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Research Paper

WAGES: A measuring system for energy efficiency of small and medium-sized buildings

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ABSTRACT

Energy efficiency methods and growth property standards facilitate resale, and increase charge occupancy rates and yields which are also economical and helpful to establish and guarantee the rapid return on investment. At present, there is an increasing need for reliable, accurate measuring and monitoring of energy intake which is the common and commercial objects in all energy-efficiency actions. It has been reported that installing an effective WAGES (water, air, gas, electricity, steam) using the measuring method can lead to substantial energy and cost savings in commercial buildings. This study evaluated WAGES measurement as the crucial first step toward achieving more energy efficiency in small to medium-sized non-critical commercial buildings although critical buildings such as hospitals and data centers with existing special power-quality supplies are beyond the scope of this study. It included the measurement of technology, metrics, and ideas as well.

Key words: Energy efficiency methods, monitoring of energy intake, non-critical commercial buildings, WAGES measuring.

Abbreviation: UN, United nations; **AGECC,** advisory group on energy and climate change; **IEA,** international energy agency; **MDGs,** millennium development goals, **GHG,** greenhouse gas; **ACEEE,** American council for an energy efficient economy; **IEA,** international energy agency; **LEED,** leadership in energy and environmental design; **ROI,** rapid return of investment; **ECM,** energy cost management; **BREEAM,** building research establishment environmental assessment method; **VSD,** variable speed drive; **DHW,** domestic hot water; **EMS,** energy management system; **BMS,** building management system; **CT,** current transformers; **THD,** harmonic distortion; **WAGES,** water, air, gas, electricity, steam.

INTRODUCTION

The global access and availability to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses, is the main goal of the United Nations (UN) Secretary-General's Advisory Board on Energy and Climate Change (AGECC) (AGECC, April, 2010). Access to modem energy services is a key element for human development which is central in achieving the millennium development goals (MDGs) (Goldthau and Witte, 2010; Energy, 2005). Electricity was highlighted by the international energy agency (IEA) as the most critical energy carrier for development. In 2009, it was expected that 1.4 billion people in the world would not have access to electricity. This number has been estimated to drop to 1.2 billion by 2030 (Wälde, 2003; Energy, 2005).

By 2030 electrical consumption would be more than 70%; that is, at present, energy efficiency solutions can account for 57% reductions in greenhouse gas (GHG) productions (Geller et al., 2006; Washburn et al., 2009). The American council for an energy efficient economy (ACEEE) recognized energy efficiency along with renewable energies as the basic parameter in sustainable energy policy (Allcott and Mullainathan, 2010). Energy efficiency, as the goal of an energy management system, has the capability to achieve the same function with less energy. In a 2006 report, the IEA indicated that improving the energy efficiency of buildings, industry, and transport could decrease world energy consumption by one-third by 2050 and help lower GHG productions significantly (Geller and Attali, 2005). The energy consumption in building and space heating, in particular, is the single largest producer of GHGs, while electricity account for more than 50% of CO2 emissions attributable to residential and commercial buildings (Pérez-Lombard et al., 2008). Passive and active energy efficiency were the two methods for handling energy more efficiently (Sadineni et al., 2011). Though the passive method alone, such as, use of insulation, heat recovery, and solar heating to achieve energy, was not sufficient (Sadineni et al., 2011). Energy efficiency is an enduring effort that needs active request organization. The crucial aim was for buildings to produce more energy than they consume (Garg and Buyya, 2012). Yet, most buildings would not be positive-energy by 2020. Effective measurement and monitoring give owners and operators fundamental data about how their buildings are performing, so that considerable progress could be applied (Garg and Buyya, 2012). The ability to find and measure the energy consumption is often enough to bring about energy-saving modifications in practices and behaviors, such as decreasing waste and avoiding peak utility rates.
Continuous automatic measuring systems used dynamic energy dashboards a lot to display information about building procedure and energy consumption. To explain data in an important way, such as homing in and tracking specific loads, features such as graphs, tables, and widgets are often used. One easy solution would be diminishing motor speed by only a few Hz to reduce consumption with no negative effect on performance. Also, automation and control systems offered a more effective, longer-time impact on overall building energy efficiency. These systems, when joined with effective automatic measurement, including variable speed motors for ventilation, indoor and outdoor lighting and thermo controller, and time-programmable HVAC systems, confirmed that a building consumes the essential energy (Culp et al., 2016). For the foundation of effective energy organization, in continuous automatic measurement, are prepared real-time information, alarms, control and, in some cases, recommendations for helpful activities. And, when measured against user-defined metrics, continuous automatic measurement could provide historic and predictive energy intelligence for high-precision energy efficiency. It is essential to measure with an efficiency metrics (like kWh/m^2 and kWh/occupant in an office for electricity consumption). If a building is seeking leadership in energy and environmental design (LEED), building research establishment environmental assessment method (BREEAM), or similar documentation, measuring system could be used to measure and detect electricity usage for each necessary space and purpose (Kubba, 2012). Also, operators could distinguish and display their energy cost management (ECM) performance against a measurement and verification metric such as the IPMVP, thus avoiding prices and demonstrating progress toward carbon commitments (Rogers et al., 2015). This study discussed about WAGES measurement as a part of the work to achieve energy efficiency in non-critical buildings which reflects measuring technology, metrics, and points of measurement (Wang et al., 2016, Broadway and Wilkins, 2017). Energy efficiency is cost-effective and earns the rapid return of investment (ROI). It increases property values, makes more attractive market prospects, and increase rental occupancy rates and yield.

