UMM Power Monitoring and Prediction Software

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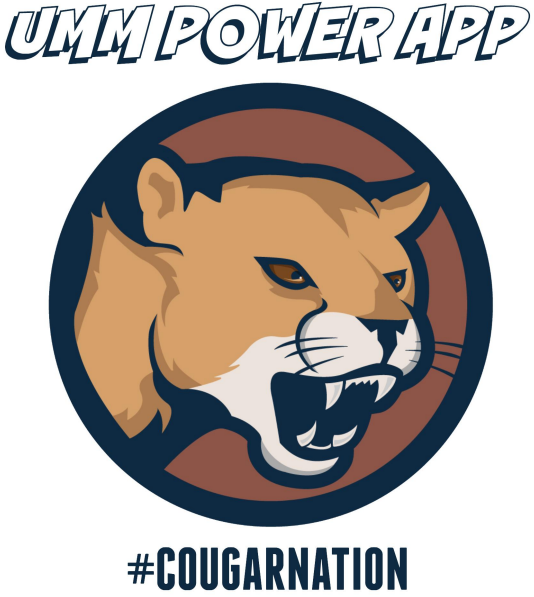


1. UMM's efforts for a better renewable and sustainable future

1.1 The Solar panels and Wind Turbines.

1.2 The power prediction system's aim to aid existing efforts.

2. The Prediction Model

2.1 Using Dark Sky API for weather forecast

2.1 Using eGauge and UMM Weather Station Data.

2.3 Using real time consumption API to monitor and predict power consumption

3. Visualisations and User Interface Design (Under Development)

3.1 Libraries used for charting

3.2 User Interface for the app.

4. Purpose and Feedback from the audience

1.1 Solar Panels

- A solar thermal array of locally produced panels heats the recreational pool at the Regional Fitness Center on campus.
- The 32 flat panels keep about 15 tons of CO_2 out of the atmosphere annually.
- There is also a 3kW photovoltaic demonstration solar array on campus outside of the Science Building.

