Engineering Problem

Consumers are unaware of wasting electricity when using appliances. This misuse causes consumers not to use electricity wisely and leads to overexertion of fossil fuels and minimized use of renewable energy which furthers global warming.

Engineering Goal

The goal of this project is to engineer a device that can display the amount of electricity consumed by the consumer per appliance while ensuring the consumer is receiving accurate data to help the consumer use electricity smartly.

Introduction

Methodology

Results

Future Work

Project Charter

- Build a sensor to read electricity from each appliance and display on smart device
- Device will help consumer to use electricity smartly
  - Buy energy efficient appliances
  - Conserve electricity
- With less (fossil fuel and thermal) and efficient utilization of electricity this sensor will help reduce global warming

Purpose

Energy is a vital resource for humans. Humans are constantly using energy. In today's world, electricity is a necessary source of energy humans need. The need of electricity has become synonymous with the need of eating and the need of sleeping. However, humans are destroying the earth in the process of collecting and utilizing this energy.

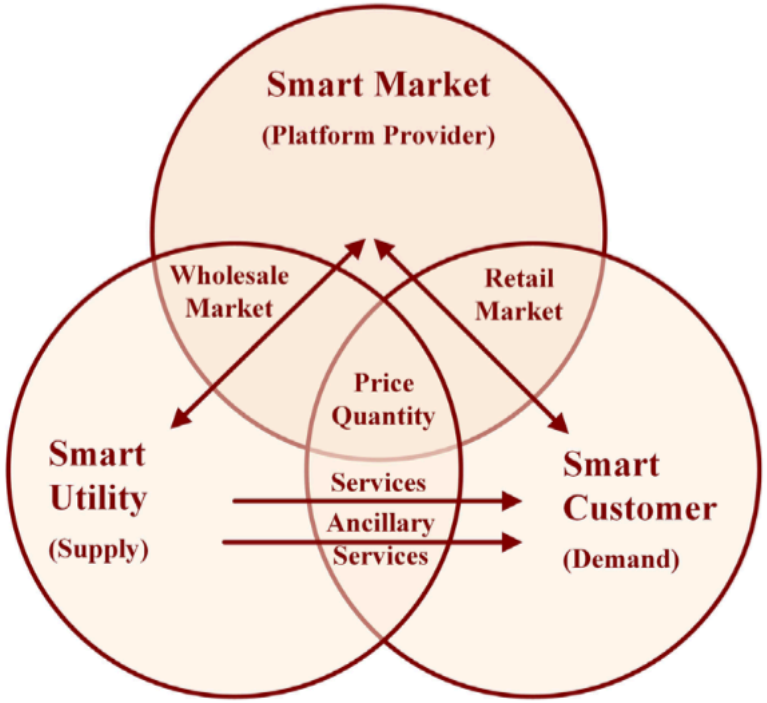
Often, consumers are unaware of how they are wasting electricity when using appliances. Consumers typically use appliances at suboptimal times when electricity is in great demand. The primary time consumers use their appliances is during the evening, specifically from 6-8 pm. During this time, the vast majority of electricity sent to consumer homes is generated by fossil fuels. The overexertion of fossil fuels is the primary cause of global warming. In the modern world, global warming is a huge problem. Climates are changing, and the balance of many ecosystems throughout the earth is becoming shattered.

Renewable energy is promoted as a way to save the earth from the effects of global warming, but it is minimally used in comparison to the consumption of electricity through the use of fossil fuels. Renewable energy is not integrated into many consumers' daily consumption of electricity.

Background

Smart Grid Technology

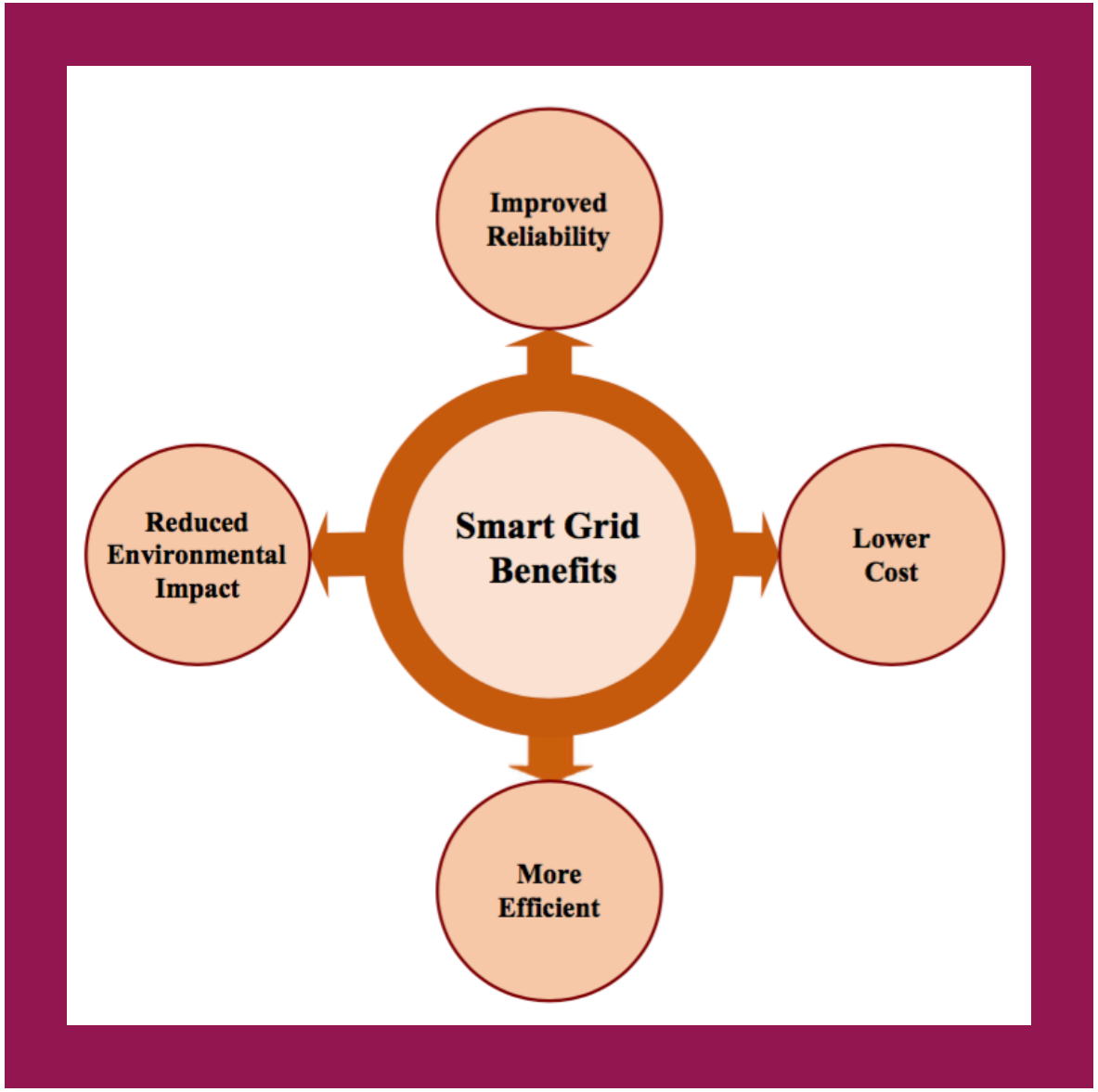
- Helps utility companies to determine when and how much of which type of electricity to be used



