Smart Grids, Sensors, and Neural Networks
Load Forecasting Optimization

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Introduction

- Current electric grid is outdated and cannot adapt to accurate, real-time demands
- This results in an inefficient flow of energy, causing waste and is costly for utility companies and consumers
- **Additional concerns**:

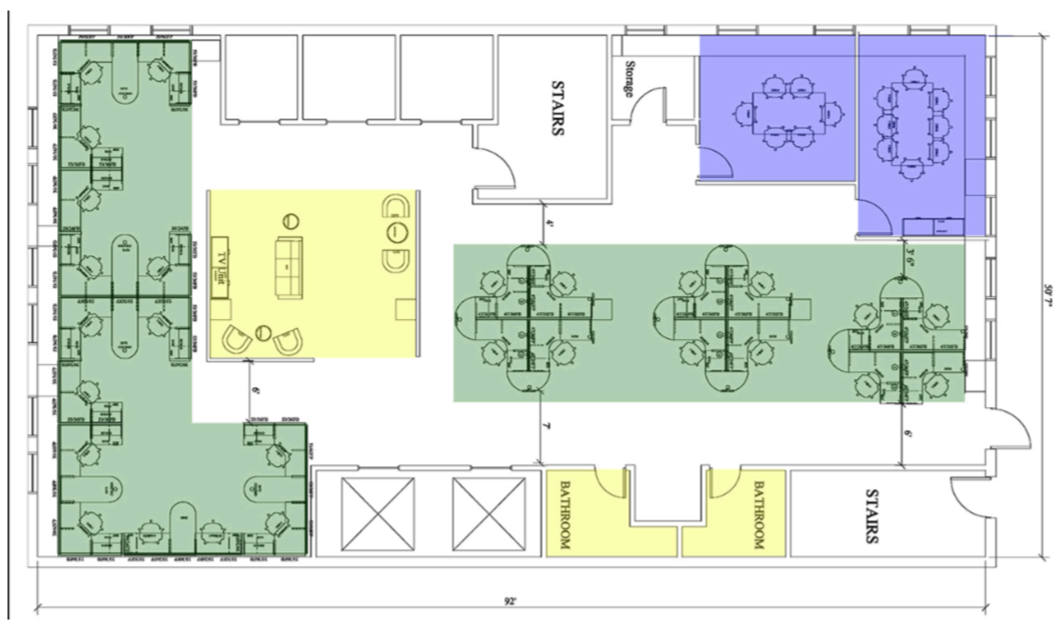
  Environmental effects | Reliance on foreign oil | Lack of consumer interaction in energy conservation efforts | Inability to incorporate natural energy sources into modern grid
- **Sensors with smart metering capabilities** generates a two-way transfer of data and energy, transmitting a more granular and current data to the smart grid to forecast and adjust supply based on projected demands
- Goal is to optimize energy demand forecasting using a Artificial Neural Network along with a back-propagation algorithm

Variables

- Real-Time lighting energy usage data from Occupancy Sensors
- The load of the previous hour
- The load of the previous day
- The load of the previous week
- The day of the week
- The hour of the day
- Work day vs. Weekend/Holiday
- Energy Prices

Model

- A template floorplan was constructed with the dimensions 120 meter by 100 meter by 3 meter and divided by room type. The ceiling to desk height of 2 meters per floor.



Violet
Conference Room

Yellow
Restroom & Breakroom

Green
Open Office Area

- Lighting requirements dictate that the area must be illuminated to 250 lux. Lighting specifications assumed are as follows:

Lux of Lamp	250 lux
Twin lamp	32 W
SHR (Space Ratio)	1.25
Maintenance Factor	0.63
Utilization Factor	0.69

- Calculating required number of lights and sensor estimate:

