated, "[l]ong-term absorption of RF energy at that level will have a considerable impact on thermoregulation, and induce compensatory changes in metabolism, as well as reducing food consumption and spontaneous activity."

In 2000, the NTP began the design and planning for a study of rats and mice to be exposed to RF fields simulated to be similar to those of mobile phones with signal modulations characteristic of 2G mobile phones (i.e., Global System for Mobile Communication [GSM] phones) and 3G mobile phones (i.e., Code Division Multiple Access [CDMA] phones). The results have been summarized most completely in two draft technical reports in February 2018 (NTP, 2018a, 2018b). Final reports were published in November 2018 (NTP, 2018c, 2018d).

Pilot studies of exposures for 5 days provided strong evidence confirming that exposure of rats to RF fields at 900 MHz and mice to RF fields at 1,900 MHz resulting in SAR levels of 10 W/kg or 12 W/kg for 10 minutes on and 10 minutes off for 18.3 hours per day produced excessive increases in body temperature leading to death in rats. In addition, the study reports that increases in body temperature above 1°C may occur in rats and mice at exposure levels above 4 W/kg and 6 W/kg.

Twenty-eight-day studies involved the exposure of groups of pregnant female rats and groups of adult male and non-pregnant female rats to GSM or CDMA RF fields at 0, 6, or 9 W/kg, and adult male and non-pregnant female mice to GSM or CDMA RF fields at 5, 10, and 15 W/kg for 18.3 hours per day (cycles of 10-minutes on, 10-minutes off) for 28 days. Significant reductions in body weight were measured in post-pregnancy (in lactation) rats exposed to GSM or CDMA fields at 9 W/kg; dose-related reductions in body weight were also seen in the pups at 9 W/kg. Similar, but apparently not significant, trends were seen in male and female adult rats as well. The body temperatures of pregnant female rats were significantly increased at 6 W/kg and 9 W/kg with GSM and CDMA exposure. Some significant decreases in the body temperatures of female pups exposed to GSM RF also were reported. In mice, exposures of males to GSM RF at 5 W/kg and 10 W/kg and CDMA at 10 W/kg and 15 W/kg significantly increased body temperatures. No effects of GSM or CDMA on the body weights of male or female mice were reported.

Two-year studies involved the exposure of rats to GSM or CDMA RF (1.5, 3, or 6 W/kg) beginning prior to birth (in utero exposure beginning on gestational day 5) through to.the end of life. Mice were similarly exposed to GSM or CDMA RF (2.5, 5, or 10 W/kg) for their lifetimes, but these exposures began in adulthood. As in the shorter-term studies, significant reductions in body weight gains of pregnant female rats as well as their male and female pups were dose-related with GSM exposure. Significantly increased survival over the 2-year period of male rats exposed to GSM fields was reported at all SAR levels in a dose-related fashion. The survival of male rats exposed to CDMA at 1.5 W/kg and 3 W/kg was also increased. Similarly, survival of female rats increased with exposure to CDMA at 6 W/kg.

The examination of multiple organs of rats at the end of the study showed dose-related increased incidence of cardiomyopathy in the right ventricle of males at 3 W/kg and 6 W/kg (GSM) and at all SAR levels (CDMA). The rate at 6 W/kg was higher than the historical range among unexposed control rats in previous NTP studies. A trend for malignant schwannomas of the heart to increase with GSM and CDMA SAR levels was observed in male rats, but the rate was only elevated above historical controls at 6 W/kg in CDMA males. An increase in the rate of brain glial tumors was not reported at any exposure levels in male rats exposed to CDMA, but a weak trend was noted.

Groups of 105 male and female mice exposed to GSM and CDMA also were evaluated after 2 years of exposure at different SAR levels than rats. The survival of male mice exposed to GSM at 5 W/kg and CDMA at 2.5 W/kg was higher than unexposed control mice. The examination of multiple organs of mice at the end of the study showed higher rates of malignant lymphoma in female mice exposed to GSM at 2.5 W/kg and 5 W/kg and to CDMA at 2.5 W/kg. Opposite effects of CDMA RF on liver cancer were reported for male mice (a decrease in carcinomas at 2.5 W/kg and an increase of hepatoblastoma at 5 W/kg). All tumor rates were within the range of historical rates of control rats reported in other NTP studies.

Tests for reparable DNA damage after 14 weeks of exposure showed trends for damage to increase with SAR levels in 1 of 3 brain regions of male mice (CDMA and GSM) and female rats (CDMA), in 2 of 3 brain regions in male rats (CDMA), in the liver in female mice (CDMA), and in the blood of both sexes of rats exposed to CDMA. No damage to chromosomes in red blood cells in rats or mice exposed to GSM or CDMA was reported. These observations were not linked in the report to histological observations on the brain or any other tissues.

Overall, the results of the NTP study indicate that exposure to levels of RF that cause heating of the body,[10] can have acute adverse effects, and that life-long exposure at slightly lower levels also may increase survival with increasing SAR exposure. Increased rates of malignant tumors above the rates in unexposed controls and historical controls in the hearts of GSM- and CDMA-exposed males provide, as the report states, "some evidence of carcinogenic activity" in rats. The report stated that data evaluated for mice only provided "equivocal evidence of carcinogenicity" with GSM and CDMA exposure. The data deserve additional scrutiny because, although the statistical testing for some measures such as body weight were adjusted for multiple comparisons, other measures like tumor incidence were not. Given the thousands of pair-wise and trend comparisons made between exposed and control rats and mice in these reports, one must assume that a substantial fraction of the statistically significant differences reported were statistical false positive findings (i.e., occurred by chance alone). The SAR level that is considered the threshold above which adverse effects of whole-body RF exposure may be

---

[10] Tissue heating is a well-established effect of RF exposure at sufficiently high levels. Scientifically-established RF exposure limits, however, are set well below levels at which adverse heating of the tissue or body may occur. Thus, the study findings of the NTP study are, in general, not informative with respect to potential effects of low-level RF exposure from everyday sources, including smart meters.

expected is 4 W/kg in rats, non-human primates, and humans (D'Andrea, 1999) and this has led federal agencies in the United States to set the standard for whole-body exposure of the general public 50-fold lower to 0.08 W/kg (FCC, 1997).

Following a review by an outside *ad hoc* peer-review panel conducted in March 2018, the NTP released its final reports in November 2018 (NTP, 2018c; 2018d). In the final reports, even though the actual study results remained unchanged, the NTP upgraded some of their statements based on the review panels' recommendations, and stated that there was "clear evidence" that RF exposure was associated with development of schwannoma in the hearts of male rats, and "some evidence" for tumors in the brain and adrenal glands of male rats. Even though the maximum RF exposures to mice were 67% higher than for rats, the evidence for any effects was weaker for mice and was rated as "equivocal."

Ramazzini Institute

A recent study conducted at the Ramazzini Institute in Italy exposed rats to 1,800 MHz GSM RF fields for 19 hours per day from gestational day 12 (in utero) until the end of life at calculated SAR levels of 0.001 W/kg, 0.03 W/kg, or 0.1 W/kg. A partial summary of the results was selected by the authors for publication (Falcioni et al., 2018). The exposures were planned to simulate RF exposures in the environment from a fixed mobile antenna, not a mobile phone. The rats were exposed in cages with 5 rats per cage with a minimum of approximately 200 rats per sex per group. Body temperature was not measured.

The investigators did not report that they had randomly assigned the rats to the control or treatment conditions, which is a major flaw in the design of the experiment (Hooijmans, 2014). No effects on food or water intake, body weight, or survival in male or female rats were reported. The investigators reported 120 additional statistical calculations to describe the potential differences between groups of rats exposed or not exposed to RF fields on numerous measures. Using a criterion of $p < 0.05$, one would expect about six statistically significant differences to be reported just by chance alone in the two tables of data presented. But from all the calculations, only one single table entry indicated a statistically significant difference. In male rats at the highest exposure of 50 volts per meter (said to correspond to an SAR of 0.1 W/kg), 1.4% were diagnosed with a schwannoma in the heart whereas no rats were diagnosed with this tumor among the control rats. No other differences in the entire report were statistically significant.

If these calculations had been corrected for multiple comparisons as had been done in some of the analyses in the NTP study, there would be no statistical differences between the groups exposed to RF and the control group at all. Moreover, the claim of the investigators that the large number of rats in each group makes it a better study than the NTP study is undercut because they exposed the rats in cages of five and so the cage, and not the individual rats, should have been the experimental unit for analysis. Thus, observations on each rat were not necessarily independent of the others in the cage and so the sample size for all the analyses should have been divided by 5 for the calculations of statistical significance.

Another reason to be cautious about this study is that EPA has criticized the Ramazzini Institute's assessments of histological data, has "decided not to rely on RI [Ramazzini Institute] data on lymphomas and leukemias in IRIS [Integrated Risk Information System] assessments" (USEPA, 2013), and has warned risk assessors about problems with the cancer bioassays conducted by the Ramazzini Institute. These problems include the accuracy of the cancer diagnoses; the categorization of tumors; errors in identifying cellular changes such as leukemia/lymphoma in certain tissues that appear to be due to infections and tissue inflammation; a unexplained significant rise in the incidence of leukemia/lymphomas over time in control groups unrelated to the exposure under study; the lack of complete reporting and documentation of analytical specifications; failure to control or analyze for potential litter effects; and the use of common controls for multiple studies (Gift et al., 2013).

In September 2018, ICNIRP published a brief summary and evaluation of the NTP and Ramazzini Institute studies (ICNIRP, 2018). Overall, ICNIRP concludes that "consideration of their [NTP and Ramazzini Institute studies] findings does not provide evidence that radiofrequency EMF is carcinogenic," and that these "studies do not provide a consistent, reliable and generalizable body of evidence that can be used as a basis for revising current human exposure guidelines." In a statement issued in November 2018 on the NTP studies, the Director of the FDA's Center for Devices and Radiological Health opined that the findings of the NTP studies "should not be applied to human cell phone usage." The FDA further concluded that "[b]ased on our ongoing evaluation of this issue, the totality of the available scientific evidence continues to not support adverse health effects in humans caused by exposures at or under the current radiofrequency energy exposure limits. We believe the existing safety limits for cell phones remain acceptable for protecting the public health" (FDA, 2018). A third commentary on these studies was offered in a newsletter by a group of scientists assembled by the Swiss Federal Office for the Environment (BERENIS, 2018). The limited commentary reported on selected aspects of these studies and pointed out "the results of the NTP study are mostly relevant for the exposure situation when using a mobile phone close to the body. In contrast, the Ramazzini study observed carcinogenicity at levels as high as the environmental exposure limits, with no statistically significant effect at lower doses."

In summary, the newest animal studies of chronic exposure to RF fields do not alter the weight of evidence accumulated from previous research reviewed by scientific agencies indicating that RF fields at very low levels are not harmful. The NTP reports suggest potential adverse effects of short- and long-term exposure to RF at levels at or above historically-recognized thresholds for causing increases in body temperatures and adverse effects of RF exposure upon which exposure standards are based. Further, the results of the Ramazzini study are consistent with no effect of RF at exposure levels that are about 100-fold lower than those of the NTP study, a finding consistent with prior research.

Studies of Potential Health Effects Other Than Cancer

While cancer development was the primary focus of many studies related to RF exposure and potential health effects, an important body of literature has also accumulated on potential health effects other than cancer. The examined non-cancer health outcomes included, among others, neurocognitive effects, reproductive and developmental effects, various cardiovascular conditions and diseases, nervous system effects, and immunological effects. Epidemiologic and laboratory studies on potential non-cancer outcomes of RF exposure have been systematically and repeatedly reviewed (e.g., Ahlbom et al.; 2004, Feychting, 2005, 2011; AGNIR, 2012; SCENIHR, 2015). Overall, the scientific literature is not in support of a causal relationship between low-level RF exposure and any of the examined non-cancer health outcomes.

Studies Related to Non-Specific Symptoms and Hypersensitivity

Overall, the scientific literature does not establish a causal link between exposure to EMF, including RF fields, and any non-specific symptoms or "electromagnetic hypersensitivity." A number of studies investigated the potential relationship between exposure to RF fields and various non-specific symptoms. Many of these studies relied on self-reported exposures, cross-sectional designs, and small sample sizes. These studies contributed little, if any, insight to our understanding of the potential effects of RF fields. Over 40 experimental studies examined the relationship between exposure to either EMF or RF fields and electromagnetic hypersensitivity, also called idiopathic environmental intolerance attributed to EMF (IEI-EMF). The symptoms claimed to be associated with to IEI-EMF generally include dizziness, palpitations, skin itching, dry mouth, sleep disorders, and digestive problems. A number of the studies of IEI-EMF are limited because they did not utilize double-blinding techniques. A group of higher quality human experimental trials, epidemiologic studies, and field intervention studies that examined the occurrence of headache, dizziness, concentration problems, sleep disturbances, or fatigue due to RF-field exposure did not provide consistent evidence of increased occurrence of symptoms or symptom patterns with exposure (Danker-Hopfe et al., 2010; Heinrich et al., 2010, 2011; Mohler et al., 2010, 2012; Röösli et al., 2010; Röösli and Hug, 2011; Frei et al., 2012). Scientists recognize that a person's symptoms may be real, and in some cases severe, however, well-conducted provocation studies consistently demonstrate that those who reported RF sensitivity cannot differentiate between exposure and no exposure scenarios, and that the reported symptoms are not causally related to RF exposure (Röösli et al., 2010; Röösli and Hug, 2011; Rubin et al., 2011).

In its fact sheet on electromagnetic hypersensitivity, the WHO states that symptoms reported by individuals identified as having electromagnetic hypersensitivity are real and can be severe, but that "[w]ell controlled and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure." The WHO further states that "EHS [electromagnetic hypersensitivity] is not a medical diagnosis, nor is it clear that it represents a single medical problem," and that "[t]reatment of affected individuals should focus on the health symptoms and the clinical picture, and not on the person's perceived need for reducing or eliminating EMF in the workplace or home."[11] Correspondingly, the most recent revision of the WHO's International Classification of Diseases (10^{th} Revision)[12] does not include a specific category for electromagnetic hypersensitivity or IEI-EMF.

With respect to electromagnetic hypersensitivity, the most recent comprehensive review by SCENIHR (2015) concluded the following:

> Symptoms that are attributed by some people to various RF EMF exposure can sometimes cause serious impairments to a person's quality of life. However, research conducted since the previous SCENIHR Opinion adds weight to the conclusion that RF EMF exposure is not causally linked to these symptoms. This applies to the general public, children and adolescents, and to people with idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). Recent meta-analyses of observational and provocation data support this conclusion.

[11] https://www.who.int/peh-emf/publications/facts/fs296/en/

[12] https://icd.who.int/browse10/2010/en

Summary and Conclusion

A large body of scientific literature has accumulated over the past several decades about exposure to RF fields and potential health effects. This area has been extensively studied and the literature includes a variety of scientific studies, including epidemiologic studies of human populations, experimental studies of laboratory animals and humans (*in vivo* studies), and laboratory studies of cells and tissues (*in vitro* studies). As the WHO states, "scientific knowledge in this area is now more extensive than for most chemicals."[13] The WHO also notes that "[w]ith more and more research data available, it has become increasingly unlikely that exposure to electromagnetic fields constitutes a serious health hazard, nevertheless, some uncertainty remains." The available scientific literature has been periodically and repeatedly reviewed by multidisciplinary panels convened by a number of national and international governmental health and scientific agencies to evaluate the overall scientific evidence on whether RF EMF at levels typically encountered in our environment pose any risk to human health. None of these expert panels, including those assembled for example by ICNIRP, HPA, IARC, and SCENIHR, has concluded that low-level exposure to RF fields (i.e., exposure below currently existing scientifically-established guideline levels) causes any adverse health effects, including cancer or any other chronic diseases. The IARC evaluation (IARC, 2013) and the press release issued in relation to the announcement of their main findings (IARC, 2011) specifically noted that the evidence from studies of environmental exposures (i.e., RF sources with fixed location, such as radio and television antennae and mobile phone base stations) and cancer development was "judged inadequate" to suggest an association.

Evaluations of potential health effects of RF emissions specifically from smart meters conducted by multiple states in the United States and other governmental agencies all concluded that the available scientific evidence does not support a claim for the existence of any health effects as a result of exposure to RF fields from smart meters.

The estimated potential exposure to RF fields from smart meters at the Edwards residence is a small fraction of RF exposure from all other sources, and is well below internationally-accepted,

[13] http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html

scientifically-based exposure guidelines, such as those set by ICNIRP, ICES, and specifically by the FCC. These exposure levels are also well within the range that could be experienced in other households in the United States. According to Dr. Cotts's evaluation in his expert report filed in this case, the contribution of a typical Duquesne Light Company's smart meter to the Complainant's exposure indoors is less than the RF exposure from other existing sources and only 0.00077% (1/130,000th) of the FCC's health-based exposure limit.

Based on my knowledge and familiarity with the relevant scientific literature, including the relevant weight-of-evidence reviews conducted by a number of international multidisciplinary expert panels, and the case materials presented to me in relation to the Complaint filed with the Pennsylvania Public Utility Commission against Duquesne Light Company on behalf of Miranda Grace Edwards (*Edwards* matter), my opinions are as follows:

1. A causal relationship is not established between environmental exposure to RF fields, including RF fields specifically from smart meters owned and operated by Duquesne Light Company, and adverse human health effects, including cancers or non-cancer health outcomes, as claimed in the Complaint and other submissions by the Complainant.

2. Exposure to RF fields estimated in the Edwards residence as a result of the operation of smart meters or from other common sources found within or outside a typical residence does not have any proven adverse effect on health.

3. The materials included in the Complaint and other submissions by Ms. Edwards do not provide a basis to reach a valid scientific conclusion that low-level RF exposure, including the RF fields associated with the operation of smart meters, causes or contributes to the development of any adverse health effects, including cancer and non-cancer health outcomes.

4. Scientific research does not support the claim that exposure to RF fields from smart meters has any proven adverse effect on health, thus, there is no support to the claim that RF fields from smart meters would adversely affect the health of Ms. Edwards, or others at the Edwards residence.

My opinions are expressed herein to a reasonable degree of scientific and medical certainty. I reserve the right to revise my opinions as more information becomes available.

Limitations

At the request of counsel for Duquesne Light Company, Exponent prepared this report that provides an overview of the scientific literature on potential health effects of RF electromagnetic fields and evaluates whether exposure to RF fields from smart meters owned and operated by Duquesne Light Company near the residence of Ms. Edwards, presents any health risk to Ms. Edwards or others. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, and through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein for other purposes are at the sole risk of the user. My opinions are expressed herein to a reasonable degree of scientific certainty. I reserve the right to revise my opinion as more information becomes available.

References

Advisory Group on Non-ionising Radiation (AGNIR). Health Effects from Radiofrequency Electromagnetic Fields. Report of the Independent Advisory Group on Non-ionising Radiation. London, England: Health Protection Agency, 2012.

Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A, ICNIRP Standing Committee on Epidemiology. Epidemiology of health effects of radiofrequency exposure. Environ Health Perspect 112:1741-1754, 2004.

Arizona Department of Health Services (ADHS), Office of Environmental Health. Public Health Evaluation of Radio Frequency Exposure from Electronic Meters. October 1, 2014.

American Academy of Environmental Medicine (AAEM). Community Resource: AAEM Position Papers. Wichita, Kansas: American Academy of Environmental Medicine, 2012.

Armstrong B, Theriault G, Guenel P, Deadman J, Goldberg M, Heroux P. Association between exposure to pulsed electromagnetic fields and cancer in electric utility workers in Quebec, Canada, and France. Am J Epidemiol 140: 805-820, 1994.

Australian Centre for Radiofrequency Bioeffects Research (ACRBR). ACRBR Position Statement on BioInitiative Report. ACRBR, December 18, 2008.

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Smart Meters and Health. March 2015. https://www.arpansa.gov.au/understanding-radiation/radiation-sources/more-radiation-sources/smart-meters (Last accessed on April 18, 2018.)

Aydin D, Feychting M, Schüz J, Tynes T, Andersen TV, Schmidt LS, Poulsen AH, Johansen C, Prochazka M, Lannering B, Klaeboe L, Eggen T, Jenni D, Grotzer M, Von der Weid N, Kuehni CE, Röösli M. Mobile phone use and brain tumors in children and adolescents: a multicenter case-control study. J Natl Cancer Inst 103: 1264-1276, 2011.

Aydin D, Feychting M, Schüz J, Röösli M, Cefalo study team. Childhood brain tumours and use of mobile phones: comparison of a case-control study with incidence data. Environ Health 11: 35, 2012.

Benson VS, Pirie K, Schüz J, Reeves GK, Beral V, Green J. Authors' response to: The case of acoustic neuroma: comment on mobile phone use and risk of brain neoplasms and other cancers. Int J Epidemiol 43:275, 2013a.

Benson VS, Pirie K, Schüz J, Reeves GK, Beral V, Green J, Million Women Study Collaborators. Mobile phone use and risk of brain neoplasms and other cancers: prospective study. Int J Epidemiol 42: 792-802, 2013b.

