Free Market P2P Energy Trading

PROJECT PLAN

Team #41

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1 Introductory Material

In this section, we discuss the problem our project is based around and our proposed solution. In section 2, we will discuss our approach to the project, and the reasoning behind any decisions that led to that approach. In section 3, we will examine the estimated resources needed to completed our proposed project, and estimated deliverable dates.

1.1 Problem Statement

The primary aim of our project is to incentivize renewable energy generation from individuals and small businesses by facilitating peer to peer trading of surplus energy. By creating a free market environment for energy trading, individuals will think more about how they produce and consume energy, and will be inclined to generate energy of their own. With this new understanding and market accessibility, energy prices will fluctuate to be at parity with their true value, not just what the utility company dictates. A more detailed description of our implementation of this free market solution is found later in this document.

Our secondary goal is aiding in the decentralization of the power generation market. The interconnectedness of grids has already contributed to the reduction of blackouts, as one individual power plant or utility company is not solely responsible for all energy generation. At the time of writing, a Chicago grid can pull from a Toronto plant if they approach their capacity curve. Our system would aid this interconnectedness a degree further, as the power loss and cost to transfer energy a mile up the road would be less than the power loss and cost to move that energy from Toronto to Chicago. A more decentralized grid would help the overall grid to be robust to fluctuations, as the sources of energy would be widespread and independent. Figure 1 displays how this distributed energy approach allows the energy generation to more accurately track the demand.

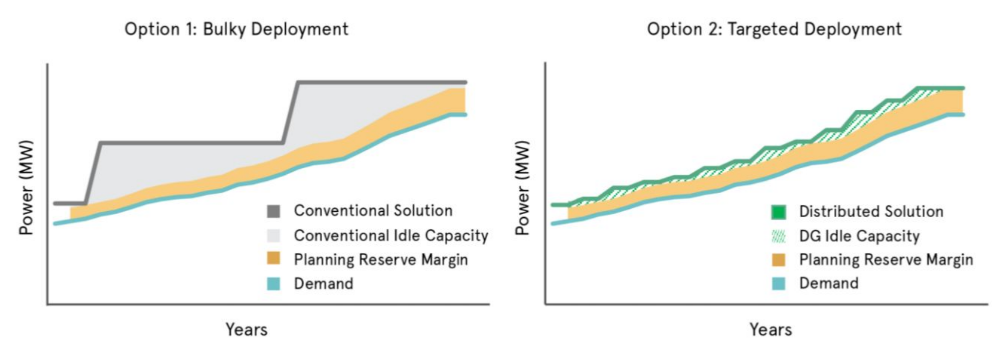

Figure 1: Bulky vs Targeted Deployment of Energy Resources [7]

The connection between decentralizing energy generation and our solution is clear. We hope that an open market will allow individuals to feasibly operate their own renewable energy sources like solar panels or wind turbines. If this goal is realized, energy will not be produced only at large plants. Because of this, consumers will be able to rely on a more diverse array of energy sources than those currently available.

A positive side effect of incentivizing renewable energy generation is that it will also contribute to slowing down climate change. Renewable energy usage is seen as one of the key ways to target this problem, but a large portion of worldwide energy does not come from this "clean" energy generation. To change this, the generation of renewable energy needs to be more accessible to individuals and businesses, rather than only those who have the resources and capabilities of a large energy company.

Our project has two major components: the development of an inexpensive and user friendly smart power meter and software to facilitate peer to peer trading of surplus energy. When these two stages of the project are complete, individuals using our hardware and software will be able to buy or sell surplus energy at significantly better rates than could be obtained going through a utility company.

A goal for the project that is still being defined is developing a marketplace where these peer to peer interactions could be facilitated. We hope to develop a way to automate this process so users would enter their desired parameters for energy transactions (maximum amount, times, etc.) and the system would be automated such that these transactions could be financially optimized with minimal work from the user.

1.2 Operating Environment

The operational environment for our solution will be a relevant factor in the final implementation. Our smart power meter has to be able to withstand all of the conditions that existing power meters currently withstand. It will have to be able to survive in various weather conditions that naturally come with being a product that lives outside of the home.

On the software side, the "operational environment" will be the economic and political climate in which our solution is being used. There are many legal factors that could come into play with this kind of trading, like use of the utility company's infrastructure or trading between different cities, states, countries. These are all factors that would need to be explored in further detail if this project were to be expanded beyond a simple test environment with two nearby homes or small businesses.

As the project continues (potentially with future senior design groups), more focus can be put into refining the robustness of the hardware and making sure our software implementation integrates effectively with the economy and politics of the location where our solution is being used.

1.3 Intended Users and Intended Uses

The users can be split into two groups, which we will refer to as "producers" and "consumers." The producers are the users who will supply excess energy that they produce into the system. Producers look to maximize the profit that they can create from producing energy, and our tradable energy market will enable them to do just that. In order to best serve these users, we are minimizing the transaction costs and maximizing the ease with which they can find buyers for their energy. The consumers are the users who will be consuming the excess energy that producers create. We can best serve them by minimizing the transaction costs and making it as easy as possible for them to find producers whose energy they can consume.

The intended use can therefore be described as incentivising personal generation of energy by creating an accessible market for both producers and consumers. Ideally, intended users would eventually include anyone with an electrical service connected to their home or business but in the current utility climate, the intent is simply to attract as many users that already have direct generation installations as possible. More producers in our user base will allow us to obtain more consumers by making the market more competitive and attractive. In due course, the flow of consumers to the marketplace will encourage more people to become producers and install their own direct generation setups. This circular growth will eventually lead to us reaching our intent of widespread incentivisation of direct generation.

1.4 Assumptions and Limitations

Because our goal is to make an impact on large scale issues like the energy market and climate change, it is important that we set certain restrictions about what aims we can realistically hope to achieve with our project. The following list gives the most important of these assumptions and limitations regarding the scope of our project.