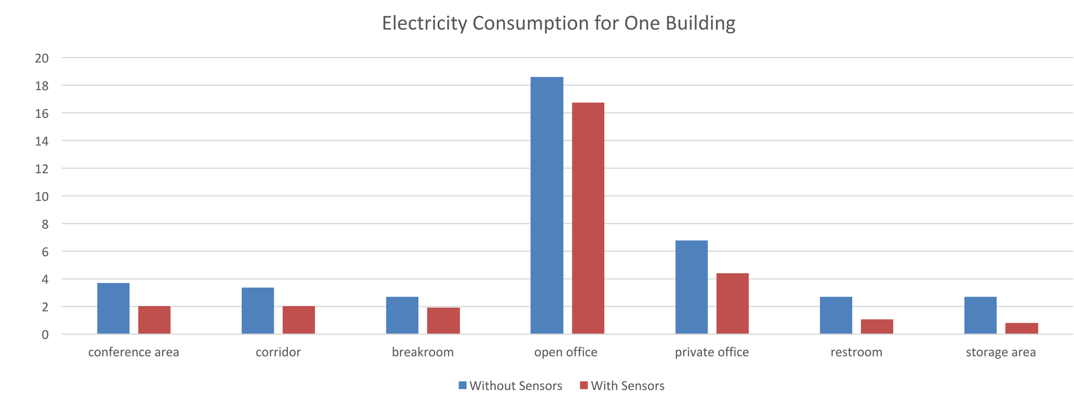
Total Wattage per Fixtures	Number of lamps * Lamp Wattage	Fixture Wattage
	2 Lamps per Fixture * 32 Watts	64
Lumen per Fixtures	Lumen Efficiency (Lumen per Watt) * Fixture Wattage	Fixture Lumens
	85 Lumen/Watt * 64 Watts	5440
Required Number of Fixtures	Required Lux * Room area / MF x UF x Lumen per fixture	Number of Fixtures
	(250 x 120 x 100) / (0.63 × 0.69 × 5440)	1268.623391
Minimum Spacing Between Fixtures	Ceiling-to-Desk Height * Space-Height Ratio	Meters Between Fixtures
	2 * 1.25	2.5
Number of Rows Required	Width of Room / Maximum Spacing	Rows Required
	100 / 2.5	40
Fixtures per Row Required	Total Fixtures / Number of Rows	Number of Fixtures
	1268.6233/40	31.71558478
Axial Spacing Between Fixtures	Length of room / Number of fixtures in each row	Axial Spacing in Meters
	120 / (31.7156)	3.7836288
Transverse Spacing Between Fixtures	Width of room / Number of fixtures in row	Transverse Spacing in Meters
	100 / (31.7156)	26.42965399
Number of Sensors Required	Number of lights / 4	Number of Sensors
		317.1558478

Savings

- Energy Consumption and Savings data for Sensor-Installed floors.

Electricity Consumption (kWh)	Total Area	Conference Area	Corridor	Breakroom	Open Office	Private Office	Restroom	Storage Area
Without Sensors	40.6	3.72	3.38	2.71	18.61	6.77	2.71	2.71
With Sensors	29.04	2.05	2.03	1.92	16.75	4.4	1.08	0.81

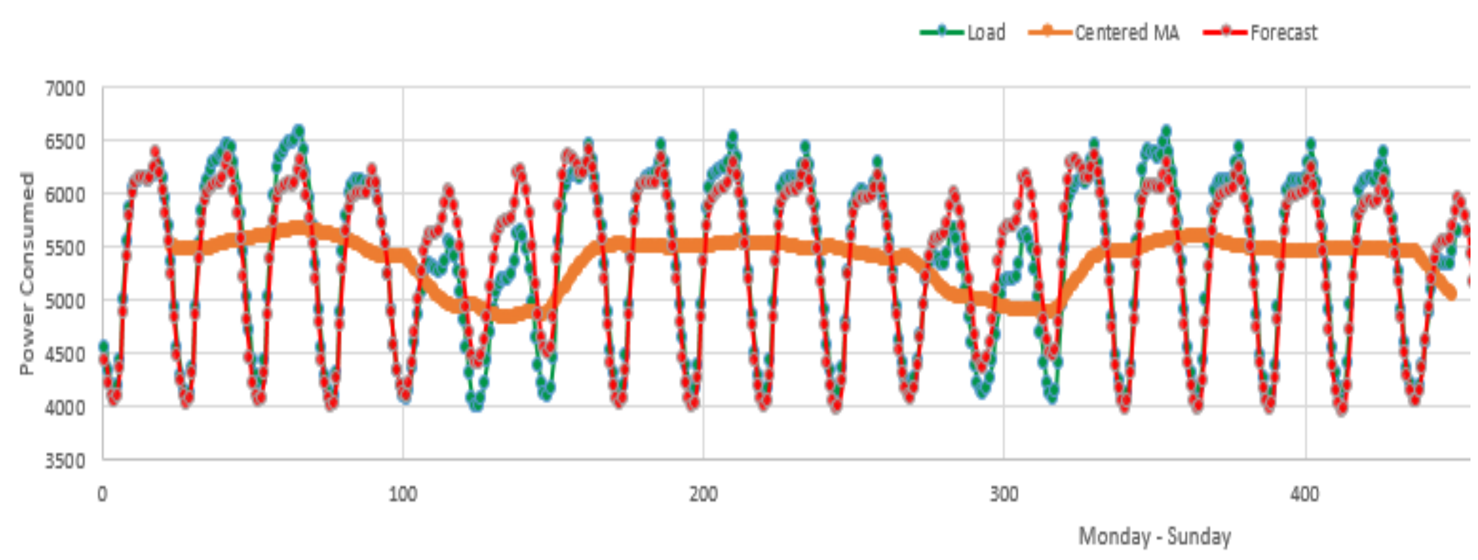
Energy Savings (Percent)	Total Area	Conference Area	Corridor	Breakroom	Open Office	Private Office	Restroom	Storage Area
Area (Sqmt)	120000	1100	1000	800	5500	2000	800	800
Savings	28.84	45	40	29	10	35	60	70



