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Optimizing Outage Management Systems with Automated Meter Reading and Predictive Analytics

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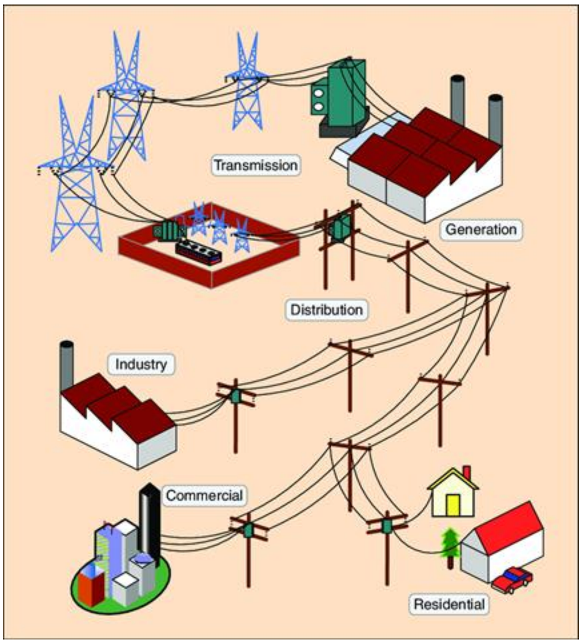
ABSTRACT

The electrical grid's stability can be ensured by optimizing power interruptions and maintenance currently. This paper revolves around how an Outage Management System (OMS) can apply the concept of Automated Meter Reading (AMR) and predictive analytics. The described solution provides advanced tools and methods for outage detection, prediction, and resolution, eventually resulting in the most reduced downtime and highest customer satisfaction. This article examines the importance of AMR and predictive analytics, which contribute to better response times and operational efficiency. This integration can be helpful to utilities and customers in making their systems more robust and more resilient by learning what the consequences of integration would be.

Keywords: Outage Management Systems (OMS), Automated Meter Reading (AMR), Predictive Analytics, Power Grid, Operational Efficiency

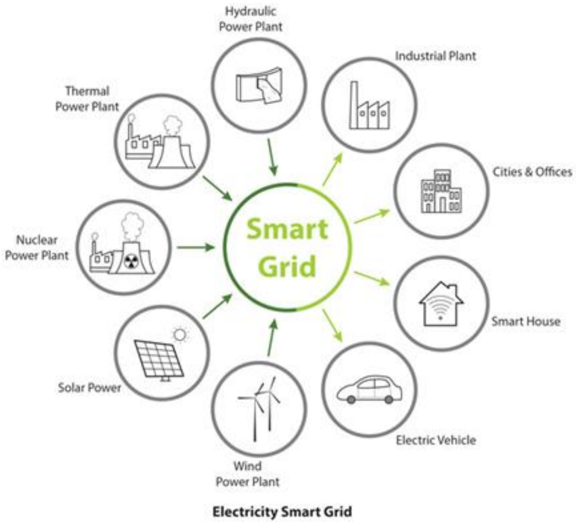
INTRODUCTION

Modern society relies heavily on unceasing electric supply. Property damage, lost money, and unhappy customers are all possible outcomes of power outages. The power supply involves a complex connection from the electricity source to the consumer, as illustrated below;



The most common electric grid

Legacy Outage Management Systems (OMS) suffer from two fundamental issues: manual monitoring and slower response time, which exacerbate these problems. AMI (Advanced Metering Infrastructure) became the reason behind the rising popularity of AMR systems. The scope of use from such systems as outage management extends beyond the remote reading of smart meters in real-time [2]. At present, one of the features of AMR is predictive analytics, which can transform the OMS to make outage occurrence and resolution far more accurate, as illustrated in the figure below;



Electricity Smart Grid

PROBLEM STATEMENT

The tasks for Outage Management Systems have been intensified. The most pressing problem is the long time it takes to get the whole cycle from discovery to realization. The OMS will likely take a long time to correct the problem if it relies so much on customer complaints and human errors to detect the issues. Power providers can utilize the following formula to determine the probability of power outages;

