Bilkent University

Department of Computer Engineering

CS 491 - Senior Design Project I

Project short-name: project title

Project Specifications Report

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Project Specifications Report
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1. Introduction

Each day our world is becoming polluted due to the usage of fossil fuels as an energy source. World Wide Fund for Nature also known as WWF specifies fossil fuels as the biggest cause of climate change. Average global temperatures have risen almost 1°C since the industrial revolution [1]. As long as passing to renewable energy sources will not come true, levels of carbon dioxide and heat-trapping greenhouse gases in the atmosphere is going to increase. Renewable energy sources ensure reliable, sustainable, environmentalist and cost efficient solutions rather than fossil fuels. Communities and governments has increasing tendency to escape the impacts of fossil fuels and to build a livable world for the future.

Renewable Technologies are considered as clean sources of energy. Their usage will drop the negative effects of fossil fuels regarding to social needs and future economics. The sun is counted as one of the biggest energy sources. It has the capability to provide more energy than we need to power everything in the world. The sun generates energy from a process called nuclear fusion. The generated energy radiates out to space by solar radiation. Solar Energy technologies are used to convert the power from solar radiation. The productivity of Solar Energy Systems are not the same everywhere around the world. However, there is a solar map for every position, time, location, and temperature. Therefore our thought as a group was “Why don’t we make a feasibility study on Solar Energy Systems to keep our world cleaner”. Our project SolarUpp will be based on energy production and efficiency on rooftops of building to increase the productivity. Moreover, it proposes tracking built solar panel systems with a cloud based system. Information such as energy production will be tracked with this system. We are planning to make a notification system to

inform users on emergency situations, and needs for care. Briefly, our project won't be a single use software only. We are offering a software as a service.

In this report, there will be a brief description of our project with details. Subsequently, project constraints will be listed under the titles of maintainability, implementation, reliability, and economic. The professional and ethical issues will also be discussed for the requirement.

1.1 Description

SolarUpp aims to have a feasibility study on solar energy production and efficiency on building rooftops in order to increase usage of green energy. In this web application, solar ratings of rooftops will be calculated by gathered information from images of rooftops. The users will easily find their building's images by entering their addresses. After finding their buildings, users will be able to choose spaces to plant solar panels on their rooftops. In order to calculate solar energy production, users will have the chance to compare different solar panels and inverters to find optimum solution on their rooftops in terms of cost, size and efficiency.

Beside a feasibility study on energy production, SolarUpp will also provide 3D model of rooftop by visualization to show user's rooftops final state after plantation of solar panels and inverters by regarding real size of solar components and chosen free space on rooftops. To calculate solar energy production in best way SolarUpp will be able to determine distinct obstacles on rooftops such as pools and air conditioning components to calculate free space on roofs .

After solar panel plantation, generated solar energy amount will be gathered from registered users's inverters in time intervals like one week. Gathered information will be uploaded to our system to compare expected and generated value of solar energy. Recent weather

conditions in the area of specified building will be checked to see if there are any additional reasons which cause low energy production than expected rather than unexpected weather conditions. For example, if a rooftop have great difference between expected and produced energy level in optimum weather conditions, registered users will be informed with a warning message about the need of maintenance check or an unexpected problem.

SolarUpp is a green field project which aims to increase solar energy usage by gathering information from rooftop's images which are taken from above. Using images of rooftops to have a feasibility study is an essential point for large scale using by users.

1.2 Constraints

1.2.1 Maintainability Constraints

- Since the constructions and buildings are very dynamic in other words every year new buildings are constructed and demolished, the 3D model of the earth should be updated periodically. The satellite data on Google Maps is typically between 1 to 3 years old. We will rely on this update rate.
- The domain for the website of the project should re-registered each year.
- Energy production value of solar panels gathered from inverter should be updated in specified time intervals to make comparison between expected solar energy production and produced solar energy.

1.2.2 Implementation Constraints

- SolarUpp will be a web-application
- Javascript, HTML, CSS will be used to implement this application
- ReactJS [2] framework will be used
- PrimeReact [3] will be used for some complex components

- Firebase will be used for back-end of the application
- Git will be used for tracking the versions of the implementation of application
- Object oriented programming will be used as a programming concept
- Since this application needs to analyze top of buildings, we will use Google Maps API and users will be able to pick their location from maps
- Solcast API will be used for getting the data about solar forecasting. This API delivers solar radiation and PV power data for anywhere on Earth [4].
- In order to get the parameters for solar energy production such as temperature APIs in the Earth Engine Data Catalog will be used [5].
- To get the data about sun such as sunrise, sunset, shadow length and sun position SunCalc API will be used [6] .
- To gather data about weather, OpenWeather API will be used.
- To get some information about building rooftops such as roof material, average roof height PSMA Buildings API will be used [7].
- Google Earth services will be used in order to get 3D models of the buildings.
- To specify different structures on the top of the roofs that are not suitable for constructing solar panels, machine learning will be used.