Set objectives in WAGES

The primary step to greater energy efficiency is using suitable measuring and monitoring method to recognize user necessities, determining the opportunity and set aims for the future system. The energy monitoring system could determine energy cost allocation, energy sub-billing, energy usage analysis, building energy performance benchmarking, electrical distribution asset management, energy consumption alarming, bill auditing, regulatory or certification compliance. These high-level objectives must be modified to encounter the unique necessities of energy monitoring project. For buildings, energy costs are generally allocated via a formula by evaluating the relation of the floor area occupied by each tenant to the total floor area. For some form of measurement system where buildings meters are usually read manually, either via a service provider, a voted individuals are employed by the property management company. The labor and costs of data integrity managing for these manual systems could be high. Similarly, the usual deficiency of separability in the data decreased the opportunities that might be available to better manage costs, and allocation of coincident demand costs is not possible. Yet consistent, truthful cost allocation was an economic necessity and, the standard for buildings that had no sub-measuring system in place at all, in some cases, is energy. Property owners often do not passe the demand costs to tenants. Improving the costs of providing electricity to individual tenants by property owners might encounter a number of problems. In most places where local laws allow billing based on the use of sub-measuring, more truthful billing is possible; though, the cost of applying this type of sub-measuring system is usually expensive. Energy is a main operating cost in industries. To abstract maximum financial and economic advantage from energy, operator's necessity is to go beyond the outdated strategic method of just changing wasteful tools. Energy usage analysis offers operators with the means to maximize energy efficiency and minimize energy-related costs. It supports them to recognize the individualities of their energy consumption, detects the chances with the biggest ROI, keeps energy-efficiency projects on track, and validates outcomes. Benchmarking permits operators to equate the effectiveness of one building or request an office building against others, or against real domain market indicators. Benchmarking could disclose incompetence and recognize key contributing factors, helping to identify the correct places to target development plans that will not have a negative impact on commercial or operators. Such developments excluded equipment advancement, procedure changes, and optimizing building efficiency according to weather situations, occupancy, or etc. Continuous monitoring of the installation could manage the data, progress the usage and behavior, cut energy costs and decrease electrical consumption and principal costs. A system of electrical distribution asset management exactly meter energy consumption and request during each facility and automatically create load profiles that propose vision into history and present load shapes. The grouped data could reveal hidden, unused ability for each building, floor, feeder, area, or piece of equipment. This extra capability could then be better leveraged, lacking the need for further principal costs on promotions. It could also support building operators that the presenting substructure would be able to manage pulsation in building occupancy and consequently request, minimizing principal costs. The power-sharing system with "Right-sizing" to meet the requirements of new abilities, developments, or retrofits, is an important chance for finances. WAGES billing mistakes were amazingly common. As most supply contracts allow efficacy to improve lost charges only months or years after a mistake had happened, under-billing could be as difficult as mistakes in the efficacy's favor. For a commercial building, this extensive mistake documentation and recovery process potentially means that costs would not be earned from tenants if a new tenant moves into space before the issue is resolved. Under- or over-billing could be from meter analysis and data record mistakes. A building could similarly be on the mistaken bill, or on a billing interval that is too long or too short, which could skew request charges. So, it is to the property manager's benefit to check all efficacy bills expected to recognize any mistakes and/or abnormalities and to have the data essential to support somewhat cost loss claims. A secondary meter is usually termed a shadow. Meter could be coupled in equivalent to the efficacy meter. The software then read the energy data picked up by the shadow meter and analyzes a truthful shadow bill that excluded all predictable energy and requested charges. This bill could then be associated with the efficacy's bill to recognize any inconsistencies. Bills could be confirmed either manually or by recording the definite efficacy bill data into the software for assessment. Shadow billing and procurement are complementary requests. The benefits of improved strategies and better supply contracts include two factors: 1) usually, greater energy consumers are in an improved situation to negotiate, mainly if the gathering of usage among several buildings could be leveraged with a single efficacy. 2) Usually, enterprises in deregulated, competitive markets remained the major beneficiary. An energy procurement system could provide energy detail and load histories of profile, as well as reliability and summaries of power quality for all properties. It similarly offers tools to analyze and assess cost from multiple or single energy sources, comparing options using "what-if" scenarios. Using this scale of data could help optimize costs lacking sacrificing reliability and quality of supply. This feature offers the user the capability to take benefit of reduced electricity charges by decreasing intake on request. A request/answer system would primarily support the operator to assess whether participation in an exact event is economically beneficial. If it is, the system would benefit and rapidly define where and how much load might be reduced in reaction to the reduction request. Lastly, request/answer systems could support users efficiently to manage a load reduction approach via automatically shedding loads or starting up generators during the event period. There are several local guidelines that need energy measuring system for buildings that exceed a certain floor area. Building owners might also agree to achieve documentation such as LEED, BREEAM, or HEQ. Each of these documentations contained a section around WAGES monitoring and powerfully encourages the usage of sub-measuring both by area or energy usage.

