Final Report
Forensic Audit of CMP's
Metering and Billing Systems

EXECUTIVE SUMMARY

Presented to:
State of Maine
Public Utilities Commission

Presented by:
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Work Scope and Objectives

The Maine Public Utilities Commission (Commission) asked The Liberty Consulting Group (Liberty) to conduct a forensic audit of Central Maine Power Company's (CMP) metering, billing, and related systems. A large increase in customer complaints and inquiries began in early 2018. These complaints followed an October 30, 2017 windstorm that produced unprecedented outages accompanied by a contemporaneous switchover to a new billing system. A cold winter followed (including a particularly frigid late December/early January), along with a large increase in standard-offer supply rates.

Many customers saw high bills, estimated bills, extensive delays in getting bills, billing mistakes requiring correction, and transparently erroneous information on bills. Customer service representatives had major difficulties in responding timely and effectively to the resulting wave of inquiries and complaints. Their problems in dealing with customers heightened already understandable concerns and even skepticism.

Our work addressed the following six elements; whether:

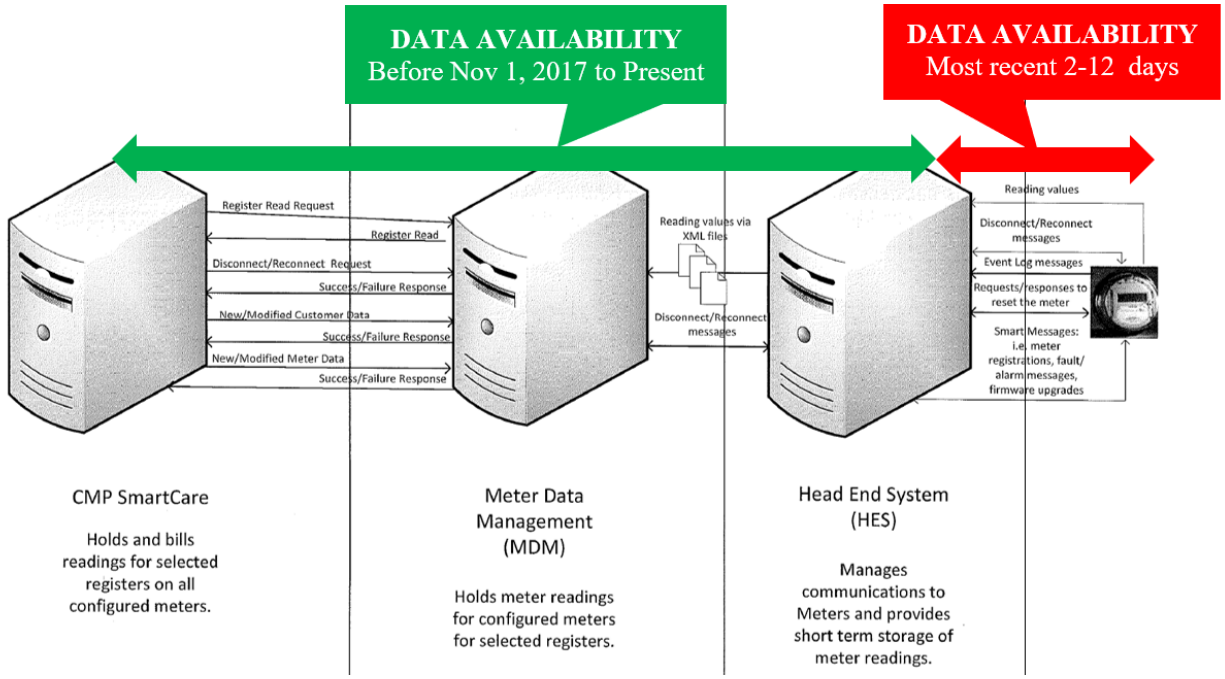
- *Meters* have produced and are producing accurate customer usage measurements
- *Databases and Communications Systems* have accurately, completely and timely transmitted meter data to meter data management and billing systems and are doing so
- *Billing Systems* have produced and are producing timely, accurate bills
- *Bills* have conveyed and are accurately conveying usage information to customers
- *SmartCare* (the new customer information system) implementation and cutover at the end of October 2017 affected billing or customer complaints

- *Customer Communications* have been timely and effective.

