Visualization

for Data Science

DS-4630 / CS-5630 / CS-6630

Project Proposal

Basic Information

Title:

Dashboard/Visuazalition related to the impacts of heatwave on the grid

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Project URL:

https://github.com/Maryamvasef99/Data-Visualization_Project.git

Background and Motivation

In an era marked by increasingly frequent and devastating heatwaves, the need for innovative solutions that address both environmental threats and critical infrastructure vulnerabilities has never been more pressing. The convergence of climate change, urban expansion, and aging power infrastructure has created a complex interplay of challenges that require sophisticated data visualization tools for effective mitigation and response. Our project, titled " dashboard/visualization related to the impacts of heatwave on the grid," is motivated by the imperative to harness the power of data to understand better, prepare for, and respond to these evolving threats.

Numerical statistics about the impact of heat waves can vary widely depending on factors such as location, severity of the heat wave, and the specific timeframe being considered. Communities worldwide are experiencing more frequent and intense heat waves, where the increased use of energy-intensive cooling systems is putting additional pressure on the power system. While power utility companies reduce this overload by applying controlled outages, this disruption inequitably impacts communities dependent on the electricity supply to unbearable indoor temperatures during extreme weather.

Considering the impact of heat waves on the power system is vital due to the following points [1,2]:

- Increased Electricity Demand

Heat waves can lead to a substantial increase in electricity demand as people use air conditioning to stay cool. According to the U.S. Energy Information Administration (EIA), electricity demand often peaks during summer heat waves [3].

- Strain on Power Generation

High temperatures can affect the efficiency of power generation equipment, particularly in fossil fuel-based power plants. Cooling systems may have to work harder to dissipate heat.

- Power Outages

Heat waves can increase the risk of power outages due to the strain on the grid. Overloaded transformers, transmission line failures, and equipment overheating can all contribute to outages.

- Emergency Measures

In some cases, utilities may implement emergency measures, such as rolling blackouts or controlled power curtailments, to prevent grid overloads and equipment damage during extreme heat events.

- Wildfires

In regions prone to wildfires, heat waves can elevate the risk of fires, which can damage or destroy power infrastructure and potentially lead to widespread power outages.

Heatwave intensity and extent within electricity grids are influenced by various factors, including temperature, moisture, precipitation, elevation, slope, and vegetation (including age, composition, and distribution). Research indicates a strong correlation between the probability of grid failures and increasing wind speed and gusts [4]. These statistics show the importance of modeling heatwave on the power systems and its resiliency. In this regard, by combining data on heatwave scenarios with information on power infrastructure, we aim to develop an interactive map that provides valuable insights into the interdependencies between these factors.

Project Objectives

1. How can the project raise public awareness about the risks associated with heatwaves, and power infrastructure vulnerabilities? How can it engage communities in proactive preparedness and response efforts?
2. How can decision-makers, emergency responders, and the public access and utilize this integrated data visualization to make more informed decisions during heatwave events?
3. How much damage has been incurred? How much load has been interrupted?
4. How can distributed energy resources help mitigate the risk of load loss?

Through this project, we can take advantage of the following items:

- It gives us an insight into the status of heatwaves and their impact on the grid, including the location and size of fires, the extent of infrastructure damage, and the event's progression.
- Issue early warnings and alerts to relevant stakeholders, including utility companies, emergency responders, and the public, in order to facilitate timely responses and evacuations.
- Help utility companies and emergency services allocate resources efficiently by identifying areas with the most severe grid disruptions and prioritizing restoration efforts.

Data

To find the heatwave data, we are going to use the below websites:
https://www.arcgis.com/home/webmap/viewer.html?webmap=df8bcc10430f48878b01c96e907a1fc3#!
https://www.nifc.gov/fire-information
https://experience.arcgis.com/experience/87cda22dccde4a35af250469ae12f40e/
https://www.climatecentral.org/climate-matters/fire-weather-2023
https://www.ncei.noaa.gov/access/monitoring/wildfires/
https://mesowest.utah.edu/
https://www.usgs.gov/tools/wildland-fire-trends-tool
https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/balancing_authority/BPAT

Data Processing

We will start by validating the integrity of the incoming data to ensure accuracy and completeness. This step involves identifying missing or erroneous data points and addressing them accordingly. As we are working with two different datasets—heatwave scenario data and power infrastructure data—we must integrate these datasets to create a unified view. This may involve data matching, aligning timestamps, and reconciling differences in data formats. Data may need to be transformed to a common format or scale to ensure consistency and comparability. For example, temperature data might need to be converted to a standard unit.
We will derive key metrics related to heatwaves, such as intensity, duration, and spatial extent. These metrics will be used to represent the severity of these events in the visualization. We will derive vulnerability assessments by analyzing power infrastructure data in conjunction with environmental data, highlighting areas where critical infrastructure is at higher risk during heatwave scenarios. Appropriate tools and programming languages like Java, HTML, and Python will be used in this project.