Determining the performance metrics in WAGES

The performance metrics were the translation of project objectives into assessable data, and usually show up on the prospect system's energy dashboards and link building activity or intake (Van Gorp, 2004).

Determining the measuring points

The measuring system must be designed to provide the desired analysis upon data gathering. The data also permitted operators to monitor and control the building according to their goals. An effective measuring system design must not gather insufficient data and analyze too much data that are not usable. It should be allowed to tie up resources that are used for other energy efficiency activities. The combination of the measuring type and its location created the measuring point. Knowing the essential data, exact time, place and mechanism of data gathering are helpful to define the most effective measuring points throughout the building. For each performance metric, the essential data could be categorized into two: the static and dynamic data. The static data, including building area, rating, or efficiency of equipment, are usually used to normalize measurements for benchmark comparisons. On the other hand, the dynamic data include energy consumption, temperatures, or flows, with the corresponding recording frequency. The recording frequency is influenced by the project goals and could be yearly monthly, daily, or time series. For energy usage analysis or energy consumption alarming, it is necessary to generate load curves after every 10 to 15 min measurement. The recording frequency must be friendly with the tariff building for energy sub-billing or bill auditing. For cost allocation or building energy performance benchmarking, once a day is enough.

Measurement method and meter locations

As soon as the measurement method and meter locations had been determined, the data are used to detect the measuring points in the building. When dealing with existing buildings, in particular, practicality is a major concern and should be checked according to the electrical architecture and wiring whether or not it is feasible to separate lighting and small power consumption, gas distribution, and accessibility of water meter or etc. Different methods exist to measure consumptions, which described in the CIBSE guide GIL 65 "Measuring energy use in new non-domestic buildings" (Jones and Davies, 2003). Measurement methods are elected according to project goals including the desired level of accuracy, expected budget, and operating situations. This analysis resulted in a list of the meters to install throughout the building. Direct measuring is appropriate for major loads or overall building consumption, when the measurement is used tenant sub-billing, as it required class 1 or 0.5 accuracy and when other data measurement such as electric power quality is essential for the same energy use. Therefore, disruptive or interruption-sensitive loads should be identified at a very early stage when designing the measuring system. For constant-power loads, such as fans without VVDs or lighting, measuring the number of operating hours is one way to calculate consumption. Knowing the rating power indicated on the equipment plate is not always sufficient, as the load factor needs to be taken into account to estimate consumption accurately. For existing buildings, the load factor could be measured using a portable meter. If there is load control, it becoms very difficult to estimate the load factor, and this method will no longer be appropriate. Readings from indirect meters could be used to measure energy consumption. Generally, the accuracy of estimation depends on the equipment data, which could change or evolve with time. Therefore, these data must be checked regularly. Two direct meters could be used to determine the third measurement by the difference. This method should only be used if the two other measurements are acquired through direct measuring. This method should not be used if a very small source of energy consumption is subtracted from a very large one, as the margin of error could be higher than the smaller consumption value. Based on information about how the building operates, one measurement could be used to break down different energy usages or to determine the consumption of different areas. The consumption of small power loads could be estimated using a ratio (e.g. kWh/m^2). Ratios are either provided in some standards or are based on known occupant behavior. Meter locations are determined according to which energy flow they need to measure. However, other criteria such as practicality, visibility and the possibility of reusing existing meters should also be taken. For electric meters, it is generally advisable to; 1) instrument the feeders of the main LV switchboard instead of the incomers of the sub-distribution switchboards in order to reduce communication cable length, 2) get an overview of consumption of all feeders of the main LV switchboard in the switchboard room, 3) use protection devices that embed measuring to avoid external meter and CT installation, 4) reduce cabling, and 5) increase switchboard spare capacity. However, in the lack of space on the main switchboard, multi-tenant building with sub-billing, an electrical distribution with a busbar trunking system for easy access to meters and, generally, due to a lack of space in the tap-off unit it might be necessary to instrument the incomer of a sub-distribution switchboard.