Berg G, Spallek J, Schüz J, Schlehofer B, Böhler E, Schlaefer K, Hettinger I, Kunna-Grass K, Wahrendorf J, Blettner M; Interphone Study Group, Germany. Occupational exposure to radio frequency/microwave radiation and the risk of brain tumors: Interphone study group, Germany. Am J Epidemiol 164: 538-548, 2006.

BioInitiative Working Group (BIWG). Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation at www.bioinitiative.org. December 31, 2012. http://www.bioinitiative.org/report/wp-content/uploads/pdfs/BioInitiativeReport2012.pdf.

California Council on Science and Technology (CCST). Health Impacts of Radio Frequency Exposure from Smart Meters. Sacramento, California: California Council on Science and Technology, 2011.

Cardis E, Richardson L, Deltour I, Armstrong B, Feychting M, Johansen C, Kilkenny M, McKinney P, Modan B, Sadetzki S, Schüz J, Swerdlow A, Vrijheid M, Auvinen A, Berg G, Blettner M, Bowman J, Brown J, Chetrit A, Christensen HC, Cook A, Hepworth S, Giles G, Hours M, Iavarone I, Jarus-Hakak A, Klaeboe L, Krewski D, Lagorio S, Lonn S, Mann S, McBride M, Muir K, Nadon L, Parent ME, Pearce N, Salminen T, Schoemaker M, Schlehofer B, Siemiatycki J, Taki M, Takebayashi T, Tynes T, van Tongeren M, Vecchia P, Wiart J, Woodward A, Yamaguchi N. The INTERPHONE study: design, epidemiological methods, and description of the study population. Eur J Epidemiol 22: 647-664, 2007.

Cardis E, Armstrong BK, Bowman JD, Giles GG, Hours M, Krewski D, McBride M, Parent ME, Sadetzki S, Woodward A, Brown J, Chetrit A, Figuerola J, Hoffmann C, Jarus-Hakak A, Montestruq L, Nadon L, Richardson L, Villegas R, Vrijheid M. Risk of brain tumours in relation to estimated RF dose from mobile phones: results from five Interphone countries. Occup Environ Med 68: 631-640, 2011.

Code of Federal Regulations (CFR). Title 47 Telecommunication, Volume 1, §1.1310 - Radiofrequency radiation exposure limits, pp. 319-321. Washington DC: Office of the Federal Register National Archives and Records Administration as a Special Edition of the Federal Register, As of October 1, 2013. https://www.gpo.gov/fdsys/pkg/CFR-2013-title47-vol1/pdf/CFR-2013-title47-vol1.pdf

Colorado Department of Public Health and Environment (CDPHE). Fact Sheet on Smart Meters and Associated Health Concerns. Denver, Colorado: Colorado Department of Public Health and Environment, 2012.

Committee on Man and Radiation (COMAR). COMAR technical information statement: expert reviews on potential health effects of radiofrequency electromagnetic fields and comments on the Bioinitiative Report. Health Phys 97:348-356, 2009.

Cook A, Woodward A, Pearce N, Marshall C. Cellular telephone use and time trends for brain, head and neck tumours. N Z Med J 116: U457, 2003.

Cooper D, Hemming K, Saunders P. Re: "Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter; II. All high power transmitters." Am J Epidemiol 153: 202-204, 2001.

D'Andrea JA. Behavioral effects of microwave irradiation. Bioelectromagnetics 20: 64-74, 1999.

Danker-Hopfe H, Dorn H, Bornkessel C, Sauter C. Do mobile phone base stations affect sleep of residents? Results from an experimental double-blind sham-controlled field study. Am J Hum Biol 22: 613-618, 2010.

de Vocht F. Analyses of temporal and spatial patterns of glioblastoma multiforme and other brain cancer subtypes in relation to mobile phones using synthetic counterfactuals. Environ Res 168:329-335, 2019.

de Vocht F, Burstyn I, Cherrie JW. Time trends (1998-2007) in brain cancer incidence rates in relation to mobile phone use in England. Bioelectromagnetics 32: 334-339, 2011.

Deltour I, Johansen C, Auvinen A, Feychting M, Klaeboe L, Schüz J. Time trends in brain tumor incidence rates in Denmark, Finland, Norway, and Sweden, 1974-2003. J Natl Cancer Inst 101: 1721-1724, 2009.

Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliott P. Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter. Am J Epidemiology 145:1-9, 1997a.

Dolk H, Elliott P, Shaddick G, Walls P, Thakrar B. Cancer incidence near radio and television transmitters in Great Britain. II. All high power transmitters. Am J Epidemiol 145:10-17, 1997b.

Electric Power Research Institute (EPRI). Comments: A Perspective on Two Smart Meter Memoranda - EMF and RF Health Assessment and Safety. Comment 1024952. Palo Alto, CA: EPRI, February 2012.

Elliott P, Toledano MB, Bennett J, Beale L, de Hoogh K, Best N, Briggs DJ. Mobile phone base stations and early childhood cancers: case-control study. BMJ 340: c3077, 2010.

EMF-NET Coordination Action – The Steering Committee (EMF-NET). Comments on the BioInitiative Working Group Report (BioInitiative Report). European Commission, 2007.

Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, Mandrioli D, Manservigi M, Manservisi F, Manzoli I, Menghetti I, Montella R, Panzacchi S, Sgargi D, Strollo V, Vornoli A, Belpoggi F. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Environ Res 165:496-503, 2018.

Federal Communications Commission (FCC). Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Edition 97-01, OET Bulletin 65. Washington, D.C.: Federal Communications Commission, 1997.

Federal Communications Commission (FCC). Chairman Pai Proposed to Maintain Current Radiofrequency Exposure Safety Standards. August 8, 2019. https://docs.fcc.gov/public/attachments/DOC-358968A1.pdf

Federal Judicial Center and National Research Council (FJC-NRC). Reference Manual on Scientific Evidence. Washington, DC: National Academies Press, 2011.

Feychting M. Non-cancer EMF effects related to children. Bioelectromagnetics Suppl 7:S69-S74, 2005.

Feychting M. Mobile phones, radiofrequency fields, and health effects in children--epidemiological studies. Prog Biophys Mol Biol 107:343-348, 2011.

Finkelstein MM. Cancer incidence among Ontario police officers. Am J Ind Med 24:157-162, 1998.

Food and Drug Administration (FDA). Statement from Jeffrey Shuren, M.D., J.D., Director of the FDA's Center for Devices and Radiological Health on the National Toxicology Program's report on radiofrequency energy exposure. November 1, 2018. https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm624809.htm

Frei P, Poulsen AH, Johansen C, Olsen JH, Steding-Jessen M, Schüz J. Use of mobile phones and risk of brain tumours: update of Danish cohort study. BMJ 343: d6387, 2011.

Frei P, Mohler E, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M, team Q. Cohort study on the effects of everyday life radio frequency electromagnetic field exposure on non-specific symptoms and tinnitus. Environ Int 38: 29-36, 2012.

Garland FC, Shaw E, Gorham ED et al. Incidence of leukemia in occupations with potential electromagnetic field exposure in United States Navy personnel. Am J Epidemiol 132: 293-303, 1990.

Gift JS, Caldwell JC, Jinot J, Evans MV, Cote I, Vandenberg JJ. Scientific considerations for evaluating cancer bioassays conducted by the Ramazzini Institute. Environ Health Perspect 121: 1253-1263, 2013.

Groves FD, Page WF, Gridley G, Lisimaque L, Stewart PA, Tarone RE, Gail MH, Boice JD, Jr., Beebe GW. Cancer in Korean War navy technicians: mortality survey after 40 years. Am J Epidemiol 155: 810-818, 2002.

Ha M, Im H, Lee M, Kim HJ, Kim BC, Gimm YM, Pack JK. Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer. Am J Epidemiol 166: 270-279, 2007.

Ha M, Im H, Kim B-C, Gimm Y-M, Pack J-K. Five authors reply. Am J Epidemiol 167: 884-885, 2008.

Hardell L, Nasman A, Pahlson A, Hallquist A, Hansson Mild K. Use of cellular telephones and the risk for brain tumours: A case-control study. Int J Oncol 15: 113-116, 1999.

Hardell L, Carlberg M, Soderqvist F, Mild KH. Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones. Int J Oncol 43: 1036-1044, 2013.

Hauri DD, Spycher B, Huss A, Zimmerman F, Grotzer M, von der Weid N, Spoerri A, Kuehni CE, Röösli M for the Swiss National Cohort and the Swiss Paediatric Oncology Group. Exposure to radio-frequency electromagnetic fields from broadcast transmitters and risk of childhood cancer: a census-based cohort study. Am J Epidemiol 179: 843-851, 2014.

Health Canada. Smart Meters. December 2011. https://www.canada.ca/en/health-canada/services/healthy-living/your-health/products/smart-meters.html (Last accessed on April 18, 2018.)

Health Council of the Netherlands (HCN). BioInitiative Report (U-5601/EvR/iv/673-L1 Publication nr 2008/17E). The Hague: HCN, 2008.

Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study. Environ Health 9:75, 2010.

Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. The impact of exposure to radio frequency electromagnetic fields on chronic well-being in young people--a cross-sectional study based on personal dosimetry. Environ Int 37:26-30, 2011.

Hill AB. The Environment and Disease: Association or Causation? Proc R Soc Med 58:295-300, 1965.

Hocking B, Gordon IR, Grain HL, Hatfield GE. Cancer incidence and mortality and proximity to TV towers. Med J Aust 165:601-605, 1996.

Hooijmans CR, Rovers MM, de Vries RB, Leenaars M, Ritskes-Hoitinga M, Langendam MW. SYRCLE's risk of bias tool for animal studies. BMC Med Res Methodol doi: 10.1186/1471-2288-14-43, 2014.

Inskip PD, Tarone RE, Hatch EE, Wilcosky TC, Shapiro WR, Selker RG, Fine HA, Black PM, Loeffler JS, Linet MS. Cellular-telephone use and brain tumors. NEJM 344:79-86, 2001.

Inskip PD, Hoover RN, Devesa SS. Brain cancer incidence trends in relation to cellular telephone use in the United States. Neuro Oncol 12:1147-1151, 2010.

Institute of Electrical and Electronics Engineers (IEEE), IEEE Standard for Safety Levels with

Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. New York, NY: IEEE, 2005.

International Agency for Research on Cancer (IARC). Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields – Volume 102. Lyon, France: IARC, 2013.

International Agency for Research on Cancer (IARC). IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans. Press Release No. 208, May 31, 2011. http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494-522, 1998.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz-300 GHz). Oberschleißheim, Germany: ICNIRP, 2009.

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 102. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. Lyon, France: IARC, 2013.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Note on Recent Animal Carcinogenesis Studies. April 9, 2018. https://www.icnirp.org/cms/upload/publications/ICNIRPnote2018.pdf

Interphone Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidemiol 39:675-694, 2010.

Interphone Study Group. Acoustic neuroma risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Cancer Epidemiol 35:453-464, 2011.

Karipidis KK, Benke G, Sim R. Occupational exposure to ionizing and non-ionizing radiation and risk of glioma. Occup Med 57:518-524, 2007a.

Karipidis KK, Benke G, Sim R, Kauppinen T, Kricker A, Hughes AM, Grulich AE, Vajdic CM, Kaldor J, Armstrong B, Fritschi L. Occupational exposure to ionizing and non-ionizing radiation and risk of non-Hodgkin lymphoma. Int Arch Occup Environ Health 80:663-670, 2007b.

Karipidis K, Elwood M, Benke G, Sanagou M, Tjong L, Croft RJ. Mobile phone use and incidence of brain tumour histological types, grading or anatomical location: a population-based ecological study. BMJ Open 8:e024489, 2018.

Lawrence Berkeley National Laboratory (LBNL). Review of the April 12, 2012 American Academy of Environmental Medicine (AAEM) submittal to the Michigan Public Service Commission. LBNL, 2012.

Li CY, Liu CC, Chang YH, Chou LP, Ko MC. A population-based case-control study of radiofrequency exposure in relation to childhood neoplasm. Sci Total Environ 435-436:472-478, 2012.

Lonn S, Ahlbom A, Hall P, Feychting M, Swedish Interphone Study G. Long-term mobile phone use and brain tumor risk. Am J Epidemiol 161:526-535, 2005.

Maine Center for Disease Control & Prevention (MCDC). Maine CDC Executive Summary of Review of Health Issues Related to Smart Meters. Augusta, Maine: Maine Center for Disease Control & Prevention, Division of Environmental Health, Maine Department of Health and Human Services, 2010.

McKean-Cowdin R, Razavi P, Barrington-Trimis J, Baldwin RT, Asgharzadeh S, Cockburn M, Tihan T, Preston-Martin S. Trends in childhood brain tumor incidence, 1973-2009. J Neurooncol 115:153-160, 2013.

McKenzie DR, Yin Y, Morrell S. Childhood incidence of acute lymphoblastic leukaemia and exposure to broadcast radiation in Sydney--a second look. Aust N Z J Public Health 22:360-367, 1998.

Merzenich H, Schmiedel S, Bennack S, Bruggemeyer H, Philipp J, Blettner M, Schüz J. Childhood leukemia in relation to radio frequency electromagnetic fields in the vicinity of TV and radio broadcast transmitters. Am J Epidemiol 168:1169-1178, 2008.

Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A, Perucci CA. Adult and childhood leukemia near a high-power radio station in Rome, Italy. Am J Epidemiol 155:1096-1103, 2002.

Michigan Public Service Commission (MPSC). U-17000 Report to the Commission. Lansing, Michigan: Michigan Public Service Commission, 2012.

Milham S. Silent keys: leukaemia mortality in amateur radio operators (letter). Lancet 1:812, 1985.

Mohler E, Frei P, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M, Qualifex T. Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: a cross-sectional study. Radiat Res 174:347-356, 2010.

Mohler E, Frei P, Fröhlich J, Braun-Fahrländer C, Röösli M, Qualifex team. Exposure to radiofrequency electromagnetic fields and sleep quality: a prospective cohort study. PLoS One 7:e37455, 2012.

Morgan RW, Kelsh MA, Zhao K, Exuzides KA, Heringer S, Negrete W. Radiofrequency exposure and mortality from cancer of the brain and lymphatic/hematopoietic systems. Epidemiology 11: 118-127, 2000.

Muscat JE, Malkin MG, Thompson S, Shore RE, Stellman SD, McRee D, Neugut AI, Wynder EL. Handheld cellular telephone use and risk of brain cancer. JAMA 284:3001-3007, 2000.

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Draft Report for Peer Review. Research Triangle Park, NC: NTP, 2018a. https://ntp.niehs.nih.gov/ntp/about_ntp/trpanel/2018/march/tr595peerdraft.pdf

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in B6C3F1/N Mice Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Draft Report for Peer Review. Research Triangle Park, NC: NTP, 2018b. https://ntp.niehs.nih.gov/ntp/about_ntp/trpanel/2018/march/tr596peerdraft.pdf

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018c. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr595_508.pdf

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in B6C3F1/N Mice Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018d. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr596_508.pdf

Natukka T, Raitanen J, Haapasalo H, Auvinen A. Incidence trends of adult malignant brain tumors in Finland, 1990-2016. Acta Oncol 58:990-996, 2019.

Nilsson J, Jaras J, Henriksson R, Holgersson G, Bergstrom S, Estenberg J, Augustsson T, Bergqvist M. No Evidence for Increased Brain Tumour Incidence in the Swedish National Cancer Register Between Years 1980-2012. Anticancer Res 39:791-796, 2019.

North Carolina Department of Health and Human Services (NCDHHS), Division of Public Health, Occupational and Environmental Epidemiology Branch, Health Impacts of Advanced Metering Systems (Smart Meters). August 24, 2015.

Olsson A, Bouaoun L, Auvinen A, Feychting M, Johansen C, Mathiesen T, Melin B, Lahkola A, Larjavaara S, Villegier AS, Byrnes G, Deltour I, Schuz J. Survival of glioma patients in relation to mobile phone use in Denmark, Finland and Sweden. J Neurooncol 141:139-149, 2019.

Oregon Health Authority (OHA). Letter of July 17, 2012, to Roger Gray, General Manager, Eugene Water & Electric Board, from Katrina Hedberg, MD, MPH, State Epidemiologist, Oregon Public Health Division. Portland, OR: Oregon Health Authority, 2012.

Park SK, Ha M, Im H-J. Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. Int Arch Occup Environ Health 77:387-394, 2004.

Philips A, Henshaw DL, Lamburn G, O'Carroll MJ. Brain tumours: rise in Glioblastoma Multiforme incidence in England 1995-2015 suggests an adverse environmental or lifestyle factor. J Environ Pub Health, 2018. doi: 10.1155/2018/7910754. Available at https://www.hindawi.com/journals/jeph/aip/7910754/

Public Health England. Smart Meters: Radio Waves and Health. https://www.gov.uk/government/publications/smart-meters-radio-waves-and-health/smart-meters-radio-waves-and-health#exposures-from-smart-meters, June 2017. (Last accessed on April 18, 2018.)

Public Utility Commission of Texas (PUCT). Health and RF EMF from Advanced Meters. An Overview of Recent Investigations and Analyses. Austin, TX: Public Utility Commission of Texas, Infrastructure & Reliability Division, 2012.

Public Utility Commission of Texas (PUCT). Rulemaking Related to Advance Metering Alternatives. Order Adopting New §25.133 and Amendment to §25.214 as Approved at the August 9, 2013 Open Meeting, 2013.

Röösli M, Michel G, Kuehni CE, Spoerri A. Cellular telephone use and time trends in brain tumour mortality in Switzerland from 1969 to 2002. Eur J Cancer Prev 16:77-82, 2007.

Röösli M, Frei P, Mohler E, Hug K. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. Bull World Health Organ 88:887-896F, 2010.

Röösli M and Hug K. Wireless communication fields and non-specific symptoms of ill health: a literature review. Wien Med Wochenschr 161:240-250, 2011.

Röösli M, Lagorio S, Schoemaker MJ, Schuz J, Feychting M. Brain and Salivary Gland Tumors and Mobile Phone Use: Evaluating the Evidence from Various Epidemiological Study Designs. Annu Rev Public Health. 40:221–38, 2019.

Rubin GJ, Hillert L, Nieto-Hernandez R, van Rongen E, Oftedal G. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? A systematic review of provocation studies. Bioelectromagnetics 32:593-609, 2011.

Schüz J, Jacobsen R, Olsen JH, Boice JD, Jr., McLaughlin JK, Johansen C. Cellular telephone use and cancer risk: update of a nationwide Danish cohort. J Natl Cancer Inst 98:1707-1713, 2006.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Potential Health Effects of Exposure to Electromagnetic Fields (EMF). Brussels, Belgium: Scientific Committee on Emerging and Newly Identified Health Risks, 2015.

Shibui S. [The present status and trend of brain tumors based on the data of the Brain Tumor Registry of Japan]. Brain Nerve 64:286-290, 2012.

Stang A, Anastassiou G, Ahrens W, Bromen K, Bronfeld N, Jockel KH. The possible role of radiofrequency radiation in the development of uveal melanoma. Epidemiology 12:7-12, 2001.

Swiss Federal Office of the Environment (BERENIS). Newsletter of the Swiss expert group on electromagnetic fields and non-ionising radiation. Evaluation of the NTP and Ramazzini studies. Special Issue November 2018.

Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. Sci Total Environ 180:9-17, 1996.

Szmigielski S, Sobiczewska E, Kubacki R. Carcinogenic potency of microwave radiation: Overview of the problem and results of epidemiological studies on Polish military personnel. Eur J Onol 6:193-199, 2001.

Toledano MB, Auvinen A, Tettamanti G, Cao Y, Feychting M, Ahlbom A, Fremling K, Heinavaara S, Kojo K, Knowles G, Smith RB, Schüz J, Johansen C, Poulsen AH, Deltour I, Vermeulen R, Kromhout H, Elliott P, Hillert L. An international prospective cohort study of mobile phone users and health (COSMOS): Factors affecting validity of self-reported mobile use phone. Int J Hyg Environ Health 221:1-8, 2018.

U.S. Environmental Protection Agency (USEPA). Update on Ramazzini Institute Data in IRIS Assessments. USEPA, 2013. https://www.epa.gov/iris/update-ramazzini-institute-data-iris-assessments.

Vermont Department of Health/Vermont Public Service Department (VDH/VPSD). Radio Frequency Radiation and Health: Smart Meters Montpelier, Vermont: Vermont Department of Health, 2012.

Vila J, Turner MC, Gracia-Lavedan E, Figuerola J, Bowman JD, Kincl L, Richardson L, Benke G, Hours M, Krewski D, McLean D, Parent ME, Sadetzki S, Schlaefer K, Schlehofer B, Schuz J, Siemiatycki J, van Tongeren M, Cardis E. Occupational exposure to high-frequency electromagnetic fields and brain tumor risk in the INTEROCC study: An individualized assessment approach. Environ Int 119: 353-365, 2018.