(Ellaban and Abu-Rub, 2016)

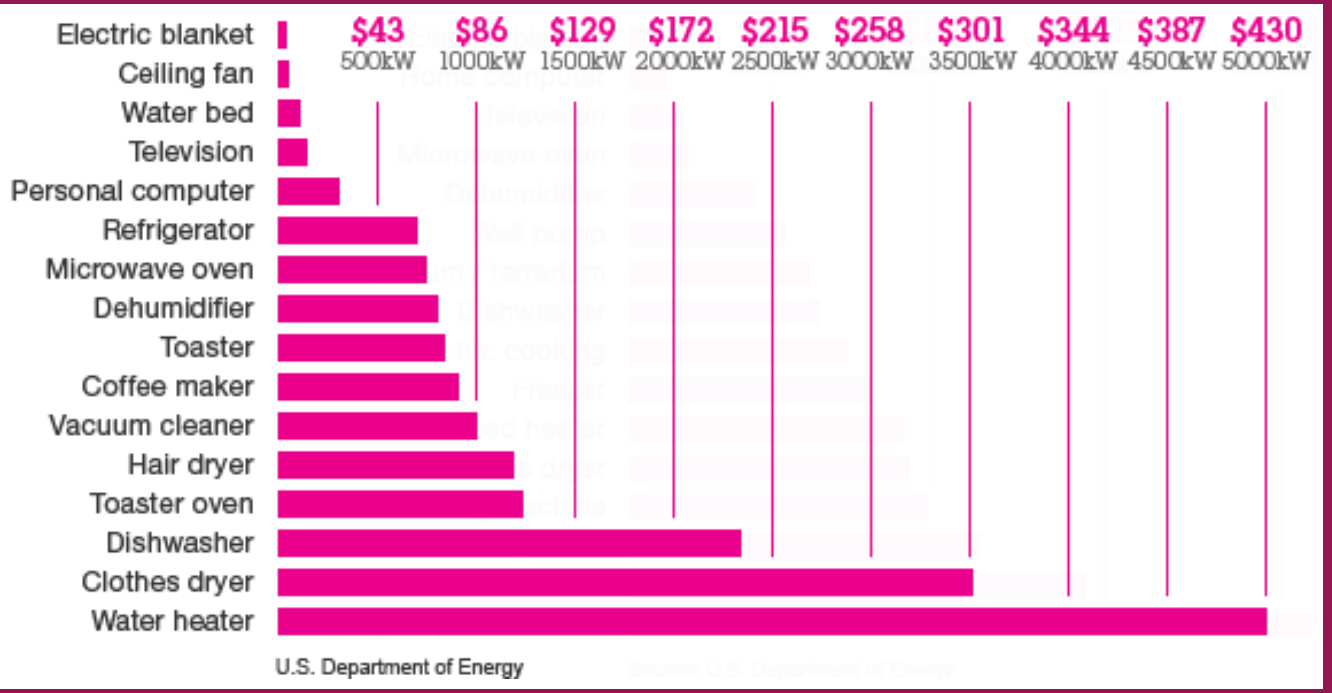
An ideal smart grid operates based on three pillars: smart market, smart utility, and smart costumer.

- Smart utility represents the efficient supply of energy
- Smart customer represents the educated and aware consumer utilizing the supply of energy
- Smart market controls these groups to provide the optimal price and quantity overall


Improved Reliability
Reduced Environmental Impact
Smart Grid Benefits
Lower Cost
More Efficient

Cost/Year

How much electricity do your appliances use?