1.2.3 Reliability Constraints

- To compare generated and expected solar energy production well, the uploaded data from inverter should be correct.
- The quality of the 3D models of constructions is important since we will get some calculation data about the rooftops. We rely on the quality of visualization of Google Earth.

1.2.4 Economic Constraints

- The domain price of the website of this project is 13.99$ per year.
- Firebase usage is free until a specific amount. At first iteration of this project back-end services will be free, but after the growth of this application, there is a fixed pricing. The fixed pricing for growing apps that Firebase specify is $25 per month [8].
- For maintaining servers, there will be some additional costs.
- If we need some more detailed data for solar energy production, we might need to use some premium APIs.
- As a future extension, mobile version of SolarUpp can be developed. If we develop mobile application and publish this app in Google Play Store or AppStore there will be publication costs.

1.3 Professional and Ethical Issues

The professional and ethical issues related to SolarUpp discussed in terms of data retrieval and storing user specific information. Some amount of data required for our project are not stored as a database. In order to use these data such as properties of solar panels or inverters data should be copied to our application by hand. Solar maps of different areas around the world are distributed without any restriction so it will not have a legal concern. Users private information such as address, email or phone number will not be distributed or shared.

2. Requirements

2.1 Functional Requirements

2.1.1 User Specific Requirements

- Users able to register to our application by providing their personal email addresses or company email addresses.
- There will be 2 main service type within the system. First of this is feasibility estimating of solar panels. In other words, this is a calculation of the amount of solar energy production that the given

rooftop is capable of. Second main service of this project is maintenance alarm system for solar panels. For now every verified user is able to see the feasibility estimation of solar panels and is able to use maintenance alarm system but for future work, maintenance alarm system service might be only for premium users.

- Users should be able to notified by maintenance notification system from multiple platforms such as email, SMS or from the web application itself.
- All users should be able to model their solar panels on the top of their houses in 3D.
- All users should be able to compare different solar panels and inverters to find optimum solution on their rooftops in terms of cost, size and efficiency.
- All users should be able to enter their addresses and find these addresses in the google earth. They also should be able to see their buildings' picture from the top.
- Users checking feasibility of solar panels on a building should be able to see how the expected cost and electricity generating capacity are calculated. The variables used in the calculation should be presented clearly to the user.

2.1.2.Data Sources

- Archive of all generated electricity and their estimated electricity generation from tracked solar panels will be held in the database.
- Information of registered users such as address, email, phone number will be stored.
- Properties like size, price, efficiency, mass and energy production for different solar panels and inverters will be stored.
- The data about generated solar energy amount of verified users which is gathered from their inverter will be stored for distinct time intervals in the database.
- Solar maps and solar rating of different regions will be provided to users before feasibility study.

2.2 Non-Functional Requirement

2.2.1 Reliability

- Users with installed solar panels should be notified if there is a problem in their solar panels, or the system.
- The values accumulated from the APIs should be accurate enough for expected cost and electric generating capacity.

2.2.2 Performance

- The application should run smoothly while browsing the map or checking for potential solar panel locations on a roof. The FPS rate should be 30 at minimum for the most part.

2.2.3 Extendability

- In case of the application reaching a critical level of user base, the system should be able to make great use of the gathered data.

2.2.4 Scalability

- The system should be able to serve to several different users at the same time.
- The system should be usable wherever used APIs are supported.

2.2.5 Usability

- Users should be able to find their desired building in a short time.
- The interface of the webpage should be easy to understand for users. The features of the application should be presented clearly.
- There should be a tutorial on how to use the application.
- The notification system of the application should be convenient for the users. For example, there should be more than one way to notify users.
- A user who had installed a solar panel prior to using the application should be able to use the application to track their solar panels.

2.2.6 Maintainability

- The relied APIs should be checked regularly, our application will fail to work if any API stops working.

3. References

1. “Climate and Energy”. http://wwf.panda.org/our_work/climate_and_energy/. [Accessed: 11 Oct 2019].
2. "Getting Started – React". *Reactjs.Org*, 2019, https://reactjs.org/docs/getting-started.html.
3. *PrimeReact*, https://www.primefaces.org/primereact/#/setup.
4. “Solar Forecasting & Solar Irradiance Data.” *Solcast*, https://solcast.com/solar-data-api/api/.
5. “Earth Engine Data Catalog | Google Developers.” *Google*, Google, https://developers.google.com/earth-engine/datasets.
6. “SunCalc Sun Position- Und Sun Phases Calculator.” *SunCalc*, https://www.suncalc.org/.
7. Johnson, Cydney. “PSMA Buildings.” *ProgrammableWeb*, 18 Dec. 2018, https://www.programmableweb.com/api/psma-buildings.
8. “Firebase Pricing | Firebase.” *Google*, Google, https://firebase.google.com/pricing.