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Statistical methodology to assess changes in the electrical consumption profile of buildings

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ABSTRACT

Many efforts have been made to define patterns, predict, and forecast energy use. However, changes in energy consumption may be studied in detail using various methodologies. This work presents a statistical methodology to assess changes in a facility consumption profile. Consumption patterns are obtained from a historical database of a predefined time interval, according to the type of day (day of the week, working or non-working), and an index that assesses change in the electrical consumption profile is proposed. Assessing these changes enables associating these values with possible events in a facility, which can serve to generate alarms in an energy management system, and reduce costs and maintenance periods. Additionally, a multi-criteria interpretation of the applied test table is presented that offers explanations and identifies possible causes of anomalous consumption.

1. Introduction

Several studies have been made to reduce the demand and use of energy in buildings around the world. Energy efficiency has been studied from the point of view of construction materials, heat ventilation air conditioning systems (HVAC), lighting systems [1], use of renewable energy, changes of devices for others of greater efficiency [2], demand management [3], integration of distributed generation with clean energy [4], and so on. One of the most important efforts related to improving energy efficiency in buildings is the concept 'zero energy buildings', which proposes that buildings become self-sufficient in renewable energy to avoid emitting CO_2 to the environment [5].

An analysis of the energy behaviour (pattern) is crucial to propose actions for improving energy efficiency. Models for energy consumption have been developed from a statistical perspective [6], including multiple regression analysis and principal components analysis [7]. Researchers have statistically analysed energy patterns [8–11], where it is possible to cluster similar consumptions for different purposes, such as monitoring, classifying consumers, or analysing power depending on the type of day. In addition, using these methodologies, it is possible to predict power consumption for consumers, traders, utilities, or generators.

The terms prediction and forecasting differ in their meanings in the literature [3,12–15]. A prediction is the output of a statistical model – even if the data is historic. Forecasting refers to predictions of future values. Methods for predicting building energy consumption are summarised in [12] and they are grouped as: simplified designed engineering methods; statistical methods; artificial intelligence (especially neural networks); support vector machines (SVM); and support vector regression (SVR). SVR is usually used to classify and solve regression problems [13]. The selection of variables and their features is maybe as important as the statistical method applied in the data analysis. However, the application of key variables is scarce in energy consumption analysis and modelling [16]. There are many factors influencing energy consumption and so analysis can be complex. In [17], it is indicated how the selection of subassemblies of feature selection characteristics impacts on the performance of learning machines when a statistical learning method is applied.

In the literature many authors state that numerous efforts have been made to define patterns, predict, and forecast energy use; however, the identification and quantification of changes in energy consumption patterns have not been evaluated in depth. This work presents a statistical assessment for identifying changes in consumption methodology (SAICC methodology) to detect changes in electrical consumption for an analysed period. The analysed day is compared with a pattern previously obtained from a historical database of a predefined time interval. An index of change (IoC) is calculated to catalogue the change in consumption of the analysed