Vrijheid M, Armstrong BK, Bedard D, Brown J, Deltour I, Iavarone I, Kewski D, Lagorio S, Moore S, Richardson L, Giles GG, McBride M, Parent M-E, Siemiatycki J, Cardis E. Recall bias in the assessment of exposure to mobile phones. J Exp Sci Environ Epidemiol 19:369-381, 2009.

Exponent®
Engineering & Scientific Consulting

Gabor Mezei, M.D., Ph.D.

Senior Managing Scientist | Health Sciences
149 Commonwealth Drive | Menlo Park, CA 94025
(650) 688-7341 tel | gmezei@exponent.com

Professional Profile

Dr. Mezei is a physician and epidemiologist with over 25 years of experience in research of clinical outcomes and environmental and occupational health issues. He designed, conducted and evaluated epidemiologic investigations and directed multidisciplinary research programs related to children's health (including childhood leukemia and brain cancer), adult cancers (e.g., leukemia, brain and breast cancer), neurodegenerative diseases (e.g., Alzheimer disease and amyotrophic lateral sclerosis [Lou Gehrig disease]), reproductive health outcomes (including birth defects), occupational injuries and ergonomics. He has been involved in studies of various occupational and environmental exposures, including electromagnetic fields (EMF), mineral fibers (asbestos), air pollutants and metals (welding fumes).

Dr. Mezei has expertise and experience in quantitatively and qualitatively aggregating epidemiologic evidence (via literature reviews, meta-analyses, and pooled analyses) for environmental and occupational risk assessments. Dr. Mezei appeared as an expert in hearings at several state (US) and provincial (Canada) public utility commissions and a parliamentary committee in Ireland.

Prior to joining Exponent, Dr. Mezei directed a multidisciplinary scientific research program at the Electric Power Research Institute designated to address potential human and animal health effects associated with residential and occupational exposure to power frequency and radiofrequency EMF. He also directed occupational health and safety research focusing on injury surveillance, ergonomics evaluations, and occupational exposure assessments. Earlier, at the Toronto Western Hospital, University of Toronto, he conducted research to identify clinical factors affecting hospital stay, adverse clinical and surgical outcomes and hospital readmissions following ambulatory surgery. He was a practicing physician at the National Institute for Dermatology in Budapest, Hungary.

Dr. Mezei trained as a physician (M.D.) at the Semmelweis University of Medicine in Budapest, Hungary, and as an epidemiologist (Ph.D.) at the School of Public Health of the University of California in Los Angeles (UCLA). He was the recipient of Fogarty and Fulbright Fellowships. He served as an affiliate associate professor in the Department of Environmental and Occupational Health Sciences of the University of Washington in Seattle, Washington, as a visiting scientist at the Hungarian National Research Institute for Radiobiology and Radiohygiene in Budapest, Hungary, and as an associate editor at the Journal of Exposure Science and Environmental Epidemiology. Dr. Mezei lectured at Stanford University, the UCLA School of Public Health, and the Electrotechnical Committee of the Hungarian Academy of Sciences. Dr. Mezei is an author or co-author of over 60 scientific publications and book chapters on topics related to the epidemiology of environmental and occupational exposures and chronic diseases (such as cancer and neurodegenerative diseases), adverse clinical outcomes, and environmental exposure assessment.

EXHIBIT H-1

Academic Credentials & Professional Honors

Ph.D., Epidemiology, University of California, Los Angeles (UCLA), 1995

M.D., Medicine, Semmelweis University of Medicine, 1990

Fogarty Fellowship, 1992-1995

Fulbright Fellowship, 1994-1995

Languages

Hungarian

Publications

Mezei G, Chang ET, Mowat FS, Moolgavkar SH. 2019. Comments on Vimercati et al., 2019, "Asbestos exposure and malignant mesothelioma of the tunica vaginalis testis: a systematic review and the experience of the Apulia (southern Italy) mesothelioma register". Environmental Health 2019; 18:111.

Mezei G, Chang ET, Mowat FS, Moolgavkar SH. 2017. Epidemiology of mesothelioma of the pericardium and tunica vaginalis testis. Ann Epidemiol 27(5):348-359. With erratum; Ann Epidemiol 2018;28(63).

Volberg V, Fordyce T, Leonhard M, Mezei G, Vergara X, Krishen L. Injuries among electric power industry workers, 1995-2013. J Safety Res 2017 Feb; 60:9-16.

Lewis RC, Minguez-Alarcon L, Meeker JD, Williams PL, Mezei G, Ford JB, Hauser R. Self-reported mobile phone use and semen parameters among men from a fertility clinic. Reproductive Toxicology 2017; 67: 42-47. (E-pub: November 9, 2016)

Fordyce TA, Leonhard MJ, Watson HN, Mezei G, Vergara XP, Krishen L. An analysis of fatal and non-fatal injuries and injury severity factors among electric power industry workers. American Journal of Industrial Medicine 2016; 59 (11): 948-958. (E-pub: June 27, 2016)

Tell RA, Hooper HC, Sias GG, Mezei G, Hung P, Kavet R. Electromagnetic field associated with commercial solar photovoltaic electric power generating facilities. Journal of Occupational and Environmental Hygiene 2015; 12 (11): 795-803.

Oksuzyan S, Crespi CM, Cockburn M, Mezei G, Vergara X, Kheifets L. Race/ethnicity and childhood leukemia: a case-control study in California. Journal of Epidemiology and Community Health 2015; 69 (8): 795-802. (E-pub: March 19, 2015)

Kheifets L, Crespi C, Hooper C, Oksuzyan S, Cockburn M, Ly T, Mezei G. Epidemiologic study of residential proximity to transmission lines and childhood cancer in California: Description of design, epidemiologic methods and study population. Journal of Exposure Science and Environmental Epidemiology 2015; 25(1):45-52.

Vergara X, Kheifets L, Mezei G. Case-control study of occupational exposure to electric shocks and magnetic fields and mortality from amyotrophic lateral sclerosis in the U.S., 1991-1999. Journal of Exposure Science and Environmental Epidemiology 2015; 25(1):65-71.

Mezei G, Sudan M, Izraeli S, Kheifets L. Epidemiology of childhood leukemia in the presence and absence of Down syndrome. Cancer Epidemiology 2014; 38(5):479-489.

Slusky DA, Does M, Metayer C, Mezei G, Kavet R, Selvin S, Buffler PA. Potential role of selection bias in

the association between childhood leukemia and residential magnetic field exposure: a population-based assessment. Cancer Epidemiology 2014; 38(3):307-313.

Souques M, Plante M, Ostiguy G, Goulet D, Deschamps F, Mezei G, Modolo J, Lambrozo J, Legros A. Anecdotal report of magnetophosphene perception in 50 mT 20, 50 and 60 Hz magnetic fields. Radioprotection 2014; 49(1):69-71.Okokon E, Roivainen P, Kheifets L, Mezei G, Juutilainen J. Indoor transformer stations and ELF magnetic field exposure: use of transformer structural characteristics to improve exposure assessment. Journal of Exposure Science and Environmental Epidemiology 2014; 24(1):100-104.

Frei P, Poulsen AH, Mezei G, Pedersen C, Salem LC, Johansen C, Roosli M, Schuz J. Residential distance to high voltage power lines and risk of neurodegenerative diseases: A Danish population-based case-control study. American Journal of Epidemiology, 2013; 177(9):970-978.

Tell RA, Kavet R, Mezei G. Characterization of radiofrequency field emissions from smart meters. Journal of Exposure Science and Environmental Epidemiology 2013; 23 (5):549-553.

Vergara X, Kheifets L, Oksuzyan S, Cho YS, Mezei G. Occupational exposure to extremely low frequency magnetic fields and neurodegenerative diseases: A meta-analysis. Journal of Occupational and Environmental Medicine 2013; 55(2):135-146.

Oksuzyan S, Crespi CM, Cockburn M, Mezei G, Kheifets L. Birth weight and other perinatal factors and childhood CNS tumors: A case-control study in California. Cancer Epidemiology 2013; 37(4):402-409.

Schüz J, Grell K, Kinsey S, Linet MS, Link MP, Mezei G, Pollock BH, Roman E, Zhang Y, McBride MN, Johansen C, Spix C, Hagihara J, Saito AM, Simpson J, Robison LR, Dockerty JD, Feychting M, Kheifets L, Frederiksen K. Extremely low frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: An international follow up study. Blood Cancer Journal 2012; 2: e98.

Oksuzyan S, Crespi CM, Cockburn M, Mezei G, Kheifets L. Birth weight and other perinatal characteristics and childhood leukemia in California. Cancer Epidemiology 2012; 36: e359-e365.

Tell RA, Sias GG, Vazquez A, Sahl J, Turman JP, Kavet RI, Mezei G. Radiofrequency fields associated with the Itron smart meter. Radiation Protection Dosimetry 2012; 151(1):17-29.

Hicks JB, McCarthy SA, Mezei G, Sayes CM. PM1 particles at coal- and gas-fired power plant work areas. Annals of Occupational Hygiene 2012; 56(2):182-193.

Slusky DA, Mezei G, Metayer C, Selvin S, Von Behren J, Buffler PA. Comparison of racial differences in childhood cancer risk in case-control studies and population-based cancer registries. Cancer Epidemiology 2012; 36(1):36-44.

Roosli M, Jenni D, Kheifets L, Mezei G. Extremely low frequency magnetic field measurements in buildings with transformer stations in Switzerland. Science of the Total Environment 2011; 409(18):3364-3369.

Stone A, Marklin R, Seeley P, Mezei G. A collaborative effort to apply ergonomics to electric utility workers at generating stations. WORK: A Journal of Prevention Assessment and Rehabilitation 2011; 39(2):103-111.

Kheifets L, Ahlbom A, Crespi CM, Feychting M, Johansen C, Monroe J, Murphy M, Oksuzyan S, Preston-Martin S, Roman E, Saito T, Savitz D, Schüz J, Simpson J, Swanson J, Tynes T, Verkasalo P, Mezei G. A pooled analysis of extremely low frequency magnetic fields and childhood brain tumors. American Journal of Epidemiology 2010; 172(7):752-761.

EXHIBIT H-1

Hareuveny R, Kandel S, Yitzhak NM, Kheifets L, Mezei G. Exposure to 50 Hz magnetic fields in apartment buildings with indoor transformer stations in Israel. Journal of Exposure Science and Environmental Epidemiology 2011; 21(4):365-371.

Fordyce TA, Morimoto L, Coalson J, Kelsh M, Mezei G. Neck injuries among electric utility workers, 1995-2007. Journal of Occupational and Environmental Medicine 2010; 52(4):441-449.

Kheifets L, Ahlbom A, Crespi CM, Draper G, Hagihara J, Lowenthal RM, Mezei G, Oksuzyan S, Schüz J, Swanson J, Tittarelli A, Vinceti M, Wunsch Filho V. Pooled analysis of recent studies of magnetic fields and childhood leukemia. British Journal of Cancer 2010; 103(7):1128-1135.

Mezei G, Gadallah M, Kheifets L. Residential magnetic field exposure and childhood brain cancer: a meta-analysis. Epidemiology 2008; 19(3):424-430.

Mezei G, Spinelli JJ, Wong P, Borugian M, McBride ML. Assessment of selection bias in the Canadian case-control study of residential magnetic field exposure and childhood leukemia. American Journal of Epidemiology 2008; 167(12):1504-1510.

Kheifets L, Monroe J, Vergara X, Mezei G, Afifi AA. Occupational EMF and leukemia and brain cancer: An update to two meta-analyses. Journal of Occupational and Environmental Medicine 2008; 50(6):677-688.

Thuroczy G, Janossy G, Nagy N, Bakos J, Szabo J, Mezei G. Exposure to 50 Hz magnetic fields in apartment buildings with built-in transformer stations in Hungary. Radiation Protection Dosimetry 2008; 131(4):469-473.

Ilonen K, Markkanen A, Mezei G, Juutilainen J. Indoor transformer stations as predictors of residential ELF magnetic field exposure. Bioëlectromagnetics 2008; 29(3):213-218.

Kheifets L, Bowman JD, Checkoway H, Feychting M, Harrington M, Kavet R, Marsh G, Mezei G, Renew D, van Wijngaarden E. Future needs of occupational epidemiology of extremely low frequency (ELF) electric and magnetic fields (EMF): Review and recommendations. Occupational and Environmental Medicine 2009; 66(2):72-80.

Li CY, Mezei G, Sung FC, Silva M, Chen PC, Lee PC, Chen LM. Survey of residential extremely-low-frequency magnetic field exposure among children in Taiwan. Environment International 2007; 33(2):233-238.

Li CY, Sung FC, Chen FL, Lee PC, Silva M, Mezei G. Extremely-low-frequency magnetic field exposure of children at schools near high voltage transmission lines. Science of the Total Environment 2007; 376(1-3):151-159.

Mezei G, Benyi M, Muller A. Mobile phone ownership and use among school children in three Hungarian cities. Bioelectromagnetics 2007; 28(4):309-315.

Li CY, Mezei G, Sung FC, Silva M, Lee PC, Chen PC, Chen LM. Assessment of nonresponse bias in a survey of residential magnetic field exposure in Taiwan. Bioelectromagnetics 2007; 28(5):340-348.

Schuz J, Svendsen AL, Linet MS, McBride ML, Roman E, Feychting M, Kheifets L, Lightfoot T, Mezei G, Simpson J, Ahlbom A. Nighttime exposure to electromagnetic fields and childhood leukemia. An extended pooled analysis. American Journal of Epidemiology 2007; 166(3):263-269.

Foliart DE, Mezei G, Iriye R, Silva JM, Ebi KL, Kheifets L, Link MP, Kavet R, Pollock BH. Magnetic field exposure and prognostic factors in childhood leukemia. Bioelectromagnetics 2007; 28(1):69-71.

Foliart DE, Pollock BH, Mezei G, Iriye R, Silva JM, Ebi KL, Kheifets L, Link MP, Kavet R. Magnetic field exposure and long-term survival among children with leukemia. British Journal of Cancer 2006; 94(1):161-164. (Corrigendum. British Journal of Cancer 2006; 94(6):940).

Savitz DA, Herring AH, Mezei G, Evenson KR, Terry JW, Kavet R. Physical activity and magnetic field exposure in pregnancy. Epidemiology 2006; 17(2):222-225.

Mezei G, Kheifets L. Selection bias and its implications for case-control studies: a case study of magnetic field exposure and childhood leukemia. International Journal of Epidemiology 2006; 35(2):397-406.

Poole C, Greenland S, Luetters C, Kelsey JL, Mezei G. Socioeconomic status and childhood leukemia: A review. International Journal of Epidemiology 2006; 35(2):370-384.

Mezei G, Borugian MJ, Spinelli JJ, Wilkins R, Abanto Z, McBride ML. Socioeconomic status and childhood solid tumor and lymphoma incidence in Canada. American Journal of Epidemiology 2006; 164(2):170-175.

Szabo J, Mezei K, Thuroczy G, Mezei G. Occupational 50 Hz magnetic field exposure measurements among female sewing machine operators in Hungary. Bioelectromagnetics 2006; 27(6):451-457.

Kheifets L, Mezei G, Greenland S. Comment concerning "Childhood leukemia and residential magnetic fields: Are pooled analyses more valid than the original studies?" Bioelectromagnetics 2006; 27(8):674-675.

Mezei G, Bracken TD, Senior R, Kavet R. Analyses of magnetic-field peak-exposure summary measures. Journal of Exposure Science and Environmental Epidemiology 2006; 16(6):477-485.

Borugian MJ, Spinelli JJ, Mezei G, Wilkins R, Abanto Z, McBride ML. Childhood leukemia and socioeconomic status in Canada. Epidemiology 2005; 16(4):526-531.

Mezei G, Cher D, Kelsh M, Edinboro C, Chapman P, Kavet R. Occupational magnetic field exposure, cardiovascular disease mortality and potential confounding by smoking. Annals of Epidemiology 2005; 15(8):622-629.

Forssen UM, Mezei G, Nise G, Feychting M. Occupational magnetic field exposure among women in Stockholm County, Sweden. Occupational and Environmental Medicine 2004; 61(7):594-602.

Mezei G, Kavet R. Power frequency magnetic field exposure and childhood leukemia — Epidemiologic evidence and research perspectives. Central European Journal of Occupational and Environmental Medicine 2004; 10(2):115-126.

Tong D, Wong J, Chung F, Friedlander M, Bremang J, Mezei G, Streiner D. Prospective study on incidence and functional impact of transient neurologic symptoms associated with 1% vs 5% hyperbaric lidocaine in short urologic procedures. Anesthesiology 2003; 98(2):485-494.

Higgins PP, Chung F, Mezei G. Postoperative sore throat after ambulatory surgery. British Journal of Anaesthesia 2002; 88(4):582-584.

Foliart DE, Iriye RN, Silva JM, Mezei G, Tarr KJ, Ebi KL. Correlation of year-to-year magnetic field exposure metrics among children in a leukemia survival study. Journal of Exposure Analysis and Environmental Epidemiology 2002; 12(6):441-447.

Sahl J, Mezei G, Kavet R, McMillan A, Silvers A, Sastre A, Kheifets L. Occupational magnetic field exposure and cardiovascular mortality in a cohort of electric utility workers. American Journal of Epidemiology 2002; 156(10):913-918.

Mezei G, Kheifets LI. Clues to the possible viral etiology of childhood leukemia. Technology 2002; 9(1-2):3-14.

Mezei G, Kheifets LI, Nelson LM, Mills KM, Iriye R, Kelsey JL. Household appliance use and residential exposure to 60-Hz magnetic fields. Journal of Exposure Analysis and Environmental Epidemiology 2001; 11(1):41-49.

Chung F, Mezei G. Adverse outcomes in ambulatory anesthesia — What can we improve? Ambulatory Surgery 2000; 8(2):73-78.

Chung F, Mezei G, Tong D. Adverse events in ambulatory surgery: A comparison between elderly and younger patients. Canadian Journal of Anesthesia 1999; 46(4):309-321.

Chung F, Mezei G. Adverse outcomes in ambulatory anesthesia. Canadian Journal of Anesthesia 1999; 46(5/II):R18-34.

Sinclair DR, Chung F. Mezei G. Can postoperative nausea and vomiting be predicted? Anesthesiology 1999; 91(1):109-118.

Chung F, Mezei G, Tong D. Pre-existing medical conditions as predictors of adverse events in day-case surgery. British Journal of Anaesthesia 1999; 83(2):262-270.

Mezei G, Chung F. Return hospital visits and hospital readmissions after ambulatory surgery. Annals of Surgery 1999; 230(5):721-727.

Chung F, Mezei G. Factors contributing to a prolonged stay after ambulatory surgery. Anesthesia & Analgesia 1999; 89(6):1352-1359.

Book Chapters

Moolgavkar SH, Chang ET, Mezei G, Mowat FS. Epidemiology of mesothelioma. Chapter 3. In, Asbestos and Mesothelioma. Testa J (Ed.). Springer Nature. Pages 43-72, 2017.

Mezei G, Vergara X. Adult cancer and extremely low-frequency magnetic fields. In: Röösli M. Epidemiology of Electromagnetic Fields, Chapter 10, pp 161-184. CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2014.

Kheifets L, Mezei G. Extremely low frequency electric and magnetic fields. In: Hunter's Diseases of Occupations, 10th edition. Baxter PJ, Aw TC, Cockcroft A, Durrington, Harrington JM (eds), Chapter 55, pp. 663-674, Hodder Arnold, United Kingdom, 2010.

Mezei G, Kheifets L. Radiofrequency fields. In: Hunter's Diseases of Occupations, 10th edition. Baxter PJ, Aw TC, Cockcroft A, Durrington, Harrington JM (eds), Chapter 56, pp. 675-681, Hodder Arnold, United Kingdom, 2010.

Kheifets L, Mezei G. Extremely low frequency electric and magnetic fields. In: Encyclopedia of Quantitative Risk Assessment. Everitt B, Melnick E (eds), pp. 691-693, John Wiley & Sons, United Kingdom, 2008.