CMP's AMI System

CMP began installing an Advanced Metering Infrastructure (AMI) system in 2010, largely completing it in 2012. The AMI system employs about 640,000 meters. GE I-210+c meters comprise about 360,000 of them, with Landis + Gyr supplying about 280,000. The next illustration shows the overall flow of information and the systems supporting the meter-to-bill process. A wireless AMI Network (provided by Trilliant) permits communication (including meter registrations of usage) between the AMI meters and a system that collects and temporarily stores meter information (the Head End System). Another system (the Meter Data Management System) stores meter information from the Head End System and uploads it on request to the system (SmartCare)that performs billing calculation and preparation functions. Suppliers GE, Landis + Gyr, Trilliant, Itron, and SAP all play lead roles, both domestically and internationally in the industry and with respect to their contributions to the CMP meter-to-bill process.

CMP Meter-to-Bill Interfaces



The red and green labels in the above chart illustrate the difference in data availability between parts of the AMI system. AMI meters only retain registered usage for between 2 and 12 days - - limiting testing of what the meters sent to the most recent few days, not what they sent during the November 2017 through April 2018 period. We did find substantial indirect performance metrics that permitted us to test communications from meters to the Head End System, however. By contrast, the Head End and Meter Data Management Systems retain information from the whole of this six-month period. SmartCare also retained information for the six-month period.

Therefore, we could trace nearly all usage-registration data points from Head End System collection through SmartCare system entries. This wealth of data enabled us to verify whether

registration data from more than 650,000 accounts for six months passed through three check points (Meter Data Management System, SmartCare, and PDF bill imaging) completely and without change. We captured the resulting 12 million data points (650,000 meters times six months, times three check points) into a master data base. The number of datapoints we ultimately captured and used was well in excess of this direct number. We compared the billing determinants (*e.g.*, energy and delivery components) used to bill customers with calculations we performed.

We tested data points for completeness and accuracy by employing a matching function for entries in a master testbed of all data points we extracted, assembled, and verified. This comprehensive approach obviated the need for a statistically-driven sample, although we did use some sampling for data validation purposes. We did use a statistical sample for meter testing. We decided on a sample of 60 meters, designed to consider the range of AMI meter types and the multiple regions of the service territory. Given the large numbers of meters tested by CMP and the uniformity of the results of that testing, we considered this sample an appropriate means for corroborating the validity of results of accuracy testing by CMP.

Meter Accuracy

CMP regularly performs accuracy tests on average on more than 10,000 of its meters annually - - testing two percent, or twice the number required by the Commission. CMP tested more than 2,000 AMI meters about which customers had raised high-bill concerns or questions since November 2017. Regular testing has rarely identified meters operation outside Maine's required +/- two percent tolerance level or outside the significantly tighter level that CMP applies internally. None of the more than 2,000 AMI meters tested in response to high-bill issues failed. These results conform to general industry experience.

We documented the results for each of the 60 sample-group meters whose accuracy testing we directly observed in the field. Each tested well within the required tolerance levels. The nature of the testing and the dispersed nature of the CMP territory make in-the-field testing a time-consuming process. Directly observing those 60 tests took more than one hour per meter. More tests would certainly provide greater confidence about the lack of meter error today. However, we made the judgment that the nearly-universal nature of the results of CMP's testing and general experience in the industry with respect to meter accuracy made the sample we chose sufficient. Accordingly, we concluded that CMP meters produce measurements of usage within the established tolerance band, and have done so since November 1, 2017.

The GE Meter Anomaly

An anomaly exists in most of the approximately 350,000 GE I-210+c meters CMP uses on its AMI system. This anomaly has caused error in some customer bills, but not at material levels system-wide. Power outages require affected meters to reset after power is restored. An uncommon set of circumstances (we termed it "reset interruption") occurring in a very narrow time window during that reset process can place these meters in an anomalous operating condition. That condition causes the meter's clock to run fast ("fast-clock" operation) and it separately causes them to register usage incorrectly ("register anomaly" mode). GE identified the potential for error, without detailing its nature or likely magnitude, offering a no-cost firmware upgrade solution in October 2012 firmware release notes. Nobody at CMP today recalls having received the release notes.

