**Power Consumption Analytics for Manufacturing Sector**

**Intro:** Thank you ----- for giving us this opportunity.

Good Evening to one and all ,

------------ My self Harsha sri lekha.

Welcome to 360digitmg youtube live channel. Today’s Project Presentation is all about Monitoring of Power Consumption in the Beverage Industry through IoT sensor.

**Title Slide:**

In this project we are trying to monitor and reduce power consumption in the beverage sector through IoT sensors fixed at different motor sections in the plant.

**2 and 3 Slides:**

To start with, I would like to introduce the team members of our team. My self Harsha Sri Lekha then we have Akshay, Anand, Aniket, Apurva, Sudarshan, Harinath, Kapil, Mahak, Ramakrishna, Reeshab, Shubham, Teja, Venkatesh and Vrushali.

**Slide 4:**

The overall content of the project will cover overview and scope of the project followed by objectives and constraints, Methodology, Technical stacks, Project architecture, Success criteria, Data collection and description, Data Understanding, Model selection and Building and finally Deployment.

For the next few minutes the presentation is taken over by my colleagues. Akshay will cover Projective overview, scope, objectives and constraints followed by vrushali going to take over the methodology and Technical stacks of the project and then kapil will be going to take over the architecture and flow of process in the industry followed by Venkatesh who is going to give a view on the Success Criteria, Data collection and Data understanding and then Shubham is going to take over the Data Preparation and Visualization and Anand is going to cover Model selection and Building and finally Deployment part is carried out by Aniket.

So that is how the organization of today’s presentation will be. Now , I request Akshay to continue with further presentation please.

**Slide 5:**

Thank you Harsha Sri Lekha for wonderful introduction, and good evening everyone, my name is Akshay Jagtap,this slideis about project overview ,as we can see the competition in world in each field has rise at tremendous rate in such conditions to have upper hand in competition one need to delivery product at cheaper cost without compromising quality ,in order to do that organization needs to reduce cost of production ,one of major contributor in cost is electricity consumption ,in this project we are going to reduce power consumption with help of IoT sensor also called as smart electricity meter which will give us an clear understanding of under performing equipment so that with help of maintenance either by repairing or replacing such equipment will reduce the electricity consumption and also will reduce cost ,we will be using IoT sensor to monitor those equipment which are the highest contributor of electric power consumption ,in our case the different hp motor are key power consuming equipment in beverage industry after implanting IoT sensor on these motor we get real time data about the energy consumption in these equipment ,though our main objective is to monitor and reduce the power consumption these sensor have given us insight of abnormal behaviour of equipment before the break down ,this has also reduced the breakdown time and production loss with help of preventive maintenance, accident due to shock has reduced as it became easier to identify the current leakage and worned out cables,thats all for project overview and scope

**Slide 6:**

Now to the next slide We have created a model considering all the losses and error occurred in process and selected the most optimal model with very least error for predictive analytics,also we have considered all the parameters affecting iot device and had selected the best fit device compatible with company environment ,as we know every organisation priority is that their data to be confidential, security was major constraint we overcame that constraint by providing encryption to the real time data and only authorised user id and password can access the data ,and same is shared only to the responsible person of organization that's all for objective goal and constraint, I request Vrushali to continue with further presentation please.

**Slide 7 :**

Thank you **Akshay**, and good evening to everyone, my name is **Vrushali Hulikoppe**. This slide is about the CRISP ML(Q) Methodology that we have used in our project. Basically CRISP ML(Q) stands for the Cross-Industry Standard Process for the development of Machine Learning applications with Quality assurance methodology. It is framework, with the help of this we can build the model, as per customer requirement.

CRISP ML(Q) involves the 6 necessary steps. That is shown in figure. So the first phase is the

1. **Business and Data Understanding:** In this stage of machine learning application we are identifying the scope of the ML application, a data quality verification and the success criteria of the project. If I talk about this particular project here we need to create a model to monitor the power consumption of each equipment using IoT sensors in the beverage industry and reduce its overall consumption.