Solar Thermal: Flat-Plate Collectors

Solar Thermal: Evacuated Tube Collectors

Solar Use in Livestock Production

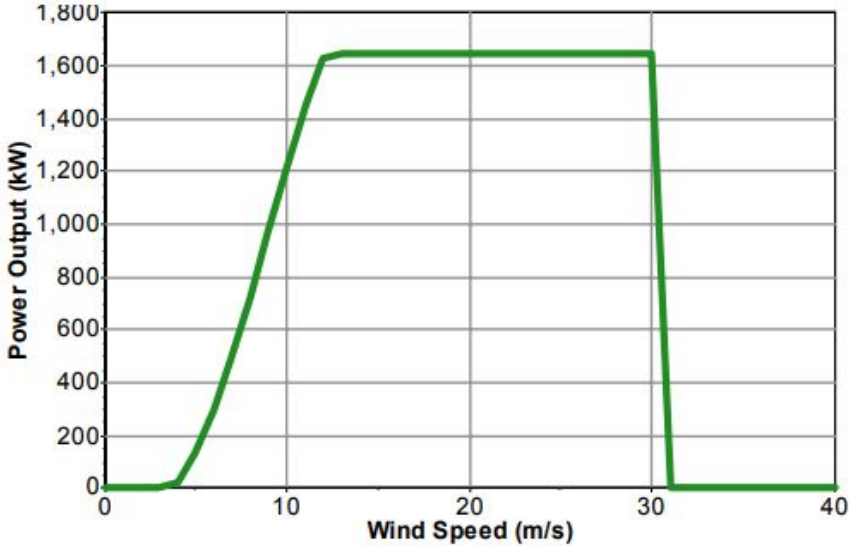
1.1.Wind Turbines

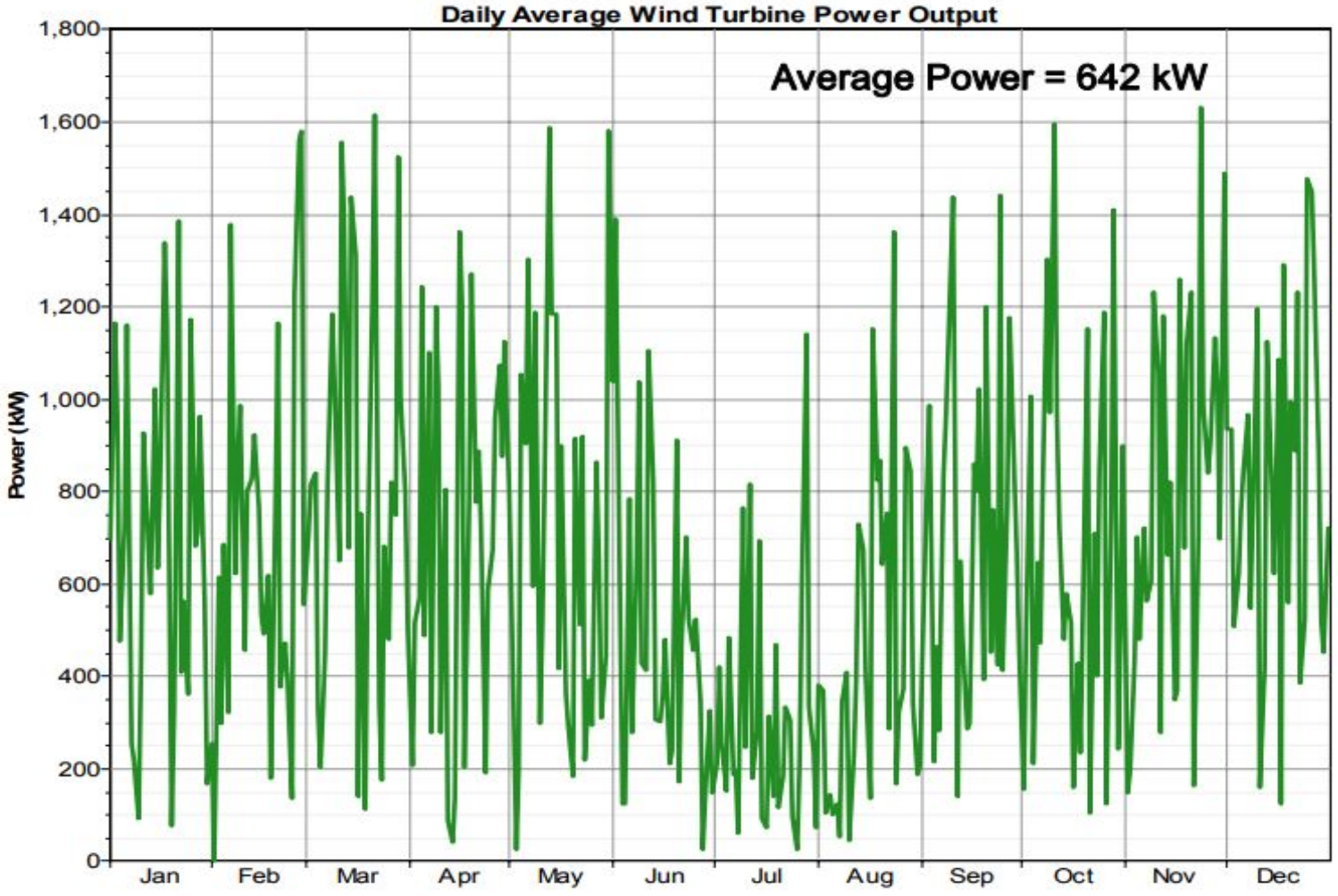
- Two 1.65 megawatt wind turbines are situated just off campus at the University of Minnesota West Central Research and Outreach Center (WCROC).

- The wind turbines generate on average 60 percent of the campus's electricity usage annually and can generate up to 100 percent on windy days.

Emissions Reductions

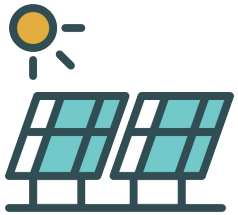
Pollutant	Emissions (kg/yr)
Carbon dioxide	-3,604,638
Sulfur dioxide	-15,628
Nitrogen oxides	-7,643




Daily Average Wind Turbine Power Output
Average Power = 642 kW
Power (kW)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

1.2 The Power Prediction Software's efforts to aid existing efforts

- Since solar cells and wind turbines both heavily depend on time and weather conditions, the power harvested fluctuates.
- The cost for returning excess electricity to the grid is substantially less than the rate to purchase and the University would prefer to adjust usage so that all produced electricity is used on campus.
- A real time power monitoring system that compares the power consumption of the entire campus with the power produced through renewable sources will help determine and address these problems.




