Ideation Document

IBM Hack 2019

Problem Statement: Energy Audit for Households

Team name: Greenticks

College: International Institute of Information Technology, Hyderabad

Overview

To build machine learning models to create energy consumption profiles for household and identify probable areas to plug wastage of energy in households. As energy audits are not regularly conducted and no measures are taken to reduce the energy wastage at the household level, this problem becomes significant. Most households may not go down the energy audit route for various reasons to assess the energy efficiency and energy usage of their homes.

It is estimated that around 35% of the energy supplied to the households is wasted. The typical sources for wastage range from inefficient insulation for cooling or heating to not using energy efficient models of appliances like refrigerators, AC, etc. While many households might not even be aware of this wastage, this wastage adds up to a significant percentage of the energy generated at the global scale. Current methods of auditing will not be feasible for households as energy auditors are few in numbers and their charges are quite high. Especially in developing countries where sufficient energy is not generated, it is quintessential that the energy already generate is not wasted. Hence there is a need for an inexpensive or free solution that could be used by typical households to identify areas of energy wastage and measures to stop those.

Proposed Solution

We propose a recommender based solution where a user gets appliance wise disaggregated energy usage for a particular month.

- ➔ The machine learning model takes the monthly bill, list of appliances and power rating of each appliance used in a particular household as input from the user. It integrates location, topography, climate and other relevant factors to output the disaggregated model.
- ➔ Based on the appliance wise disaggregated model, the application provides insightful recommendations to the user to reduce their energy consumption and enables the user to become a conscious and sustainable member of society.
- ➔ To incentivize energy saving, we rank households in a particular geographic location based on the amount of energy they have saved cumulatively. This encourages users to save more energy with respect to others and on a global scale, reduces energy wastage exponentially.
- ➔ Knowing the energy efficiency of a particular building or a locality is a key factor for potential house owners. Apartment renting/selling agencies can make use of this data to help customers make informed decisions.

The system is a web application deployed on IBM Cloud services. The machine learning model was trained on the IAWE (Indian dataset for Ambient Water and Energy, 2013) dataset using Tensorflow.

Advantages

- ➔ Scalable: It is a non-intrusive method and uses predictive modelling, there are no hardware parts.
- ➔ Cost-effective: Does not require any installation or moving parts. Only minor deployment cost required.
- ➔ Accurate: The proposed ML model learns better with more data. Hence, gets more accurate with more users.
- ➔ Adaptable: It incorporates location, climate, topography data for prediction and hence can be used in a variety of scenarios.
- ➔ Practical: The application provides practical tips and recommendations to improve energy efficiency.
- ➔ Data visualization: Provide intuitive data visualizations for users to better understand their energy consumption habits.
- ➔ Incentivization & domino effect: Introducing a leaderboard ranking system drives users to be energy conscious thus making the whole society energy conscious. As more people come to live looking for an energy efficient neighborhood, more energy is saved.

Impact

Current State

There are two broad types of load monitoring. Intrusive load monitoring requires the use of monitoring devices to measure the amount of energy spent. Smart meters give usage at the aggregate level for the household. Individual appliance level consumption monitoring requires the use of additional plug level monitoring devices. This is not scalable as an average household with 10+ appliances need to be plugged into 10 different plug points and 10 plug level monitors need to be used. This turns out to be very expensive and complicated for the average household and results in spending more money than actually saved by energy optimisation.

Non-intrusive load monitoring (NILM) is an important task for creating public awareness of electrical power consumption in households. It is required to accurately eliminate wastage and reduce overall energy consumption in society. It uses machine learning methods to predict appliance level usage from large amounts of monthly aggregate data.

Our solution

Our disaggregation model is completely non-intrusive. Our model learns from large amounts of monthly data to accurately predict appliance level usage. The overall impact is on multiple levels:

- ➔ User level: Gains insight into their energy consumption habits and are provided with recommendations to reduce their overall energy wastage in smart and easy ways.
- ➔ Potential buyers: Provided with valuable information regarding the energy efficiency of a locality or a building to reduce their overall carbon footprint.
- ➔ Government: Use the disaggregation data to pinpoint which locality suffers from energy management/scarcity issues and appropriate rules and initiatives can be implemented.
- ➔ IBM: Since this uses predictive modelling, the system can be scaled and deployed easily to cover the entire country and further analytics can be done on the data. Eg: Deploying the application in different states will provide information on comparative energy usage patterns. Can be integrated with smart power grids to dynamically distribute electrical energy to households.

Implementation

Stack

- Backend: Django
- Frontend templating framework: MDB
- ML Model training: Keras Tensorflow
- Database: SQLite 3
- Deployment: IBM Cloud Foundry Apps

Architectural Flow Diagram

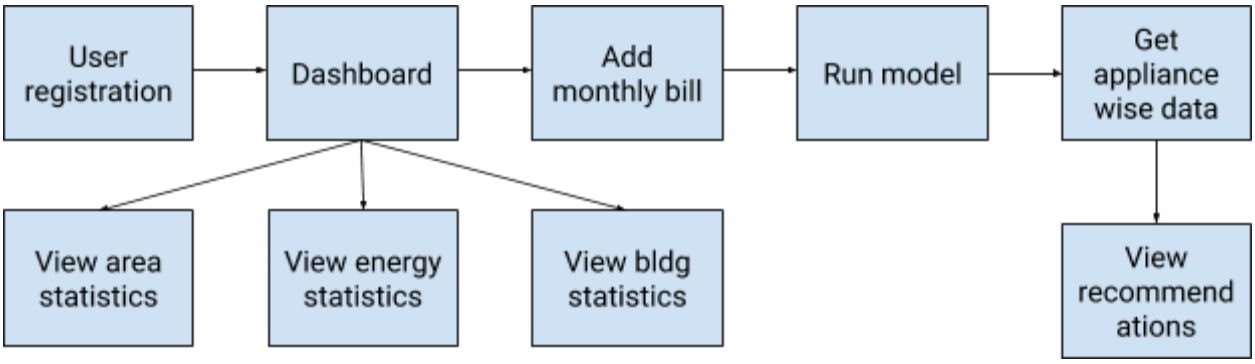

Figure - 1) User registers on the web application. 2) User is directed to the dashboard where he/she can view energy statistics at different levels. 3) User inputs monthly electricity consumption bill as input. 4) The model is run on the input data and outputs the appliance level disaggregated data. 5) Appropriate recommendations are provided to the user to reduce energy wastage.

Scope

The scope of our solution is as follows:

- ➔ Provide an application to a user of an Indian household to help them reduce energy wastage.
- ➔ Use a machine learning model that takes input as monthly energy bill from user and outputs the predicted appliance level energy consumption.
- ➔ A recommendation system which uses the predicted appliance wise energy consumption to provide energy saving tips/recommendations for the user to follow based on location, climate, topography.
- ➔ Provide intuitive data visualizations of user's energy consumption habits.
- ➔ Provide incentivization to the user using a leaderboard ranking based on maximum energy saved.
- ➔ Allow potential home-owners to identify energy saving localities/apartments to reduce their own carbon footprint.

Modules

- Web Application
  - Landing Page
  - Register/Login Page
  - Dashboard
  - Leaderboard
  - Add monthly Bill
- Prediction model
- Recommender System