CMP did little about the issue until the fall of 2014. CMP then observed fast clocks and circumstances suggesting improper usage registration, particularly following storm events. Management asked GE to examine the issue. GE's responsive report cited the October 2012 firmware upgrade as a permanent solution. A temporary solution (we termed it "special reset") identified would eliminate anomalous operation, but, until the firmware upgrade delivered a permanent solution, would leave the meter at risk of future reset-interrupt conditions. The AMI network never had and still lacks the capability to deliver the firmware upgrade over the air to all the affected GE meters en masse. CMP decided in 2014 to await that capability, which it states it then expected Trilliant to deliver imminently. CMP did not implement a rigorous procedure for identifying the need for and performing the special resets.

CMP's 2014 examination did not address register error risk or causes initiating it. That kind of examination came in 2018, following a surge in customer billing inquiries and complaints in early 2018. CMP's response to inquiries and complaints led it to press Aclara (which had since acquired GE's meter business) for an examination. Aclara's examination at CMP's urging discovered the precise chain of initiating events and how register anomaly mis-recorded usage.

We believe that CMP management should have pressed for resolution of the issue not later than 2014 (earlier if it had access to the October 2012 GE information). Had it done so, it would have understood both the need for a rigorously applied temporary (special reset) solution and for either confirming the imminence of the Trilliant solution or finding another way to upgrade the meter firmware in the absence of such confirmation. The reason management would have done so is that it would have had ***certainty*** about what it believed was ***possible*** in 2014 - - that some number of meter registrations and therefore bills were inaccurate.

However, management did not learn what it could and should have learned in 2014, and moreover did not rigorously search for and perform special resets of meters operating anomalously. The records show only inconsistent attention to anomalous GE meter operation until March 2018, leaving the customers served by them with registration error, subject to occasional special resets.

Customer Consequences from the GE I-210+c Meter Anomaly

The GE I-210+c meter anomaly did produce inaccurate bills, but the nature of that anomaly is largely self-cancelling at the individual customer level. We did not see in the anomaly the potential for creating a material gap between actual and meter-registered usage system-wide. Typical control panel configurations on customer premises include one 240-volt and two 120-volt (termed Phase A and Phase C) sources. The mitigation of register error occurs in such configurations because the anomaly: (a) does not affect accuracy of usage registration for customer devices operating at 240 volts, (b) records usage on Phase A (one of two carrying a customer's 120-volt load) at twice actual usage, and (c) records no usage on the other, Phase C.

Overall, the error is limited to cases where there is, during register-anomaly operation, more 120-volt load on Phase A than on Phase C. Error is limited to 120-volt usage and zero usage recording on Phase C offsets double recording on Phase A. This offsetting will limit error to very small amounts in most cases. Over the whole system, the customers with over-registered usage and those with under-registered usage generally balance each other as well.

We do not consider the GE meter anomaly a material contributor to inaccuracy on a total system basis, either now, or since November 1, 2017. However, customers, perhaps in the several thousands, have been overcharged or undercharged (likely in roughly equal numbers) due to register error. We believe that most of these instances involve very small amounts, but some unknown number are likely more substantial. CMP could have minimized these occasions by instituting its more rigorous 2018 approach to special resets. It can do even more to minimize them in the future by compressing its *Day 1 - - Identify*, then *Day 2 - - Correct* process to a single day.

CMP management did not keep complete records of instances of register-anomaly operation of its GE I-210+c meters. There is today no practicable way to identify all those that occurred in the past. Even if identification was practicable, determining which customers were over- or under-billed and by how much would require knowledge of the devices were in use at the premises during register-anomaly operation and knowledge of their usage distribution between Phases A and C.