Appendix B

Agency Reviews and Opinions on Exposure to RF Fields and Health

Table 1. Agency Reviews and Opinions on Exposure to RF Fields and Health

Year	Organization	Review	Link
2019	Australian Radiation Protection and Nuclear Safety Agency	Non-Ionising Radiation Protection in Australia	https://www.arpansa.gov.au/sites/default/files/tr182.pdf
2019	IEEE International Committee on Electromagnetic Safety	IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz	https://standards.ieee.org/standard/C95_1-2019.html
2019	Swedish Radiation Safety Authority	Research 2019:08 – Recent Research on EMF and Health Risk – Thirteenth Report from SSM's Scientific Council on Electromagnetic Fields, 2018	https://www.stralsakerhetsmyndigheten.se/contentassets/ea182ee131d049f1b3b1140dd0fbc0f8/201908-recent-research-on-emf-and-health-risk-thirteenth-report-from-ssms-scientific-council-on-electromagnetic-fields-2018.pdf
2018	French Agency for Food, Environmental and Occupational Health & Safety	OPINION of the French Agency for Food, Environmental and Occupational Health & Safety Regarding the Expert Appraisal on "Electromagnetic Hypersensitivity (EHS) or Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (IEI-EMF")	https://www.anses.fr/en/system/files/AP2011SA0150EN.pdf
2018	Swedish Radiation Safety Authority	Research 2018:09 – Recent Research on EMF and Health Risk – Twelfth Report from SSM's Scientific Council on Electromagnetic Fields, 2017	https://www.stralsakerhetsmyndigheten.se/contentassets/f34de8333acd4ac2b22a9b072d9b33f9/201809-recent-research-on-emf-and-health-risk
2016	Health Council of the Netherlands	Mobile Phones and Cancer. Part 3: Update and Overall Conclusions From Epidemiological and Animal Studies.	https://www.healthcouncil.nl/documents/advisory-reports/2016/06/01/mobile-phones-and-cancer-part-3-update-and-overall-conclusions-from-epidemiological-and-animal-studies
2016	Swedish Radiation Safety Authority	Research 2016:15 – Recent Research on EMF and Health Risk – Eleventh Report from SSM's Scientific Council on Electromagnetic Fields, 2016	https://www.stralsakerhetsmyndigheten.se/en/publications/reports/radiation-protection/2016/201615/
2015	New Zealand Ministry of Health	Interagency Committee on the Health Effects of Non-ionising Fields: Report to Ministers 2015	https://www.health.govt.nz/

EXHIBIT H-1

Year	Organization	Review	Link
2015	Scientific Committee on Emerging and Newly Identified Health Risks	Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF)	https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf
2015	Swedish Radiation Safety Authority	Research 2015:19 – Recent Research on EMF and Health Risk – Tenth Report from SSM's Scientific Council on Electromagnetic Fields, 2015	https://www.stralsakerhetsmyndigheten.se/contentassets/ee7b28e0fee04e80bcaf84c24663a004/201519-recent-research-on-emf-and-health-risk---tenth-report-from-ssms-scientific-council-on-electromagnetic-fields-2015
2014	Australian Radiation Protection and Nuclear Safety Agency	Review of Radiofrequency Health Effects Research – Scientific Literature 2002- 2012	https://www.arpansa.gov.au/sites/default/files/legacy/pubs/technicalreports/tr164.pdf?acsf_files_redirect
2014	Health Canada/Royal Society of Canada	The Royal Society of Canada Expert Panel: A Review of Safety Code 6 (2013): Health Canada's Safety Limits for Exposure to Radiofrequency Fields. Spring 2014	https://rsc-src.ca/sites/default/files/SC6_Report_Formatted_1.pdf
2014	Health Council of the Netherlands	Mobile Phones and Cancer. Part 2: Animal Studies on Carcinogenesis	https://www.healthcouncil.nl/documents/advisory-reports/2014/09/05/mobile-phones-and-cancer-part-2-animal-studies-on-carcinogenesis
2014	Swedish Radiation Safety Authority	Research 2014:16 – Recent Research on EMF and Health Risk – Ninth Report from SSM's Scientific Council on Electromagnetic Fields, 2014	https://www.stralsakerhetsmyndigheten.se/contentassets/08b2f497b3ad48cf9e29a1d0008e7d82/201416-recent-research-on-emf-and-health-risk-ninth-report-from-ssms-scientific-council-on-electromagnetic-fields-2014
2013	British Columbia Centre for Disease Control and Canadian National Collaborating Centre for Environmental Health	Radiofrequency Toolkit for Environmental Health Practitioners	http://electromagnetichealth.org/wp-content/uploads/2013/07/RadiofrequencyToolkit_v4_06132013.pdf
2013	French Agency for Food, Environmental and Occupational Health & Safety	OPINION of the French Agency for Food, Environmental and Occupational Health & Safety Concerning the Update of the "Radiofrequency Electromagnetic Fields and Health" Expert Appraisal"	https://www.anses.fr/en/system/files/AP2011sa0150RaEN.pdf

Year	Organization	Review	Link
2013	Health Council of the Netherlands	Mobile Phones and Cancer. Part 1: Epidemiology of Tumours in the Head	https://www.gezondheidsraad.nl/en/task-and-procedure/areas-of-activity/environmental-health/mobile-phones-and-cancer-part-1
2013	International Agency for Research on Cancer	IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 102. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields	https://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf
2013	Swedish Radiation Safety Authority	Research 2013:19 – Eighth Report from SSMs Scientific Council on Electromagnetic Fields	https://www.stralsakerhetsmyndigheten.se/contentassets/7f20edcd0b024940bca450d596568e30/201319-eighth-report-from-ssms-scientific-council-on-electromagnetic-fields
2013	Swiss Federal Office for the Environment	Radiation from Transmission Installations and Effects on Health	https://www.bafu.admin.ch/bafu/en/home/topics/electrosmog/publications-studies/publications/radiation-from-transmission-installations-and-effects-on-health.html
2012	Advisory Group on Non-ionizing Radiation for the Health Protection Agency of the United Kingdom	Health Effects from Radiofrequency Electromagnetic Fields	https://www.ices-emfsafety.org/wp-content/uploads/2014/11/AGNIR_report_2012.pdf
2012	European Health Risk Assessment Network on Electromagnetic Fields Exposure	Deliverable Report D2 - Risk Analysis of Human Exposure to Electromagnetic Fields (Revised)	https://pdfs.semanticscholar.org/eec1/c4df72681e512ab95be3c8455961bbc57589.pdf
2012	Norwegian Institute of Public Health	Low-Level Radiofrequency Electromagnetic Fields - An Assessment of Health Risks and Evaluation of Regulatory Practice	https://www.fhi.no/en/publ/2012/svake-hoyfrekvente-elektromagnetiske-felt--en-vurdering-av-helserisiko-og-f/
2011	Health Council of the Netherlands	Influence of Radiofrequency Telecommunications Signals on Children's Brains (2011)	http://www.gezondheidsraad.nl/sites/default/files/201120E.pdf
2010	European Health Risk Assessment Network on Electromagnetic Fields Exposure	Deliverable Report D2 - Risk Analysis of Human Exposure to Electromagnetic Fields	https://pdfs.semanticscholar.org/0275/43895137f44a6abfcbcdc68c2828f1116b11.pdf

Year	Organization	Review	Link
2010	European Health Risk Assessment Network on Electromagnetic Fields Exposure	Deliverable Report D-3 - Report on the Analysis of Risks Associated to Exposure to EMF: *In Vitro* and *In Vivo* (Animals) Studies	http://efhran.polimi.it/docs/IMS-EFHRAN_09072010.pdf
2010	Latin American Experts Committee on High Frequency Electromagnetic Fields and Human Health	Non-Ionizing Electromagnetic Radiation in the Radiofrequency Spectrum and its Effects on Human Health, with a Review on the Standards and Policies of Radiofrequency Radiation Protection in Latin America	http://www.wireless-health.org.br/downloads/LatinAmericanScienceReviewReport.pdf
2010	Swedish Radiation Safety Authority	Recent Research on EMF and Health Risk – Seventh Annual Report from SSMs Independent Expert Group on Electromagnetic Fields	http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2010/201044/
2009	EMF-NET: European Commission 6th Framework Programme Coordination Action	EMF-NET: Effects of the Exposure to Electromagnetic Fields: From Science to Public Health and Safer Workplace. Deliverable D17: Report on Health Effects of RF with Recommendations for Non-Ionising Radiation Protection and Research Needs Deliverable D15_c: Report on New Epidemiological Studies on Static Fields, ELF, Intermediate Frequencies, and RF	https://www.emf.ethz.ch/fileadmin/redaktion/public/downloads/4_wissen/externes_material/Interphone%20Cardis_%20Report%20on%20health%20effects%20of%20RF.pdf
2009	Health Council of the Netherlands	Electromagnetic Fields: Annual Update 2008	http://www.gezondheidsraad.nl/sites/default/files/200902.pdf
2009	International Commission on Non-ionizing Radiation Protection	Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz – 300 GHz)	https://www.icnirp.org/en/publications/article/hf-review-2009.html
2009	Scientific Committee on Emerging and Newly Identified Health Risks	Health Effects of EMF Exposure	http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf

Exponent®

Electrical Engineering & Computer Science Practice

Report of Benjamin Cotts, Ph.D., P.E.

Re: Miranda Grace Edwards v. Duquesne Light Company, Pennsylvania Public Utility Commission Docket No. C-2018-3002741

EXHIBIT H-2

Report of Benjamin Cotts, Ph.D., P.E.

Re: Miranda Grace Edwards v. Duquesne Light Company, Pennsylvania Public Utility Commission Docket No. C-2018-3002741

Prepared for

Duquesne Light Company
411 7th Avenue
Pittsburgh, PA 15219

Prepared by

Benjamin Cotts, Ph.D., P.E.
Exponent, Inc.
17000 Science Drive, Suite 200
Bowie, MD 20715

February 4, 2020

1902236 000 - 4631

EXHIBIT H-2

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AM	Amplitude modulated
CDMA	Code-division multiple access
DC	Direct Current
DLC	Duquesne Light Company
FM	Frequency modulated
FCC	Federal Communications Commission
GHz	Gigahertz
GSM	Global system for mobile communications
HAN	Home area network
ICNIRP	International Commission on Non-Ionizing Radiation Protection
Itron, Inc.	Itron
IEEE	Institute of Electrical and Electronics Engineers
LAN	Local area network
MHz	Megahertz
mW/cm^2	Milliwatts per square centimeter
RF	Radiofrequency
SAR	Specific absorption rate
W/cm^2	Watts per square centimeter
W/kg	Watts per kilogram
W/m^2	Watts per square meter

Executive Summary

Electric power utilities throughout the United States are in the process of modernizing their infrastructure in a "smart grid." In Pennsylvania, Act 129 of 2008 required the deployment of smart meters, and Duquesne Light Company (DLC) selected OpenWay Centron smart meters provided by Itron, Inc. (Itron) for their smart grid network.

I have been retained in this matter by DLC in the matter of Miranda Grace Edwards v. Duquesne Light Company, before the Pennsylvania Public Utility Commission No: C-2018-3002741. My services have been requested in order to provide context on radiofrequency (RF) exposures that are the focus of concerns raised by the Complainant in this matter.

My report describes the RF signal technology that smart meters use to communicate and the relative levels of RF fields that are expected during transmissions. This provides a basis for describing the RF exposure from DLC smart meters and explaining how this exposure compares to the Complainant's exposures from other RF sources, both natural and anthropogenic.

Through my investigation of the DLC Itron smart meters, as well as existing RF sources near the Complainant's home, I have determined that the contribution of a typical smart meter to the RF exposure indoors would be about 0.00077% (1/130,000th) of the Federal Communications Commission's (FCC) health-based exposure limit. Furthermore, potential exposures from DLC smart meters are substantially less than the RF exposures from common natural and manmade sources.

Based on my review of the facts in this case; the available material; my background, experience, and training; and my work completed to date, the following opinions are submitted within a reasonable degree of engineering and scientific certainty:

1) The Itron smart meters operated by DLC will represent a negligible contribution to the overall RF exposure of the Complainant.
2) The RF exposures from other common sources are many times greater than from a typical DLC smart meter.

3) The RF exposure from a typical DLC smart meter, whether evaluated inside or outside the Complainant's residence, represents a fraction of the allowable FCC limit and complies with applicable industry standards.

I reserve the right to revise or amend these opinions and conclusions if additional information becomes available or if further analysis is performed.

Introduction

Electric power utilities throughout the United States are modernizing their infrastructure in a "smart grid." One component of this modernization is the installation of advanced metering infrastructure, also known as smart meters. A hallmark feature of smart meters that sets them apart from their predecessors is the capability of using radiofrequency (RF) signals for two-way wireless radio communication, which use miniature radio transceivers to communicate electricity consumption data back to the utility and to receive signals from the utility.

Pennsylvania's Act 129 of 2008 required the deployment of smart meters and Duquesne Light Company (DLC) selected OpenWay Centron smart meters provided by Itron, Inc. (Itron) for their network. Similar to many other smart meter mesh networks, the DLC network operates in the license-free, 902 to 928 megahertz (MHz), portion of the electromagnetic spectrum.

DLC requested that I provide the scientific background underlying the nature of electromagnetic fields, their natural and manmade sources, and standards relating to human exposure to these fields.

My educational background, qualifications, and Curriculum Vitae are summarized in Appendix A. Appendix B includes a figure from the Federal Communications Commission (FCC) that depicts the various portions of the RF spectrum. The figure illustrates the uses and applications of the many hundreds of RF communication frequency bands licensed in the United States. Appendix C summarizes the methods and results of calculations of exposure to RF from a smart meter at the Complainant's residence.

1. Basic Physics of Electromagnetics

There are many natural sources and man-made sources of electromagnetic fields. Although not widely recognized, naturally occurring visible light is the most common natural electromagnetic field to which we are exposed every day. Man-made electromagnetic fields include extremely low frequency sources such as the fields from power transmission and distribution lines, as well as higher frequency sources that are associated with transmission of radio and television broadcast signals and various wireless personal communication devices used daily in modern society.

The primary defining characteristic of electromagnetic fields is their frequency. The frequency of an electromagnetic field is determined by the number of times it oscillates (i.e., changes direction) each second, and frequency is what governs how these fields interact with humans in their daily lives.[1]

Electromagnetic Waves

Electromagnetic waves are difficult to intuitively understand since most are not only invisible to the human eye, but they cannot be heard, tasted, touched, or smelled. Sound waves or water waves, on the other hand, are quite familiar and can be used through analogy to illustrate some of the relevant properties of electromagnetic waves. For instance, when one drops a rock in a pond, the rock creates a water wave, which expands outward from the source. The wave propagating on the surface of the pond does not actually carry water molecules with it, rather the wave spreads to adjacent water molecules (propagates) when adjacent water molecules move up-and-down. The wave with the highest amplitude (i.e., height above the pond's surface) is at the source and as it spreads outward the height of the waves gets successively smaller. Figure 1, taken with a high-speed camera, illustrates how the up and down motion of the wave is highest at the source and diminishes as it expands outward.

1 Both electromagnetic fields and electromagnetic waves are used concurrently in this report depending on which is more intuitive and more readily understandable, but in all instances, their meaning is the same.

Figure 1. Illustration of the concept of wave energy movement from a source.

Electromagnetic waves are made up of individual electric fields and magnetic fields and, similar to water waves, as electromagnetic waves propagate away from the source, the amplitude (i.e., the strength of the constituent electric and magnetic fields) decreases.

The Electromagnetic Spectrum

Although often assumed to include only RF fields, the electromagnetic spectrum in fact includes all forms of electromagnetic fields. As shown in Figure 2 electromagnetic fields are broadly classified as either *non-ionizing radiation* or *ionizing radiation.*[2] *Non-ionizing radiation* in the radio portion of the electromagnetic spectrum includes RF broadcast signals from amplitude-modulated (AM) and frequency-modulated (FM) radio stations and from television broadcasts, while light from the sun or from a flashlight are common examples of electromagnetic fields in the visible portion of the electromagnetic spectrum. Microwave (sometimes included in the definition of RF) and infrared portions of the electromagnetic spectrum fall between the radio and visible portions of the electromagnetic spectrum. All these non-ionizing fields are too weak to break the bonds within atoms or molecules. In contrast, *ionizing radiation* such as from X-rays or gamma rays is strong enough to break molecular or atomic bonds.[3]

---

[2] The term radiation simply means "energy propagated through space." It is used to describe energy emitted from any particular source such as heat from a campfire, light from a flashlight, acoustic energy from a stereo system, or the broadcast signal from an FM radio antenna (http://er.jsc.nasa.gov/seh/e.html#electromagnetic radiation and http://er.jsc.nasa.gov/seh/r.html#radiation).

[3] http://www.who.int/ionizing_radiation/about/what_is_ir/en/

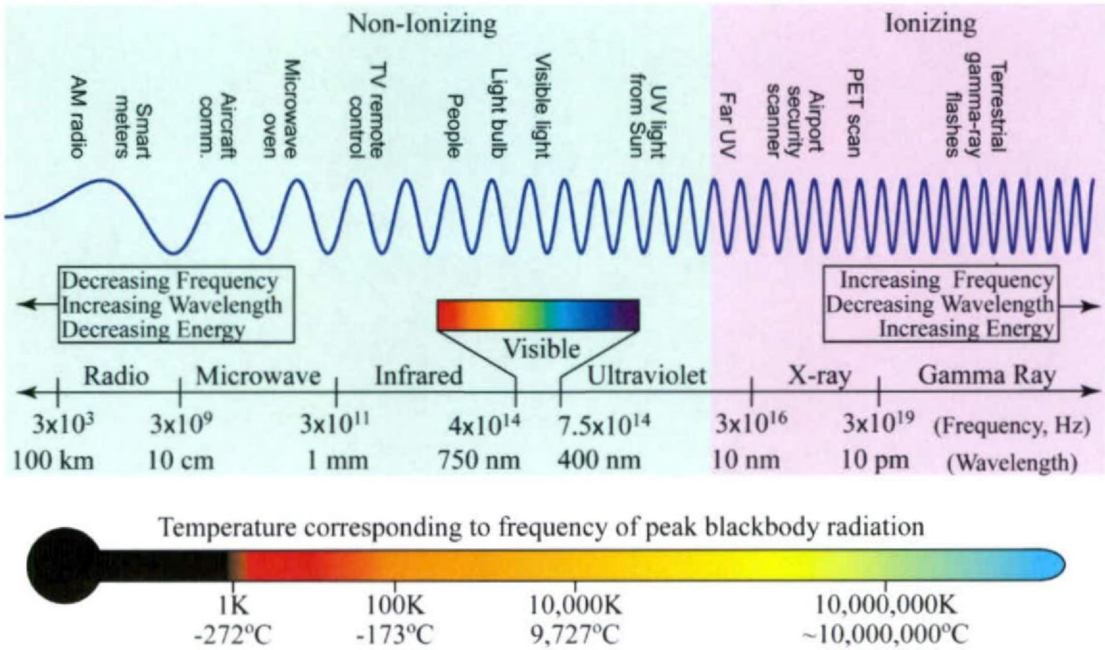


Figure 2. The electromagnetic spectrum and the relationship between frequency, wavelength, energy, and temperature.

Common Sources of Electromagnetic Fields

Modern technologies such as broadcast transmissions, radar, cell phones, and Wi-Fi are some of the most common man-made sources of electromagnetic fields, but in fact natural sources of RF are far more common and include lightning, the earth itself, and even other organisms, including humans.

Although common, the concept that the earth and humans, as well as virtually all objects, are sources of electromagnetic fields warrants additional attention. Extremely hot objects such as the sun produce electromagnetic fields primarily in the visible and ultraviolet portions of the spectrum, while colder objects such as the earth produce fields primarily in the infrared portion of the spectrum. This phenomenon is called thermal radiation or heat radiation, while scientists refer to it as blackbody radiation.

Blackbody Radiation

Any object (i.e., blackbody) that has a temperature above absolute zero[4] will radiate electromagnetic energy; the temperature of the object determines the frequency at which most of the electromagnetic energy radiates. Hotter objects emit both more energy and energy at higher frequencies than colder objects.

Blackbody radiation from man-made sources

An electric stove provides a good example to illustrate how electromagnetic energy emitted by a blackbody changes at colder and hotter temperatures. When the stove burner is first turned on, it begins to heat up and produces stronger electromagnetic fields in the infrared portion of the spectrum than in the visual portion. This means that the burner still appears the same (black) but the electromagnetic energy can be felt by placing a hand nearby and feeling the infrared heat. As the burner gets hotter, it begins to glow reddish-orange, which is electromagnetic energy in the lower part of the visible spectrum. Household burners cannot heat beyond this point; however, if the temperature did increase further it would begin to glow a yellowish-white color (in the higher portion of the visible spectrum). At still hotter temperatures, such as from a welder's torch, the light would become bluish (the highest part of the visible spectrum), and at even higher temperatures, the light from the welder's torch would be in the ultraviolet range.[5]

Blackbody radiation from natural sources

As noted above, any object that has a temperature above absolute zero radiates electromagnetic energy and it does so at all frequencies (although very small amounts at very low or very high frequencies). Since humans and the earth both have a temperature of ~300 Kelvin, most of their emitted energy is in the infrared portion of the electromagnetic spectrum (i.e., it can be seen with the use of infrared imagers), but a very small portion of that energy is also emitted in the

[4] Absolute zero is the temperature at which the motion of molecules theoretically stops, which is 0 on the Kelvin scale and equivalent to about -273 degrees Celsius or about -460 degrees Fahrenheit.

[5] The emission of this intense heat and ultraviolet light are among the reasons that welders wear protective glasses when performing their work.

radio and microwave portions of the electromagnetic spectrum. Humans and the earth are therefore sources of RF energy (albeit very small sources).