Assumptions:

- Enacting the distribution of power after our transaction is completed is outside of the scope of our project, including the new power equipment that could be required for this distribution
- For a full implementation of our project, an agreement will have to be completed with the utility company owning the power infrastructure so they will allow these transactions to take place
- Failing to reach an agreement with a regular utility, an agreement will have to be completed with a developer of a subdivision, whom would typically own the power infrastructure of said subdivision
- The level of testing that we will complete will be within an individual municipality, so interstate/international trading laws will not be applicable

Limitations:

- The cost of the IoT smart power meter must not exceed that of the average power meter used in Ames, IA (the area of testing)
- The purchase of all hardware components and software licenses must be approved by our client and must not exceed the amount of funds they have allocated for the project
- The cost for user operation of our smart power meter must be minimal so as to make the implementation worthwhile for the customer

1.5 Expected End Product and Other Deliverables

IOT Smart Meter - Estimated delivery: March 15

An "internet of things" capable smart meter will need to be installed at a user's property to read the flow of energy into their home/building. This smart meter will be connected to the internet, and will interact with the energy marketplace to enact transactions. The smart meter will be able to verify transactions of power over set periods of time, as determined by the agreement between the buyer and seller in the transaction. The goal for the end of this semester is to have functioning basic communication between the smart meter and the web application. By the end of the year, we will develop a working prototype that is able to verify the completion of a transaction, connect to the web application, and display vital information to the user via a user interface directly on the physical meter.

Energy Marketplace Implementation - Estimated delivery: April 1

Power transactions will be made and recorded using a MongoDB database which is manipulated by a marketplace controller on the backend of the web application. This marketplace controller will be manipulated using the web application. A stretch goal is to implement a transaction matchmaker, which would automatically create and accept transactions based on predetermined criteria from the user.

Web Application - Estimated delivery: April 15

Users will manage their power transactions through an easy-to-use web application, which will interact with the energy marketplace through API calls, receiving and changing information through a MongoDB API. This application will allow the user to monitor and learn from their energy use and production, and will also allow users to buy and sell energy through a marketplace interface. Users will also be able to download personal usage and production statistics through the web application. The web application will include login/account creation capability and viewing transaction history as well.

2 Proposed Approach and Statement of Work

In this section, we will discuss our requirements, options we considered for meeting those requirements, and our proposed approach.

2.1 Functional requirements:

1. *An IoT Smart Meter device*
2. *Web app for management of transactions*
3. *API for communication between the smart meter and the web application*

2.2 Non-functional Requirements:

1. *Ease of setup*: Any user must be able to easily install and configure our hardware/software.
2. *Portability*: The web application must be usable on various platforms.
3. *Robustness*: The hardware must be able to withstand environmental conditions and be able

to respond to signal loss and power outages. The software must be tested to handle edge cases and avoid fatal errors.

4. *Scalability*: The hardware and software must designed in such a way that it could handle a large network homes that would be required for a full implementation of our design.
5. *Code quality/documentation*: In order to fully achieve the aforementioned requirements, we must write code that is understandable and well-documented.

2.3 Constraints Considerations

Our goal is to end up with a product that we can be proud of and have it be something that we are eager to present to the client. Each group member will strive to put their best work forward and each contribute their own unique values to the project.

These values will include efforts by all team members to adhere to the engineering ethics that we have been studying while at Iowa State University. Every member of the team has a bevy of university-mandated ethics training in addition to their own personal values informing their decisions as engineers. The ethics program at Iowa State emphasizes the importance of integrity, honesty, and responsibility in the work of engineers. Keeping these in mind and following the IEEE Code of Ethics is of the utmost importance for our group as we work on this project.

Project development will follow a structured model for Git version control. We will use pull requests that will require at least one other member's approval. Each task will have its own branch and those branches will be appropriately named based on their task. All commits will have will have sufficiently descriptive comments. All code will include descriptive objects and class names. Each method and class will be sufficiently commented except obvious getters and setters.

2.4 Technology Considerations

While assembling our proposed solution, we looked into several different options for technology. Each technology, with our evaluations, are provided below.

Arduino

Advantages:

- Entire team has experience and can develop MVPs
- Multiple libraries and shields for wifi and other extraneous processes
- I/O system is the easiest

Disadvantages:

- Little learning in terms of team's intellectual growth
- Can't house the ethereum web3.js code base
- Doesn't provide a strong IP story

Arduino would be best used if we encounter high I/O in our system while not requiring heavy web based protocols. The shields and libraries are cohesive for simple Wi-Fi connectivity, but lack libraries for connecting to blockchain networks. Every member of our team has worked with Arduino.

Raspberry Pi

Advantages:

- Easiest connectivity process (wifi)
- Experienced members on our team
- Libraries and shields for extraneous processes
- Allows web server code/processing
- Rolling new updates is simpler

Disadvantages:

- Doesn't provide a strong IP story
- Single point of failure on the system

A Raspberry Pi system will allow us the greatest extensibility and code reusability. Many of the Arduino advantages are present with the Raspberry Pi and it was originally chosen for its ability to allow us to use js libraries that connect directly to the blockchain. By connecting direct, we can remove a node that would be required for computational logic (cloud or local server) that both the Arduino and PCB require. Now that we are looking at alternative options to blockchain, the main advantage of the Raspberry Pi is less relevant and there is a lot more consideration being given in the direction of Arduino and PCB hardware. Our team similarly has experience working with these.

PCB/Embedded

Advantages:

- We can improve our knowledge or fabrication and low level hardware/software
- Capability to be fastest processing
- Least amount of resources used - power/computation

Disadvantages:

- Learning curve is highest
- Development cycle is the longest
- Documentation for our application is minimal

In going the PCB/Embedded route we have the opportunity to become more adept in a technology our team isn't familiar with. This would also allow us the best intellectual property scenario as the technology isn't easily reproducible in code. The drawbacks are large in terms of development cycles and resources that we can tap to work through any issues. Many otherwise seamless processes such as Wi-Fi connectivity will be more difficult on this platform. However, the finalized product has the potential to be faster while consuming less resources.

2.5 Safety Considerations

The one safety concern which needs to be addressed when approaching our project is the linking of the smart meter to the power lines going into each of the homes, businesses, or other entities that are going to be included in the network. The meter clamps are designed such that no physical connection is required to any conductors, so the safety risks should be minimal. If the long-term smart meter solution requires a direct connection to the power input of a building, this would most likely require a licensed electrician for safe installation.

2.6 Overview of the State of the Art

We now present an overview of the previous work and literature that we have reviewed regarding comparable technologies.