Communication from Meters to the Head End System

Our system-to-system matches of data moving from the Head End to the SmartCare System (discussed below) tested the accuracy and completeness of communications between them. As noted, information about AMI communications from the meters to the Head End System has severely time-limited availability. We could directly test that communication for the 60 meters in our field accuracy-test sample. The meters retain up to 12 days of data sent to the Head End System. Pulling that data from the meters and comparing it with corresponding Head End Systems produced exact matches for each data point held in the Head End System. We also verified that data communicated from the meter during its field accuracy test entered the Head End System accurately for all of the 60 meters then in live communication with the Head End System.

We examined metrics addressing information (packet data) sent but not received, automated meter read rates, and network trouble reports for the November 2017 through April 2018 period. Available performance metrics for all three provide an indirect indicator of communications reliability between AMI meters and the Head End System. We did not find concentrations of troubled or reduced read rates that would have led us to question availability of the AMI Network to operate satisfactorily in transmitting meter data to the Head End System during this period. We concluded that the AMI Network accurately, completely, and timely transmits usage data from meters to the Head End System meter data management and billing systems, and has performed with a reasonably high availability rate since November 1, 2017.

Communication from the Head End System to SmartCare

Our process for end-to-end testing of billing accuracy began with the meter usage registrations and the meter-to-Head End communications addressed above. The remainder of that testing took us from Head End data to actual bills, which CMP maintains in the form of PDF files depicting actual bills as sent to customers. We also tested the companion path for manually-read meters. The Itron Field Collection System (as opposed to the Head End System for AMI meters) collects manually-read meter data from analog meters and customers who have opted out of the AMI network.

A comparative wealth of data exists from the Head End and Field Collection Systems. We took advantage of the millions of measurements available to develop a series of tests, many of which involved nearly all meters for every month of the period from November 2017 through April 2018. These tests sought to validate that meter data collection, storage, and transmission occur accurately, completely, timely, and consistently.

The specific tests performed addressed each recording of usage information and its transmission to SmartCare, where billing calculation occurs. The goal was to ensure that the data transmitted to and received by each component remained complete and unchanged, in order to ensure that usage initially recorded matched the usage ultimately driving billing calculation, absent a justified basis for correcting it. Our testing sequence first sought to match the data as captured in the Head End System with corresponding data in the Meter Data Management System and then match it again in the SAP SmartCare system data used for billing. We performed similar matching tests for Field Collection System and SmartCare data.

Our testing matched 99.8 percent of meter data points between the Head End System and the Meter Data Management System, indicating a largely successful collection, transfer, and storage of readings as communicated through the AMI network. We also 99.8 percent matching between Meter Data Management and SmartCare billing system values. In both cases, the exceptions indicated timing issues (more than one read received on the same day and only one is used for billing) and a small number of readings not picked up when CMP extracted Head End System from which we created our testbed.

This extensive review found no material indicator of corruption, lack of completeness, or delay with respect to the usage registration data from meters. We concluded that meter-related databases and communications systems are accurately, completely and timely transmitting usage data from meters to meter data management and billing systems, and have been since November 1, 2017.

However, until CMP can address the GE meter anomalies permanently, management should strengthen meter-data storage practices to ensure that meter data is collected and stored on the actual date collected. CMP should investigate adopting VEE standards for handling data within the Meter Data Management System and expand Meter Data Management System storage to include all meter usage readings.

SmartCare Billing Timing & Accuracy

We calculated expected billings for rate classifications Residential Service, Residential Time of Use, Small General Service, Small General Service Time of Use, Intermediate General Service, Medium General Service and Large Service. We employed the usage measurements whose flow through CMP's systems and processes we had examined and tested as described above. We prepared fields in our testbed of more than 3.9 million bills using the billing determinants provided by CMP. We used them to calculate expected delivery and supplier charges for each sampled bill. We then compared our calculated ("expected") bills to those actually billed by CMP. We excluded records with cancelled/reversed billings (59,001) and accounts with multiple meters or multiple accounts billed together (189,646 records).