Radiofrequency Communications

RF fields are an integral part of modern technology; they are used in emergency beacon services, air traffic control systems, cell phones, and smart meters, to name a few. RF fields are also widely used in scientific research and many more industrial, commercial, medical, and personal applications. In addition to frequency discussed above, **power, duty cycle, reflection, and attenuation** are common concepts to most RF communication. These concepts are particularly important to understand a person's exposure level to RF energy from a variety of RF sources including smart meters.

Power

The importance of power is obvious; higher output power leads to higher RF signal levels and thus higher potential RF exposure. The other factors are discussed in greater detail below.

Duty Cycle

An important way man-made sources differ from one another is how often and in what patterns they transmit. Some sources transmit all the time at relatively constant power levels (e.g., FM radio and television broadcasts), while others transmit all the time but vary how much power is transmitted (e.g., AM radio). Intermittent operation is used by technology that only transmits based on data transfer needs and user demand. For example, smart meters transmit only when they need to transfer data; cell phones transmit based both on user demand and when they interact with the mobile network; and microwave ovens only emit RF fields when they are used.[6]

[6] Some cell phones may also change transmission power output based upon circumstances while smart meters always transmit with the same power output.

RF exposure to a particular source based on transmission patterns can be simplified into the source's "duty cycle." Duty cycle is determined as a percentage of time the source transmits information. For example, sources that transmit continuously, whether at constant or varying power, have a duty cycle of 100%. The duty cycle of a device that utilizes an intermittent transmission pattern can be reported as either an operational duty cycle or an average duty cycle.

The duty cycle of a source with an intermittent transmission pattern will vary depending on use. For example, a code-division multiple access (CDMA) cell phone used for 6 minutes in a 30-minute period has as a duty cycle of 20%, while one used for 1.5 minutes in a 30-minute period has a duty cycle of 5%.[7,8] In contrast, a smart meter sends information in a series of short transmissions typically of a few hundred milliseconds or less. The duty cycle of DLC smart meters depends on a number of factors (discussed in more detail in the following Section); these units have an *average* duty cycle near 0.21% (transmitting for only a few seconds per day) and a maximum expected duty cycle of 8.0% (Itron, 2015).

Reflection and Attenuation

When an electromagnetic wave reaches a boundary (such as the ground or a wall) part of the energy from the wave will reflect from that boundary and some will be transmitted through (with some level of associated attenuation). The amount of energy reflected and the amount that passes through depends both on the frequency of the electromagnetic wave and on the material properties of the boundary.

The building materials of an individual's home therefore can have a significant effect on a person's RF exposure from external sources. For example, at the frequency of smart meters or cell phones, an 8-inch thick concrete wall allows less than 1% of incident RF energy through, a

[7] When a call is made, a CDMA cell phone transmits continuously. This calculated *operational* duty cycle example should not be confused with the duty cycle of the emission of a CDMA cell phone when in use.

[8] Global System for Mobile (GSM) communications is another communication technology used by cell phones. Rather than transmitting continuously, a GSM phone transmits only 1/8th of the time, but at 8 times the power of a CDMA transmission. The duty cycle *of the emissions* from a GSM phone when in use is therefore 12.5%. If a GSM phone is used for 6 minutes in a 30-minute period, then the total duty cycle is the product of the *operational* duty cycle and the duty cycle of the emissions: 20% x 12.5% = 2.5%.

3.5-inch thick brick wall allows about 45% of the energy through, and a 0.75-inch thick plywood wall allows over 80% of the energy through (NIST, 1997).[9]

Distance from the Source

While a boundary will cause some of the energy in an electromagnetic wave to reflect and attenuate, distance from the source also causes attenuation, even if the wave does not pass through any material that causes it to lose energy. This attenuation is due simply to the expansion of the wave, similar to the motion of a water wave described above. When the electromagnetic wave is transmitted, it has a finite amount of energy concentrated at the source. As the wave expands, this same amount of energy is spread out over a larger and larger area so that the amount of energy in any particular location decreases as the wave gets farther from the source. The power density of the RF field decreases with the square of the distance from the source according to the inverse-square law.[10] So, an individual located 10 yards away from a source will be exposed to 100 times less RF energy than an individual located 1 yard away from the same source.

---

[9] At lower frequencies, such as those used in television or radio broadcast, the fraction of energy that passes through these materials is substantially higher.

[10] A discussion of the inverse square law specific to smart meters is provided in Appendix C.

2. Smart Meters and Mesh Networks

The primary purpose of smart meters in the DLC network is to record electricity usage at residences and other buildings and transmit that usage wirelessly back to DLC. The smart meters used by DLC communicate in the frequency range of 902 to 928 MHz.[11]

Most radio communication devices used in the United States must be certified by the FCC. Itron OpenWay Centron smart meters deployed by DLC are certified by the FCC (FCC No. SK9AMI7), according to which, the transmission power of these smart meters is less than 1 watt.

Smart Meter Mesh Network

A smart meter mesh network is a collection of smart meters deployed in the same geographic area. The term mesh network derives from considering each smart meter as a node and visualizing the communication paths between each node as lines. When all the nodes in their respective locations are connected to one another by drawn lines, the resulting picture looks like wire mesh. Each smart meter in the network has the capability of communicating with other nearby smart meters as well as with cell relays, which act as collection units. The role of the collectors within the mesh network is to gather the data from the individual smart meters and send the information back to the utility company.

A smart meter network operates by transmitting information at a low power level to a nearby neighbor (a "hop"). This second smart meter transmits information onward, also at a low power level, and this step is repeated from smart meter to smart meter in several hops until the information from all the smart meters in the chain reach the collector (i.e., the cell relay). Figure 3 illustrates the hopping process to the cell relay. The most efficient communication paths are shown by solid black arrows, typically using the shortest individual hops to get back to

[11] The Itron OpenWay Centron smart meters are also capable of communicating in Industrial, Scientific, Medical (i.e., ISM) radio bands in the 2.4 to 2.5 GHz range via an IEEE standard 802.15.4 Zigbee Radio, at much lower power output of approximately 65 milliwatts.

the cell relay. The gray arrows show alternate paths that can be used if a bottleneck or fault occurs.

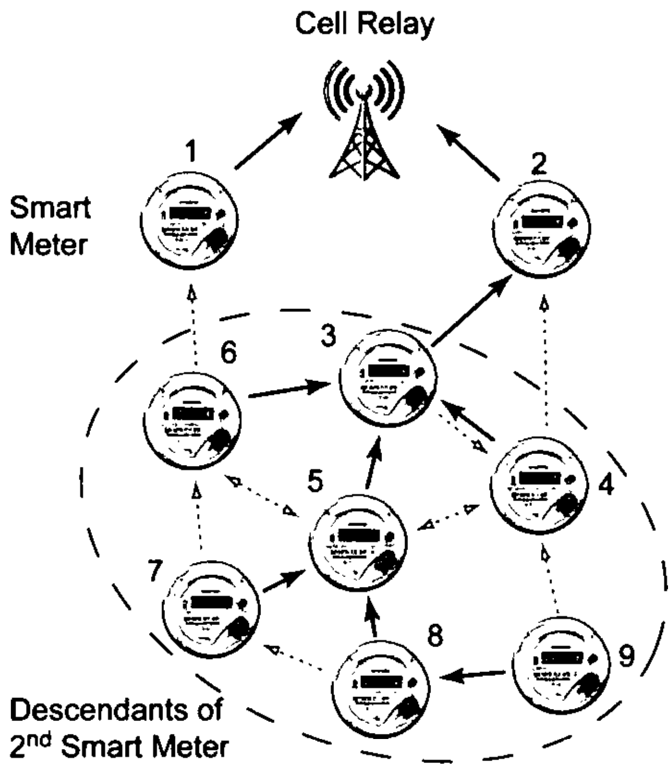


Figure 3. Illustrative example of a smart meter mesh network.

The close proximity of neighboring smart meters and the ability to communicate with one another is one of the primary advantages of a mesh network. Transmissions between nearby smart meters can be made at relatively low power levels. If meters could only communicate with the cell relays, then only smart meters physically close to them could transmit efficiently at lower power; more distant smart meters would need to transmit at significantly more power.[12] In Figure 3, smart meters 1 and 2 are close enough to interact directly with the cell relay, while smart meters 3 through 9 are too far from the cell relay to interact directly and use hops to transmit to smart meter 2 for transmission to the cell relay. Since smart meters 3 through 9

[12] For example, a smart meter located approximately 500 yards from a communicator would need to transmit a signal about 10,000 times stronger than a smart meter located 5 yards away from the collector.

eventually transmit their data to smart meter 2, they are called descendants of smart meter 2. This scenario illustrates that while many smart meters will transmit only their own data, most meters will also transmit the data of descendant meters.

Typical Smart Meter Operation

Unlike other common devices that communicate using RF fields, the amount of data a smart meter transmits is very small, so they only need to communicate for a very short time each day. According to DLC, there are two to three scheduled data requests from each smart meter every 24 hours. In addition to these scheduled data requests, each smart meter must confirm its capability to connect with at least one other smart meter to maintain the communication capability of the network. This communication occurs approximately every 30 minutes by sending out a very brief beacon signal transmission.[13]

Smart Meter Duty Cycle

The amount of data each smart meter transmits will vary widely depending on where it is located within the mesh network and the amount of data it must transfer from descendants. The minimum, average, and maximum duty cycles in the DLC smart meter network are summarized in Table 1. Additional analysis regarding the OpenWay Centron network indicates that the vast majority (97%) of smart meters in the network have a duty cycle of less than 0.5% (i.e., they transmit for short periods a total of 7.2 minutes per day or less).

[13] Information received from DLC.

Table 1. Duty cycle of DLC smart meters*,†

Duty Cycle Description	Duty Cycle Value
Minimum	0.002% (0.03 minutes per day)
Average	0.21% (2.99 minutes per day)
Maximum	8.0% (115.2 minutes)

* Itron (2015).

† This table includes values after a November 2019 upgrade to the DLC system in order to allow the DLC network to utilize IPv6 standards and architecture. Prior to this upgrade the minimum, average, and maximum duty cycle of the DLC smart meters were 0.02%, 0.06%, and 0.58%, respectively.

Home Area Network

In addition to the RF signals used by smart meters to communicate within the mesh network (i.e., the Local Area Network [LAN]), each smart meter is also equipped with a second RF transmitter (i.e., a Zigbee Radio) that transmits at 2.4 gigahertz (GHz) and allows the smart meter to communicate over a Home Area Network (HAN). If the consumer chooses, the HAN allows compatible appliances in the home to interact with the smart meter and evaluate how much power that appliance consumes relative to the total power consumption of the home. The transmission power of the Zigbee Radio is approximately 10 times lower than that of the RF LAN signal from the smart meter due to the smaller distance over which communication takes place. The duty cycle of the Zigbee Radio is shown below in Table 2 for an idle Zigbee Radio (with no devices joined) or a smart meter with an example device joined (an in-home display).

Table 2. Duty cycle of the Zigbee Radio in DLC smart meters*

Duty Cycle Description	Duty Cycle Value
Idle Zigbee Radio (no devices joined)	0.01% (9.9 seconds per day)
Smart Meter with Tendril HD (In Home Display)	0.15% (132 seconds per day)

* Information received from DLC.

3. Standards

Radiofrequency Fields

In the United States, the government agency responsible for regulating RF-emitting devices is the FCC. These regulations are included in the Code of Federal Regulations Title 47 (§1.1310 and §2.1093) and are based upon the recommendations of organizations such as the National Council for Radiation Protection and the Institute of Electrical and Electronics Engineers (IEEE), and input from federal health agencies including the Environmental Protection Agency, the National Institute for Occupational Safety and Health, and the Occupational Safety and Health Administration. The IEEE developed exposure limits for electromagnetic fields based on lengthy and comprehensive assessments of the scientific literature, a process also undertaken by other international agencies such as the European-based International Commission on Non-Ionizing Radiation Protection (ICNIRP).

These limits restrict the amount of energy the FCC has determined that the body can safely absorb without adverse effect. This is described as the specific absorption rate (SAR) and is measured in units of watts per kilogram (W/kg). This quantity is difficult to measure in practice, so the FCC also provides a maximum permissible exposure that limits the strength of an RF field outside the body, which is more easily measured. The FCC limits for the general public at frequencies of smart meter transmissions (900 MHz and 2.4 GHz) are summarized in Table 3, along with the current IEEE and ICNIRP standards, which incorporate safety factors of 50 or more.[14,15,16]

---

[14] The FCC, in Bulletin 56 (1999), states that the "...exposure criteria are based on a determination that potentially harmful biological effects can occur at an SAR level of 4 W/kg as averaged over the whole-body. Appropriate safety factors have been incorporated to arrive at limits for both whole-body exposure (0.4 W/kg for 'controlled' or 'occupational' exposure and 0.08 W/kg for 'uncontrolled' or 'general population' exposure, respectively) and for partial-body (localized SAR), such as might occur in the head of the user of a hand-held cellular telephone."

[15] Bulletin 65 (FCC, 1997) and Bulletin 56 (FCC, 1999), among others, provide additional details on SAR regarding exposure limits, averaging times, and body locations.

[16] ICNIRP is in the process of updating their standards with a focus on frequencies > 6 GHz. Publicly available information indicates no change to the standard levels at the frequencies of DLC smart meter operation. The revised standard is expected to be released in 2020.

Table 3. Exposure limits specified by the FCC, IEEE, and ICNIRP

Agency	Power Density Limit at 900 MHz		Power Density Limit at 2.4 GHz (W/m^2)		SAR Limit (W/kg)
	(W/m^2)	(mW/cm^2)	(W/m^2)	(mW/cm^2)	
FCC (CFR §1.1310 and §2.1093)	6	0.6	10	1.0	0.08 (Whole body) 1.6 (over any 1 gram of tissue)
ICNIRP (1998)	4.5	0.45	10	1.0	0.08 (Whole body) 2 (over any 10 grams of tissue)
IEEE, (C95.1, 2019)	4.5	0.45	10	1.0	0.08 (Whole body) 2 (over any 10 grams of tissue)

Note: mW/cm^2 = milliwatts per square centimeter; W/m^2 = watts per square centimeter and 1 mW/cm^2 = 10 W/m2.

Industry Standards

In addition to standards related to the RF fields produced during smart meter communication, electrical utility meters (whether analog, digital, or smart meters) are subject to other standards and regulations such as the American National Standard Institute's Standard C12.1. This standard tests a number of meter characteristics including the accuracy of metering, meter construction, and safety performance tests, among others. The DLC Itron meters have been tested to, and are in compliance with, ANSI C12.1-2008 (Itron, 2011).

4. Sources of Radiofrequency Fields

Natural Sources

As discussed in the introduction, some of the natural sources of RF fields are produced by blackbody radiation from warm objects such as the earth and humans; the representative RF exposure values for these sources are summarized in Table 4 (ICNIRP, 2009).

Table 4. RF exposure values for common natural RF sources

Source	RF Exposure (mW/cm^2)	RF Exposure (% of FCC Limit)
Blackbody radiation from the earth	1.3	0.0027
Blackbody radiation from humans	3	0.0054

Common Manmade Sources

There are numerous manmade sources of RF fields, including devices used for communications and many other purposes. Communication devices used in the home, such as cell phones, Wi-Fi, and Bluetooth devices produce relatively weak fields; however, they are often used in very close proximity to the individual and may therefore result in higher exposures than remote (but more powerful) sources such as AM, FM, or television broadcast signals. Other devices that emit RF fields, like microwave ovens and radar guns, are used for non-communication purposes such as heating food or measuring speed and distances.

The frequency and representative RF exposure values for some common manmade RF sources to which the Complainant may be exposed are shown below in Table 5. Large ranges of RF exposure can be seen for several of the RF sources, which are due to the large number of factors affecting exposure from a given RF source. While Table 5 provides a list of some of the common manmade sources, it is only a very small subset of all RF sources. Figure B-1 in Appendix B shows the many hundreds of RF communication bands used in modern society, all of which have the potential to contribute to an RF exposure assessment. Other sources such as those from local broadcast (AM, FM, and television) stations and from DLC Smart meters are discussed in greater detail the following section.

Table 5. Frequency and representative RF exposure values for common manmade RF sources

Source	Frequency (MHz)	Reported Value (% of the FCC Limit)*	Exposure Conditions†	Reference†
Cell Phone	800 – 1,900	5 – 12	Personal Use	Abdulla and Badra (2009) Tables 7-10
Cordless Phone	1,880 – 1,900	0.5 – 4	Handheld Unit	HPA, 2014
Wi-Fi	2,400 – 2,484	0.00004 – 0.4	Typical Exposures	Viel et al. (2009), Table 4; Foster (2007), Table 2
Bluetooth	2,400 – 2,484	0.001 – 0.25	At a 0.2- to 3-meter Distance	Valberg et al. (2007), Table 4
Microwave Oven	2,450	0.007 – 1.3	At a 1-meter Distance	Mantiply et al. (1997), p. 573

* RF exposure is presented as a percentage of the FCC limit to keep these exposure values both consistent and accurate. The FCC limit is defined as the applicable SAR limit, wave power density limit, or square of the field magnitude limit, all for uncontrolled environments. Both whole body exposure and spatial peak SAR for the head are used where appropriate.

† RF exposure can be heavily dependent upon situation, so exposure conditions and references are provided for each exposure value.

Sources Specific to the Complainant

Currently there is no information available related to the types and nature of sources used either within the Complainant's residence or by neighbors. Available information includes data for the DLC smart meter, as well as data on the broadcasts from local television stations (e.g., WQED, WINP-TV, WTPG-CD, etc.) and local radio stations (e.g., WRRK, WQED-FM, WYEP-FM, WKST-FM, etc.). In order to account for the potential exposure from these sources, it is important to account for factors such as distance from the source, duty cycle, and attenuation from wall materials. A discussion of the effects of each of these parameters was provided in Section 1. The calculation methods are described in Appendix C.

Example calculations of RF exposure for DLC smart meters and local broadcast stations are shown in Table 6. The distance from the source and the duty cycle, in particular, have a large effect on the potential level of exposure. For example, exposure from a DLC smart meter at a distance of 20 centimeters (~8 inches) directly in front of the smart meter for constant transmission (100% duty cycle) results in an exposure of 38% of the FCC limit (see FCC Certification No. SK9AMI7 for Itron smart meters). In contrast, at the average duty cycle of

0.21%, exposure at 1 yard directly in front of the smart meter is 0.0096% (1/10,000th) of the FCC limit, and at 1 yard behind the smart meter is 0.00077% (1/130,000th) of the FCC limit (Table 6).[17,18] For comparison, the contribution of the existing local broadcast stations to the RF exposure inside the Complainant's residence is approximately 0.24% of the FCC limit (315 times greater than the exposure indoors from the smart meter).

Table 6. Calculations of RF exposure for DLC smart meters and local broadcast stations

Source	Distance from source	Duty Cycle (in a 30-minute period)*	Calculated value (% of FCC limit)
Smart Meter LAN (Inside, Average)†,§	1 yard	0.21%	0.00077
Smart Meter LAN (Outside, Average)	1 yard	0.21%	0.0096
Local Broadcast Stations	~5 – 10 miles away	100%	0.24

* The FCC specifies a 30-minute averaging period in assessing RF exposure.

† The exposure inside the home from the smart meter will be reduced by the exterior wall material, assumed to be plywood. As discussed in Section 1, ~80% of the energy incident on the outer wall will penetrate into the residence. This factor is included in the calculation of exposure inside the residence due to the smart meter.

§ The smart meter preferentially transmits in the forward direction. The amount of energy transmitted toward the back of the smart meter is approximately 10% that of the forward direction (EPRI, 2010). This factor of 10% is included in the calculation of exposure due to the smart meter inside the residence.

17 Note that calculations both 1 yard in front of and 1 yard behind the smart meter include a ground reflection increase factor of 2.56, which is not included in the FCC certification document. This factor of 2.56 is referenced by the Office of Engineering and Technology for powerful distant sources such as radio or television transmissions. It is included here in an abundance of caution so as to overestimate the contribution of the smart meter.

18 These exposures are also far below the IEEE and ICNIRP guidelines discussed above.

5. RF Exposure Comparison

The discussion in Section 4 detailed existing sources of RF fields, including natural sources, common man-made sources, and local sources specific to the Complainant. Figure 4 shows a graphic comparison of estimated exposures from these RF sources to the exposure calculated for the DLC smart meter inside the residence. The exposure of each source relative to the FCC limits (sorted from smallest to largest) is shown beneath a graphic of each source, as well as the factor describing how much larger that exposure is than the exposure from an average smart meter. This figure demonstrates that not only does the RF exposure from a smart meter inside a residence represent a tiny fraction of the FCC allowable limit, but that the exposure from other sources both inside and outside the residence are many times greater than that from the smart meter.