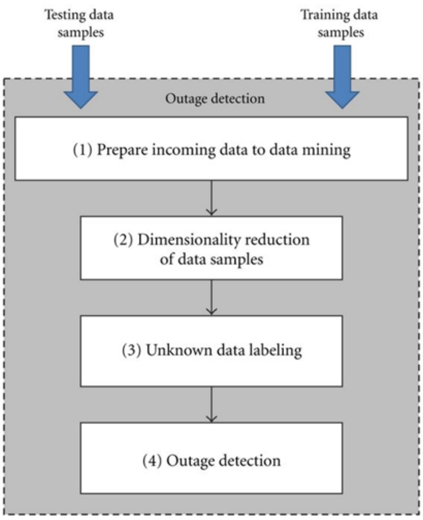
P.D.(t)=1−e∧−λt

Where;

- λ is the rate of outage occurrence.
- t is the time interval.

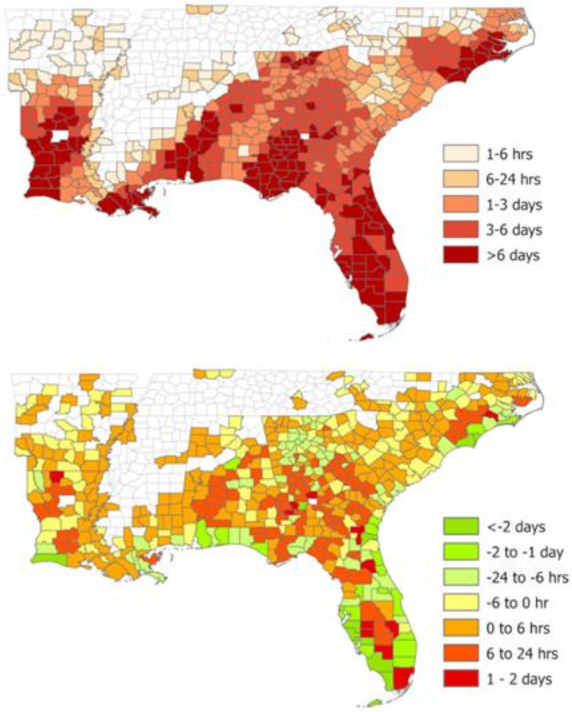
This equation portrays the limitations of human recording methods by helping to realize the possibility of detecting an outage within a certain period.

The process of detecting faulty locations and addressing them takes a few steps. This increases the time taken for outage detection; below is the procedure followed;

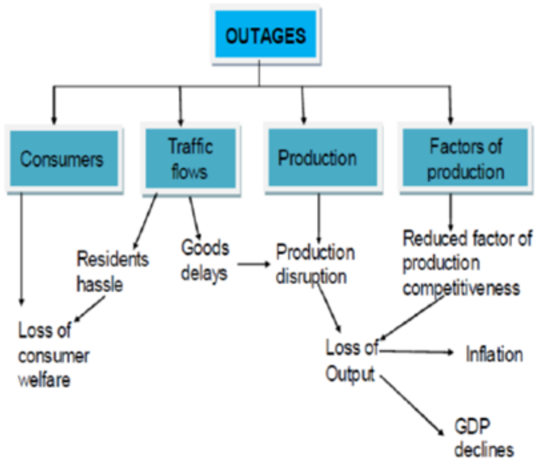


Outage detection-phase

Customers will also become upset and angrier if the breakdowns continue for longer, ultimately slowing down the service and aggravating them [3]. In addition, most automated systems need to be more accurate in predicting outcomes. An unexpected outage significantly impacts consumers and other sectors, such as Traffic flows, which gets worse with increasing time if left unchecked, as illustrated below;



As illustrated above, the total amount of time that electricity was out during eight storms was broken down by county. On the comparison that considers socioeconomic level, shown on the bottom map, regions with below-average income levels have prolonged downtime longer than anticipated.