TransActive Grid + LO3 Energy

TransActive Grid is the IP holding company of LO3 Energy. The Consensys team previously teamed up with LO3 Energy to test the viability of energy blockchain. In 2016 there was a blockchain energy implementation in New York City, specifically the Brooklyn borough. The pair wired up two Brooklyn residences and traded energy on the blockchain. The details of this transaction were left out due to IP implications from the organization [7].

Besides the 2016 article LO3 energy has been relatively quiet about their progress. The gist from their end is that energy blockchain is viable from a technical perspective. The Brooklyn Microgrid is now being brought to other countries, most recently Germany.

Grid+

Grid plus is an Austin, TX based energy retailer. The parent company is New York City based ConsenSys. Grid+ provides a smart argent and blockchain implementation. The smart agent is used to buy and sell the GRID token. They also have another coin, BOLT. This coin is known as a stable coin. The advantage to stable coins is while a cryptocurrency will readily fluctuate in price a stable coin reflects a more stable currency, in this case the USD. A single BOLT is equivalent to a single USD. The end user will have the advantage of near real time service and security of the blockchain while not having a wildly fluctuating cost of energy.

Grid+ however, does not have a peer to peer energy model. The business model they use is to cut administrative costs from the distributor and retailer in the energy supply chain. From a technical perspective the Grid+ energy blockchain implementation is using the ethereum blockchain [5]. The ERC20 token standard is their building block for the smart contract. The focus of their contracts is on the token and ICO, while they have long term development outlines for their energy business.

SolarCity

SolarCity wrote a report [11] in which they explain the distributed energy environment and its subsequent advantages. They specify that the distributed energy model is a net benefit for society through benefits related to voltage and power quality, conservation voltage reduction, grid reliability and resiliency, equipment life extension, and reduced energy prices. The hurdle they present is that the current utility incentive model doesn't coincide with a distributed energy focus. To convert to their model they propose legislative changes.

Power Ledger

From the Power Ledger whitepaper [12], the Australian based energy blockchain startup looks to provide peer to peer energy trading. The will facilitate these energy transactions with the ethereum blockchain. Power Ledger provides very little technical documentation of their work but boast a trading matching algorithm, meter reading device and token sale.

2.7 Possible Risks and Risk Management

As we proceed with development, there are a few concerns that we are aware of that have a chance to hinder our progress. Though we are fairly knowledgeable about most areas of our project, because we are inexperienced in interacting with power lines, there may be unexpected roadblocks that we run into that will need to be addressed. We are in the process of eliminating any timing issues associated with energy transactions over a multiple-hour period of time while working with transactions, which are typically one-time events. This will help us mitigate the risk of users exploiting other users. Finally, we are working diligently to ensure that the software we write is error-free and secure.

2.8 Project Tracking Procedures

We are using a Gantt chart to outline the variety of tasks that are necessary to complete our project. This chart serves as a visual tool with clear milestones that need to be completed, including dates, task owners, duration, and more. This schedule can and will be adjusted as progress is made and issues arise, but it will be in our best interest to keep up with the deadlines in order to stay on track to complete the project in a timely manner. A live-updated version of this document can be found at the following link, with sections for both the first and second semesters of the senior design course.

https://docs.google.com/a/iastate.edu/spreadsheets/d/1gSY1sHtt_i6-RaNFEG1_S9uw0KnE5iEDKWcexmxvTxs/edit?usp=drive_web

As our progress continues, this document will be updated to reflect our current plan for each phase of the project.

2.9 Objective of the Task

We anticipate that this project, in the long run, has the potential to be implemented in a large scale. Taking into account the time and resource constraints associated with this project, our goal is to have a working prototype that can be tested first on a preliminary level and potentially on a network of 400 homes.

A stretch goal for the project is to develop an automated marketplace where these peer to peer interactions could be facilitated. We would have to find a way to automate this process so users just have to enter how much power they will be consuming at what times and the system arranges the transaction to take place.

In addition to our goals related to the application of our solution, we also have some goals throughout the process of developing our solution. We hope that this design process will be a beneficial experience for us, aiding us in learning how to interact with contacts in industry and respond to their feedback in order to tailor our work to most effectively solve the problem at hand. We also hope to gain technical experience in areas with which we do not have significant experience, like PCB design.

2.10 Task Approach

We have researched various ways to go about solving our problem. Those that received the most notable consideration are detailed below.

Software

1. Ethereum Approach

    Using the open-source ethereum (blockchain) platform to develop smart contracts for buying and selling energy. Using ethereum we can utilize their stable Solidity language to implement our smart contracts. The advantage here is there are many projects built with this stack allowing for more resources and support.

2. Hyperledger Approach

Using the open-source hyperledger (blockchain) platform, which is newer compared to the more established ethereum approach. Hyperledger is supported by larger organizations such as IBM. We believe this will allow the technology to stabilize long term with the backing of a large company compared to the burn-out many open-source projects that lack an organization have seen.

3. Traditional Marketplace Approach

Using a traditional marketplace instead of a blockchain implementation will allow us to provide cheaper transaction rates to our customers. This is because paying for each blockchain transaction is a fairly expensive overhead ($0.20-0.40 in the last 6 months) to selling energy. Implementing a traditional marketplace will also be more simple and easier to customize.

Hardware

1. Raspberry Pi Approach

This approach would use GPIO to continuously ready energy input and output. The data will then be used for buying and selling. Raspberry Pi has built in IoT capabilities which provide the needed support for transactions.

In the prototype form, the Raspberry Pi will non-intrusively connect to the existing power buses, serving as a smart meter to connect to the Mongo database in addition to the existing traditional meter. Current and power usage will be tracked and data will be transmitted to the server.

2. Microcontroller/custom PCB Approach

This approach is functionally identical to the Raspberry Pi, but built with a different set of components. Both will record and send data for buying and selling. This approach would require more work, but it may allow us to optimize power consumption and only use the hardware that is vitally necessary for the functionality of the meter. The options that we have explored on this front include sticking with standard Internet connectivity, local connections such as Bluetooth or Zigbee, or cellular connectivity. Internet connectivity is the implementation strategy with which our team is the most familiar, but the other options discussed could provide benefits in ease of configuration for the user. The pros and cons of each of these solutions will be explored in more detail as we continue our designs and prototyping into the second semester of senior design.