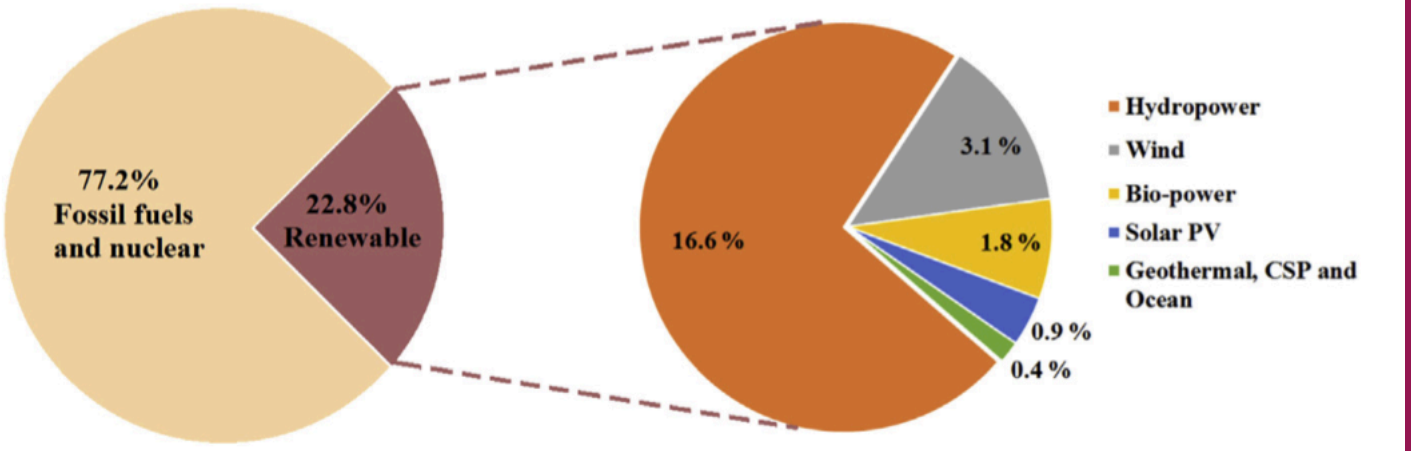


Electricity Generation

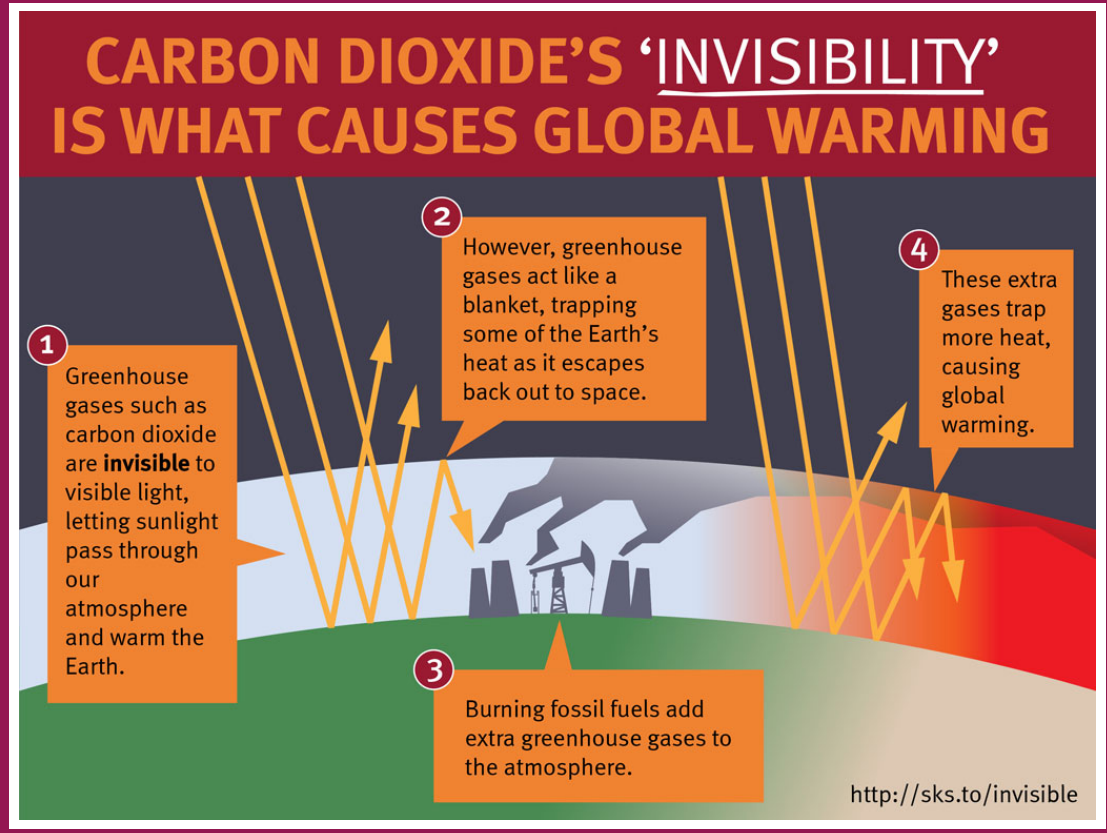
Primary Types of Electricity

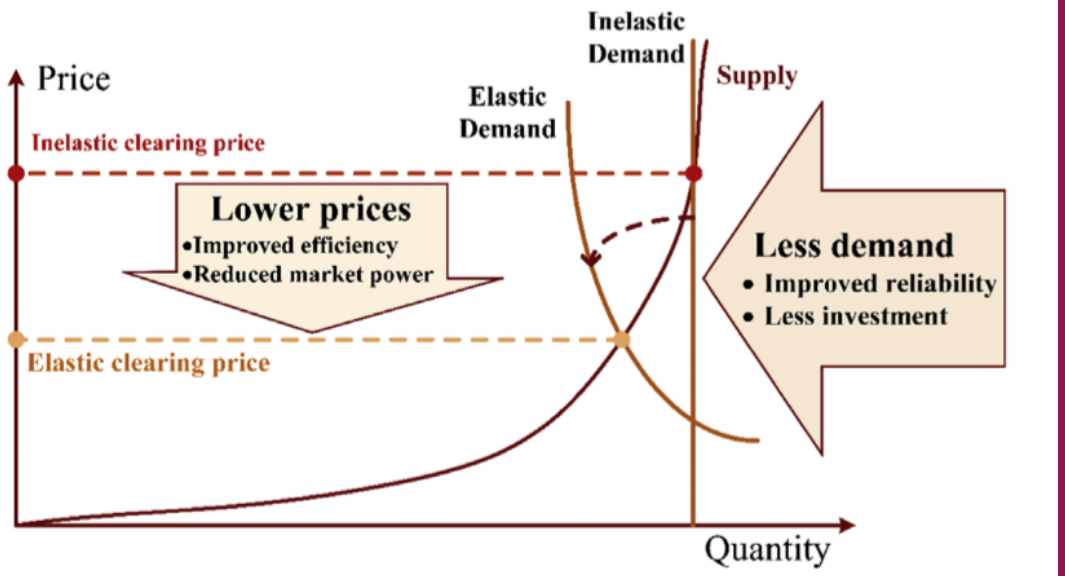
- Thermal (Fossil Fuels)
- Nuclear
- Hydropower
- Photovoltaic (Solar)
- Wind

According to the U.S. Department of Energy, in 2015, the United States generated about 4 trillion kilowatt-hours (kWh) of electricity. About 67% of the electricity generated was from fossil fuels.