Summary Impact of Power Outages

Utility agencies often yield to disruption with no alternative but to address it as it happens partly because they need a means of foreseeing it accurately or predictively with the aid of real-time and historical data [4]. Inequality in the distribution of assets during periods of disruption is also one of the great struggles. Utilities need help dispatching according to the repair teams' time plan and resources due to the absence of such information [5]. The consequences of this may be the prolonged time needed to recover and increased operation expenses. The following diagram visualizes the relative time there are power outages that leave businesses on hold;

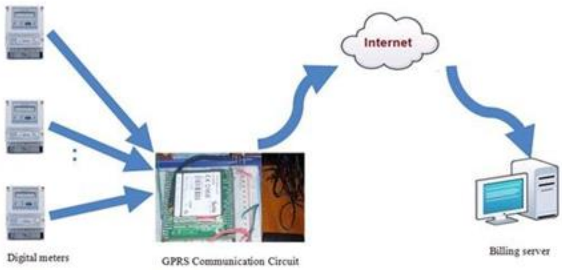
The second most crucial issue is the customer dissatisfaction. Trust and satisfaction of loyal customers are deeply affected due to the need for more prompt answers and extended outages [6]. Customers experience hardship during power outages, for example, store owners, as illustrated in the figure below;

The store was forced to close due to a power outage.

Utility service providers could experience the loss of customers and cash revenue because the conventional OMS's negative aspects are now ineffective and obsolete with the emergence of instant chat and total Transparency.

SOLUTION

To overcome these constraints, OMS can be developed by mixing AMR with statistical analysis. The connection for the AMR system is illustrated below;



AMR System connection to the grip and billing server

Instantaneous data collection determines the essence of this bond. AMR systems monitor the power consumption and grid condition daily to maintain the grid in the best mode. They collect data in real-time, allowing quick detection of abnormalities that may result from bleak actions like a possible breakdown or outage [7]. The desired value can be derived by employing the following mathematical expression:

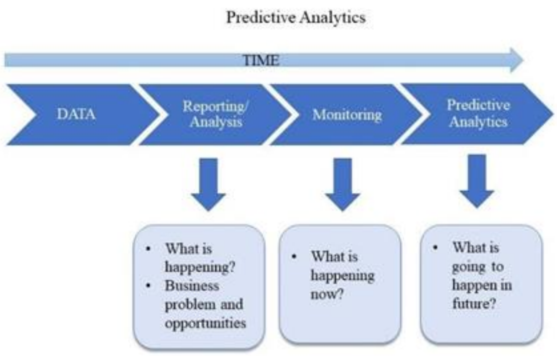
The rate at which real-time data is processed *RR* by AMR systems can be expressed as:

$R = N \cdot S / T$

Where;

- N is the number of smart meters.
- S is the size of data packets from each meter.
- T is the total processing time.

Using state-of-the-art forecasting tools, the OMS with AMR integration can perform much more for you. Predictions of forecasts determine possible blackouts and weak areas of the system by collecting historical data with real-time inputs.



Predictive Analytics Process

Unlike in the past, utility providers now can predict outages before they happen so they can perform regular repairs. The predictive analytics model can be formulated as follows;

A linear regression model used for predictive analytics to forecast outages based on historical data:

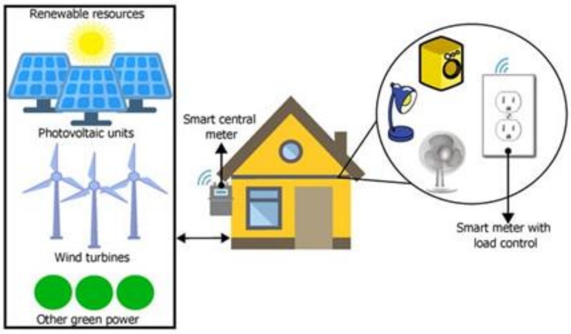
$z = \beta0 + \beta1x1 + \beta2x2 + ... + \beta nxn + \epsilon$

Where;

- z is the predicted variable (e.g., likelihood of outage).
- $\beta0\beta0$ is the intercept.
- $\beta1,\beta2,\ldots,\beta n\beta1,\beta2,\ldots,\beta n$ are the coefficients for each predictor $x1,x2,\ldots,xnx1,x2,\ldots,xn$.
- $\epsilon\epsilon$ is the error term.