Measuring point per energy usage

The measuring devices could be set on an external measuring panelboard or on the switchboard when requested or when space is limited. These attentions have impact on the meter type to be used. Lighting, ventilation and domestic hot water helped to define measuring points per energy usage, conditional the level of detail required. For each energy usage, three steps, data gathering, appropriate measurement method and meter locations, should be evaluated. Lighting data collection methods according to granulometry of consumption are overall and area consumption. Measurement methods include without and with individual control or dimmer switches. The measuring points include lighting feeders or group of feeders on the electric switchboards. For mechanical ventilation, fans are the main sources of energy consumption. For ventilation, data collection according to granulometry of consumption includes overall and area consumption and the number of starts and stops. The measuring was done with/without Variable Speed Drive (VSD) and the measuring points are fan feeders, the group of fan feeders, or VSD on the main electric switchboards or HVAC switchboards. Also, the heating and cooling energy used is the major consumer in commercial buildings. Therefore, it is strongly advised to use direct measuring to achieve accuracy. In refrigerant fluid – split and multi-split systems, the external units are supplied from the LV switchboard and it supplied wall internal units. Data collection according to granulometry of consumption is by global or area consumption. The measuring is directly done by electrical meter. Point of measurement locations are feeders in the main electrical switchboards for small buildings or floor/tenant panelboard for large buildings. The breakdown between heating and cooling could be provided by some split systems such as inverters. To break down heating and cooling consumption, an additional measurement such as control signal and measurement of the supply and return fluid temperatures should indicate the mode of operation. In refrigerant fluid–VRF/VRV, the external unit is supplied from the LV switchboard and supplies all internal units. The data collection methods in VRF system according to granulometry of consumption are overall and area consumption. The measurement method was direct measuring. Measuring points are feeders on the main electric switchboards or floor/tenant panelboard. The breakdown between heating and cooling could be provided by two kinds of VRF including two-pipe and three-pipe. In two-pipe, all terminal units heated or cooled at the same time and the additional measures such as signal controlling and measurement of the supply and return fluid temperatures must be taken at the outdoor unit level to indicate the mode of operation. But in three-pipe each terminal unit is independent; therefore, some units might heat while others might cool at the same time and thus making it difficult to get a breakdown.⍰In air system – rooftop, the rooftop is supplied directly from an LV switchboard. The air distribution in the duct system is provided by the rooftop. This system is usually used for a large open area such as a supermarket sales floor. Data collection according to granulometry of consumption is provided by overall and area consumption. The measurement is done directly, and the measuring points are feeders on the main electric switchboards or HVAC switchboard. In the breakdown of heating and cooling, the rooftop provides only cooling most of the time.⍰In air system–VAV (Variable Air Volume), data are collected according to granulometry of consumption by overall and area consumption. The measurement method is direct measuring. The measuring points are feeders on the main electric switchboards or HVAC switchboard. For breakdown between heating and cooling, assuming cooling is provided by the AHU, heating could be provided by the electric battery in each VAV terminal unit or by hot water battery from a central boiler. In the water system, in the case of a two-pipe system (2P inverter), only heating or cooling is possible at the same time. In the case of a four-pipe (4P) or a two-pipe, two-wire (2P+2W) system, cooling and heating could occur simultaneously. Combined heating and cooling system–2P inverter is a reversible heat pumps that typically combine