Second phase is the

2. **Data Engineering (Data Preparation):**In the stage we have decided what type of data we require for our model. And prepared it accordingly. After preparing we need to perform basic EDA i. e cleaning the selected data, constructing new features, finding relationships between features. And also perform the basic simulation on the data so that data can be used for building the perfect model.

The third phase is the

3. **Model building:** Once our data is ready, we need to put this data to train the model. Here we need to select basic modelling techniques that we will use to create the model. Also we need to finalise the technique which we used for building the model. In our project we build the two models – one is a regression model and another is the classification model. Based on the accuracy of the given dataset we go ahead with the decision tree classification model.

The fourth phase is

4. **Evaluation:**  Evaluating the model is a very important step. Here, we decide the trained model is good enough to prepare to go to production as per customer requirement or not. In our project we used cross validation evaluation techniques to understand whether our model is good enough to be live.

The fifth phase is

5. **Deployment :** Here in this phase we have to make our model live for our customer as per their requirement and also we should get the feedback for the customer satisfaction and work on the continuous service improvement as a futuristic scope.

And the last phase is

6. **Monitoring and Maintenance:** Once our model has been put into production, it is essential to monitor its performance and maintain it. When a model performs with real world data, the model performance may be affected by some hardware performance. So we need to continuously monitor our model and if something is affected we need to retrain the model.

**Slide 8 :**

Move on to the next slide which shows the technical stacks used in our project to create the model and deployment.

Ø So the first tool that we used is python - it is a high level general purpose programming language. We used it to write our code.

Ø And For application development we used Spyder, Jupyter, Collab, and Atom IDE’s.

Ø And developing Machine learning algorithm and data visualization we used NumPy, Pandas, SciPy, Matplotlib, Seaborn.

Ø Flask, Heroku, Html tools are used for deployment of our project.

**Slide 9 :**

Move on to the next slide which shows the different types of IoT sensors.

These are: Motion sensor, humidity, optimal, Gas, vibration,

Acceleration, ultrasound, RFID,magnetic,electric,leak,pressure and temperature sensor. In these humidity,Gas,magnetic and temperature sensors are mostly used in the market.

**Slide 10 :**

Next slide please.The image of this slide shows the smart electric meter used for IoT sensors. These are Three-phase Long Range current sensor and current transformer (CT) sensor

So this all from me now Kapil makes you understand about project architecture.

Kapil over to you

**Slide 11:**

Thank You Vrushali. Good evening everyone I , kapil dev singh will now explain the project architecture and flow of the process in the beverage industry. First let's understand the project architecture. Overall the project has mainly four stages : Data Collection , Data Preparation along with Visualisation , Modelling and Deployment. In the data collection stage the data is collected through IoT sensors installed at various motors in different sections of the manufacturing plant . The IoT sensor sends the data to the influx Database and further the data is sent to python through MY SQL Connector for further processing. Then Exploratory data analysis is performed to understand basic features of data such as various business moment decisions like mean, median, skewness, standard deviation and kurtosis then data is visualised for getting a broader perspective about the data. Then Some data preprocessing steps were carried out such as Removal of nominal features, handling missing values , outlier treatment and Binning of output variable i.e. “ Allplant” . Allplant is the target variable which contains the energy consumption by the whole plant . To make it compatible for classification binning process was done to convert it into a categorical feature. The preprocessed data is then sent for the modelling stage where different models were tried and it was then concluded that “ Decision tree classification “ is the best suited model. The data is then split into train and test and the model is built on train data followed by the model evaluation process . Then at the end , the model is deployed using Heroku and hence it is then ready to be used by the user at his interface. So , This sums up the overall project architecture and the flow of data.

**Slide 12:**

Next we will be now going to understand the flow of the whole process in the beverage plant.