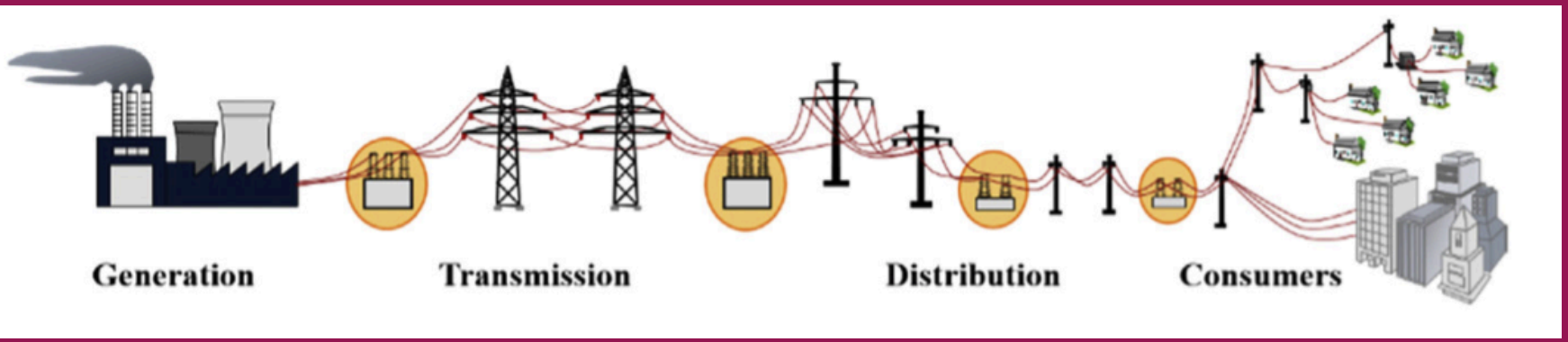


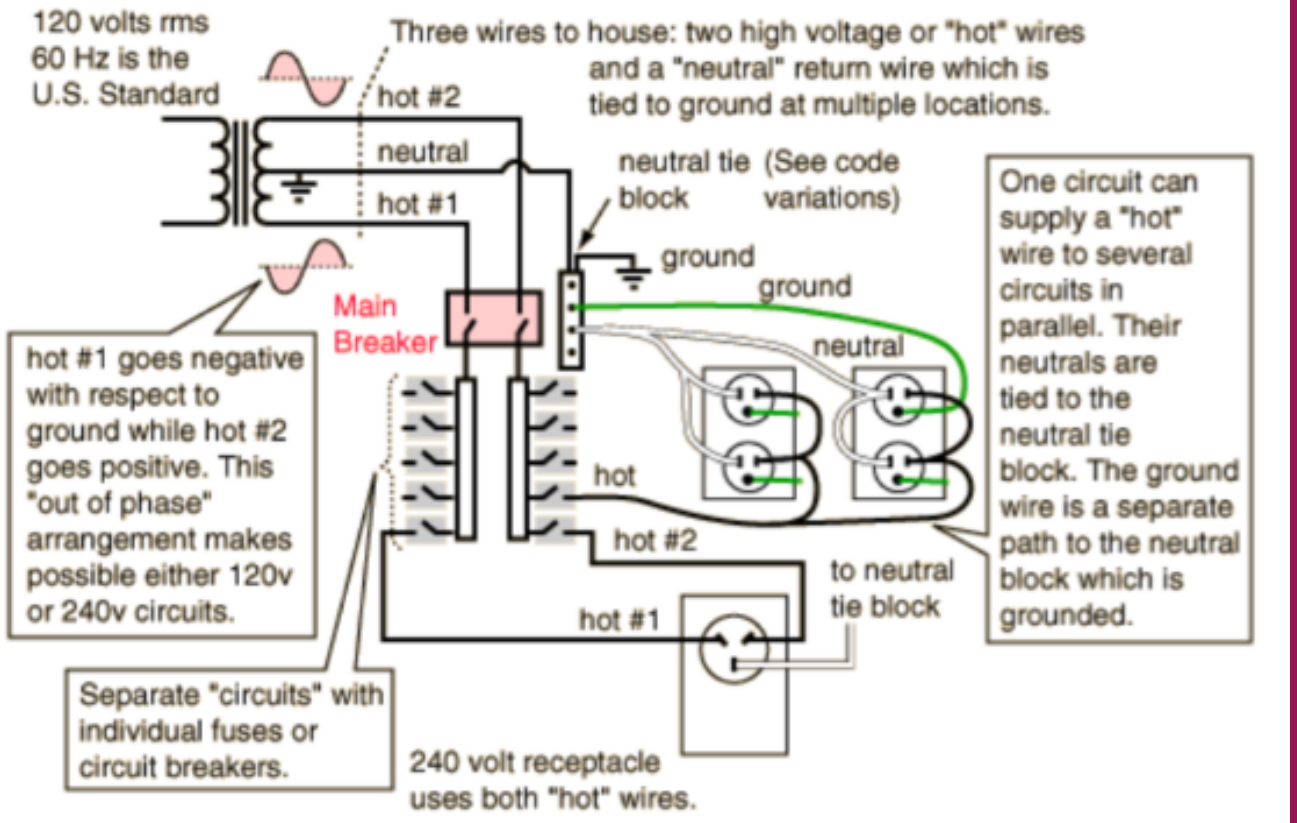
(Ellaban and Abu-Rub, 2016)


CARBON DIOXIDE'S 'INVISIBILITY'
IS WHAT CAUSES GLOBAL WARMING
1
Greenhouse gases such as carbon dioxide are **invisible** to visible light, letting sunlight pass through our atmosphere and warm the Earth.
2
However, greenhouse gases act like a blanket, trapping some of the Earth's heat as it escapes back out to space.
3
Burning fossil fuels add extra greenhouse gases to the atmosphere.
4
These extra gases trap more heat, causing global warming.
http://sks.to/invisible