heating and cooling. In this system, data collection according to granulometry of consumption could be done by overall heating and cooling production, overall heating and cooling distribution or Area consumption. Also, the measurement is done directly and measuring points are the heat pump, pump, and area consumption. To obtain heating/cooling breakdown in overall consumption, the heating-cooling meter should be used at heat pump level, the signal controlling the heat pump controller, and supply measurement and water temperatures returning. In area consumption, heating-cooling meter at the heat pump level should be used. In addition, at independent heating and cooling systems–4P data collection according to granulometry of consumption include overall heating-cooling production/distribution and area consumption. The measurement methods are direct (for boiler, chiller, pump distribution and area consumption), as well as indirect (for boiler consumption). Measuring points are the chiller and pump consumption, gas consumption for boiler and area consumption. With 4P distribution, heating and cooling are naturally independent. In this study, it is shown that an independent heating and cooling systems–2P inverter data collection according to granulometry of consumption include overall heating and cooling production (for boiler gas consumption and chiller electrical consumption), overall heating and cooling distribution (for pump electrical consumption) and area consumption (for heating and cooling consumption of the dedicated area). Measurement methods were including direct (for boiler consumption, chiller consumption, pump distribution consumption, area consumption) and indirect measuring (for boiler consumption). Measuring points include chiller and pump consumption, gas consumption for boiler and area consumption. In overall consumption, the heating and cooling production are independent. To obtain heating/cooling breakdown in area consumption, heating-cooling meter should be used and the cooling or heating mode could also be provided by the operator via the data analysis system. In independent heating and cooling systems–2P+2W, the location of the heating measuring point depends on either there being independent floor HVAC panel boards for electricity or floor panel boards that combine lighting, HVAC, and office equipment. In this system, data collection according to granulometry of consumption are provided by overall cooling, overall cooling distribution, overall heating, and area consumption. Measurement methods are directly done for all consumptions and measuring points are the chiller and pump consumption, electric battery consumption and area consumption. In this system, heating and cooling production are independent. In domestic hot water (DHW), the DHW production and DHW load must be considered when choosing meter locations. The DHW production is the primary energy used to heat the water and the DHW load is the thermal energy delivered to the distribution system. The following equation can be used to find the relationship between these two values:

DHW production = heating system efficiency × DHW load.

Heating system efficiency is calculated according to boiler efficiency and loss in the hot water storage tank. Data collection in the independent electric boiler according to granulometry of consumption is done by overall and area consumption. Measurement is done directly with electric meter and feeders on the sub-electric switchboards are the measuring points.In independent central gas boiler, data are collected according to granulometry of consumption through overall and area consumption. Measurement methods are direct and indirect for both boiler and area consumption. It is then possible to calculate the DHW load. Heating system efficiency must then be estimated in order to calculate the primary energy used for hot water heating. In this system, the measuring points include boiler and area consumption. If the DHW system is combined with space heating, indirect measurement is the only way to separate space heating from DHW production. The heat meter can be fixed on the DHW distribution pipe system. Some certifications or standards are required to measure renewable energy production separately, so as to be able to split the DHW produced by solar heating from that produced by the heating booster.