The whole beverage plant consist of many individual units such as water and flavour mixing unit , cooling water terminal , carbonated gas line , filler machine, washer unit , Packaging unit which consists of capping , scanning , Batch coding etc and conveyor system that contains running chain with motor installed which facilitate the movement of the product across different units in the plant. Each unit in the beverage plants runs by various motors of different power. Running chain motors consists of six motors , each having the power of 1HP , these are indicated by the red boxes in the diagram as we all can see and it makes . Then cooling water terminal consists of three motors having power of 1HP, 7HP and 48HP respectively , Gas supply tank uses 3 HP motor , filler machine uses 7HP motor , electrical glass bottle washer machine has 19 HP motor, Firewood boiler uses 6 units per hour .In packaging unit mainly consumption is by Bottle batch coding machine i.e. 1 KWH then some other power consumption of about 20 KWH is carried by other electrical equipments and machines in the plant such as lightning , air conditioner etc .Each of the unit discussed has IoT sensor installed which will continuously do the real time monitoring of power consumption across the plant. So that's how the usual setup of the beverage manufacturing plant is

So , that's all about the project architecture and the flow of the process in the beverage industry . Thank you

Now I would request my colleague Venkatesh to continue with further presentation

**Slide 13:**

Thank You Kapil. A Good Evening to one and all. I am Kurapati Venkatesh. I would like to present the Success Criteria of our project and explain all about the Data Collection and Data Preparation.

Firstly, the Success Criteria of our project will be:

1. This model will act as an alerting or notifying agent whenever there is a high power consumption. Thus immediate steps can be taken to reduce the further consumption.
2. The model can also provide energy consumption data for each unit, so that action can be taken to improve the efficiency of each unit, which in-turn contributes to overall power efficiency.
3. Hence, the power consumption monitoring for the whole plant will be effective.

Assuming that, there is a proper IoT architecture setup in the plant.

**Slide 14:**

This slide is a preview of the data collection stage of our project. Most of the dataset is constructed by using the data collected by the IoT sensors on a real time basis. In other words, Source of the data is IoT sensors. Each individual unit in the production system is equipped with an IoT sensor which acts as independent variables. Another meter is installed at the outlet of the production system that measures overall electricity consumption and acts as a target variable.

**Slide 15:**

In this Data Understanding slide, I’m going to give a general idea about the dataset. The data is calculated for every 10 seconds i.e. energy in watts consumed by each of the units in 10 seconds. Table shows the abbreviations of the independent variables used in the dataset, their description along with the units of the metric system, their nature of data and the type of the variable.

For example: if we look at the FWB variable, it tells us that the energy consumption data of the Firewood Boiler of 6 KWH capacity is collected by the IoT sensor on a real time basis within a 10 seconds interval is a Quantitative and a Continuous variable.

**Slide 16:**

In data preparation, Exploratory Data Analysis(EDA) and Data Visualization has been done.

* Output variable “allplant” was transformed from continuous variable to categorical as “high” and “low” through a binning process.
* Removed the “Timestamp” column, which has no use or importance in model building.
* Results of EDA are - There are no Null or duplicate values in the dataset and the obvious outcome is Higher the HP more the consumption.

So , that's all about the Success Criteria, the Data Collection and Data Preparation of our project . Thank you

Now I would request my colleague Shubham to continue with further presentation

**Slide 17:**

Thank You Venkatesh. Good Evening to everyone . I , Shubham khandare will now explain the univariate analysis that we did in the data visualisation process**.** This bar graph represents the share of power consumption by various sections of plant indicated by respective featuresIt can be clearly understood that CWT i.e. (cooling water terminal ) is consuming higher power than the rest of the motors and BBCM i.e. (bottle batch coding machine) is consuming least power consumption so mainly water terminal, other consumption (OC) and Electrical glass bottle washer (M13HP19) are contributing mostly in the overall electrical power consumption in the plant indicated by “ Allplant”.

**Slide 18:**

Then here the distribution of the data points of various features in the categories of low and high consumption is represented. The pie chart indicates the overall distribution of the data points in the two categories i.e. high and low consumption and it can be clearly understood that the number of data points falling in each of the categories of target variable is nearly the same.

So, that's all about the Univariate analysis .