Approach Taken

After considering the above approaches, we determined that the best initial plan of action is to implement our marketplace through a traditional marketplace approach, and to use a Raspberry Pi approach for our smart meter. In Figure 2, we visualize an overview of our proposed system. Each user/property will use the smart power meter to monitor the flow of power from the property (and any power-generating devices, such as solar panels or wind turbines) to their power company. Each smart meter will be linked to a user's account via the web application. A user for any given property may access the marketplace and view analytics about their energy consumption through this web application.

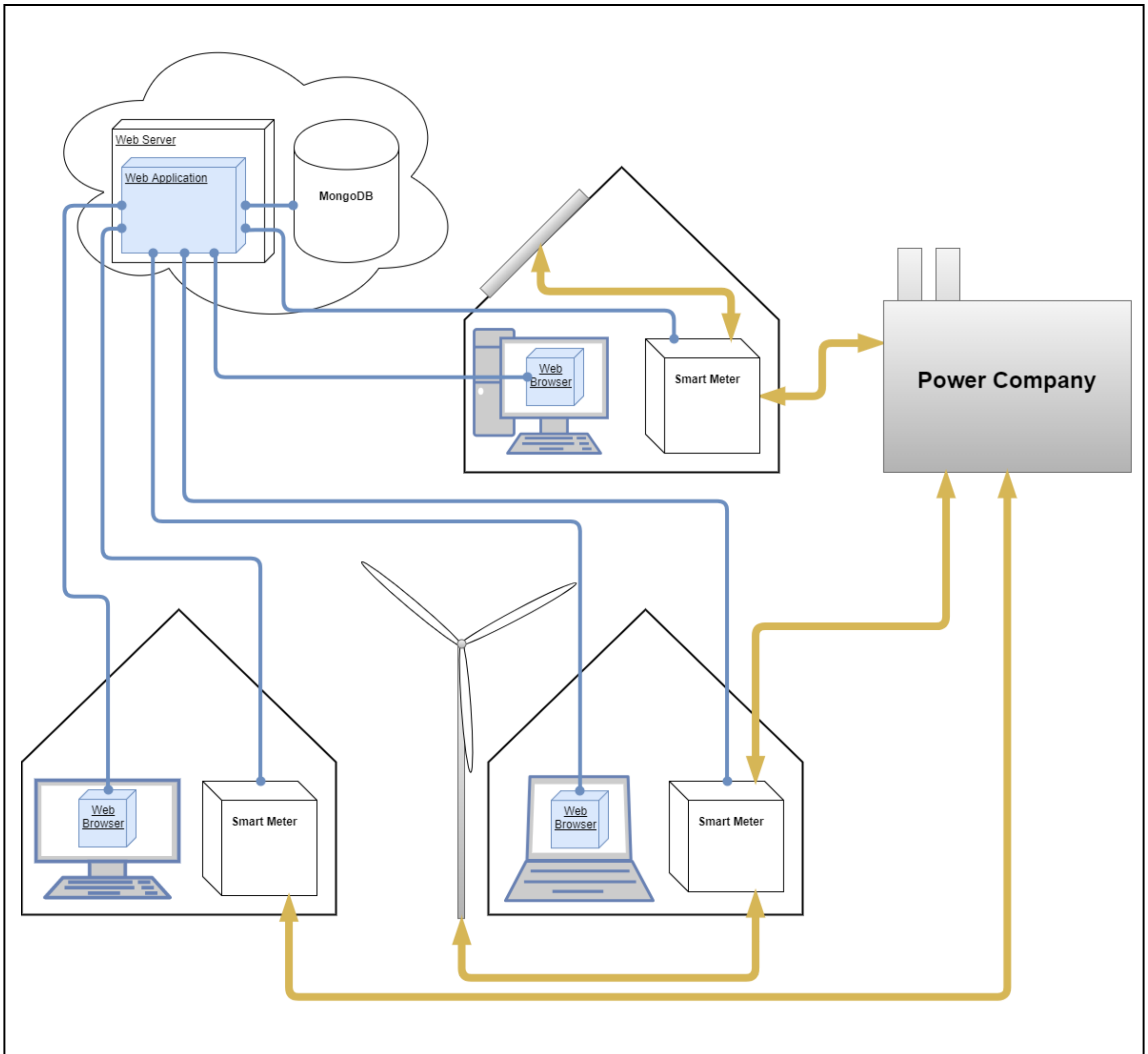

Figure 2: A diagram of our proposed system

Figure 3 provides a broad view of the components involved in our web application. The web application will interact with a MongoDB database, implemented on the back end, which will store all of the user data and information about energy transactions. User analytics will be accessible through the energy dashboard, and any transactions will be managed through the marketplace. As mentioned in Section 2.9, one of our stretch goals is the development of an automated system to find and match transactions, so that users will not have to manually track down producers if they cannot find an offer they like.

