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Adaptive Weather Correction of Energy Consumption Data

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Abstract

A framework for adaptive weather correction of energy consumption data is presented. The procedure is conducted in two steps: I) a regression model is trained on a building's recent historical energy consumption, weather and calendar data; II) energy consumption is predicted by using long term weather data as input to the trained model. Thus the buildings long term energy consumption is obtained, from which the building's expected (alias normalised or weather corrected) yearly energy consumption is derived. For older Swedish residential buildings, the proposed regression method matches traditional heating degree days method in accuracy. But for low energy and near zero energy buildings the regression method is more accurate, especially for years of extreme weather and for building with more complex installations such as heat pumps or solar thermal panels. The main benefit of the developed weather correction method is that it adapts to the data, therefore most buildings (or any kinds of weather dependent processes) can be weather corrected in an automated way.

Keywords—weather correction; normalisation; adaptive regression; statistical learning

1. Introduction

The purpose of weather correction is to normalise energy consumption so that it is representative of a building's expected long-term performance. Normalised energy consumption is used for example for energy statistics; cost analyses and prognoses; or to verify that the buildings energy performance meets building code requirements or a target agreed upon in the design phase. A Swedish project report [1] compares and quantifies uncertainties for three weather correction methods: heating degree days (HDD),

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energy signature and "Energi-Index". The authors states that all three methods have relative high uncertainty; and that today's highly energy efficient buildings' needs improved normalisation methods. The framework presented here achieves better energy consumption normalisation that is accurate also for today's complex and highly energy efficient buildings. The main benefits of the developed weather correction method are that a) it adapts to the data, therefore any kinds of weather dependent processes can be weather corrected for, such as buildings' heating and cooling consumption b) also performs well with buildings utilising more complex technologies like thermal solar or heat pumps; c) outliers, unusual energy consumption patterns and operation schedules are identified.

The statistical learning procedure multivariate adaptive regression splines (MARS) is utilised. It is an adaptive procedure that can be viewed as a generalisation of stepwise linear regression where the piecewise linear segments as well as parameters associated with each are automatically determined by the data. A web application is developed to demonstrate the weather correction framework: https://rokka.shinyapps.io/awcdemo. Users can explore example dataset of buildings energy consumption (including the datasets used in this paper) or upload their own data. The work presented here builds upon well-known and tested methods; the novelty lays in gluing it all together to a working framework which can be applied todays weather normalisation tasks with improved accuracy compared to standard methods.

2. Methods

An adaptive weather correction framework is developed as illustrated Fig. 1, described in more detail in the following subsections.

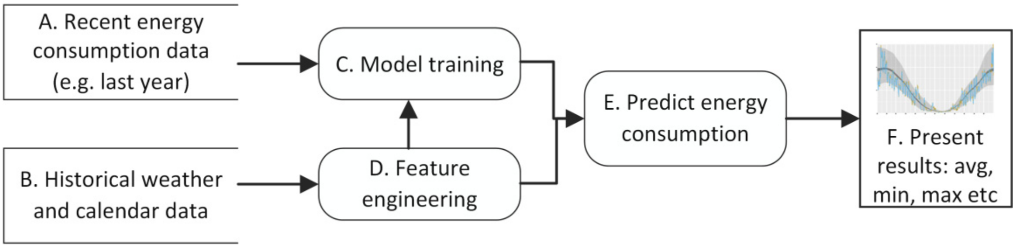

Fig. 1. Adaptive weather correction framework.

2.1. Data

Historical weather data is imported from the Shiny Weather Data [2] web service, https://rokka.shinyapps.io/shinyweatherdata. Which uses open sourced data from two meteorological models at the Swedish Meteorological and Hydrological Institute (SMHI), called MESAN [3] and STRÅNG [4]. SvebySMHI [5] is used as source for typical meteorological year (TMY) data. SvebySMHI weather files are based on MESAN as well, but use a different method for calculating solar radiation. They are representative of the long term weather conditions of the period 1980-2010.

Two measured (Case 1 & 3) and four simulated (Case 101-104) energy consumption datasets are studied in this paper (these datasets can be explored interactively in the attached tool). Case 1 consists of district heating for a building complex with both residential and office spaces; Case 3 consists of district heating for a residential building with solar thermal panels. The simulated datasets are based on an IDA ICE building model, with specifications as follows: domestic hot water 25 kWh/m^2,y; hot water circulation 5 kWh/m^2,y; domestic electricity 25 kWh/m^2,y; facility electricity 15 kWh/m^2,y. The domestic