7 Bills and Meter Readings – Understanding and Analysing Data

7.1 Introduction

An electric meter or energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device. Electric meters are typically calibrated in billing units, the most common one being the kilowatt hour (kWh). Periodic readings of electric meters establish billing cycles and energy used during a cycle. In settings when energy savings during certain periods are desired, meters may measure demand, the maximum use of power in some interval. In some areas, the electric rates are higher during certain times of day, to encourage reduction in use. Also, in some areas meters have relays to turn off non-essential equipment. The first accurate, recording electricity consumption meter was a direct current meter invented by Hermann Aron, who patented it in 1883. Hugo Hirst of the General Electric Company introduced it commercially into Great Britain from 1888. Meters had been used prior to this, but they measured the rate of power consumption at that particular moment. Aron's meter recorded the total energy used over time, and showed it on a series of clock dials. The first specimen of the alternative current (AC) kWh meter produced on the basis of Hungarian Ottó Bláthy's patent and named after him was presented by the Ganz Works at the Frankfurt Fair in the autumn of 1889, and the first induction kWh meter was marketed by the factory at the end of the same year. These were the first AC wattmeters, known by the name of Bláthy-meters.

7.2 Measurement

7.2.1 Measurement Unit

The most common unit of measurement on the electricity meter is the kWh, which is equal to the amount of energy used by a load of one kilowatt (kW) over a period of one hour, or 3,600,000 joules. Some electricity companies use the International System of Units (SI) megajoule instead. Demand is normally measured in watts, but averaged over a period, most often a quarter or half hour.

Reactive power is measured in volt-ampere reactive hours, (varh) in kilovar-hours. By convention, a 'lagging' or inductive load, such as a motor, will have positive reactive power. A 'leading', or capacitive load, will have negative reactive power.

Volt-ampere measures all power passed through a distribution network, including reactive and actual. This is equal to the product of root-mean-square volts and amperes.

Distortion of the electric current by loads is measured in several ways. Power factor is the ratio of resistive (or real power) to volt-ampere. A capacitive load has a leading power factor, and an inductive load has a lagging power factor. A purely resistive load (such as a filament lamp, heater or kettle) exhibits a power factor of 1. Current harmonics are a measure of distortion of the wave form. For example, electronic loads such as computer power supplies draw their current at the voltage peak to fill their internal storage elements. This can lead to a significant voltage drop near the supply voltage peak which shows as a flattening of the voltage waveform. This flattening causes odd harmonics which are not permissible if they exceed specific limits, as they are not only wasteful, but may interfere with the operation of other equipment. Harmonic emissions are mandated by law in European Union (EU) and other countries to fall within specified limits.

7.2.2 Electromechanical Meters

This mechanical electricity meter has every other dial rotating counter-clockwise. The most common type of electricity meter is the Thomson or electromechanical induction watt-hour meter, invented by Elihu Thomson in 1888. The electromechanical induction meter operates by counting the revolutions of an aluminium disc which is made to rotate at a speed proportional to the power. The number of revolutions is thus proportional to the energy usage. It consumes a small amount of power, typically around 2 watts.

Two coils act upon the metallic disc. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the current. The field of the voltage coil is delayed by 90 degrees by using a lag coil. This produces eddy currents in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc. The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power being used. The disc drives a register mechanism which integrates the speed of the disc over time by counting revolutions (much like the odometer in a car), to give a measurement