Several Benefits including such as:

- Students with an app on their phones could see that renewable energy can actually meet their entire power consumption needs and at times exceeds it (like during the peak hours).

Current Scenario:

As of the current time, Renewabale Energy production is greater than Total Consumption of the UMM Campus. Utilize this by doing more power intensive jobs such as doing Laundry etc right now!

- It could also provide encouragement for behavior changing initiatives such as doing laundry or other power intensive activities.

- We could encourage more investments to be made so that we can have renewable generation to match consumption not only during these peak hours but all the time.

2. The Prediction Model

2.1 Using Dark Sky API for weather prediction and hence power prediction

Dark Sky is one of the many APIs online available for weather information.


```
{
    latitude: 46.7296,
    longitude: 94.6859,
    timezone: "Asia/Hovd",
  - currently: {
        time: 1520932405,
        summary: "Mostly Cloudy",
        icon: "partly-cloudy-day",
        precipIntensity: 0.0002,
        precipProbability: 0.03,
        precipType: "rain",
        temperature: 46.37,
        apparentTemperature: 42.5,
        dewPoint: 22.08,
        humidity: 0.38,
        pressure: 1010.82,
        windSpeed: 7.68,
        windGust: 8.27,
        windBearing: 332,
        cloudCover: 0.83,
        uvIndex: 1,
        ozone: 361.94
    },
-
```

```
hourly: {
    summary: "Mostly cloudy until tomorrow afternoon.",
    icon: "partly-cloudy-night",
  - data: [
      - {
            time: 1520931600,
            summary: "Mostly Cloudy",
            icon: "partly-cloudy-day",
            precipIntensity: 0.0002,
            precipProbability: 0.03,
            precipType: "rain",
            temperature: 46.95,
            apparentTemperature: 43.27,
            dewPoint: 21.99,
            humidity: 0.37,
            pressure: 1010.62,
            windSpeed: 7.5,
            windGust: 7.8,
            windBearing: 334,
            cloudCover: 0.83,
            uvIndex: 1,
            ozone: 361.67
        },
```


Powered by Dark Sky

2. The Prediction Model :

2.2 Collecting data.

- The first set of data we analysed is the weather data that comes from UMM monthly weather summaries that is from Dr. Sylke Boyd who is working on the weather station of UMM. (https://weather-data.morris.umn.edu/)

- The campus weather station is located on top of the science building and has been in operation since June 7, 2007. It is registered at 45° 35’ 20” N, 95° 54’' 7” W, at an altitude of 1175 ft (measurement includes building height).

- The Vantage Pro weather station includes sensors for temperature, pressure, humidity, wind speed and direction, and rainfall. Weather information is updated approximately every 5 minutes.

- The second set of data we analysed is the solar panel production data for UMM Green Prairie Community that comes from an interface named eGauge.

2.2 Assumptions and Result:

- Our data starts at 0:15 of January 1st in 2015, and ends at 0:00 of January 1st in 2016 with 15 minutes' interval, and we ignored the time switching of Time and Daylight Saving Time (DST).
- The production data combined by the production of each solar panel (3 solar panels in total) and the sum of their production is called general production.
- Our final linear model are as follows:

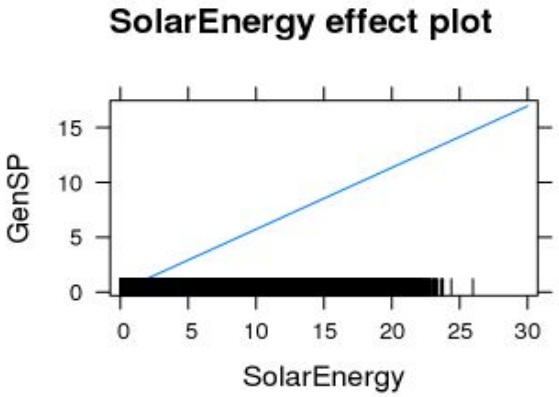
$$GenSP = 1.3038386 + 0.5613333 * SolarEnergy + 0.0035486 * TempOut - 0.0183855 * HumOut$$