This extensive review did not identify variances that would materially contribute to erroneously high customer bills. We also examined archived PDFs of the actual bill issued for more than 400 sampled accounts to ensure that data in the SmartCare system was appropriately presented on each customer's bill. One Hundred percent of PDF bills reviewed matched data found in the SmartCare system. There remains a body of instances where our calculation of billings does not match the amounts billed by CMP. Management needs to investigate these variances.

Analysis of Customer Usage from November 2017 through April 2018

Weather has a significant impact on electricity usage, particularly for cold-weather service territories with high levels of electric heat usage. Maine has experienced high rates of heat pump growth following efforts to stimulate this heating source. We examined whether cold temperatures may have had an effect on high levels of electricity usage by CMP customers last winter. We had both usage and degree-day information since 2013. Higher numbers of degree days mean colder weather.

Before adjustment, we began with a very high correlation between weather and usage. We then matched each day from November 2017 through April 2018 to the day from the prior years (back to 2013) having the closest number of degree days. Our matching "slid" each prior year's sequence of days so that we could match days of the week (an important driver of usage). This adjusted measurement basis showed an extremely close correlation between the days of the last winter period and the closest matching weather day from the historical period.

Historical data - - daily, monthly, yearly, and across 2013 – 2017 - - indicates that recorded system-usage from November 2017 through April 2018 matched expected usage given the weather conditions. We found only small differences from what prior usage patterns on days with similar degree day values would suggest. The conformity of expected to actual usage, based on comparisons with historical experience, corroborates our conclusions that meter registration of usage, temporary storage and transmission of that data, and its use in calculating and providing bills to customers did not contribute to material billing error from November 2017 through April 2018.

Smart Care Implementation and Go-Live

CMP's new customer information system (SmartCare) went live at the end of October 2017. It has functioned largely as planned, but defects in its operation have substantially contributed to very large numbers of exceptions to expected billing processes. Management has been taking corrective actions to address the billing issues, but resulting exceptions and delays have been substantial, and still affect some 10,000 customers each month. SmartCare's generation of an excessive number of incorrect bills after go-live has served as the main contributor to delays, as management worked to correct errors found in billings to be issued.

The resources and time needed for system corrections to address -process exceptions have delayed bills. They have also required time-consuming manual bill corrections, and generated bill cancellations, rebills and deposit and refund issues. The visibility of such problems to customers has contributed to concerns underlying complaints and skepticism about billings. Without knowledge of the status of fixes and with the need for manual corrections increasing, CMP's

customer representatives have frequently been unable to give customers meaningful answers about cause, corrections, and timing of solutions, further increasing concern and frustration.

Performance weaknesses in managing CIS development and go-live processes contributed substantially to the high level of billing and customer-service challenges experienced. The specific gaps in effective management we found included: inadequate testing, insufficient project staffing, lack of a sufficiently strong focus on quality, insufficiencies in project reporting for identifying and planning to address problems, and inadequate project readiness.

Customer Complaints and Inquiries

We examined the timeliness and quality of communications with customers and effectiveness in responding to calls, concerns, and billing complaints. Significant issues surrounding these elements of the "customer experience" occurred following October 2017. We examined the customer service organization's systems, tools, and resources. We also examined call center and billing performance, resource levels, storm planning and execution, communications about coming changes in bill format and information, complaint resolution timeliness and effectiveness.

The transition to SmartCare introduced problems that drove customer satisfaction below targets and customer complaints well above normal levels. Management experienced undue difficulty in eliminating underlying causes of billing complaints and in timely resolving individual customer issues. Continued high rates of complaint generation and extensive delay in resolving them have continued. Delays in resolving billing issues added to already elevated levels of customer concern, creating a cycle of escalating customer impatience and skepticism.

Insufficient Billing group staffing resulted from an inability to identify correctly the time needed to stabilize SmartCare. Insufficient numbers of staff slowed identification and correction of errors at their system sources and as part of manual efforts required to correct individual bills held for issuance due to known problems or identified by customers after receiving them.