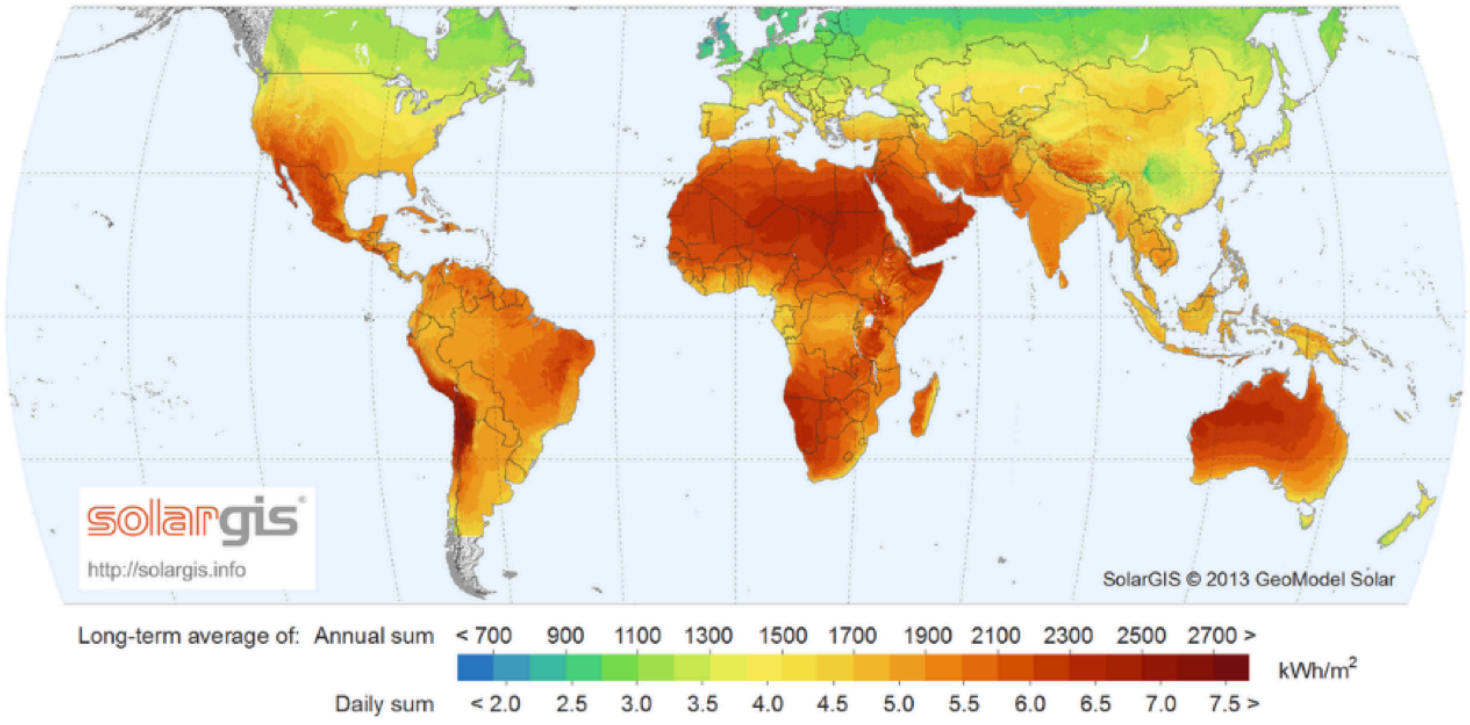
(Ellaban and Abu-Rub, 2016)

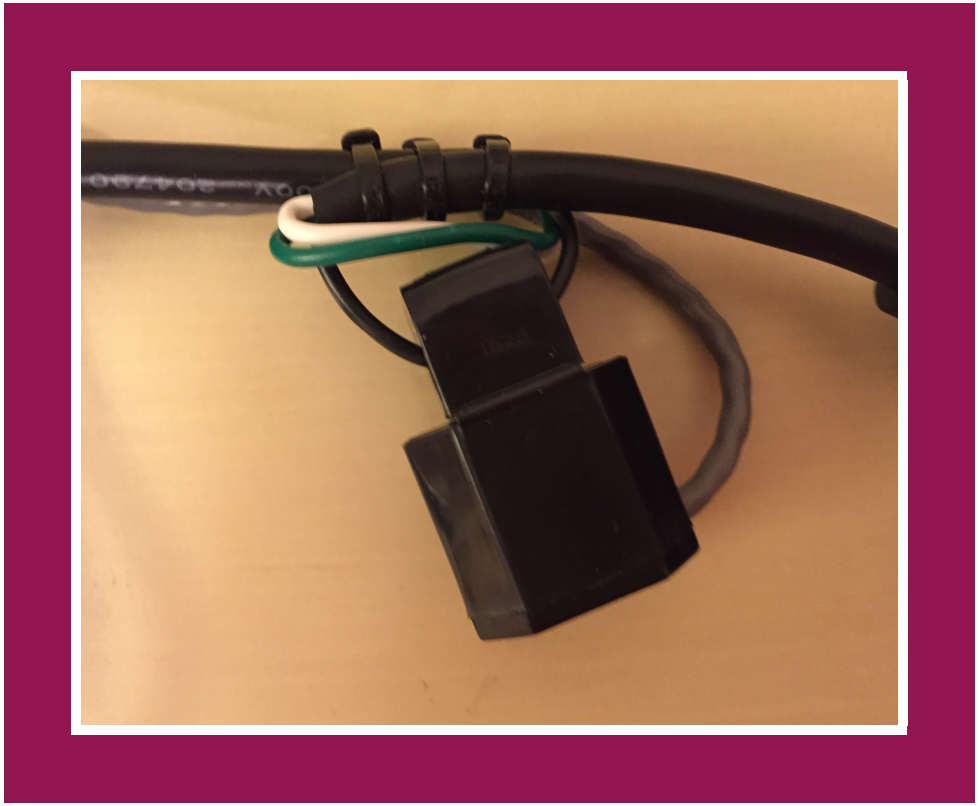




(McNally, 2010)