The regression method could utilize variables, such as statistics about past outages, current weather conditions, and grid stress, to aid in outage forecasting.

The next essential step in the proposed method is automatic notification and action. Operators may add automated alerts and proactive strategies to avoid system interruptions [8]. For example, homes can be connected with smart meters with load control to calculate real-time power consumption.



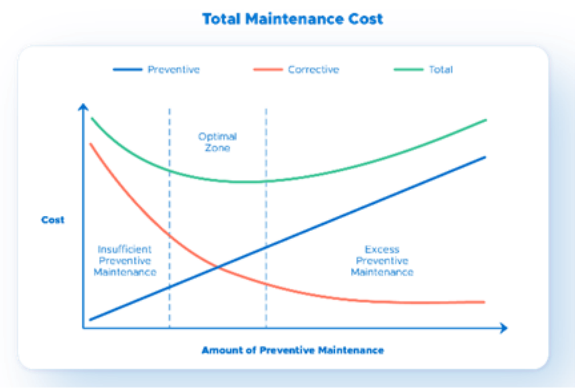
The home is connected to the smart meter with load control

The data collected for each house allows the electricity system to remain up and running even during high-demand times.

An essential part of integrating AMR with predictive analytics in OMS is optimizing resource allocation [9]. By distributing visibility and predictive insights more efficiently, repair personnel and maintenance resources can be more smartly distributed, decreasing downtime and costs.

USES

Integrating AMR with statistical analysis offers OMS several benefits. One of its most important functions is to prevent damage. Utility companies can pave the way for an uninterrupted electricity supply by foreseeing possible problems and doing the repair work beforehand, by having planned maintenance in the optimal zone as seen below;



Following facts regarding the tool's planned functioning and the manufacturer's instructions might help find this ideal zone. In our effort to be proactive, the periods of operation for each equipment and infrastructure will increase while pauses are minimized [10]. The utilities will be able to quickly figure out the causes of power interruptions and fix them by applying data analysis tools with mighty analytical power. Another significant benefit is the strengthened customer relations. Communicating solutions, which include modern information about the time and restoration period, is beneficial in giving information [12].

IMPACT

Utilities and their end users will probably be affected by such a holistic approach in the most direct way. The consumers are either industrial or domestic, and they are the energy providers, and they need this kind of consistency as they do their daily activities [13]. There are also savings-money benefits. Maintenance methods may be cost-effective for utility providers because they maximize resource utilization. Utility companies can avoid the need to deploy the resources needed for this. The second reason is customer satisfaction. The clients will become more confident in the company if they quickly respond to outages [14]. Such a company's reputation will be highly elevated and maintained in the customer experience era by resolving customer issues promptly. Customer satisfaction S can be modeled as a function of outage duration and response time:

$S=\alpha-\beta Tr-\gamma To$

Where;

- α is the baseline satisfaction level.
- ββ is the dissatisfaction rate per unit of response time TrTr.
- γγ is the dissatisfaction rate per unit of outage duration To*To*.

SCOPE

Several topics speckled the mornings. Size is the key factor. Utility size will also be redefined based on the sophistication level of the scalable solution. Scaling to any size of municipal water or big regional utility companies, their demands and requirements can be answered using AMR and predictive analytic tools [1]. One of the significant areas of development would be in the fields of AMR and predictive analysis. The competencies for A.I. and M.L. will improve with time; thus, OMS will be more trusted and effective.