Now I would request my colleague Anand to continue with further presentation

**Slide-19**

Thank You Shubham. Good evening everyone, I am Anand, here I will explain about the model building part of our Project.

In the model building part we go for both classification and regression models by considering output variables in its continuous and discrete form. In the regression model we considered the output variable in its primary or actual form, that is real time power consumption of all beverage plants over every 10 sec. But R2 values obtained for every regression model are comparatively less and close to zero. So convert the output variable into binary format by setting a threshold limit for the power consumption value. The whole beverages plant power consumption comes above the threshold limit treated as "low" power consumption class of output variable with minimum or acceptable power loss. And those comes above the limit are treated as "High" power consumption class, indicating the occurrence of high power loss in the plant under constant production rate.

These are some of the models that give better performance in classification and regression approaches. The regression models are multilinear regression, lasso regression, and random forest and in classification that are decision tree classification and k-nearest neighbor classification.

**Slide-20**

These slides show accuracy, RMSE, and R2 value of regression and classification models that we built. Since there has less variance in output continuous data, that makes RMSE value for train and test errors fall in the range of 8 to 9. But R2 value for all the regression models is very less and that is in the range of 0.001. That indicates poor explainability of input variables for changes in output over every regression model. So go for classification models after categorising the output variable into "Low" & "High" classes according to the power consumption range. Under constant production rate "Low" class in output variable indicating less power loss occurrence and that of "High" class indicating high power loss occurrence. Out of all classification models, the decision tree has given the best accuracy and faster performance. And the corresponding train and test accuracy values are 97% & 93.1%. And that of KNN classification models are 91% & 92%, and also its performance is slower compared to the decision tree model.

**Slide-21**

This slide shows the hyper parameter that was chosen in the decision tree model. Here the criterion parameter is chosen as entropy and max depth of the tree as 9. The corresponding accuracy we got are 97.5% for train and 93.2% for test data, and cross table for train and test data also given there.

So , this is all about the model building part . Thank you

Now I would request my colleague Aniket to continue with further presentation

**Slide 22:**

Thank You Anand, Good Evening Everyone,(My Self Aniket Annam) I am going to give a complete tour to the deployment process used in our project. As we built a classification model which gives two classes i.e. whether the overall consumption is low or High.

Now, In deployment we used following tools,

* 1)python: python is high level programming language we used this language to built our classification model and now we are using this language for our deployment
* 2)Flask: Flask is an open source python library that makes it easy to create custom web apps for machine learning.
* 3)HTML/CSS : HTML(Hyper Text markup language) is used for making the structure of the website. Here in our deployment we used html for taking inputs from the user .

CSS(cascading style sheet): is used for styling the html structure to make it look good

**Slide 23:**

* 4)Heroku: heroku is a platform as a service that enables developers to build, run and operate applications entirely in the cloud.
* 5)GitHub: github is a web based interface that uses git, the open source version control software that lets multiple people make separate changes to web pages at the same time. Here Heroku integrates with github to make it easy to deploy code living on github to apps running on heroku. When github integration is configured for the heroku app, heroku can automatically build and release to specified github repository

**Slide 24:**

This is the view of our deployment ,here you can see we have labels and inputs boxes. Every input box takes inputs in a range as mentioned in the labels and it takes upto 5 Decimal points. And we have one submit button after entering values in the input box and clicking on submit button we get output as if the overall consumption is low or high

**Slide 25:**

Here after entering values in the inputs box we got output as Overall consumption is high

**Slide 26:**

Here after Entering values in the inputs box we got output as overall consumption is Low

**Slide 27:**

Conclusion of our Project, This model will help to predict if the overall consumption in the industry as “LOW” or “HIGH” in accordance with the threshold value for power consumption under constant production rate , if the overall consumption crosses threshold value limit then it will indicate increased power loses happening in the plant. Then this model will predict such a scenario as overall consumption is high. So the plant operators enforce predictive maintenance on inefficient electrical parts of the plant and rectify extra power losses issues .