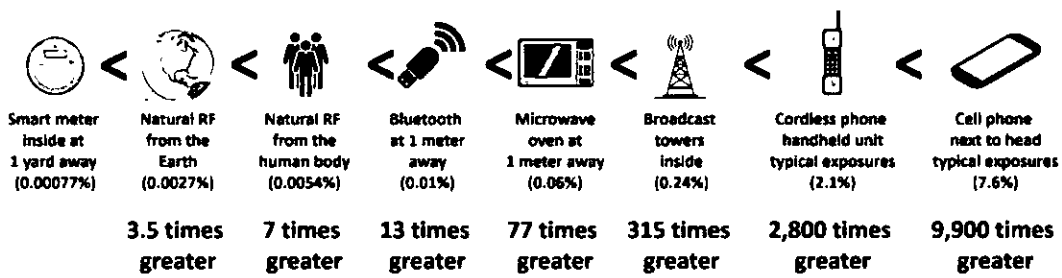


Figure 4. RF exposure of smart meters relative to other RF sources.

The RF exposure as a percentage of FCC limits is shown beneath each graphic in parentheses and a comparison of how much greater each exposure is than the smart meter is shown below that in bold font.

The comparison of exposures shown in Figure 4 represents a simple comparison of some of the relevant potential exposures. A more detailed description is shown below in Figure 5 in which the RF exposures are plotted as a percentage of the FCC limit in a bar graph. In order to show the very small exposure sources on the same scale as the larger sources, the results are presented on a logarithmic scale where each vertical tick in the axis represents an increase by a factor of 10. The graphic is divided into two sections. The "RF Exposures in General Environments" portion shows the general background of RF energy encountered in rural, suburban, and urban environments, and is included to provide context of typical background levels reported in peer-reviewed literature (Joseph et al., 2012). The "Typical RF Sources" portion compares the RF exposures from each of the items shown above in Figure 4. In Figure 5, additional scenarios for the DLC smart meter are shown for potential exposure to a smart meter outside, as well as potential exposure inside from the Zigbee Radio.

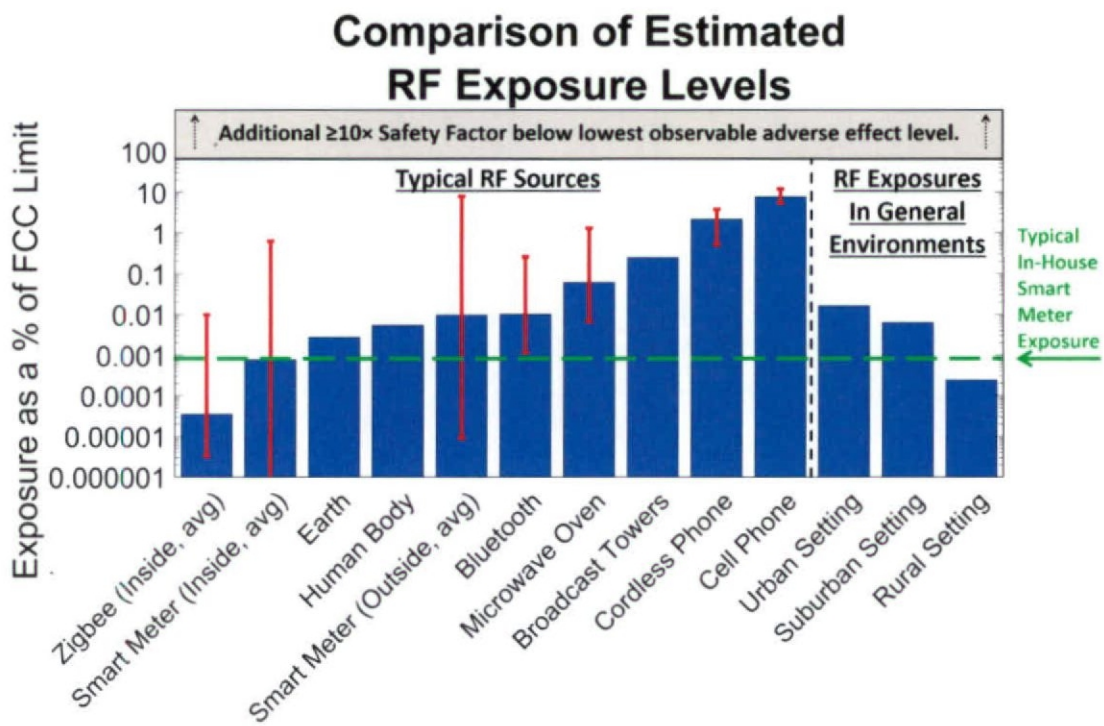


Figure 5. Comparison of RF exposure from the RF-LAN and Zigbee signals to RF exposure from other sources under typical use. The red lines show the potential range of RF levels associated with the manmade sources.

The RF exposures in general environments are reported in Joseph et al. (2012).

A red line is shown overlaid on the bar for most man-made sources in Figure 5 to provide an indication of the potential variability in the exposures for these sources. As an example, the exposure from the hypothetical smart meter (both inside and outside) is detailed in Table 7. The "Inside Average" exposure (second blue bar from the left in Figure 5) is calculated at a distance of 1 yard behind the smart meter using an average duty cycle of 0.21%. In addition, this calculation accounts for smart meters preferentially transmitting in the forward direction so that the amount of energy directed toward the house is approximately 1/10th of that transmitted away from the house (EPRI, 2010). The calculation also accounts for attenuation of the signal when passing through the plywood on the front of the house (only about 80% of the signal penetrates through the plywood).[19] Similar variability estimates are also provided for other man-made sources based on the peer-reviewed references detailed in Table 5.

Table 7. Example variability of smart meter in different exposure scenarios

Scenario	Forward/Back Transmission Factor	Transmission through Wall Material	Distance from Smart Meter	Duty Cycle	Calculated Value (% of FCC Limit)
Inside Minimum	0.1	0.8	10 feet	0.002%	0.0000007%
Inside Average	0.1	0.8	1 yard	0.21%	0.00077%
Inside Maximum	0.1	0.8	~8 inches	8.0%	0.62%
Outside Minimum	1	1	10 feet	0. 002%	0.0000090%
Outside Average	1	1	1 yard	0.21%	0.0096%
Outside Maximum	1	1	~8 inches	8.0%	7.8%

Additional Discussion

The highest calculated exposure due to the smart meter at the residence was evaluated at a distance of approximately 8 inches from the smart meter at the maximum duty cycle of 8.0% (i.e., transmissions for short periods a total of approximately 115 minutes per day). This maximum calculated exposure is approximately 7.8% of the FCC limit directly in front of the smart meter and 0.62% of the FCC limit behind the smart meter inside the house. Smart meters have a duty cycle of less than 0.5%, (i.e., they transmit for short periods a total of 7.2 minutes per day or less) (Itron, 2015). The exposure then would be about 16 times lower than calculated for the maximum duty cycle. Furthermore, the calculations above are performed at a close distance of approximately 8 inches in front of or behind the smart meter. At greater distances, the exposure from smart meter signals will be far less. The RF exposure from a smart meter approximately 6 feet away will be only ~1/100 of the exposure at approximately 8 inches.[20] As noted by the FCC, the RF from smart meters would comply with FCC limits on SAR, even if held against the body or clustered together at one location (Knapp, 2010).

---

[19] Both indoor and outdoor calculations also include the conservative ground reflection factor of 2.56 included in the Office of Engineering and Technology Bulletin 65 (FCC, 1997)

[20] For the unrealistic scenario in which the smart meter transmits continuously (i.e., all ~115.2 minutes of transmission occur consecutively), the duty cycle during that time of transmission would be 100% and the exposure from the smart meter at a distance of 1 yard behind the smart meter in the residence would be about 0.37% of the FCC limit. At a distance of ~8 inches in front of a smart meter that transmits continuously, i.e., all ~115.2 minutes of transmission occur consecutively), the exposure from the smart meter would be that from the FCC Certification discussed in relation to Table 6 (i.e., 38% of the FCC limit), while at a distance of 1 yard in front of the smart meter the exposure for this scenario would be approximately 4.6% of the FCC limit.

Another way to contextualize RF exposure from different sources is to determine the distance from a particular source at which the RF exposure from that source is the same as RF exposure from the earth. For the inside average scenario shown in Table 7, this distance is approximately 19 inches from the smart meter.[21] At distances greater than approximately 19 inches, the RF exposure from an average DLC smart meter is less than the RF exposure one constantly receives from the earth.

[21] This calculation assumes the decrease in field level follows the inverse square law.

6. Conclusions

A smart meter mesh network operates by transmitting information to neighboring smart meters and passing this information from smart meter to smart meter in several hops. This network architecture allows the smart meters to operate using low power levels. Furthermore, since required information transfer is relatively limited, smart meters only transmit a small fraction of the time.

An investigation into the potential RF exposure from smart meters in the context of other sources has shown two key features. Not only does the RF exposure inside a residence from a smart meter represent a tiny fraction of the FCC allowable limit, but exposure from other sources both inside and outside a residence are many times greater than from a DLC Itron smart meter.

In particular, calculations have shown that the contribution of a typical DLC smart meter to RF exposure indoors would be more than 40 times less than the natural RF emitted by people, more than a thousand times less than the exposure from local broadcast television and FM radio stations, and many thousands of times less than the RF exposure from other common electronic devices. The contribution of a typical DLC smart meter to the Complainant's exposure indoors is less than the RF exposure from other existing sources and only 0.00077% (1/130,000th) of the FCC's health-based exposure limit.

7. Facts Relied Upon

In this analysis, I have relied upon facts about the characteristics of the DLC smart meters manufactured by Itron, as summarized in Table 8.

Table 8. Sources of data used to model RF signal transmission from DLC smart meters

Parameter	Value	Reference
Power Output of Itron Smart Meters	688.65 mW	FCC ID: SK9-AMI7
Gain of Itron Smart Meter Antenna	1.66	FCC ID: SK9-AMI7
Minimum Duty Cycle of DLC Smart Meters	0.002%	Itron, 2015
Average Duty Cycle of DLC Smart Meters	0.21%	Itron, 2015
Maximum Duty Cycle of DLC Smart Meters	8.0%	Itron, 2015

In this report, I have also relied upon peer-reviewed research papers, comprehensive reviews of subject matter by internationally-recognized organizations, FCC certification documents, and publications of national standards. The information relied upon is cited in text and the full source is documented in Section 8.

8. References

Advanced Compliance Solutions (ACS). EMI Test Report in Accordance with ANSI C12.1. Report 11-0134.C14.11.B, Rev. B for Itron HW 3.1, ANSI Single Phase Model Variants 1S, 2S and 12S (issued June 22, 2011). Buford, GA: ACS, 2011.

American National Standards Institute (ANSI). American National Standard for Electric Meters—Code for Electricity Metering (ANSI C12.1). Rosslyn, Virginia: National Electrical Manufacturers Association, 2008.

Abdulla H and Badra RE. Head exposure to cellular telephones: A system-level study. 2010 IEEE Latin-American Conference on Communications 15-17 September 2010.

Code of Federal Regulations (CFR). Title 47 Telecommunication, Volume 1, §1.1310 - Radiofrequency radiation exposure limits; §2.1093 – Radiofrequency radiation exposure evaluation: portable devices; §15.207 – Conducted limits. Washington DC: Office of the Federal Register National Archives and Records Administration as a Special Edition of the Federal Register, As of December 20, 2018.

Electric Power Research Institute. An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter. Palo Alto, CA: EPRI, 2010.

Federal Communications Commission (FCC). Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Office of Engineering and Technology Bulletin 65, Edition 97-01. Washington, DC: FCC, 1997.

Federal Communications Commission (FCC). Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields. Office of Engineering and Technology Bulletin 56, Fourth Edition. Washington, DC: FCC, 1999.

Foster KR. Radiofrequency exposure from wireless LANs utilizing Wi-Fi technology. Health Phys 92:280-289, 2007.

Health Protection Agency (HPA). Cordless Telephones: Digital Enhanced Cordless Telecommunications (DECT) and Other Cordless Phones. Available from http://webarchive.nationalarchives.gov.uk/20140714084352/http:/www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733767519

Institute of Electrical and Electronics Engineers (IEEE), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 0 kHz to 300 GHz. New York, NY: IEEE, 2019.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz-300 GHz). Oberschleißheim, Germany: ICNIRP, 2009.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494-522, 1998.

Itron ANSI Qualification Report for the CENTRON® OpenWay® Hardware 2.1 Single Phase Meters (CENOPENWAYHW31SPAUG2011, Document Version 1). Itron, August 23, 2011.

Itron. RF Safety Compliance of OpenWay Smart Meters and the CG-Mesh IPv6 Network. Itron, 2015.

Joseph W, Verloock L, Goeminne F, Vermeeren G, Martens L. Assessment of RF exposures from emerging wireless communication technologies in different environments. Health Phys 102:161-172, 2012.

Knapp JP. Letter to Cindy Sage from Julius P. Knapp, FCC, August 6, 2010.

Mantiply ED, Pohl KR, Poppell SW, Murphy JA. Summary of measured radiofrequency electric and magnetic fields (10 kHz to 30 GHz) in the general and work environment. Bioelectromagnetics 18:563-577, 1997.

National Institute of Standards and Technology (NIST). NIST Construction Automation Program, Report No. 3. Electromagnetic Signal Attenuation in Construction Materials (NISTIR 6055). Gaithersburg, Maryland: US Department of Commerce, 1997.

Valberg PA, van Deventer TE, Repacholi MH. Workgroup report: base stations and wireless networks-radiofrequency (RF) exposures and health consequences. Environ Health Perspect 115:416-424, 2007.

Viel JF, Cardis E, Moissonnier M, de Seze R, Hours M. Radiofrequency exposure in the French general population: band, time, location and activity variability. Environ Int 35:1150-1154, 2009.

Limitations

At the request of DLC, I performed an assessment of RF fields related to Itron smart meters deployed by DLC. The scope of services was determined by the circumstances associated with this case as well as applicable codes, rules, and regulations. The findings presented herein are made to a reasonable degree of engineering and scientific certainty. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation.

Appendix A

Educational Background, Qualifications, and Curriculum Vitae

Qualifications and Education

I am a Senior Managing Engineer in the Electrical Engineering and Computer Science Practice at Exponent, Inc., an international science and engineering firm. My work address is 17000 Science Drive, Suite 200, Bowie, MD 20715.

I earned my Bachelor of Science degree *summa cum laude* in Electrical Engineering from the University of Portland as well as a Master of Science degree and a Doctor of Philosophy degree in Electrical Engineering from Stanford University. I am a member of several technical organizations including the IEEE and the International Council on Large Electric Systems. I am a member of the IEEE Power Engineering Society Corona and Field Effects Working Group as well as the International Committee on Electromagnetic Safety, Subcommittees 3 and 4.

I am the author of numerous peer-reviewed papers and conference presentations on the topic of electromagnetic fields and the earth's geomagnetic field, as listed in my *curriculum vitae*. I was also the co-founder of an international conference series established under the auspices of the United Nations with the purpose of bringing the science of electromagnetics to developing countries and to assist in starting doctorate-level research programs in electromagnetics in those countries.

I have expertise in both applied and theoretical electromagnetics including modeling, measurement, and analysis studies of natural and manmade RF fields in the earth's environment. I regularly assist clients in evaluating RF fields from varied sources ranging from portable diesel generators to *ad hoc* networks (such as the mesh network established by smart meters) to government/military communication facilities (high-frequency band through microwave-frequency band). My work includes the evaluation of RF exposure with respect to electromagnetic interference to devices and the safety of medical and non-medical devices. My expertise is requested by federal agencies, utilities, construction developers, and patients with implanted medical devices, their physicians, and their employers.

Appendix B

Common RF Sources and FCC RF Usage Spectrum Chart

EXHIBIT H-2

The frequency and representative RF exposure values for some man-made RF sources commonly encountered in daily life are shown below in Table B-1. Large ranges of RF exposure can be seen for several of the RF sources. These ranges are due to the large number of factors affecting exposure from a given RF source. While Table B-1 provides a list of some of the common manmade sources, it is only a very small subset of all RF sources. Figure B-1 shows the many hundreds of RF communication bands used in modern society, all of which have the potential to contribute to an RF exposure assessment.

Table B-1. Frequency and representative RF exposure values for common man-made RF sources

Source	Frequency (MHz)	Reported Value (% of FCC Limit)*	Exposure Conditions†	Reference†
Mobile Phone	800 – 1,900	5 – 12	Personal Use	Abdulla and Badra (2009) Tables 7-10
Cordless Phone	1,880 – 1,900	0.5 – 4	Handheld Unit	HPA, 2014
Wi-Fi	2,400 – 2,484	0.00004 – 0.4	Typical Exposures	Viel et al. (2009), Table 4; Foster (2007), Table 2
Bluetooth	2,400 – 2,484	0.001 – 0.25	At 0.2 m to 3 m Distance	Valberg et al. (2007), Table 4
Microwave Oven	2,450	0.007 – 1.3	At 1 m Distance	Mantiply et al. (1997), p. 573

* RF exposure is presented as a percentage of the FCC limit to keep these exposure values both consistent and accurate. The FCC limit is defined as the applicable SAR limit, wave power density limit, or square of the field magnitude limit, all for uncontrolled environments. Both whole body exposure and spatial peak SAR for the head are used where appropriate.

† RF exposure can be heavily dependent upon situation, so exposure conditions and references are provided for each exposure value.

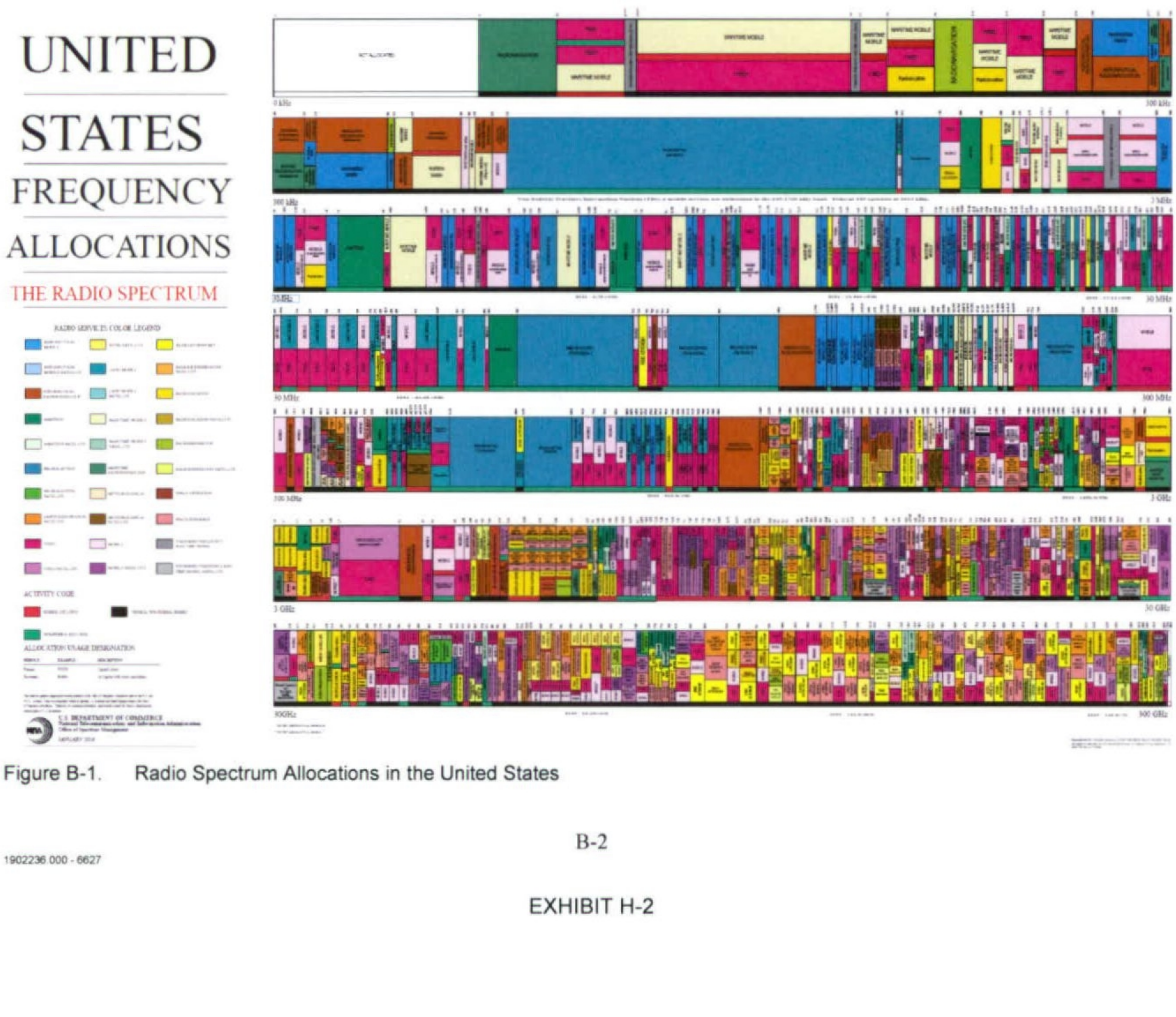


Figure B-1. Radio Spectrum Allocations in the United States

Appendix C

Example Exposure Calculation for the Complainant

Exposure from a smart meter

When a DLC Itron smart meter is transmitting, the power of that transmission is constant and so the variation in the potential exposure level (excluding the effect of any external environmental factor such as walls or distance) is determined by the duty cycle of a particular smart meter. Using a duty cycle consistent with the minimum, average, and maximum duty cycles of Itron smart meters (0.002%, 0.21%, and 8.0%, respectively), it is possible to calculate exposure levels from a smart meter based upon the duty cycle (at a particular distance).[22]

The exposure to RF energy from a smart meter (as well as most other sources of RF not used in close proximity to the body) is based upon computational modeling recommended by the FCC (Office of Engineering and Technology Bulletin 65) which is used to calculate the power density (S) of a signal at a distance R from the transmitter, with an input power P, an antenna gain G, transmission coefficient T, and a duty cycle of δ. The applicable formula is:

$$S = 2.56\frac{PGT}{4\pi R^2}\delta$$

The factor of 2.56 is used to include the potential reflection of the signal from the ground that may increase the exposure above the case using the standard inverse square law. This factor of 2.56 is applied by the Office of Engineering and Technology to far-away sources such as television or radio broadcast signals and is not generally applicable to the signal from a smart meter (FCC, 1997). *It is included here, however, to provide a very conservative calculation of the RF exposure from the Itron smart meters deployed by DLC.* In addition, when a signal passes through some material such as a wall a portion of the energy is reflected, reducing the amount of energy that is transmitted through the material. The transmission coefficient, T, depends on the type of material, its thickness, and the frequency of the wave. For the Itron smart meters, several exposure calculations using the above formula are summarized in Table C-1.