Results

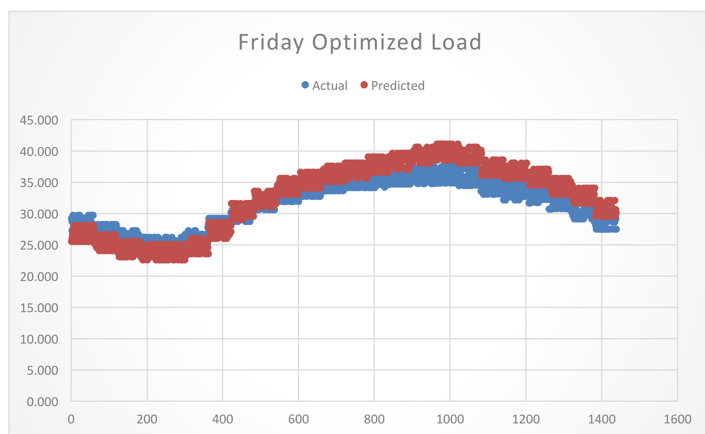
Time Series

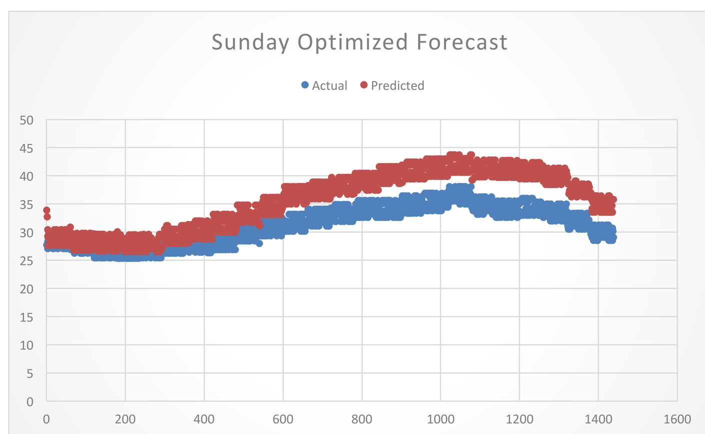
- Current forecasting techniques anticipate load demand based on historical load volumes. Because data is hourly and collected post facto, companies have a more generalized perspective on demand behavior and can only predict usage based on similar past variables.



Neural Networks

- The Artificial Neural Network (ANN) is trained on input data and associated target values. The trained ANN can then make predictions based on the relationships learned during training and provide any adjustments from the real time data.





Model Expansion

- Additional variables can be included to increase accuracy and savings:

  Weather: Temperature | Humidity | Precipitation | Light Intensity | Wind

  Consumer Type: Residential | Commercial | Industrial

  Economic Metrics: Economic Growth | Per Capita Growth | Oil Prices

  Additional Smart Sensors Technology: HVAC | Appliances | Energy Management Systems