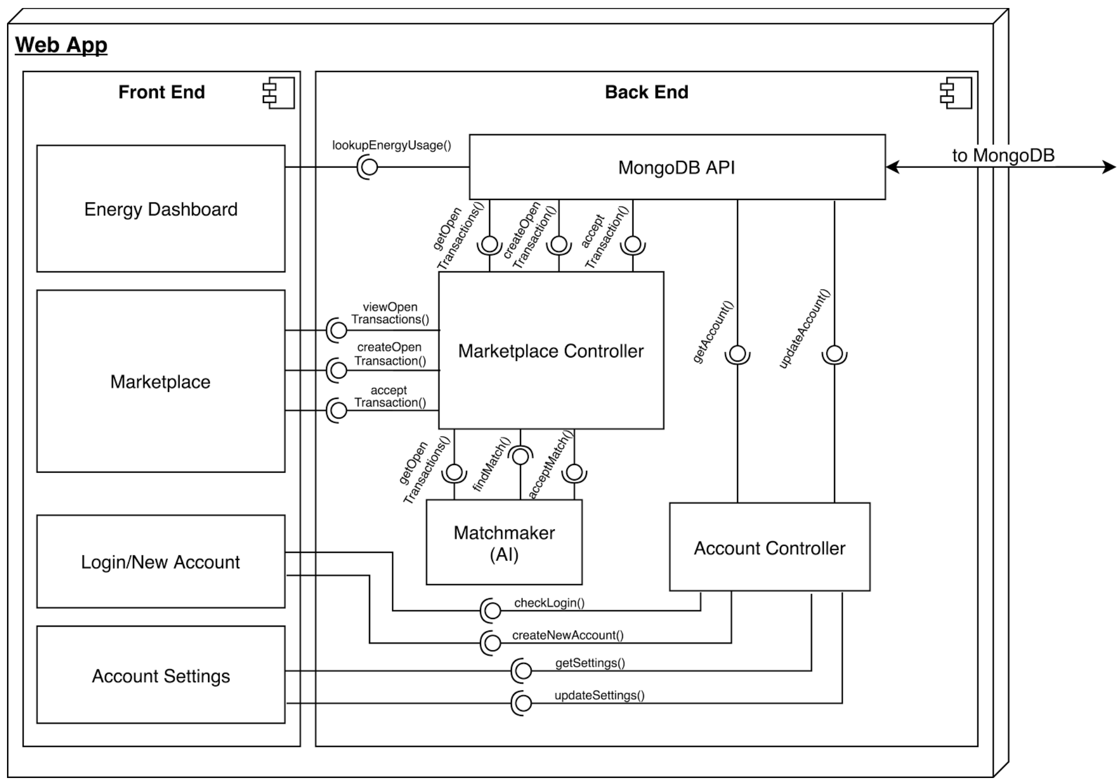

Figure 3: A macro-component diagram of our web application

2.11 Expected Results and Validation

The simplest way for us to confirm that our solution works is by testing it. Because our project is broken into three parts (smart meter, analytics and marketplace software), there will be multiple stages of testing for each component. In respect to hardware we expect to have an Analog Digital Converter (ADC) reading in data from our passive current sensor that will then act as a Smart Meter and will send the data to the analytics server. It is there where the data will be stored and made available to the user for analytics and the marketplace.

In respect to validation we will be using multiple levels of unit testing. For hardware validation we've begun testing the use of an MCP3008 with a Raspberry Pi 3. We will ensure that Raspberry Pi is receiving and decoding values from the ADC by providing a known voltage from a power supply to the ADC. To verify the current sensor is providing the correct voltage and the voltage is being converted to the correct amperage we will clamp the current sensor to a home that has a smart meter. We will use the provided data from the existing smart meter to verify our smart meter is functioning correctly. Concurrently, we will be testing the functionality of the software to make sure we can reliably and securely upload meter data and process transactions. For the software side of validation we will perform unit tests on each method and then perform integration testing on the larger components and front-end functional testing. If we have the opportunity, it could also be beneficial to work on testing in a system with a large number of points (houses) to make sure that everything is scalable.

2.12 Challenges

1. Does a user have to put energy into the system at the same rate that it is being consumed? Will there be any timing issues? More research is being done.
2. We will need to figure out the optimal way to connect the IoT device to the power supply.

3 Estimated Resources and Project Timeline

In this section, we discuss the monetary, time, and personnel resources required to complete the project, and our expected timeline of task completion.

3.1 Personnel Effort Requirements

Task	Team	Effort Required	Reference/Explanation
Program User Interface	Hardware	Low	The libraries available for Raspberry Pi devices should make it fairly simple to take in input and display output to the user on the meter.
Coordinate Interfacing with Web App	Hardware	Medium	This step will require effective communication with the software team on what data they need to receive and what form it will come in.
Test Initial Proof of Concept Prototype	Hardware	Medium	The focus of this step will be to ensure that this version of the system has all of the basic desired capabilities that are needed for an early implementation of the project. Essentially we will need to make sure that we are able to reliably acquire and transmit data.
Design PCB/Embedded Board	Hardware	High	To implement the hardware required for this project from scratch, we would need to acquire various individual components and connect them on a PCB. In addition, we would have to write our own drivers for this board.

Order Board	Hardware	Low	Once we have the design completed, ordering the board will just be a matter of determining the best option to have it fabricated
Test and Compare with Raspberry Pi Version	Hardware	Medium	This step should just be a matter of determining which aspects of performance we will give the most weight and comparing the two implementations, including the effort and cost that went into creating them.
Marketplace: Init Transaction	Software	Low	Transactions are a standard procedure for applications to perform, and initializing a request and posting it to the marketplace should be straightforward
Marketplace: Accept Transaction	Software	Medium	We will need to do some extra programming to deal with the timing of when accounts receive payment, such as using a holding pot until the transaction is complete
Smart Meter API: Power Transaction Signal	Software	High	Requires blockchain/smart meter interaction, which will require collaboration between teams and probably more testing, since this is essential to our project
Web App: Create Account/Register Smart Meter	Software	Medium	We will tie each account to an Ethereum account, so account creation will be handled elsewhere; however, we will need to handle linking an account to a smart meter
Web App: Login	Software	Low	We will just need to pass login through Ethereum, so there should be little programming required for this step
Web App: View Transaction History	Software	Low	This will simply require some queries to the MongoDB database, followed by displaying that data in a meaningful way
Web App: User Analytics	Software	Medium	Retrieving the information that we need will be easy, as will displaying the raw information to the dashboard. Depending on how complex we want our analytics to be, there is potential for more intensive algorithms to write and program

Web App: Automated Transaction Matching	Software	High	This task will probably involve some form of artificial intelligence, or a very efficient matching algorithm. Optimizing our strategy will be key, since this process may run for hundreds of users at a time, if our market caught on
Perform End-to-End Acceptance Tests	Software	Medium	We will want to be thorough with our tests, and will probably need to do quite a bit of debugging and refining, but if our designs are well thought out, and each previous task goes well, we should not have any major changes to make

3.2 Other Resource Requirements

The main parts that will be required for this project will be on the hardware (smart meter) side, as this is the physically tangible part of the project. For the early prototype, we will need two Raspberry Pi modules (one to act as the buyer and another to act as the seller) and current sensors to detect the power input and output at each of our test "homes." In addition, if we are able to get to testing with fabricating a PCB, there would be quite a few components necessary. While we cannot be sure exactly what would be required for the design at this point, we would certainly need a microcontroller with WiFi capabilities along with the basic components that go into making a PCB (circuit design software, solder, etc.). These could include licenses to software such as Cadence Virtuoso, PSpice, OrCAD, Eagle, etc. The options for microcontrollers will depend on the use of either Raspberry Pis or arduinos but the current top choice is an ARM microcontroller from Texas Instruments. The software team will require the React, Node, and Express libraries to run local unit tests and generate local development environments for the web app.