Visualization Design

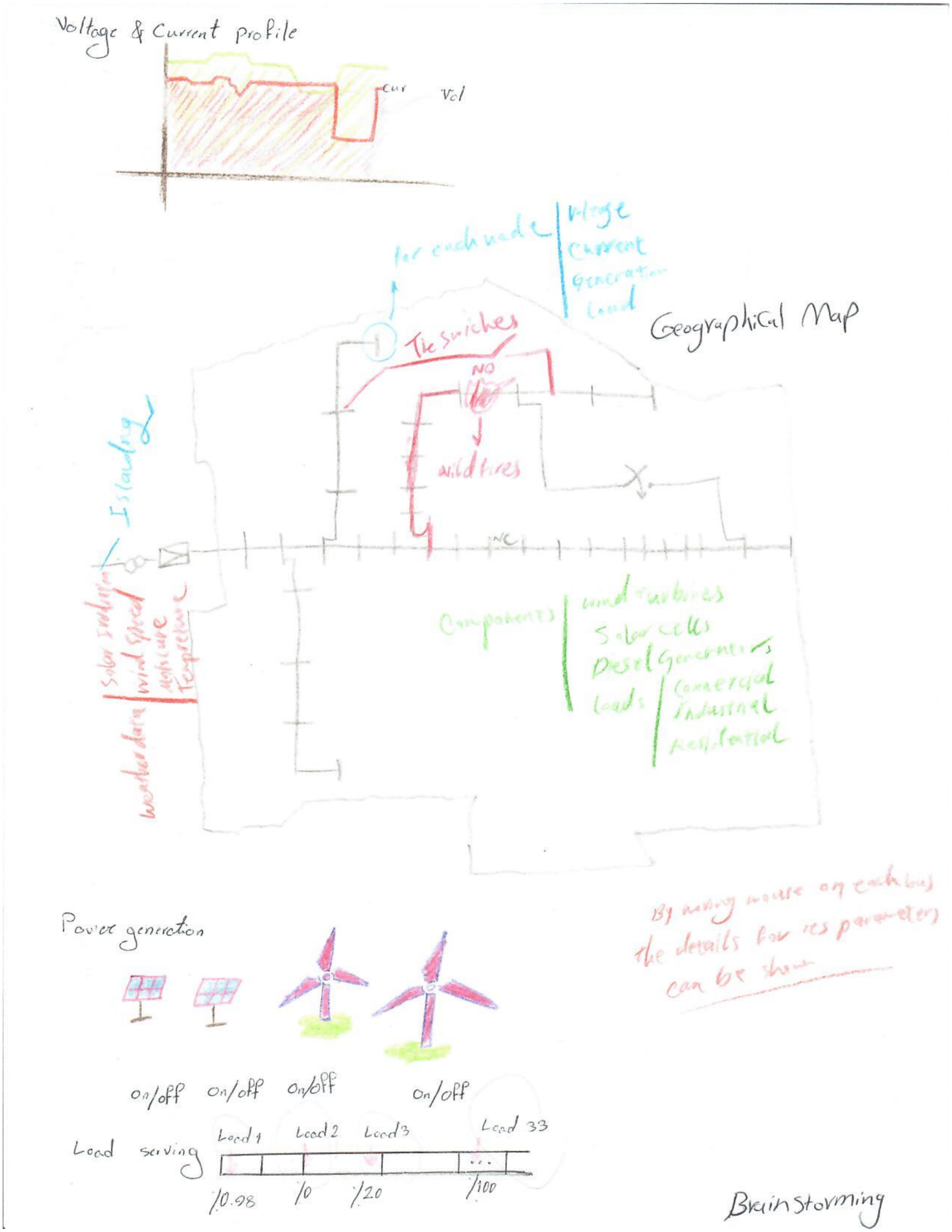

Fig. 1: Brainstorming

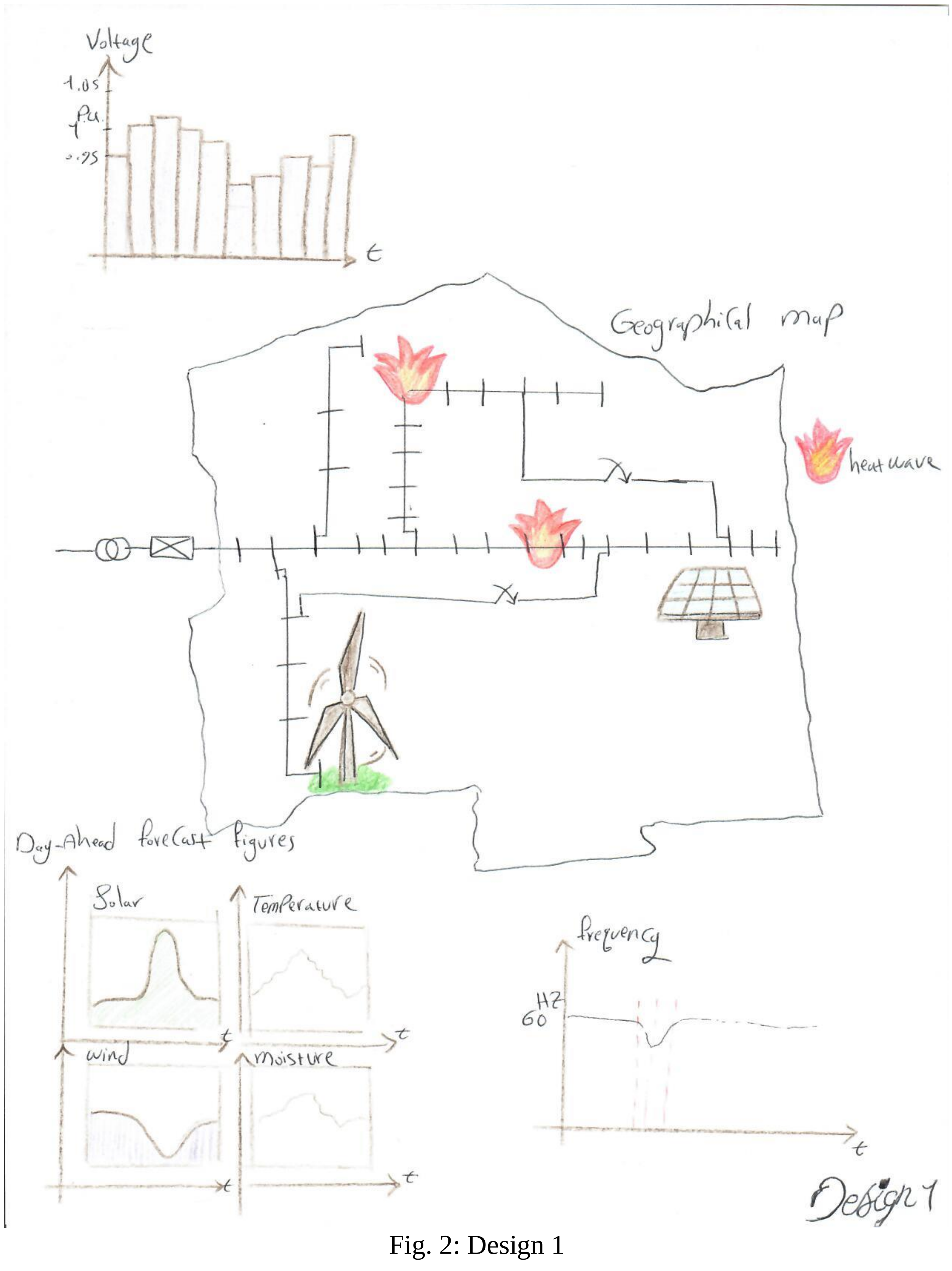

Fig. 2: Design 1

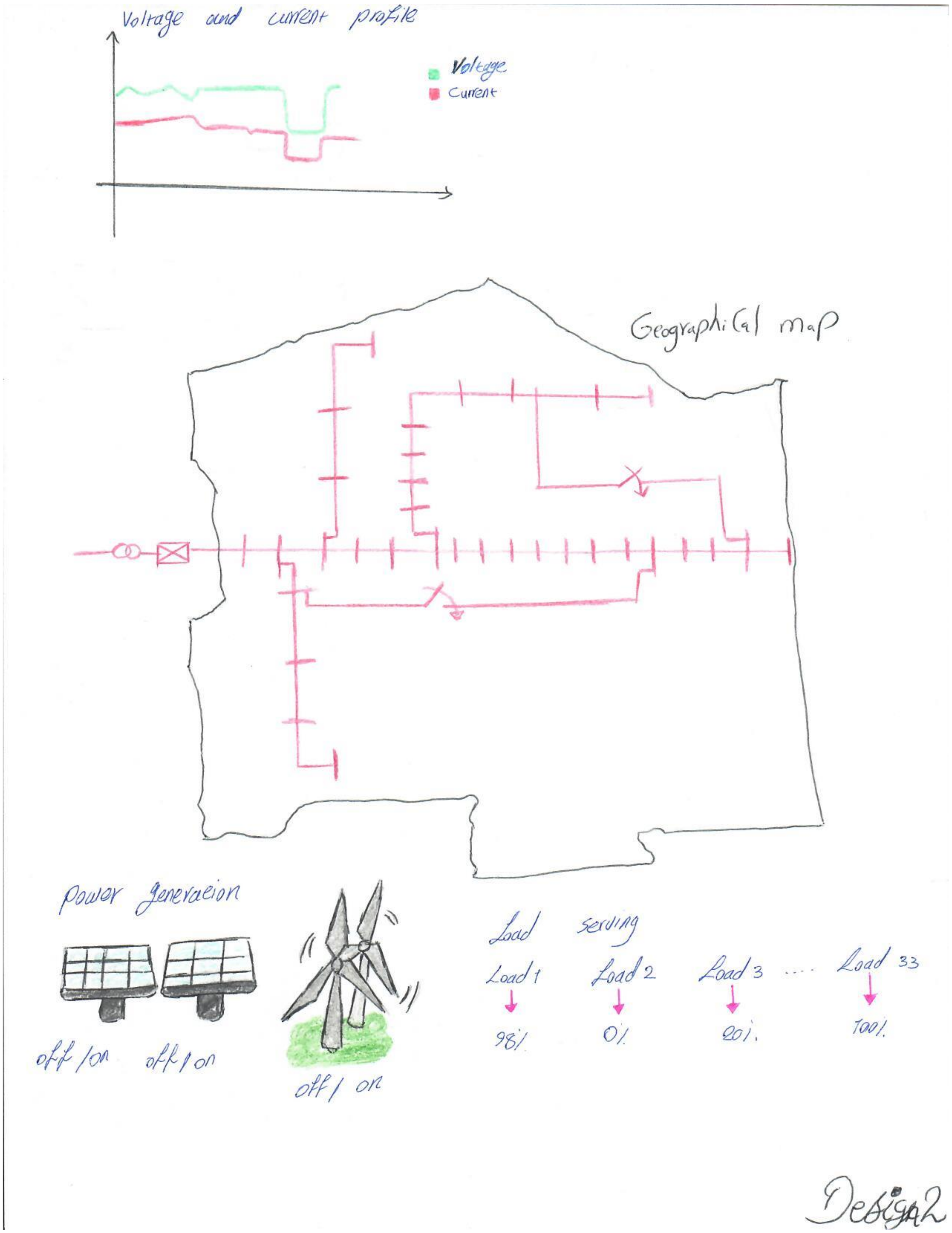

Fig. 3: Design 2

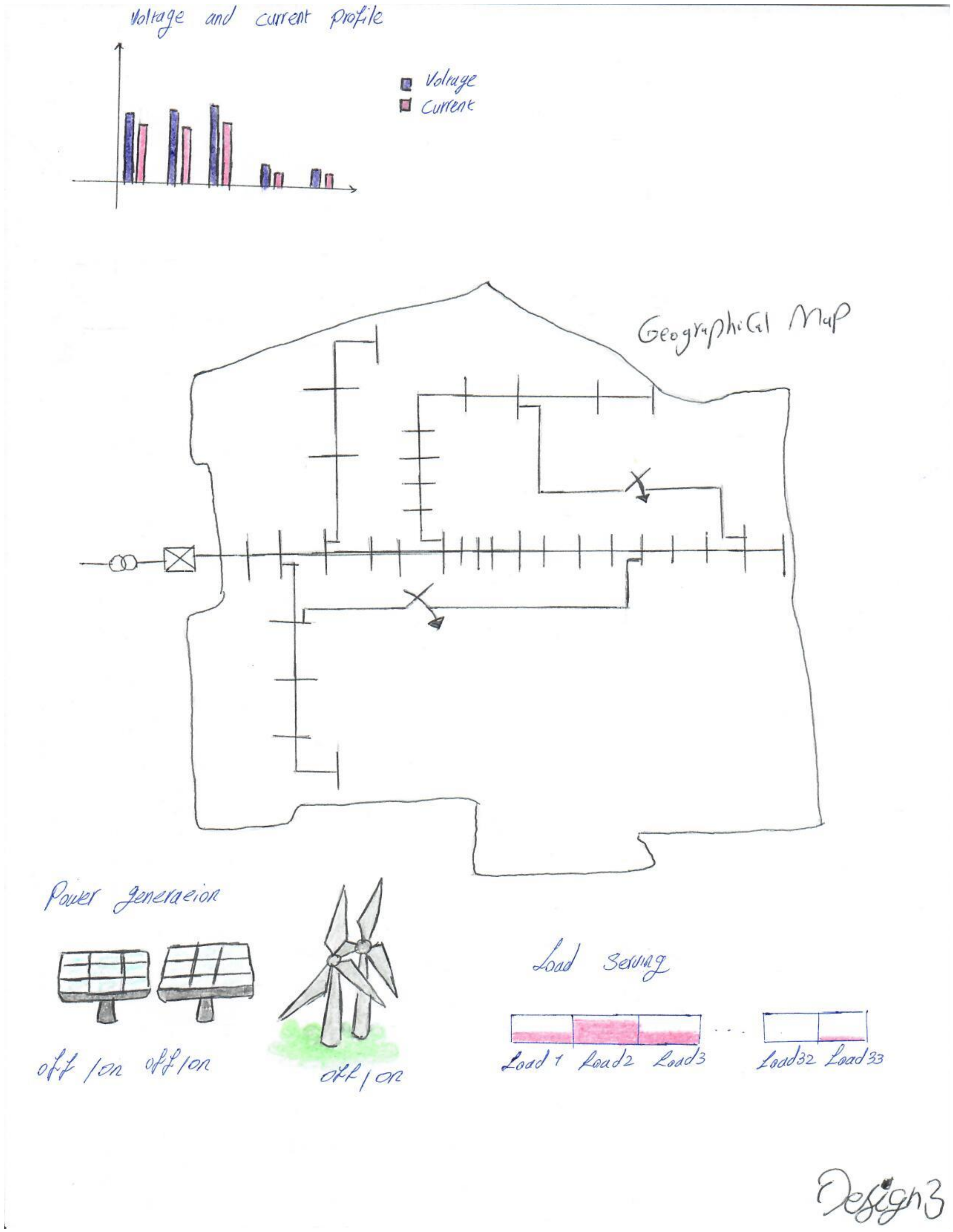

Fig. 4: Design 3

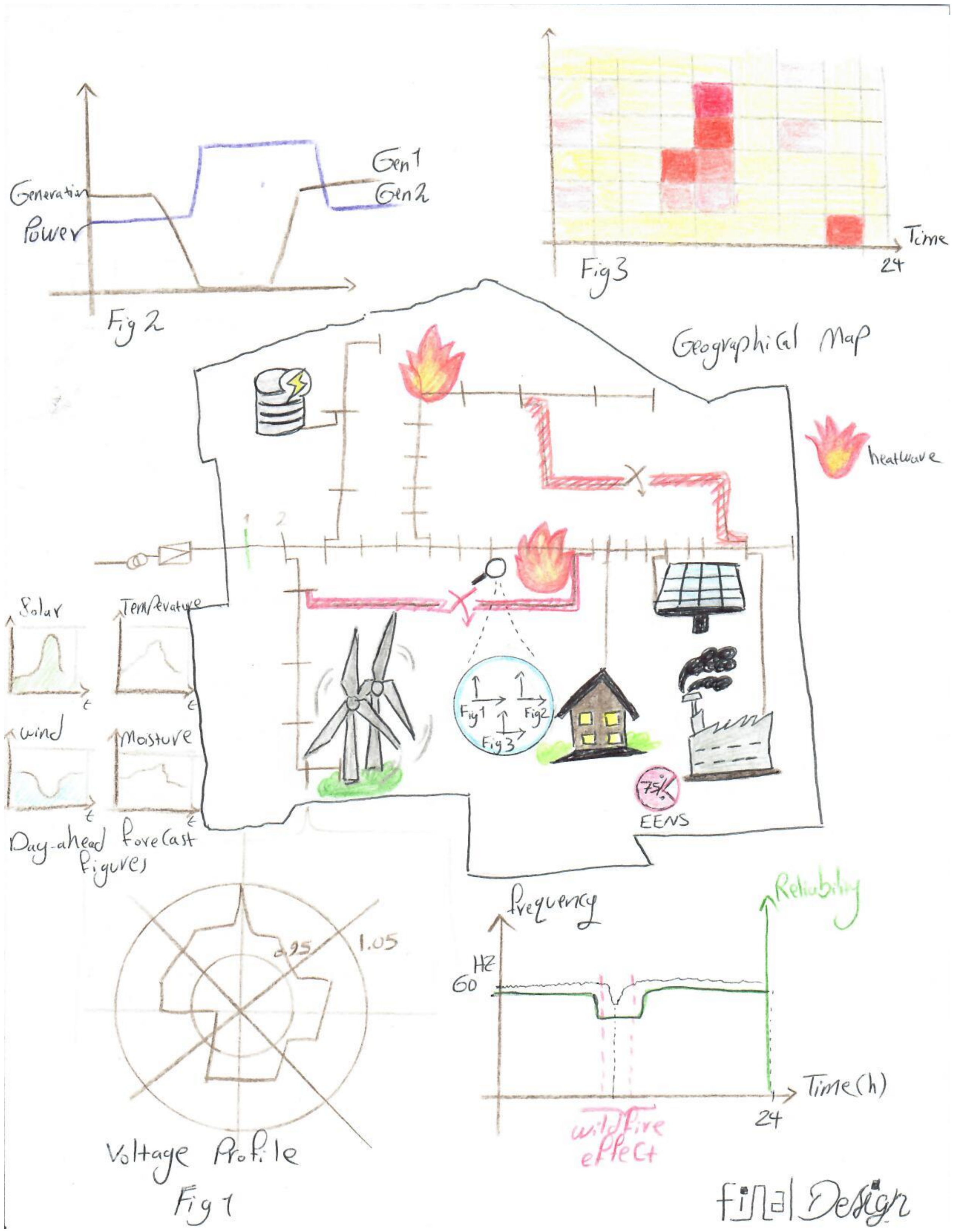

Fig. 5: Final design

Must-Have Features