Reusing existing main meters

The main electric meters could provide data about active and reactive energy for the whole facility, time of use signals to estimate electricity bills and take advantage of low rate periods, billing base synchronization and overload signal. Usually, pulse or contact outputs on the meter could gather the data and if not, a new incoming meter should be installed. Water and gas meters gathered data from existing water and gas meters and followed process for choosing the optimal solution for turning non-communicating water and gas. Electric meters for calculating energy consumption requires voltage and current measurements. Many other parameters that might not be part of energy management but that are important for the building operator are based on these two values. Voltage and current measurements are also important factors to consider when selecting an electric meter, as they are generally measured by the same meter.

Selecting additional meters

Meter characteristics varied according to project goals. The main criteria for selecting the best type of meter were; 1) gathering data for energy management including Energy meters (for basic energy management, they measure kWh and feature an optional communication output) and Power meters (for measuring active and reactive energy consumption, four quadrants, especially for local energy production, the power factor, the apparent power, the demand for active and reactive power, overload alarm on active power demand, save active power demand, peak power demand, and load profile), 2) gathering data for electrical distribution monitoring, installation monitoring or power quality measurement. Data necessary for installation monitoring and PQ measurement are Switchgear status, electric parameters with maximum and minimum values, alarms and event time stamping for electrical parameters and harmonics monitoring. 3) Gathering requirements for specific applications, such as sub-billing or shadow measuring. 4) Gathering local or remote reading which ensures that operations managers get the data at the right location. For several reasons, such as the different types of data to gather or the need for constant consumption monitoring, the measuring device must be equipped with a communication output. The type of communication is also a factor when selecting the device. The pulse and communication protocols, such as Modbus, Ethernet or M-Bus, are very important. Data must be integrated into a pulse concentrator (a dedicated product or PLC), which converts pulses into energy data and stored the data in a local data log. The recording frequency must also be taken into account, as the number of pulses per kWh may differ from one device to another. Data are transferred to an Energy Management System (EMS) or Building Management System (BMS) to be aggregated, normalized and analyzed. 5) Gathering installation mode and shut down time differ due to difficulty in installing current transformers (CT) or limited space on the switchboard, especially in existing buildings. Therefore, factors including embedded or separate measurement, direct measurement or external CTs, clamped-on CTs and flush or DIN rail are important when selecting the following measuring devices and types of installation. For instance more devices installed in buildings feature embedded electronics with communication capabilities. As soon as their core function needs current measuring, they are able to calculate energy consumption data. As compared with independent meters, these devices did not require additional external CTs. In general, these CTs (and VTs in some cases) are chosen for features such as protection. These devices are generally not as accurate as power meters and do not provide advanced measuring features. For direct measuring or external CTs, when a separate meter is used, it could be equipped with internal CTs that would facilitate installation on the switchboard, as there is no need for CT cabling or meter protection. Internal CTs are available for EN40-type energy meters (kWh only) and ME-type meters up to 63A. For clamp-on current transformers, when continuity of service is required in an existing building, clamp-on current transformers could be used, eliminating the need to disconnect the circuit being measured and the need to thread a wire through the CT opening. For these reasons, clamp-on CTs worked best for crowded electrical panels. These CTs cost around five times more than solid-core CTs. For flush-mounted or DIN rail, the installation of the meters in the switchboard could be Flush mounted or DIN rail type. In the flush mounted, the meter was installed on the front door of the switchboard with easy access for operation and maintenance via a cut-out in the door. Instead in DIN rail, the meter is mounted directly on the rail on the switchboard which requires available space on the switchboard and, preferably, a transparent door.