3.3 Financial Requirements

MASTECH MS3302 AC Current 0.1A-400A Clamp Meter Transducer True RMS

at $17 x 2 = **$34**

Justification: To measure the current entering and leaving the building.

Raspberry Pi 3

at $35 x 2 = **$70**

Justification: To connect the current sensing device to the blockchain. Import our logic libraries and subsequent code base.

PCB + device parts (Pi 3 substitute)

at $65 x 1 = **$65**

Justification: Time permitting we may substitute the Pi 3 for a custom PCB board that we can run our systems on in the same fashion as we would with the Pi.

Total: **$169**

3.4 Project Timeline

A large portion of the success of our project will be centered around adhering to our timeline. Although at this point, many of our tasks are in the preliminary stage, it will still be vital for us to use this tool to maintain steady progress. An overview of our major tasks and milestones is shown below, while the more detailed version is shown in the attached Gantt charts for both first (EE/CprE/SE 491) and second semester (EE/CprE/SE 492).

First Semester

Class Deliverables

1. Project Plan
2. Design Document
3. Team Website

Hardware Team (Jack, Joe, Arun)

1. Research parts and determine platform to be used
2. Create tentative parts list with pricing
3. Obtain current sensor and meter platform (Raspberry Pi)
4. Research available software libraries for Raspberry Pi module we are using
5. Determine preliminary version of desired capabilities of meter (sensors required, data stored, etc.)
6. Initiate programming of data acquisition and transmission capabilities

Software Team (Brendon, Noah, Alec, Arun)

1. Experiment with Ethereum and creating smart contracts
2. Experiment with MERN stack
3. Web app user interface mockups
4. Component diagram for web app
5. Component diagram for smart meter API
6. Basic web app development environment setup

Second Semester

Class Deliverables

1. Working prototype smart meter
2. Basic functional web application
3. Working energy marketplace implementation
4. All components successfully interact

Hardware Team (Jack, Joe, Arun)

1. Program user interface
2. Coordinate interfacing with web app
3. Test initial proof of concept prototype
4. Design PCB/embedded board
5. Order board
6. Test and compare with Raspberry Pi version
7. Program data acquisition and transmission capabilities

Software Team (Brendon, Noah, Alec, Arun)

1. Base web app functional
2. API components for communicating between web app and smart meter
3. Create account functionality through web app
4. Login functionality through web app
5. View transaction history functionality through web app
6. Initiate and accept transaction functionality through web app
7. View energy consumption analytics
8. (Stretch goal) Automated transaction matching

Full Project Timeline:
https://docs.google.com/spreadsheets/d/1gSY1sHtt_i6-RaNFEG1_S9uw0KnE5iEDKWcexmxvTxs/edit?usp=sharing

4 Conclusion

If we complete our goals, our project has the potential to have important implications on the future of the energy market. We believe that with our team, we can make this project reach its full potential. By the end of the second semester of the project, we hope to have a functional prototype that we can use as a proof of concept in order to gain the traction to apply our solution at a large scale. Between the smart meter and blockchain free market trading software, all of the vital components will be present to show the benefits that this approach to distributing surplus energy has over the existing methodology.

While there are groups like Grid+, LO3, and ConsenSys that have already made strides towards a similar solution, we feel that our team is starting our project at just the right time. We are able to learn from the mistakes from our predecessors by taking what they would have done differently and actually doing it differently. While we are not the first to work on this type of project, we are early enough that we are not fighting against any other groups that are dominating or monopolizing the market. With the structural background that we have established in this document, we hope to be able to develop a solution that meets the needs of the users at hand and takes strides towards increasing the worldwide consumption and generation of renewable energy.

4.1 Acknowledgement

To preface our project plan, we would like to thank those who have made contributions to the project, outside of the members of our team. First and foremost, we would like to thank our adviser, Dr. Goce Trajcevski, for his technical assistance and comprehensive guidance throughout the project. We would also like to thank Sodima Solutions for providing the funding for the required hardware for the project, as well as providing the overall idea of the project. Lastly, we would like to express our gratitude towards the faculty of Iowa State University for their support in giving us the technical background and knowledge for us to handle a project of this scale. Without the support of these individuals and organizations, our project's success would not have been possible.

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5 Appendices

Here, we provide any figures used in this document, as well as several from past iterations of this document.

5.1 Current Figures

Comparison of Deployment Options

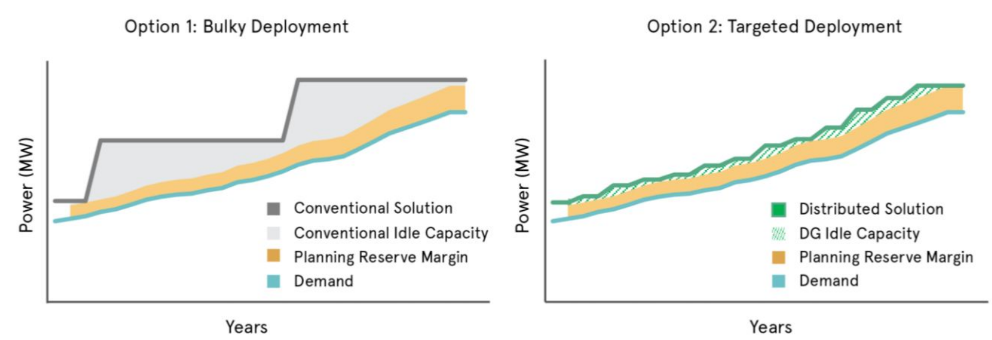

Figure 1: Bulky vs Targeted Deployment of Energy Resources

Updated System Overview Diagram

For more information, see Section 2.10: Task Approach. For past versions of this diagram, see Figure 4 in Section 5.2: Original Figures.