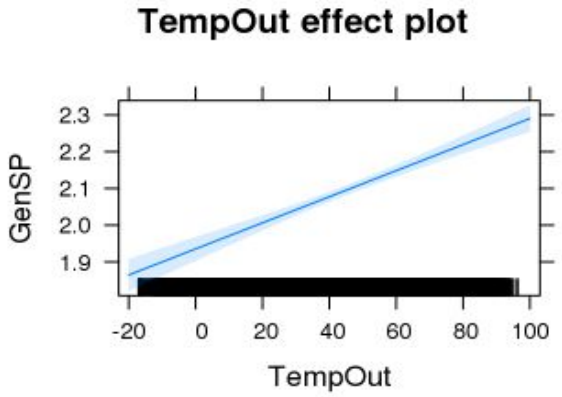
Modeling Processes:

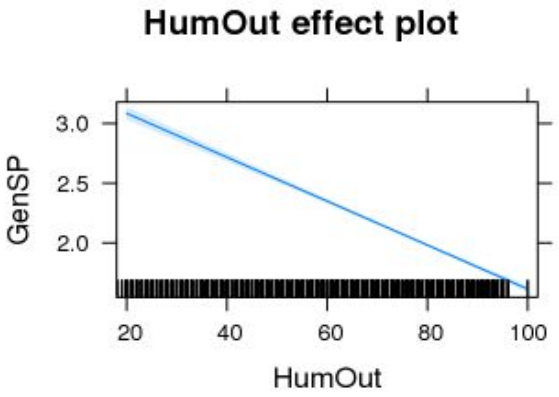
- Cleaning data:
  - Weather data: 164 rows of missing data
  - Production data: set negative values to 0.

- Building models:
  - Variable selection: tree decision and backward selection.
  - Choosing model:
    - Analysis of variance (ANOVA), F-test(joint hypothesis test)
    - Lower residual standard error and higher R^2

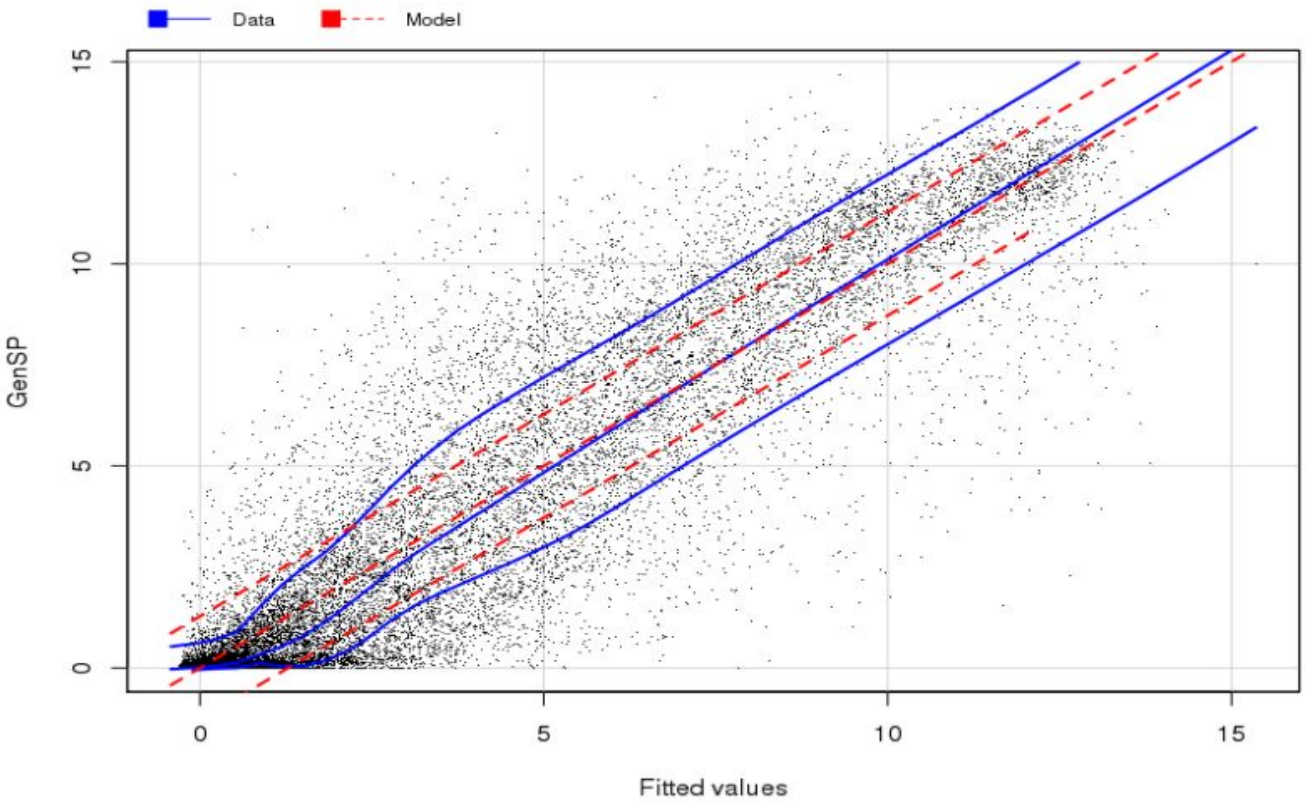
Effect plots of model:







Marginal plot of our model:



2.3 Using real time consumption API to monitor and predict power consumption

- By using API(Application Programming Interface), we are able to get energy consumption data of all buildings.
- Since our campus doesn't have a database to store energy consumption data, UMM sends all the data from each electric meter to the twin-cities campus to be stored.
- We are collecting this API data from the Twin Cities campus and using these consumption data over time period, specific campus buildings to model our power consumption model.

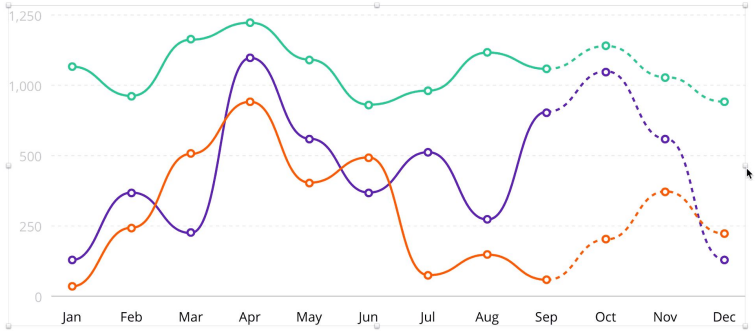
em-cof.energy.umn.edu/meterapi/api/modbus/getvalues?meterId=001-BH-V101&meterId=001-CN-R101&startTime=2017-05-01&endTime=2017-05-02


```
- {
    Id: "001-BH-V101",
    Unit: "BH",
    BldgNu: "001",
    Type: 1,
  - Values: [
      - {
            t: "2017-05-01T02:00:00",
            v: 277134.436174,
            q: 0
        },
      - {
            t: "2017-05-01T03:00:00",
            v: 277134.543877,
            q: 0
        },
      - {
            t: "2017-05-01T04:00:00",
            v: 277134.65158,
            q: 0
        },
      - {
            t: "2017-05-01T01:00:00",
            v: 277134.328471,
            q: 0
        },
```

3.1 Libraries Used for charting

We used Google Charts because of functionalities such as:

- A huge collection of already many pre-built charts.
- Various customization options that help in changing the look of the graph.
- Renders using HTML5/SVG to provide cross-browser compatibility and cross platform portability to iPhones,iPads and Androids.