CONCLUSION

In conclusion, merging automatic meter readings and predictive analytics in the outage management system will be an outstanding success for utility management. One of the main objectives of the integrated model is increased operational efficiency, reduced interruptions, client satisfaction, and trust, which can bypass OMS disadvantages. Power grids of the future will be more flexible with the aid of the applied AMR technology and forecasting methods, which are continuously making advancements and expecting further developments. The hybrid approach for replacing traditional systems combines OMS and AMR with implementing predictive analytics. To create a power system that is resilient enough to address future energy needs, it is of paramount importance that these technologies be implemented to gear the energy landscape transformation

REFERENCES

[1]. S. Abolhosseini, A. Heshmati, and J. Altmann, "A Review of Renewable Energy Supply and Energy Efficiency Technologies," *SSRN Electronic Journal*, 2014, https://doi.org/10.2139/ssrn.2432429

[2]. Y. Zhang, T. Huang, and E. F. Bompard, "Big data analytics in smart grids: a review," *Energy Informatics*, Aug. 13, 2018, https://doi.org/10.1186/s42162-018-0007-5

[3]. A. Zakariazadeh, O. Homaee, S. Jadid, and P. Siano, "A new approach for real-time voltage control using demand response in an automated distribution system," *Applied Energy*, Mar. 01, 2014, https://doi.org/10.1016/j.apenergy.2013.12.004

[4]. A. Safdarian, M. Fotuhi-Firuzabad, and M. Lehtonen, "A Distributed Algorithm for Managing Residential Demand Response in Smart Grids," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 4, pp. 2385–2393, Nov. 2014, https://doi.org/10.1109/tii.2014.2316639

[5]. Dong-Min Kim and Jin-O Kim, "Design of Emergency Demand Response Program Using Analytic Hierarchy Process," *IEEE Transactions on Smart Grid*, vol. 3, no. 2, pp. 635–644, Jun. 2012, https://doi.org/10.1109/tsg.2012.2188653

[6]. Dong-Min Kim and Jin-O Kim, "Design of Emergency Demand Response Program Using Analytic Hierarchy Process," *IEEE Transactions on Smart Grid*, vol. 3, no. 2, pp. 635–644, Jun. 2012, https://doi.org/10.1109/tsg.2012.2188653

[7]. M. He and J. Zhang, "Fault Detection and Localization in Smart Grid: A Probabilistic Dependence Graph Approach," *2010 First IEEE International Conference on Smart Grid Communications*, Oct. 2010, https://doi.org/10.1109/smartgrid.2010.5622016

[8]. B. Yang, S. Liu, M. Gaterell, and Y. Wang, "Smart metering and systems for low-energy households: challenges, issues and benefits," *Advances in Building Energy Research*, vol. 13, no. 1, pp. 80–100, Jul. 2017, https://doi.org/10.1080/17512549.2017.1354782

[9]. Z. Baharlouei and M. Hashemi, "Demand Side Management challenges in smart grid: A review," *2013 Smart Grid Conference (SGC)*, Dec. 2013, https://doi.org/10.1109/sgc.2013.6733807

[10]. B. K. Barman, S. N. Yadav, S. Kumar, and S. Gope, "IOT Based Smart Energy Meter for Efficient Energy Utilization in Smart Grid," *2018 2nd International Conference on Power, Energy and Environment: Towards Smart Technology (ICEPE)*, Jun. 2018, https://doi.org/10.1109/epetsg.2018.8658501

[11]. R. Rashed Mohassel, A. Fung, F. Mohammadi, and K. Raahemifar, "A survey on Advanced Metering Infrastructure," *International Journal of Electrical Power & Energy Systems*, vol. 63, pp. 473–484, Dec. 2014, https://doi.org/10.1016/j.ijepes.2014.06.025

[12]. V. Delgado-Gomes, J. F. Martins, C. Lima, and P. N. Borza, "Towards the use of Unbundle Smart Meter for advanced inverters integration," *2017 IEEE 26th International Symposium on Industrial Electronics (ISIE)*, Jun. 2017, https://doi.org/10.1109/isie.2017.8001507

[13]. R. R. Mohassel, A. S. Fung, F. Mohammadi, and K. Raahemifar, "A survey on advanced metering infrastructure and its application in Smart Grids," *2014 IEEE 27th Canadian Conference on Electrical and Computer Engineering (CCECE)*, May 2014, https://doi.org/10.1109/ccece.2014.6901102

[14]. A. K. Chakraborty and N. Sharma, "Advanced metering infrastructure: Technology and challenges," *2016 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)*, May 2016, https://doi.org/10.1109/tdc.2016.7520076