Potential of Sun Coverage in Developing Countries



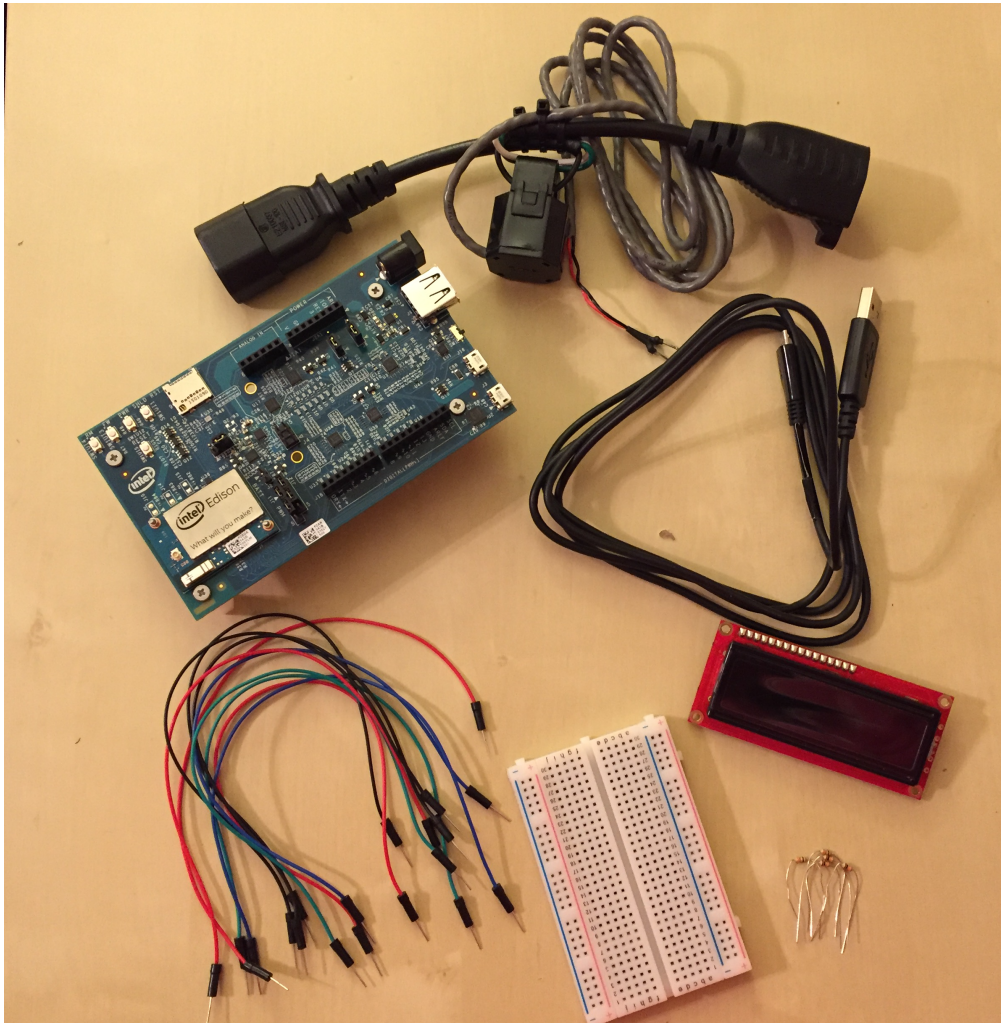


Procedure

The Intel Edison was chosen based on its capabilities of receiving and sending Wi-Fi and Bluetooth signals. It came with an Arduino breakout board that included an SD card reader, two micro-USB connections, and a USB connection. The split core current transducer is a sensor that measures current non-intrusively by attaching itself on a wire. The sensor measures only DC (Direct Current), although households are wired as AC (Alternating Current). Another wire was obtained where one end was a plug and the other was an outlet. Parts of the wire were stripped using a wire stripper to reveal a ground, positive, and neutral wire. The split core was attached over the ground wire. The wire stripper was also used to strip parts of the wire and jack to connect the split core to the Arduino breakout board. Two wires, a ground and positive, were revealed. The ground wire was put into pin GND and the positive wire was put into pin A0. The Arduino open-source software was used to read the information coming through the split core wire. A library called EmonLib was imported to help code the software. After the code was finished, it was compiled to the Intel Edison through a USB to micro-USB cable. The wire attached to the split core was plugged into an outlet at one end and connected to the appliance wire at the other. An LCD was added to conveniently display the data since the app was not developed. It read the apparent power in watts and the current in amps at a sending speed of 9600 baud. The data was compared to a commercial device called Kill-A-Watt, where the device measured the same data except from the outlet instead.

Materials

- Intel Edison and Arduino Breakout Board
- Jumper Wires
- Wire Stripper
- 330 Ω Resistor
- Breadboard
- LCD (Liquid Crystal Display)
- Split Core Current Transducer
- Compiler to run code
- USB to Micro-USB cable
- Appliances


intel
Edison
What will you make?