In the months following SmartCare go-live, many bills were also delayed (for December and January particularly) due to CMP's pre-issuance error-identification processes. Management has addressed sources of these errors and reduced them, but more than 100,000 accounts have experienced billing error and CMP is still reporting customer-affecting errors. Bill presentation errors, avoidable had management tested presentation well before go-live, further contributed to customer confusion, promoting doubt about billing accuracy.

The October 2017 storm drove an increased number of estimated bills CMP for November 2017 (24,000). The means for generating estimated bills caused CMP's estimate to show less than actual usage in colder-than-average months. Thus, the next bill based on an actual read would show a higher usage, which would in turn cause customers to suspect the usage shown. These circumstances contributed to high bill concerns.

CMP experienced a 22 percent increase in times to handle calls following SmartCare go-live and high rates of calls abandoned by customers before response by the company. CMP has also failed to meet consistently its target level of service (answering 80 percent of customer calls within 45 seconds, a target consistent with industry experience) as it continued in the second and third

quarters of 2018 to struggle to address customer billing issues. A lack of sufficient staffing has materially contributed to long answer and call handling times. A lack of sufficient experience and supervision have impaired the ability to resolve specific customer inquiries and complaints and to address systemic issues underlying them.

Numbers of representatives hired have not kept pace with management's analyses of needs. The firm CMP uses to supplement internal resources has experienced exceptionally high turnover, which has plagued efforts to keep an experienced group of customer service representatives in place. CMP did not add supervisors to maintain their ratio to representatives. CMP actually lost three experienced supervisors, one in 2016 and two in early 2018. Management did not replace them until mid-2018 even though CMP added representatives during this period. The extraordinarily high ratio of representatives to supervisors impaired efforts to apply experience in addressing the root causes of customer inquiries and complaints, to direct inexperienced representatives, and to provide coaching and training needed to give representatives the skills and confidence to function independently in helping customers with questions and issues.

Summary of Major Conclusions

CMP's meters produce accurate measurements of customer usage. Its meter-related databases and communications systems accurately, completely, and timely collect and store usage, and transmit it accurately, completely, and timely to the billing systems of CMP's customer information system, SmartCare. The meters, systems, and databases have done so since November 1, 2017. The introduction of SmartCare at the end of October 2017 introduced errors and significant delay into the billing process. Billing error rates for delivery and for fairly standard supply arrangements proved minimal in number and in dollar value. We have not been able to match billing calculations for several thousand other supply arrangements, but are confident that the reason for the vast majority of the remaining mismatches is our inability to account fully for the unique billing factors involved. In any event, the total dollar value of these mismatches is also minimal. Management should, however, rationalize the remaining calculation differences. The overall magnitude of those differences, however, is too small to be considered a contributor to high bills last winter. We also found instances of very uncommon circumstances that cause one of CMP's AMI meter types to register usage inaccurately. Those anomalies may have produced occasions of inaccurate registration numbering in the low thousands since installation of those meters starting in 2010. Not only uncommon, the instances produced error too small to be material overall, but could have had more material consequence for much smaller numbers of customers.

Significant gaps in SmartCare testing and training and in the transition to it produced in its initial phase of operation unnecessarily large numbers of errors requiring lengthy manual correction before bill issuance. A shortage of personnel contributed to the inability to eliminate errors before go-live. Continuing shortages of experienced personnel after go-live unduly delayed fixes to the errors, caused significant customer difficulty in reaching CMP representatives and in getting answers to questions and concerns, and meant overly long delays in resolving billing problems. Customer performance metrics fell below norms and remained so for some time, some of them still today.

The extent and degree of performance degradation contributed strongly to a level of customer frustration, doubt, and skepticism already high due to uncharacteristically large bills last winter.

Our analysis showed usage at levels consistent with the expectations that the cold weather of last winter would suggest. Moreover, supplier rates then increased substantially, adding to the effects of higher than typical usage. Weather and rate changes, not meter or AMI system error, caused high usage registration and rates across the system as a whole. Even so, we consider management responsible for generating a high level of customer concern, produced by less than adequate SmartCare development and transition to operations processes and by a continuing shortage of sufficient numbers of customer service personnel after SmartCare go-live.