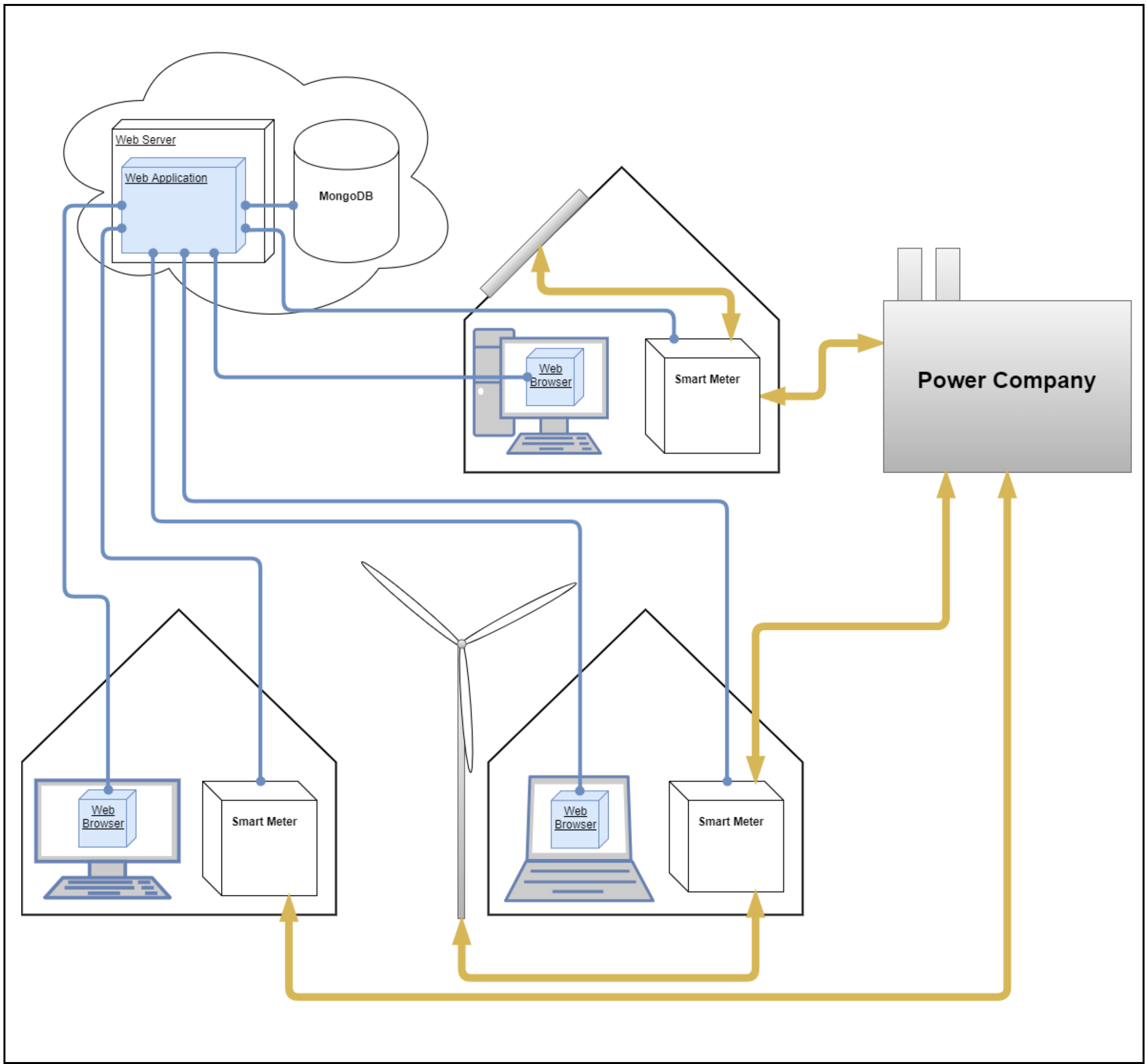

Figure 2: A diagram of our proposed system

Updated Macro-Component Diagram

For more information, see Section 2.10: Task Approach. For past versions of this diagram, see Figure 5 in Section 5.2: Original Figures.

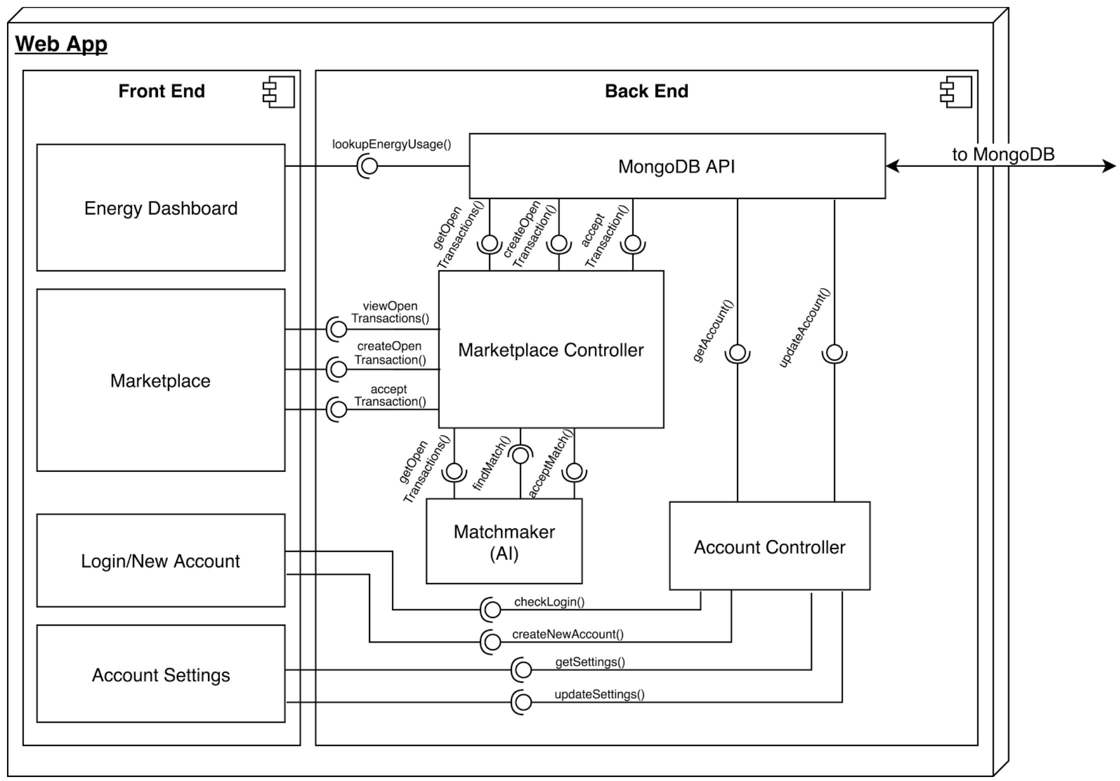

Figure 3: A macro-component diagram of our web application

5.2 Original Figures

Original System Overview Diagram

For an updated version of this diagram, see Figure 2 in Section 5.1: Current Figures