Data Analysis

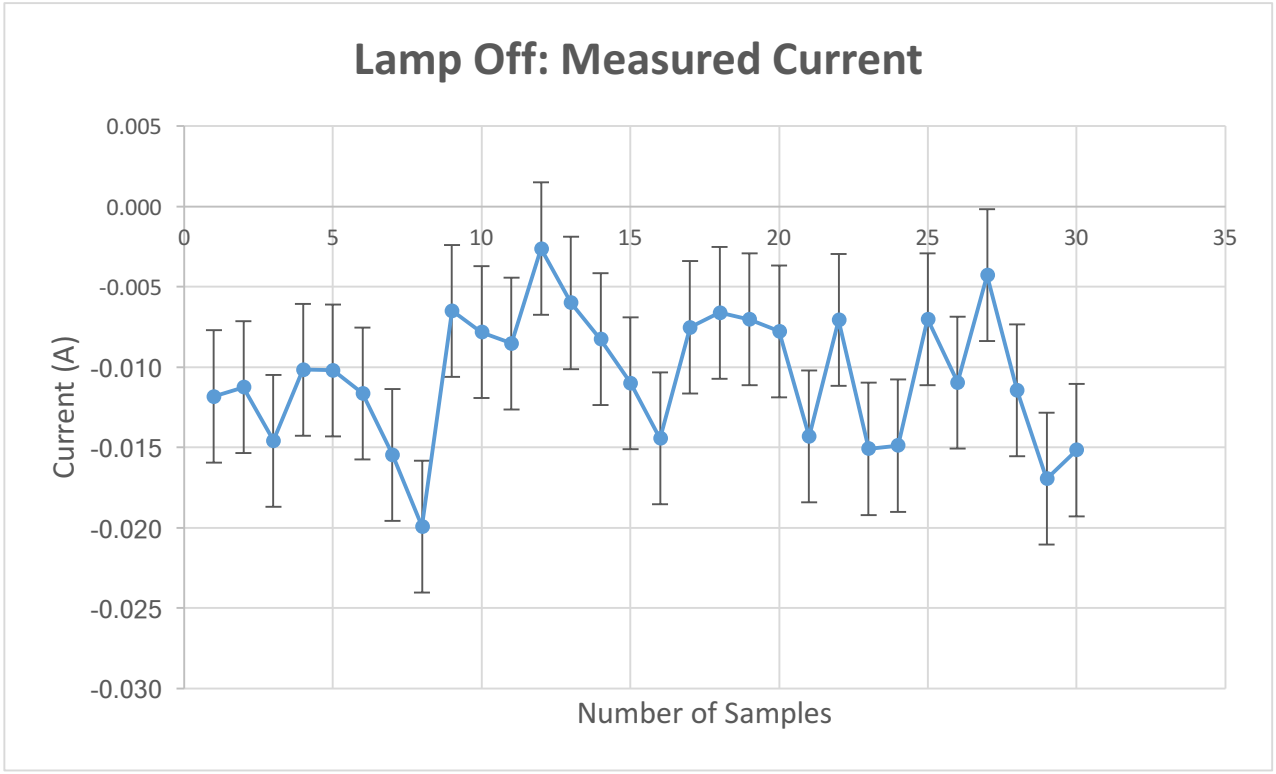
The data collected from the prototype was apparent power (W) and current (A). Because apparent power is directly proportionally to current, t-tests were only conducted on the measured samples for current. One group of 30 values was measured when the lamp was off, and another group of 30 values was measured when the lamp was on. These groups were compared to the value displayed on the Kill-A-Watt device for when the lamp was turned off and on respectively. The hypotheses were:

> H_0: There is no difference between the prototype's measured values of current and the Kill-A-Watt's value of current.
>
> H_1: There is a difference between the prototype's measured values of current and the Kill-A-Watt's value of current.

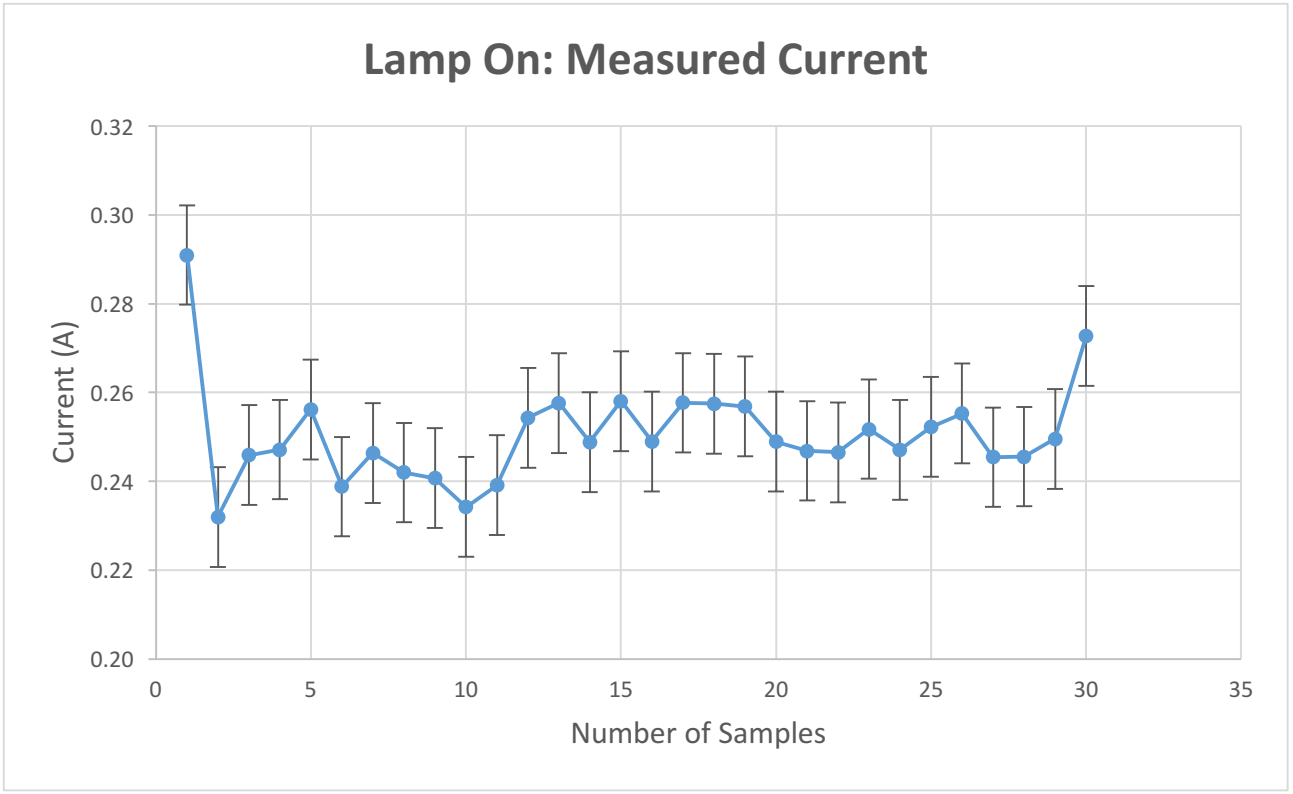
The p value of when the lamp was off came out to 0.0001, which makes the data extremely statistically significant. The Kill-A-Watt's value of current was 0.0 A and the prototype's values of current are displayed in **Graph 1**. The p value of when the lamp was off came out to 0.0001, which makes the data extremely statistically significant. The Kill-A-Watt's value of current was 0.24 A and the prototype's values of current are displayed in **Graph 2**.