DISCUSSION

Based on our experiences, some of the key points are very important in commercial building. Sensitive feeders are considered as one of the main point in terms of power quality and monitoring of electrical distribution. However, each project should be considered with regard to network configuration and customer needs. The category of the measuring device generally depends on where it is installed in the electrical distribution system. Devices that are installed at the installation's main supply must be capable of analyzing building power and peak demand, verification of energy bills and penalties, and eventually analyzing power quality such as harmonic distortion. Therefore, devices that are installed at the main low voltage switchboard feeder should allow sub-measuring for cost allocation and consumption monitoring for building utilities such as air handling units, boilers, chillers or other major energy usages for energy usage analysis, building benchmarking, standards or certifications, as well as building control optimization. To improve maintenance with alarms, measuring devices that are installed closest to the point of consumption should allow energy use breakdowns and energy consumption monitoring. Also, to determine the number of operating hours of a machine or engine, the measuring devices installed at the main supply should provide common data for the whole installation. These data include overall active and reactive energy consumption with the overall power fact, harmonic distortion (THD) for checking network power quality, overload alarming and min/max power/voltage/current to monitor overall energy consumption and maintenance. The rating current is more than 630 A. In addition to the previous requirements, it is recommended for this rating to limit the uncertainty by setting a meter with a precision of 0.5°, analyze the event for maintenance, obtain the load profile and synchronize the 10 mn with the utility meter for contract optimization purposes. In this rating also big-box store, for instance, due to the substantial lighting, IT, and TV department consumption, harmonic distortion could be high and as such, detailed harmonics analysis should be performed to determine the best filtering solution to reduce harmonics. For renewable energy production such as photovoltaic, a simple energy meter is sufficient to measure energy production but it is different from the wind. When the wind speed is low, the generator could be used as a motor but when the wind turbine consumed energy, it is therefore advisable to select a meter with four quadrants to enable a breakdown between production and consumption. When the backup generator is used a few hours a month due to poor utility reliability, it might be useful to measure energy produced as the energy cost and the amount of related greenhouse gas emissions associated with heating oil consumption. However, a simple energy meter is generally sufficient to measure energy production and as such, data such as voltage and current could be useful for alerts. In sub-distribution board feeders, there are two rating currents such as less than 630 A (for active and reactive power to more easily identify sources of reactive power consumption) and more than 630 A exist. In addition to the previous requirements, more than 630 A rating is advisable to determine the degree of uncertainty by choosing a meter with a precision of 0.5°, check harmonic distortion to facilitate analysis for harmonics sources identification, measure neutral current to detect overloads on the neutral conductor, and monitor energy consumption and maintenance with over-alarm and min/max power/voltage/current. Special feeders on the main switchboard referred to feeders that provide critical loads (which could not be interrupted or could tolerate only short interruptions) and loads such as motors with variable speed drives or lighting that disrupted sensitive loads. For these feeders, energy measuring should be combined with installation and power quality monitoring. The rating current less than 63 A (in the main electrical parameters to check the proper performance and power supplies of the load and communication capabilities in case of load malfunctions) and 630 A existed. In addition to the previous requirements, for less than 630 A rating, it is recommended that the data be: 1) harmonic distortion for the loads that produce harmonics (motors, lighting, and IT servers) and 2) overly alert and min/max power/voltage/current to monitor energy consumption and maintain sensitive loads. And for high harmonic producers, the neutral current needs to be measured. To detect overloads of the neutral conductor by choosing a meter with a precision of 0.5°, there is the possibility of determining the uncertainty limit that allows the approval of the energy bill, capable of conducting event analysis for maintenance (meter with event stamping) and obtain the load profile and 10 mn synchronization with the utility meter for contract optimization purposes. Special feeders in a sub-distribution board rating current are less than 63 A (for energy consumption, main electric parameters to check proper performance and power supplies of the load) and 630 A (for communication output to generate alerts in the event of malfunctions). Common feeders rating current are less than 63 A (a simple energy meter was sufficient for measuring energy consumption), less than 630 A (gathering the data of main electric parameters to check proper performance and power supplies of the load) and more than 630 A (gathering the data of communication capabilities in case of load malfunctions).

Conclusion

These finding showed that WAGES measuring as a part of the work to achieve energy efficiency in non-critical buildings reflected measuring technology, metrics, and points. This measuring system also increased property values, the outlook for more attractive market, and the rental occupancy rates and yield.

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