---

[22] A smart meter transmits about one-tenth as much power in the backward direction as in the forward direction. Additional factors, such as the metal backplate on a smart meter and type of wall construction are not considered in this illustrative comparison (EPRI, 2010).

Table C-1. Calculations of RF exposure from DLC smart meter at the Complainant's residence

Scenario	Power (Watt)	Gain	Ground Reflection Factor (δ)	Transmission through Wall Material (T)	Distance from Source	Duty Cycle	Calculated Value (% of FCC Limit)
Smart Meter (Inside, min)	0.689	0.166	2.56	0.80	~10 feet	0.002%	0.0000007%
Smart Meter (Inside, avg)	0.689	0.166	2.56	0. 80	1 yard	0.21%	0.00077%
Smart Meter (Inside, max)	0.689	0.166	2.56	0. 80	~8 inches	8.0%	0.62%
Smart Meter (Outside, min)	0.689	1.66	2.56	--	~10 feet	0.002%	0.0000090%
Smart Meter (Outside, avg)	0.689	1.66	2.56	--	1 yard	0.21%	0.0096%
Smart Meter (Outside, max)	0.689	1.66	2.56	--	~8 inches	8.0%	7.8%
2nd Smart Meter (Inside, min)*	0.689	0.166	2.56	0. 80	35 feet	0.002%	0.00000006%
2nd Smart Meter (Inside, avg)*	0.689	0.166	2.56	0. 80	35 feet	0.21%	0.0000057%
2nd Smart Meter (Inside, max)*	0.689	0.166	2.56	0. 80	35 feet	8.0%	0.00022%
Zigbee (Inside, min)	0.065	2.40	2.56	0. 80	~10 feet	0.011%	0.0000018%
Zigbee (Inside, avg)	0.065	2.40	2.56	0. 80	1 yard	0.011%	0.000020%
Zigbee (Inside, max)	0.065	2.40	2.56	0. 80	~8 inches	0.15%	0.0054%

* Representative of a second smart meter located approximately 35 feet away (such as the estimated distance between meter sockets at 3835 Acorn Street and 3837Acorn Street). The evaluation here is performed at a location 1 yard from the smart meter (inside the residence) or 35 feet (~12 yards) from the meter socket at 3837 Acorn Street.

Figure 1. Illustration of the concept of wave energy movement from a source.

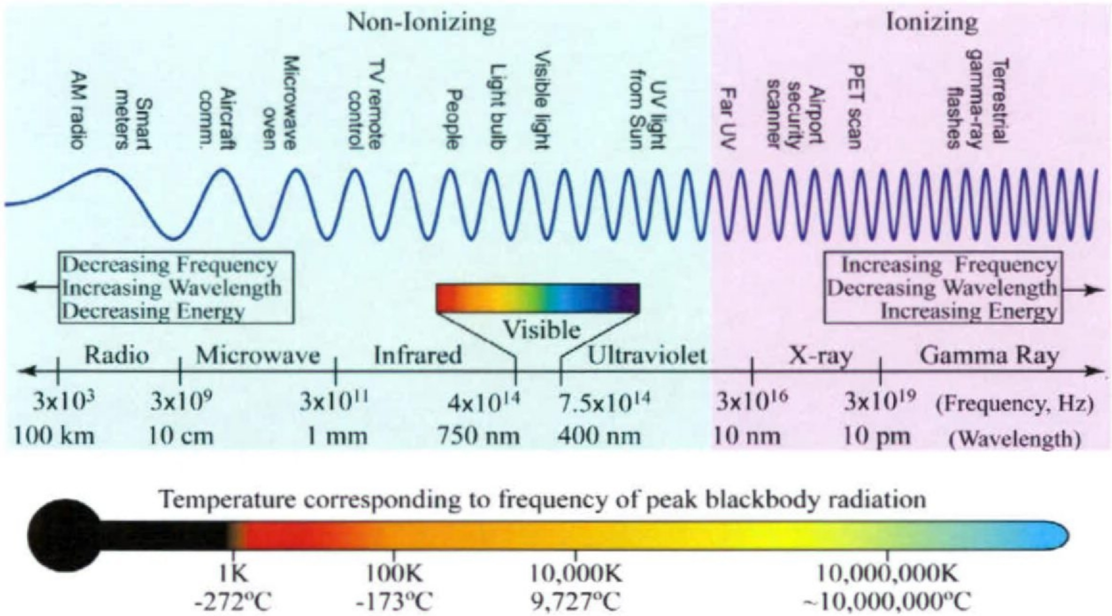


Figure 2. The electromagnetic spectrum and the relationship between frequency, wavelength, energy, and temperature.

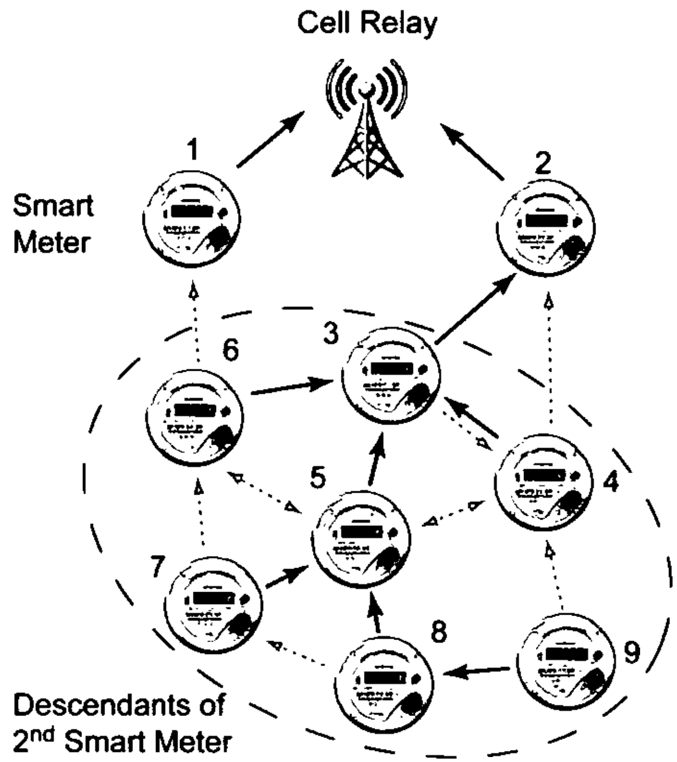


Figure 3. Illustrative example of a smart meter mesh network.

Table 1. Duty cycle of DLC smart meters*,†

Duty Cycle Description	Duty Cycle Value
Minimum	0.002% (0.03 minutes per day)
Average	0.21% (2.99 minutes per day)
Maximum	8.0% (115.2 minutes)

* Itron (2015).

† This table includes values after a November 2019 upgrade to the DLC system in order to allow the DLC network to utilize IPv6 standards and architecture. Prior to this upgrade the minimum, average, and maximum duty cycle of the DLC smart meters were 0.02%, 0.06%, and 0.58%, respectively.

Table 2. Duty cycle of the Zigbee Radio in DLC smart meters*

Duty Cycle Description	Duty Cycle Value
Idle Zigbee Radio (no devices joined)	0.01% (9.9 seconds per day)
Smart Meter with Tendril HD (In Home Display)	0.15% (132 seconds per day)

* Information received from DLC.

Table 3. Exposure limits specified by the FCC, IEEE, and ICNIRP

Agency	Power Density Limit at 900 MHz		Power Density Limit at 2.4 GHz (W/m^2)		SAR Limit (W/kg)
	(W/m^2)	(mW/cm^2)	(W/m^2)	(mW/cm^2)	
FCC (CFR §1.1310 and §2.1093)	6	0.6	10	1.0	0.08 (Whole body) 1.6 (over any 1 gram of tissue)
ICNIRP (1998)	4.5	0.45	10	1.0	0.08 (Whole body) 2 (over any 10 grams of tissue)
IEEE, (C95.1, 2019)	4.5	0.45	10	1.0	0.08 (Whole body) 2 (over any 10 grams of tissue)

Note: mW/cm^2 = milliwatts per square centimeter; W/m^2 = watts per square centimeter and 1 mW/cm^2 = 10 W/m2.

Table 4. RF exposure values for common natural RF sources

Source	RF Exposure (mW/cm^2)	RF Exposure (% of FCC Limit)
Blackbody radiation from the earth	1.3	0.0027
Blackbody radiation from humans	3	0.0054

Table 5. Frequency and representative RF exposure values for common manmade RF sources

Source	Frequency (MHz)	Reported Value (% of the FCC Limit)*	Exposure Conditions†	Reference†
Cell Phone	800 – 1,900	5 – 12	Personal Use	Abdulla and Badra (2009) Tables 7-10
Cordless Phone	1,880 – 1,900	0.5 – 4	Handheld Unit	HPA, 2014
Wi-Fi	2,400 – 2,484	0.00004 – 0.4	Typical Exposures	Viel et al. (2009), Table 4; Foster (2007), Table 2
Bluetooth	2,400 – 2,484	0.001 – 0.25	At a 0.2- to 3-meter Distance	Valberg et al. (2007), Table 4
Microwave Oven	2,450	0.007 – 1.3	At a 1-meter Distance	Mantiply et al. (1997), p. 573

* RF exposure is presented as a percentage of the FCC limit to keep these exposure values both consistent and accurate. The FCC limit is defined as the applicable SAR limit, wave power density limit, or square of the field magnitude limit, all for uncontrolled environments. Both whole body exposure and spatial peak SAR for the head are used where appropriate.

† RF exposure can be heavily dependent upon situation, so exposure conditions and references are provided for each exposure value.

Table 6. Calculations of RF exposure for DLC smart meters and local broadcast stations

Source	Distance from source	Duty Cycle (in a 30-minute period)*	Calculated value (% of FCC limit)
Smart Meter LAN (Inside, Average)†,§	1 yard	0.21%	0.00077
Smart Meter LAN (Outside, Average)	1 yard	0.21%	0.0096
Local Broadcast Stations	~5 – 10 miles away	100%	0.24

* The FCC specifies a 30-minute averaging period in assessing RF exposure.

† The exposure inside the home from the smart meter will be reduced by the exterior wall material, assumed to be plywood. As discussed in Section 1, ~80% of the energy incident on the outer wall will penetrate into the residence. This factor is included in the calculation of exposure inside the residence due to the smart meter.

§ The smart meter preferentially transmits in the forward direction. The amount of energy transmitted toward the back of the smart meter is approximately 10% that of the forward direction (EPRI, 2010). This factor of 10% is included in the calculation of exposure due to the smart meter inside the residence.

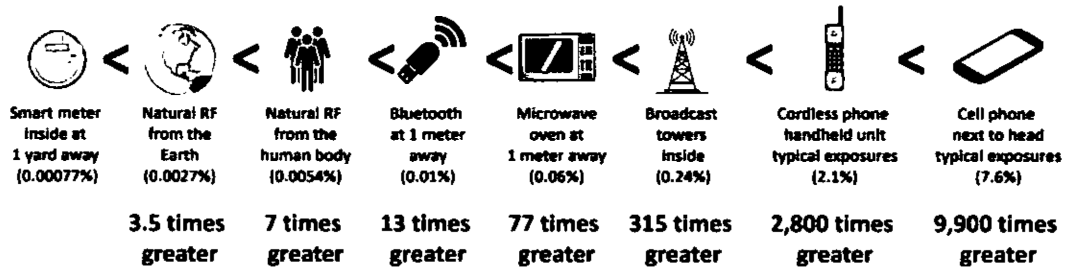


Figure 4. RF exposure of smart meters relative to other RF sources.

The RF exposure as a percentage of FCC limits is shown beneath each graphic in parentheses and a comparison of how much greater each exposure is than the smart meter is shown below that in bold font.

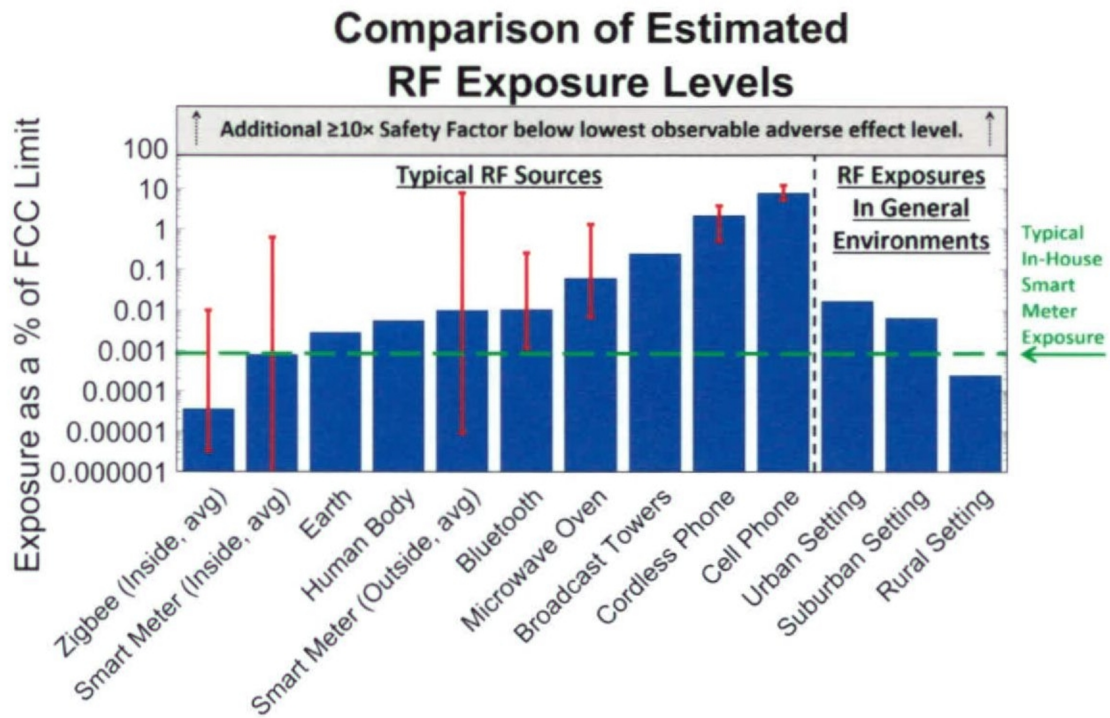


Figure 5. Comparison of RF exposure from the RF-LAN and Zigbee signals to RF exposure from other sources under typical use. The red lines show the potential range of RF levels associated with the manmade sources.

The RF exposures in general environments are reported in Joseph et al. (2012).

Table 7. Example variability of smart meter in different exposure scenarios

Scenario	Forward/Back Transmission Factor	Transmission through Wall Material	Distance from Smart Meter	Duty Cycle	Calculated Value (% of FCC Limit)
Inside Minimum	0.1	0.8	10 feet	0.002%	0.0000007%
Inside Average	0.1	0.8	1 yard	0.21%	0.00077%
Inside Maximum	0.1	0.8	~8 inches	8.0%	0.62%
Outside Minimum	1	1	10 feet	0. 002%	0.0000090%
Outside Average	1	1	1 yard	0.21%	0.0096%
Outside Maximum	1	1	~8 inches	8.0%	7.8%

Table 8. Sources of data used to model RF signal transmission from DLC smart meters

Parameter	Value	Reference
Power Output of Itron Smart Meters	688.65 mW	FCC ID: SK9-AMI7
Gain of Itron Smart Meter Antenna	1.66	FCC ID: SK9-AMI7
Minimum Duty Cycle of DLC Smart Meters	0.002%	Itron, 2015
Average Duty Cycle of DLC Smart Meters	0.21%	Itron, 2015
Maximum Duty Cycle of DLC Smart Meters	8.0%	Itron, 2015

Table B-1. Frequency and representative RF exposure values for common man-made RF sources

Source	Frequency (MHz)	Reported Value (% of FCC Limit)*	Exposure Conditions†	Reference†
Mobile Phone	800 – 1,900	5 – 12	Personal Use	Abdulla and Badra (2009) Tables 7-10
Cordless Phone	1,880 – 1,900	0.5 – 4	Handheld Unit	HPA, 2014
Wi-Fi	2,400 – 2,484	0.00004 – 0.4	Typical Exposures	Viel et al. (2009), Table 4; Foster (2007), Table 2
Bluetooth	2,400 – 2,484	0.001 – 0.25	At 0.2 m to 3 m Distance	Valberg et al. (2007), Table 4
Microwave Oven	2,450	0.007 – 1.3	At 1 m Distance	Mantiply et al. (1997), p. 573

* RF exposure is presented as a percentage of the FCC limit to keep these exposure values both consistent and accurate. The FCC limit is defined as the applicable SAR limit, wave power density limit, or square of the field magnitude limit, all for uncontrolled environments. Both whole body exposure and spatial peak SAR for the head are used where appropriate.

† RF exposure can be heavily dependent upon situation, so exposure conditions and references are provided for each exposure value.