It should be noted that for when the lamp is off, the Kill-A-Watt is not taking into account phantom power whereas the prototype is.

Graph 1



Graph 2


Lamp On: Measured Current
Current (A)
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0
5
10
15
20
25
30
35
Number of Samples

Future Work

The sensor does not include many features that the final prototype for February Fair will. These features help improve the current prototype's accuracy, and the added features will make reading electricity consumption of easier access to the consumer. These features include but are not limited to:

- Voltage Sensor Circuit
  - Sense slight fluctuations in voltage
- Current Sensor Circuit
  - More accurate than current prototype
- App
  - Current electricity consumption
  - Previous electricity consumption (stored since the consumer started using the app)
  - Suggestions of when to use electricity
  - How much the electricity consumption costs

Timeline

December 14 - December 25

Build Prototype 2: Improve accuracy of current readings and add a voltage sensor circuit to sense voltage fluctuations

December 26 - January 5

Test Prototype 2: Read electrical usage of appliances and compare with commerical devices

Rebuild Prototype 2 based on the data collected

January 6 - January 12

Develop app to communicate with sensor to display electrical usage

January 13 - January 24

Test app connection with sensor

Reconstruct app to collect history of the consumer

January 25 - February 14

Improve app based on the data collected above

Modify sensor to be as accurate as it can be

Design Criteria

1. High Safety (10 pts)
2. User Friendly App (10 pts)
3. Read electricity usage accurately (9 pts)
4. High data sending speed (8 pts)
5. High Availability/Accessibility (6 pts)

Enhanci

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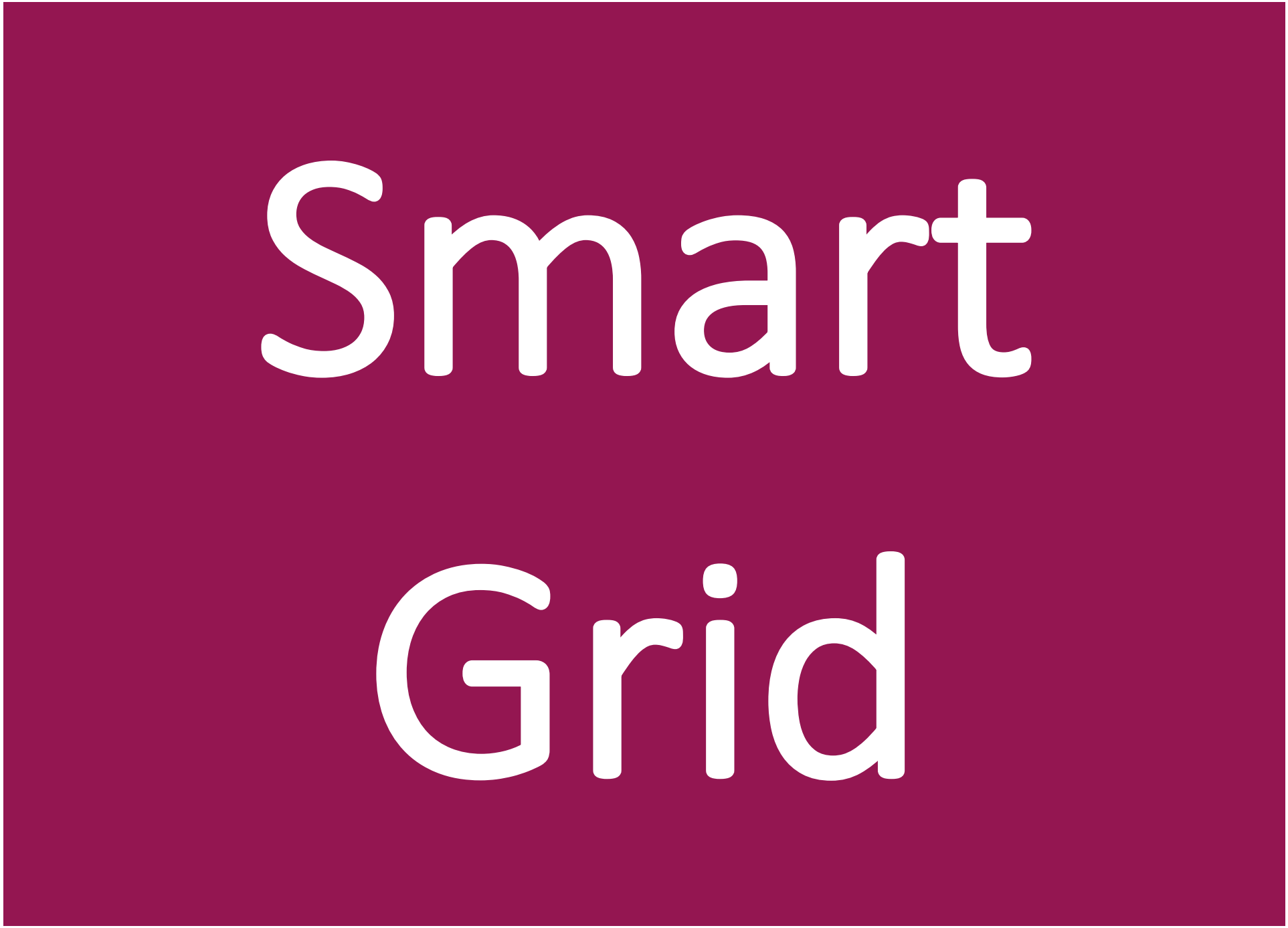
Smart
Grid

Technol

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the

Consum

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