The project should effectively present the data clearly and understandably. If the data presentation is confusing or misleading, it would hinder the project's objective of informing stakeholders.

The seamless integration of heatwave scenario data and power infrastructure data is fundamental. If the data integration is inaccurate or incomplete, the project will lack the foundation required for meaningful analysis. Moreover, the voltage and current measurements for each node within the network are vital data points, as they reveal the network's stability and overall condition.

Optional Features

Optional Features we can add:

1. Forecasted renewable energy resources generation.
2. Information about the input data, such as load.
3. Allowing users to select specific nodes within the network to access more detailed information about those buses.
4. Allowing users to export selected data or visualizations for further analysis or reporting purposes.
5. Integrating social sharing features such as energy not supplied.
6. Sending emails to customers who are under unusual conditions.
7. Considering different sets of color for curves and background in the pictures; therefore, users can use the color that they are more comfortable with.

References

[1] Federal Emergency Management Agency (FEMA), https://www.fema.gov/.

[2] National Oceanic and Atmospheric Administration (NOAA), https://www.noaa.gov.

[3] U.S. Department of Energy (DOE), https://www.energy.gov/.

[4] R. Bayani, S.D. Manshadi, Resilient Expansion Planning of Electricity Grid under Prolonged Wildfire Risk, IEEE Trans Smart Grid. (2023).