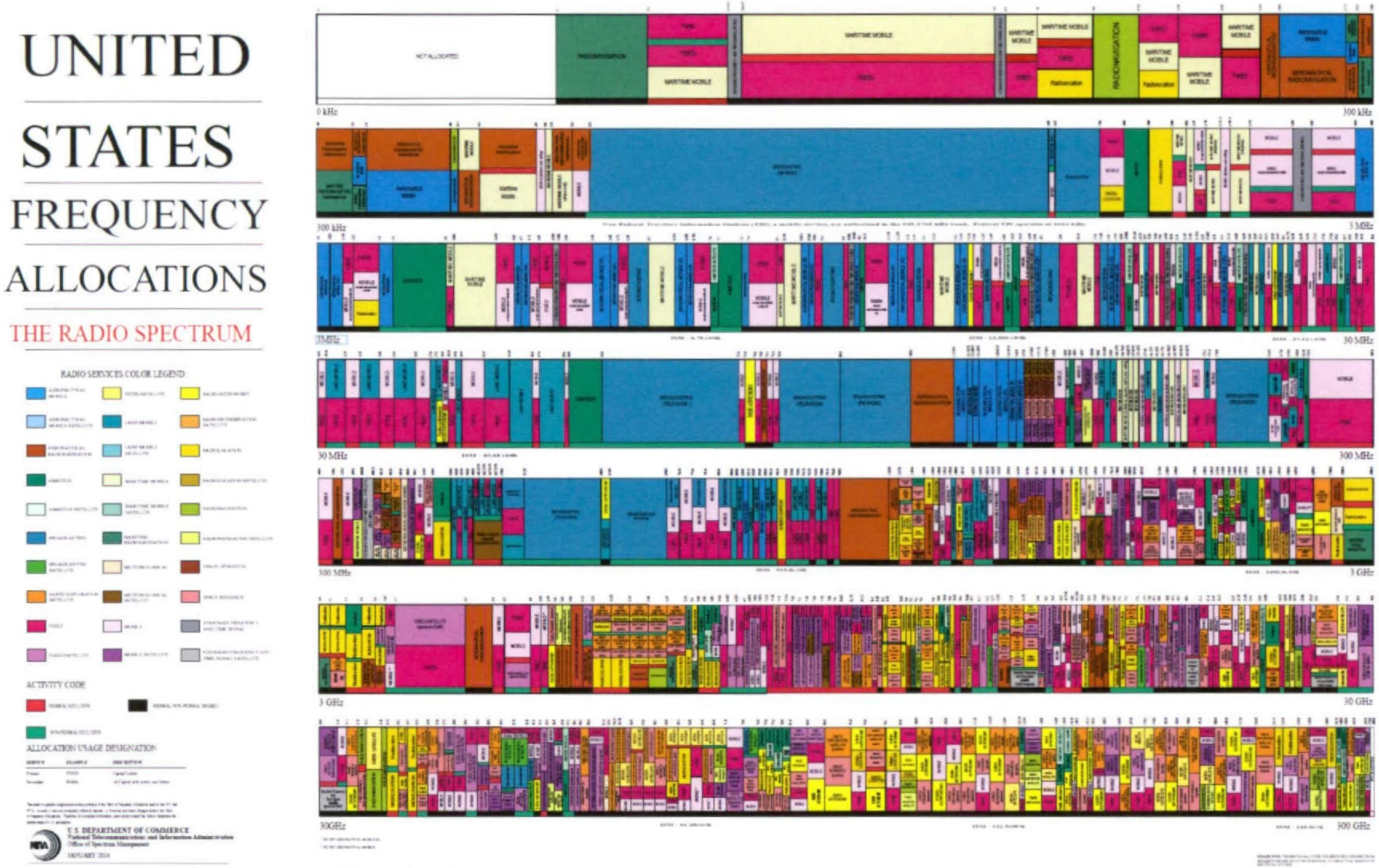


Figure B-1. Radio Spectrum Allocations in the United States

Table C-1. Calculations of RF exposure from DLC smart meter at the Complainant's residence

Scenario	Power (Watt)	Gain	Ground Reflection Factor (δ)	Transmission through Wall Material (T)	Distance from Source	Duty Cycle	Calculated Value (% of FCC Limit)
Smart Meter (Inside, min)	0.689	0.166	2.56	0.80	~10 feet	0.002%	0.0000007%
Smart Meter (Inside, avg)	0.689	0.166	2.56	0. 80	1 yard	0.21%	0.00077%
Smart Meter (Inside, max)	0.689	0.166	2.56	0. 80	~8 inches	8.0%	0.62%
Smart Meter (Outside, min)	0.689	1.66	2.56	--	~10 feet	0.002%	0.0000090%
Smart Meter (Outside, avg)	0.689	1.66	2.56	--	1 yard	0.21%	0.0096%
Smart Meter (Outside, max)	0.689	1.66	2.56	--	~8 inches	8.0%	7.8%
2nd Smart Meter (Inside, min)*	0.689	0.166	2.56	0. 80	35 feet	0.002%	0.00000006%
2nd Smart Meter (Inside, avg)*	0.689	0.166	2.56	0. 80	35 feet	0.21%	0.0000057%
2nd Smart Meter (Inside, max)*	0.689	0.166	2.56	0. 80	35 feet	8.0%	0.00022%
Zigbee (Inside, min)	0.065	2.40	2.56	0. 80	~10 feet	0.011%	0.0000018%
Zigbee (Inside, avg)	0.065	2.40	2.56	0. 80	1 yard	0.011%	0.000020%
Zigbee (Inside, max)	0.065	2.40	2.56	0. 80	~8 inches	0.15%	0.0054%

* Representative of a second smart meter located approximately 35 feet away (such as the estimated distance between meter sockets at 3835 Acorn Street and 3837Acorn Street). The evaluation here is performed at a location 1 yard from the smart meter (inside the residence) or 35 feet (~12 yards) from the meter socket at 3837 Acorn Street.

REDACTED

CCBPROD [redacted]

Home Menu ▾ History ▾ Customer Contact

Main | Log | Characteristics

Customer Contact Info	GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/AMI 30 Day Meter Exchange Noti, Contacted 04-04-2018
Person ID	[redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open ☐
Preferred Contact Method	User ID SOAUSER SOAUSER, SOAUSER
Contact Date/Time	04-04-2018 / 12:00PM
Contact Class	Advanced Metering Infrastructure
Contact Type	AMI30DAYLTR AMI 30 Day Meter Exchange Notification Letter
Comments	Notification of Advanced Meter Exchange
Related Records	

PENGAD 800-631-6989
EXHIBIT
Respondent M-1
02/27/2020

REDACTED

CCBPROD [redacted]

Home Menu ▾ History ▾ Customer Contact

Main Log Characteristics

Main Menu

Customer Contact Info	GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/Robo Call, Contacted 05-04-2018
Person ID	[redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open
Preferred Contact Method	User ID SOAUSER SOAUSER, SOAUSER
Contact Date/Time	05-04-2018 / 05:38PM
Contact Class	Advanced Metering Infrastructure
Contact Type	ROBOCL Robo Call
Comments	Robocall results - No Answer 5-4-18 5:38 PM
Related Records	
Letter Information	

CCBPROD [redacted]

Home Menu ▾ History ▾ Customer C

Main | Log | Characteristics

Main Menu

Customer Contact Info	GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/General Inquiry, Contacted 05-11-2018
Person ID	[redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open ☐
Preferred Contact Method	User ID KBADEN Baden, Kevin
Contact Date/Time	05-11-2018 / 02:48PM
Contact Class	Advanced Metering Infrastructure
Contact Type	GENINQ General Inquiry
Comments	Customer refused Wellington meter exchange, left message for customer to call me.
Related Records	
Letter Information	

REDACTED

CCBPROD [redacted]

Home Menu ▾ History ▾ Customer Cont

Main Log Characteristics

Main Menu

Customer Contact Info: GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/General Inquiry, Contacted 06-04-2018

Person ID: [redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open ☐

Preferred Contact Method: User ID KBADEN Baden, Kevin

Contact Date/Time: 06-04-2018 / 04:33PM

Contact Class: Advanced Metering Infrastructure

Contact Type: GENINQ General Inquiry

Comments: Email received from Miranda, customer states still refusing the meter and filing a puc complaint. Per DLC legal, until we receive a PUC complaint we are to move forward with the process.

Related Records

Letter Information

CCBPROD [redacted]

Home Menu History Field Activity

Main | Steps | Characteristics/Remarks | Miscellaneous | Log

Field Activity: 120/240 - 1PH 3W, On-line User, AMI Investigation, Completed, Scheduled 06-04-2018 12:00AM, Completed

Service Point ID	[redacted]	120/240 - 1PH 3W Residential - AMR/Monthly Mtr Read Cyc - Day 16/Route 000022/35 ACORN ST, PITTSBURGH, PA, 152071001355	
Activity Type	MOSAMIIN	AMI Investigation	
	Created on 06-04-2018 05:28PM by user KBADEN.		
Schedule Date/Time	06-04-2018 / 12:00AM		
Field Activity Status	Completed		
Field Activity Priority	Priority 50	Eligible for Dispatch	☑
Dispatch Group	707000	PGH-HAZELWOOD	
Field Order ID		No Field Order Information	
External ID	[redacted]	Intermediate Status	Completed
Instructions	Meter exchange order, customer previously refused meter. If customer refuses the meter exchange then post the premis.		
Comments	knocked had contact, customer stated she does not want the meter posted 72 hr notice 6-12-18 DGT		
Additional Info			

Main Menu

CCBPROD [redacted]

Home Menu ▾ History ▾ Customer Contact

Main | Log | Characteristics

Customer Contact Info: **GRACE ROSEN,MIRANDA, Legal / Regulatory/PUC Complaint / Issue, Contacted 11-27-2018**

Person ID: [redacted] **GRACE ROSEN,MIRANDA - Primary Phone:** [redacted] Open ☐

Preferred Contact Method: User ID **RMORRIS Morris, Roxanne**

Contact Date/Time: 11-27-2018 / 01:57PM

Contact Class: Legal / Regulatory

Contact Type: PUC ISSUE PUC Complaint / Issue

Comments

Related Records

Letter Informatio

Edit data - Internet Explorer

[redacted]2885 - LETTER TO CUSTOMER DATED 11/19/18 FROM OUR ATTORNEY OFFICE TUCKER-ARENSBERG ADVISING CUSTOMER A TAG WILL BE PLACED ON METER INDICATING METER NOT TO BE EXCHANGED WHILE FORMAL COMPLAINT REMAINS ACTIVE

Home Menu History

Main Log Characteristics

Customer Contact Info GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/General Inquiry, Contacted 06-04-2018

Person ID [redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open

Preferred Contact Method

User ID KB/

Contact Date/Time 06-04-2018 / 05:13PM

Contact Class Advanced Metering Infrastructure

Contact Type GENINQ General Inquiry

Comments Refusal acknowledgement letter and PAPUC faqs mailed.

Related Records

CCBPROD

Home Menu | History

Main | Log | Characteristics

Main Menu

Customer Contact Info: GRACE ROSEN,MIRANDA, Advanced Metering Infrastructu/General Inquiry, Contacted 05-18-2018

Person ID: [redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open

Preferred Contact Method: — User ID KBADEN B

Contact Date/Time: 05-18-2018 / 01:27PM

Contact Class: Advanced Metering Infrastructure

Contact Type: GENINQ General Inquiry

Comments: AMI Meter Exchange No Access letter mailed 05-18-18 with a reply date of 06-1-18, the meter exchange requires an appointment, CSR's should contact DLC scheduling.

Related Records

CCBPROD [redacted]

Home Menu ▾ | History ▾

Main | Log | Characteristics

Main Menu

Customer Contact Info	GRACE ROSEN,MIRANDA, General Customer Contact/General Customer Contact, Contacted 04-10-2018
Person ID	[redacted] GRACE ROSEN,MIRANDA - Primary Phone: [redacted] Open ☐
Preferred Contact Method	Phone — Primary Phone: [redacted] — User ID NAHENDE
Contact Date/Time	04-10-2018 / 11:23AM
Contact Class	General Customer Contact
Contact Type	GCC — General Customer Contact
Comments	[redacted]2885 - MIRANDA WANTS TO OPT OUT OF GETTING NEW METER, ADV HER METER WILL BE CHANGED, ADV OF POLE DISCONNECTION, WANTS METER CHANGED STALLED ADV WOULD NOTE ACCT
Related Records	
Letter Information	

<Date>

«FIRST_NAME» «LAST_NAME»
«ADDRESS»
«CITY_STATE» «ZIP»

Dear «FIRST_NAME» «LAST_NAME»,

During the next several weeks, Duquesne Light will exchange your existing electric meter with a new, digital model. This exchange is part of an overall upgrade of the company's metering infrastructure required by Pennsylvania Act 129.

The new digital meter will operate as your existing meter does today, and you will not notice any difference in how it measures your electric use. In the future, as the advanced metering infrastructure is activated in your neighborhood, Duquesne Light will offer a variety of programs and services that can help you save energy, in addition to benefiting the environment.

What We Will Do

Before the Exchange	Day of the Exchange		After the Exchange
We will call to remind you of the upcoming work using the following phone number: «SERV_ADDR_PHONE»	A Duquesne Light authorized installer, with a valid ID, will arrive at your residence to complete the exchange between 7 a.m. - 5 p.m. You do not need to be home for the exchange.	Once the meter exchange is complete, the installer will verify that your new meter is working properly. The installer will leave behind a door hanger, indicating the type of work that was performed.	You may be asked to participate in a telephone survey regarding your meter exchange experience. On a future bill, you will temporarily see multiple readings and ID numbers for your meter – once when it is exchanged and again when it is activated on our network. For more info, visit the Meter Exchange Program (FAQs) section of DuquesneLight.com.

Steps You Should Take

1. **If the phone number above is incorrect, or one is not listed,** please contact us via email at MeterExchangeInquiry@duqlight.com or by phone at 1-888-928-8539 (press "1" and follow the prompts) to update your contact information.
2. **Make sure we can access the meter** by removing any barriers, such as locked gates, pets or material blocking the meter.
3. **If your meter is located inside your residence,** please call 1-888-895-1044 to set up an appointment for the installer to gain access to your home to complete the meter exchange.
4. **Notify others in your household** about the upcoming exchange.

In some limited cases, the meter replacement will result in a brief interruption (approximately 10 minutes) of your electric service. After the exchange is complete, your service will return to normal. We apologize for any inconvenience this outage may cause.

EXHIBIT M-2

EXHIBIT AA
02/27/2020
RESPONDENT M-2
C-2018-3002741
PENGAD 800-631-6989

Please note: Even if your electric service is not interrupted, we recommend that you check and, if necessary, reset clocks, surge protectors, Ground Fault Interrupter (GFI) outlets – the type of outlet commonly used near water sources such as kitchens and bathrooms – and other electronic devices.

Thank you for your patience during the meter exchange. Over time, the new advanced metering infrastructure and the future services it enables will help you better manage your energy use.

Online Portal: Putting More Energy Use Info in Your Hands

You soon will have access to a secure online portal that provides near real-time information and analysis about your electric use. The portal also will provide options to help you manage your electric bill, including displaying your energy-use patterns by day of week and time of day, providing a projected monthly bill to-date and sending email or phone alerts to reduce high-bill surprise if your monthly usage passes a certain level. Watch your mail for additional information.

In order to provide you with these services, Duquesne Light will need to share your usage data with our portal provider, Opower, a company we've worked with in the past. Opower will not use your data for any purpose other than what is necessary to provide your online benefits.

You will be automatically enrolled in the online portal program and your customer usage data will be provided to Opower unless you notify us within 30 days. If you do not want us to make your usage data available to Opower, please contact Duquesne Light Customer Service within 30 days by email at customercare@duqlight.com or by calling 1-888-928-8539 (press "1" and follow the prompts). Customers that unenroll from the program will not have access to the Online Portal.

Future Benefits

Longer-term, thanks to technology enabled by the new advanced metering infrastructure, we also plan to offer additional programs and services, such as:

- An optional Time-of-Use program that may provide benefits to customers who can shift portions of their power use to non-peak hours.
- Outage alerts and restoration estimates that will help our customers plan during storm-related service interruptions.

If you have any questions about this letter or any of the services and programs offered, contact us via email at customercare@duqlight.com or by phone at 1-888-928-8539 (press "1" and follow the prompts.) You also can check the Meter Exchange Program section of DuquesneLight.com for more information.

Sincerely,

Michele Sandoe
Vice President of Customer Care

PUC complaint

DUQUESNE LIGHT CO.

June 5, 2018

Miranda Grace Rosen
35 Acorn Street
Pittsburgh, PA 15207

Dear Miranda Grace Rosen,

As you may recall, Duquesne Light is exchanging its existing electric meters with new, advanced digital models to provide new options to help customers manage their electricity usage. The exchange is part of an overall upgrade to the company's metering infrastructure required by the Public Utility Commission (PUC) under Pennsylvania Act 129 of 2008. It will enable Duquesne Light to offer a variety of programs and services that can help you save energy, in addition to benefiting the environment.

You are receiving this letter because Duquesne Light will soon be replacing your electric meter. While the company previously delayed your meter exchange, nearly half a million meters have been replaced and the company is nearing completion of the program.

As a result, per Pennsylvania law, the existing Duquesne Light meter at your residence will be replaced with an advanced digital meter. Duquesne Light will attempt to contact you before the meter exchange takes place.

Before the Exchange	Day of the Exchange		After the Exchange
We will call to remind you of the upcoming work using the following phone number: 412-726-8329	A Duquesne Light authorized installer, with a valid ID, will arrive to complete the exchange between 7 a.m. - 5 p.m. *You do not need to be present for the exchange.*	Once the meter exchange is complete, the installer will verify that your new meter is working properly. The installer will *leave behind a* door hanger, indicating the type of work that was performed.	You may be asked to participate in a telephone survey regarding your meter exchange experience. Quality checks will be conducted on a small percentage of completed meter exchanges. You do not need to be *present for this activity.* On a future bill, you will temporarily see multiple readings and ID numbers for your meter when it is exchanged and activated on our network.

In addition, there are circumstances that may require the exchange of the meter prior to this scheduled installation. These include, but are not limited to: the failure of the current meter, if the meter at your address is randomly selected for PUC-required accuracy testing, or when the current automated meter reading system for meters is

Este es un mensaje importante. Si usted no lo entiende, favor de llama a 412-393-7100.

EXHIBIT N

EXHIBIT
02/27/2020
Respondent N
C-2018-3002741
PENGAD 800-631-6989

taken offline later this year. Duquesne Light will attempt to contact you in such circumstances before this exchange takes place.

Steps You Should Take

1. **If the phone number above is incorrect, or one is not listed,** please contact us via email at MeterExchangeInquiry@duqlight.com or by phone at 1-888-928-8539 (press "5" and follow the prompts) to update your contact information.
2. **Make sure we can access the meter** by removing any barriers, such as locked gates, pets or material blocking the meter.
3. **If your meter is located inside your residence/business,** please call 1-888- 928-8539 (press "5" and follow the prompts) to set up an appointment for the installer to gain access to your home to complete the exchange.
4. **Notify others in your residence/business** about the upcoming exchange.

In some limited cases, the meter replacement will result in a brief interruption (approximately 10 minutes) of your electric service. After the exchange is complete, your service will return to normal. We apologize for any inconvenience this outage may cause.

Please note: Even if your electric service is not interrupted, we recommend that you check and, if necessary, reset clocks, surge protectors, Ground Fault Interrupter (GFI) outlets – the type of outlet commonly used near water sources such as kitchens and bathrooms – and other electronic devices.

Online Portal: Putting More Energy Use Information in Your Hands

You soon will have access to a secure online portal that provides information and analysis about your electric use. The portal also will provide options to help you manage your electric bill, including displaying your energy-use patterns by day of week and time of day, providing a projected monthly bill to-date and sending email or phone alerts to reduce high-bill surprise if your monthly usage passes a certain level. Watch your mail for *additional information.*

In order to provide you with these services, Duquesne Light will need to share your usage data with our portal provider, Opower, a company we've worked with in the past. Opower will not use your data for any purpose other than what is necessary to provide your online benefits.

You will be automatically enrolled in the online portal program and your customer usage data will be provided to Opower. If you do not want us to make your usage data available to Opower, please contact us by email at MeterExchangeInquiry@duqlight.com or by calling 1-888-928-8539 (press "5" and follow the prompts). Customers who choose not to enroll in the program will not have access to the online portal.

More Information at DuquesneLight.com

For more information on other customer benefits available through the new metering infrastructure, visit the Meter Exchange section of our website, DuquesneLight.com. If you have any questions about this letter, or any of the services and programs offered, contact us via email at DLCCustomerService@duqlight.com or by phone at 1-888-928-8539 (press "5" and follow the prompts).

Sincerely,

Campbell Hawkins
Vice President of Customer Service

Este es un mensaje importante. Si usted no lo entiende, favor de llama a 412-393-7100.

EXHIBIT N

DLC
— DUQUESNE LIGHT CO. —

10/17/2017

JON CUSTOMER
1034 MAIN ST
CORAOPOLIS, PA 15108

Dear JON CUSTOMER,

As you may be aware, Duquesne Light is exchanging existing electric meters with new, digital models as part of an overall upgrade to the company's metering infrastructure. This infrastructure upgrade is required by the Pennsylvania Public Utility Commission under Pennsylvania Act 129 of 2008. Additionally, these new meters will give you access to a variety of programs and services that can help you save energy, as well as benefiting the environment.

We have made several attempts to contact you to exchange the meter at your residence/business; however, we have not been able to gain safe access to the meter. As a customer, you are responsible for ensuring that we can safely access and exchange the meter so that we can continue to provide you safe and reliable electric service. **Customers who do not allow access for a meter exchange could face service termination.**

If your service is terminated, you may be responsible for a fee up to $250 to restore service. Additionally, your service will not be restored until you provide Duquesne Light access to conduct a meter exchange.

Please contact us no later than [DATE] to arrange a time for a Duquesne Light technician to exchange your meter. You can contact us by phone at 412 393-7100 or via email at DLCAppointmentReminder@duqlight.com.

Sincerely,

Duquesne Light

PENGAD 800-631-6989
EXHIBIT OO
02/27/2020
Respondent O
C-2018-3002741

Este es un mensaje muy importante. Si usted no lo entiende, favor de llama a 412-393-7100.

EXHIBIT O

CCBPROD [redacted]

Home Menu ▾ History ▾ SP/Meter Installation

Main | SP Installation History

SP/Meter History: Install Date/Time. 12-14-1996 11:59PM / 120/240 - 1PH 3W Residential - AMR/Monthly Mtr Read Cyc - Day 16/Route 000022/35 ACORN ST, PITTSBURGH, PA, 152071001355

	Badge Number	Meter Type	Install Date/Time	Removal Date/Time	Meter ID
	G90231606	6W-X	12-14-1996 11:59PM		1176760673

EXHIBIT Q

PENGAD 800-631-6989 EXHIBIT
02/27/2020
RESPONDENT Q
C-2018-3002741

UNITED STATES POSTAGE
PITNEY BOWES
02 1P $ 007.85⁰
0000314936 JUN 10 2020
MAILED FROM ZIP CODE 15101

Suite 1101 The Gulf Tower Pittsburgh, PA 15219 412-281-7908

NDS

Pennsylvania Public Utility Commission
Office of the Secretary
P.O. Box 3265
Harrisburg, PA 17105

UNITED STATES POSTAL SERVICE®

USPS TRACKING #

PRIORITY®