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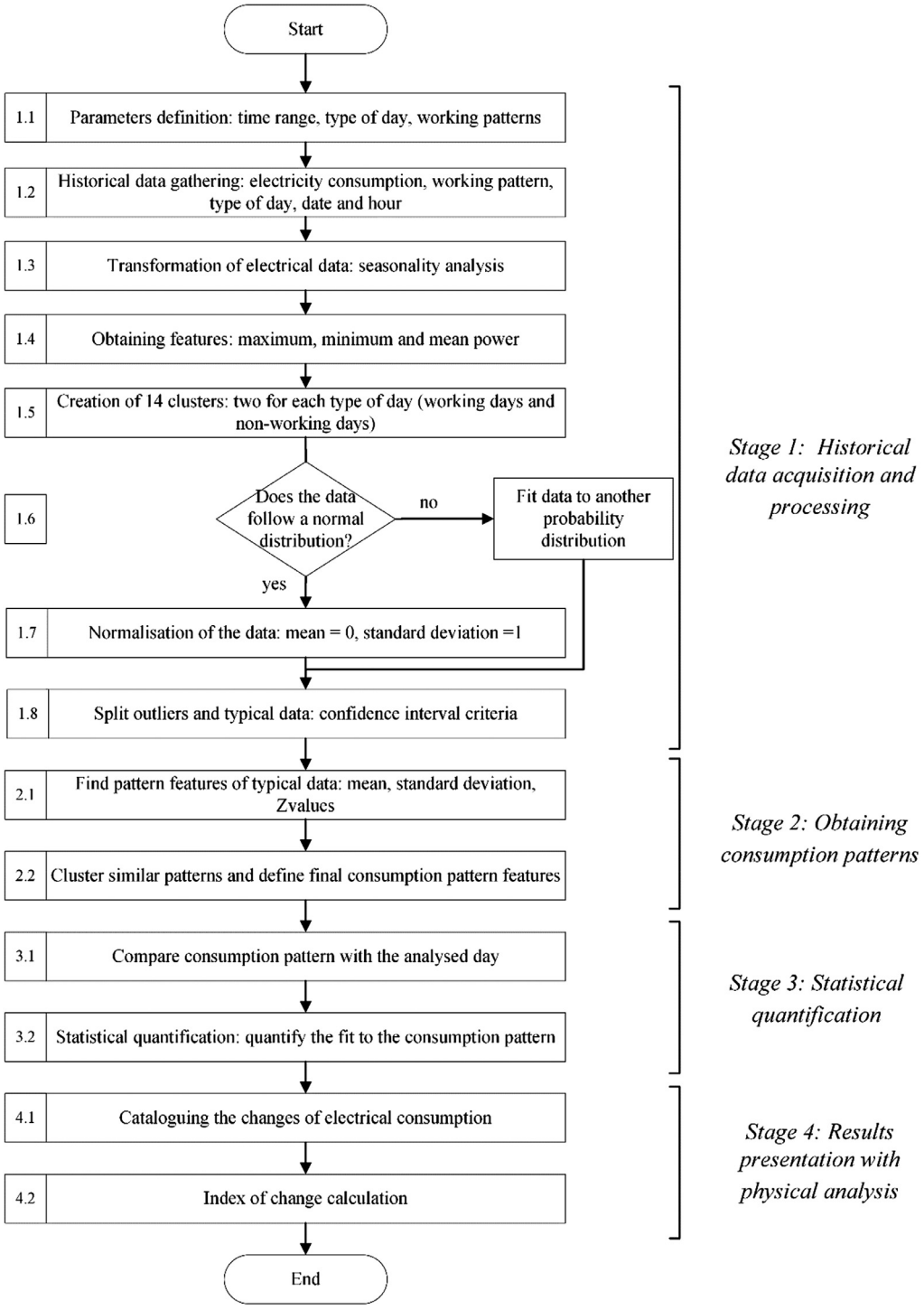

Fig. 1. Flowchart of SAICC methodology.

day and using a multi-criteria interpretation table, the cause of the abnormal consumption is inferred.

Assessing changes in consumption profiles enables associating these values with possible events of abnormal consumption in a facility. This may be used to generate alarms, reduce costs in maintenance, and respond quickly to anomalous consumption.

This paper is organised as follows. Section 2 explains the proposed methodology. Section 3 presents the application and validation of the proposed statistical methodology. Finally, some conclusions are drawn in Section 4.

2. Proposed statistical methodology

A statistical methodology (SAICC methodology) is proposed to analyse and evaluate changes in the electrical consumption in a facility.

Fig. 1 shows the flow diagram of SAICC methodology with four stages. Stage 1 acquires the data and selects data that will be used in Stage 2 to obtain consumption patterns. Stage 3 compares consumption patterns with the analysed day; and finally, Stage 4 catalogues the detected changes and calculates the IoC. The following sections describe this methodology in detail.