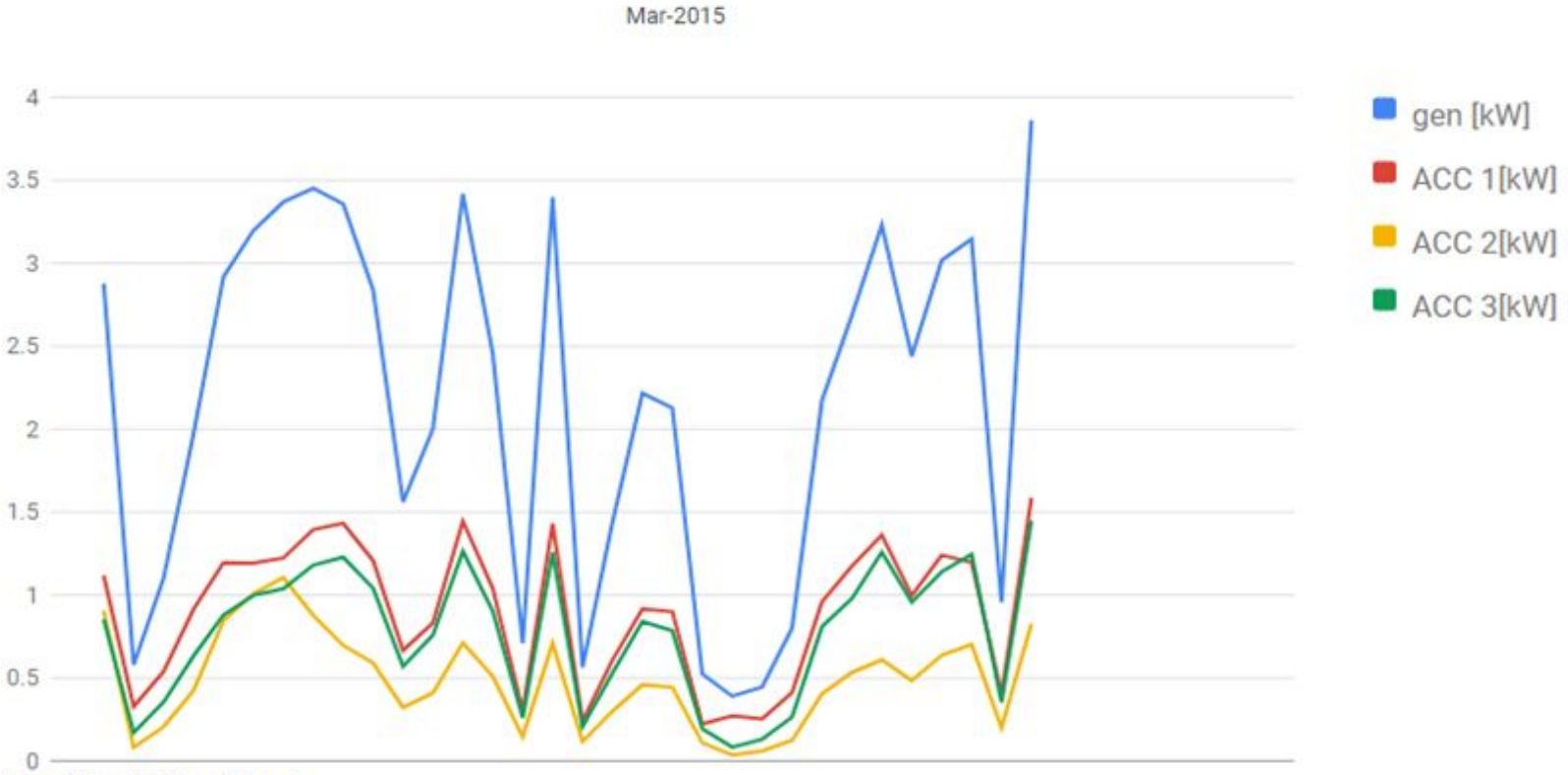


Google Developers CHARTS

localhost:3667/energy-data-display/Solar%20panel/03_2015.html

Solar Panel data

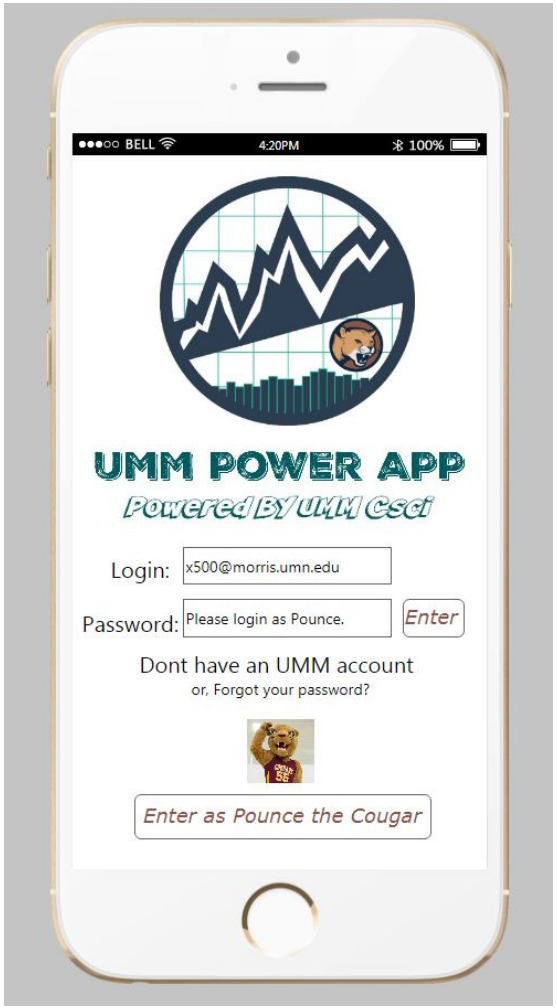
energy in kW

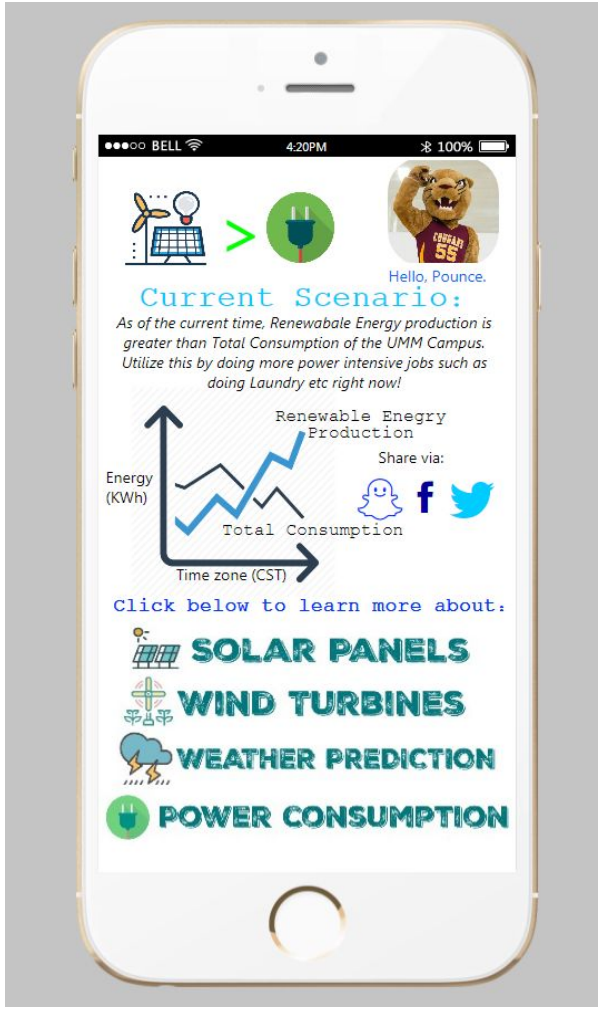


Last Month Next Month

3.2 User Interface

- A great deal of the front development of the software is targeted towards it being implemented by the campus.
- Push-in-notifications will be send to students so make them aware of these “peak hours”
- The login page is going to be synced with the U of M campus wide login page.
- There are going to be seperated pages for Solar Panel, Wind Turbines where users can see their location and power generation for the campus.


●●●○○ BELL
4:20PM
100%
UMM POWER APP
Powered By UMM Csci
Login:
x500@morris.umn.edu
Password:
Please login as Pounce.
Enter
Dont have an UMM account
or, Forgot your password?
Enter as Pounce the Cougar


●●●○○ BELL
4:20PM
100%
Hello, Pounce.
Current Scenario:
As of the current time, Renewabale Energy production is greater than Total Consumption of the UMM Campus. Utilize this by doing more power intensive jobs such as doing Laundry etc right now!
Renewable Energy Production
Total Consumption
Energy (KWh)
Time zone (CST)
Share via:
Click below to learn more about:
SOLAR PANELS
WIND TURBINES
WEATHER PREDICTION
POWER CONSUMPTION

- There will also be single website that will feature live feed of real time data.
- It will be displayed at places like the Student center and the dinning hall.
- We will make sure it will display the last chart, if the server is down or error happens in order to not display an empty feed.

file:///C:/Users/User/Desktop/User%20interface/a/index.html

Home

UMM POWER APP

Renewable Energy

Energy
(kWh)

Power Consumption

Time (CST)

Real Time Data

Powered By UMM Csci

4. Purpose

- Save money by fully utilizing our energy production.
- Assist the school in budgeting money on electric usage.
- Analysing if having battery/energy storages would be beneficial for the campus.
- The detailed analysis of real time power consumption of the campus would give us insights to truly understand the nature and tweak it accordingly to our renewable sources to make sure we can maximum affordability and benefits.

Acknowledgements:

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The University of Minnesota TC Facilities Management
The URS 2018 Committee
And most importantly all of you! :D

UMM POWER APP

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