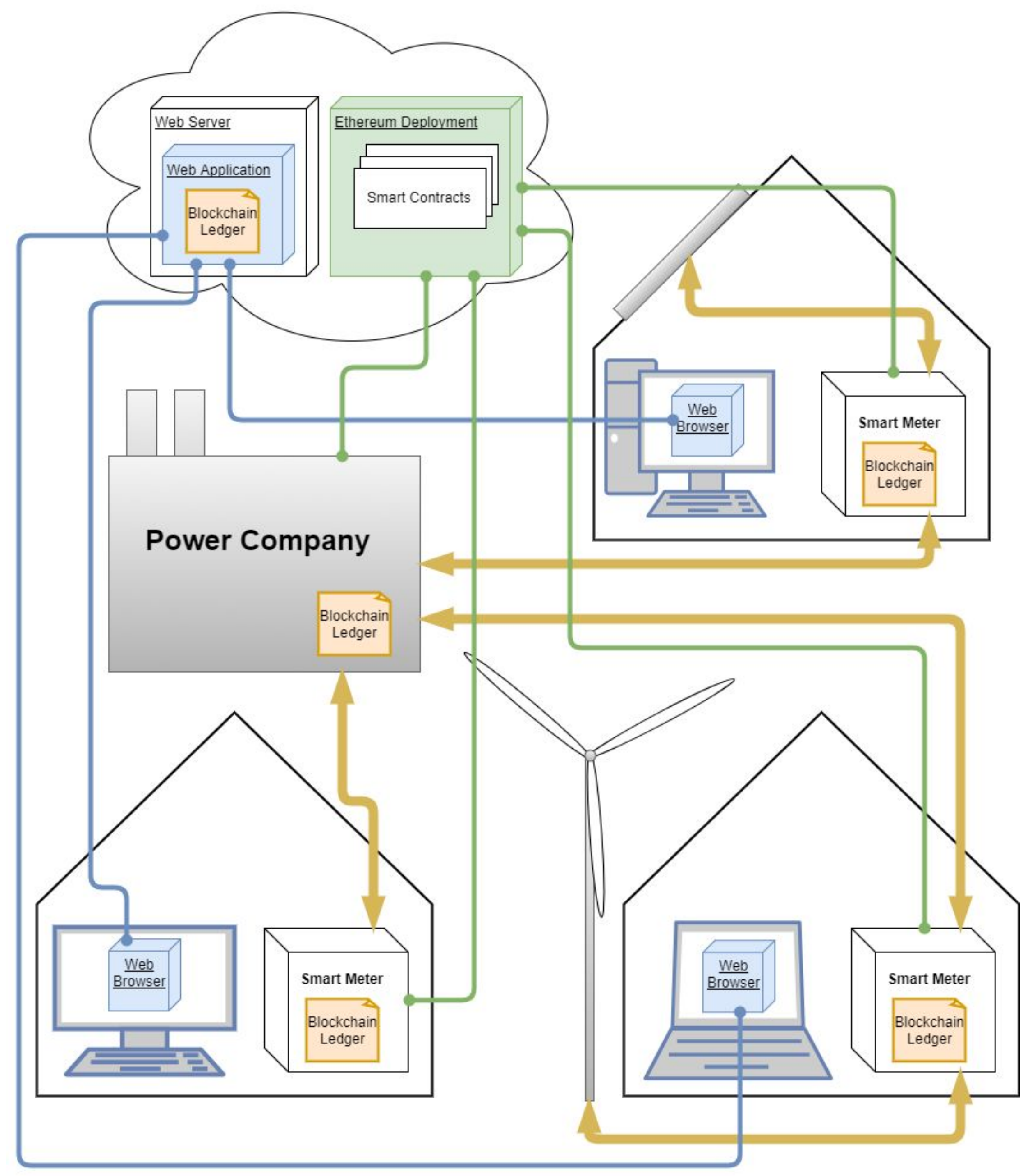

Figure 4: Our original system overview, which implemented Ethereum (blockchain) into the energy marketplace

Original Macro-Component Diagram

For an updated version of this diagram, see Figure 5 in Section 5.1: Current Figures.

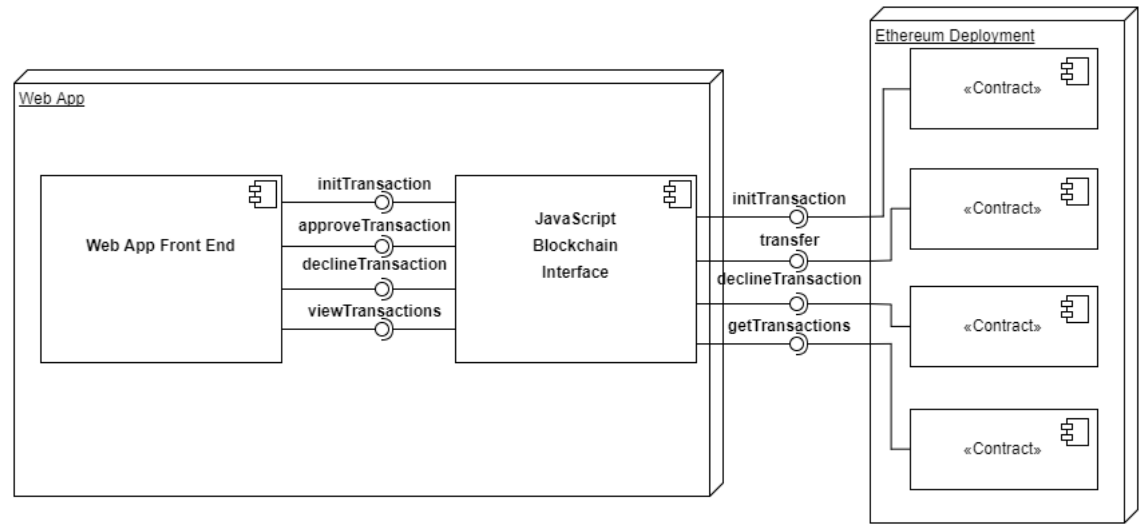

Figure 5: Our original macro-component diagram for the web application, in which the web app interacted with Ethereum smart contracts to perform transactions