U@

utilities at illinois institute of technology

Jennifer Guilfoyle
Timothy Baldwin
Pat Becker
Jeffrey Burke
Fatima Chippo
Alok Kashyap
Nathan Lee
Sam Martin
Juliana Masci
Ryan Murphy
Yomola Shonekan
Nizar Zhani
Prof. Joseph Clair

IPRO 326

1. Abstract

We have worked this semester developing a "Micro-Utility" model which serves the IIT community. The model provides a framework which promotes efficiency, the use of renewable resources and on-site generation while providing the funds necessary for the upkeep of campus infrastructure. To tackle this problem, we have researched public and private utilities operations, regulations and rate structures. We developed an understanding of the obstacles which must be overcome for a utility to remain financially stable while consumers reduce consumption and turn to renewable energy resources.

We allowed ourselves half of the semester to educate ourselves on nationwide and IIT utility operations, rate structures, government regulations, energy conservation and renewable resources. The team was divided into three research subgroups: Electricity, Steam and Water/Natural Gas. The extensive research provided our team with the foundation from which new solutions were based. The subgroups spent the remainder of the semester developing solutions based on large regional utilities and scaling them to a solution for the IIT community. Solutions presented by the subgroups were evaluated by the entire team and it was decided to agree on one solution. We are delivering the potential solutions developed by the subgroups as well the agreed upon 'master solution' for the IIT community.

2. Background

What is a Utility?
One of the first definitions that we had to clarify for our IPRO was utility. Although everyone has a generic knowledge of how utilities affect them, they have a specific definition that is particularly applicable to resource-supplying systems. A utility can be defined as any monopoly organization that provides a metered resource. All resource transportation has to be a utility, as it would be impractical to run multiple competing power lines, sewers, or gas pipes to all buildings in a city. Land line telephone service is also a utility. Utilities are private companies more often than they are government entities, but their status as monopolies that provide basic needs sets them apart from normal businesses. Although there is governmental regulation on all corporations in this country, utilities are very strictly regulated as to their required service levels, rates, and operational procedures. Because of the way they are regulated and operate, it is almost always more profitable for a utility to sell more of its resource rather than promote conservation. It is that aspect of utilities that we are studying.

A modern utility delivers commodities such as electricity, steam, natural gas and water to consumers. Electricity and natural gas are tradable commodities whose prices are affected by market forces rather than government regulation. Because both water and natural gas are use to generate steam its price also market driven. Water is typically sourced locally and not subject to market forces; therefore, its commodity price is bundled with a water utility's delivery rate.

Our team has researched utilities and the obstacles they must overcome to remain financially viable. Of primary concern is the need to maintain or replace aging and overburdened infrastructures without reducing service levels. A regulated utility must have its rate approved by a public utilities commission in what is known as a rate case. When approving a rate, the utilities commission must take into account the projected operating expenses of the utility based on historical data and projected growth, the cost efficiency of the utility and reasonable profit margins. Because the rate is based on historical usage, reduced consumption and on-site generation can threaten a utility's ability to remain financially viable as their profits are tied to energy consumption. In short, a utility's revenue is dependent on usage and a decrease in consumption results in reduced revenue.

Because efficiency is beneficial to both the utility and consumer, a new model is needed to encourage the efficient use of energy and the integration of renewable energy sources. For consumers, efficiency stabilizes energy demand. The price of energy, which is dependent upon the laws of supply and demand, will in turn stabilize. When our energy use is more efficient, the total cost of energy which includes the commodity price and the transmission costs will be weighted more towards the transmission cost. This will open the door for on-site generation and renewable energy use which will become more cost effective options. For utilities, efficiency extends the life of their infrastructure because they can serve more consumers with the same at the same capacity.

IIT has on-site generation of steam and electricity and owns its utility infrastructure. Therefore, it has the opportunity to implement a new utility model which promotes efficiency, on-site generation and the use of renewable resources while providing excellent reliability. This "Micro-Utility" will provide electricity, steam, natural gas and water to the IIT community.

We divided our team into 3 sub-teams to research the commodities our "Micro-Utility" will provide to IIT. Our research included utility structure, rate structures and efficiency methods. Our findings for the three groups; steam, electricity, water and natural gas are detailed in the following section.

Electricity Utilities

Existing Service

The current physical electric network is set up to work with very centralized turbine power production. The regulation and rate systems also encourage this system. In addition, although the electric utility has never promoted consumption, the rate model is set up so that the utility will go into debt if there is any dip in power usage.

Production

Electricity production in the United States is dominated by coal power. More than half of the power used in the US is produced at coal power plants. The remainder is made up mostly of other, slightly cleaner fossil fuels, including natural gas and oil. A small percentage is made up of hydroelectric power and nuclear power. In Illinois specifically the ratio is about half coal and half nuclear. This reinforces the dominance of centralized generating stations on the American power system. All nuclear and hydroelectric power plants generate at least 3 MW of electricity, and any turbine based power plant gains efficiency the larger and hotter it gets. This poses a challenge for those pushing the introduction of small, decentralized groups of solar panels and wind turbines.

Transmission

Power is currently distributed in a national grid tailored to large, centralized power plants. These consist of fossil-fuel plants, nuclear plants, and hydroelectric plants. Most renewable energy, however, may be better suited to a decentralized system. Solar panels and wind farms have the advantage of not having to pay for fuel, but unlike power plants, they take of vast amounts of land. This might be better used in small clusters near consumers, rather than in single locations far from the city.

Because of this reliance upon centralized power plants, the transmission system is set up for long-range movement of power. Feeder lines are stretched across the country, from power plants to cities, and electricity may be bought from hundreds of miles away. This requires Alternating Current and high voltages on power lines.

Usage

Electricity is the majority of the energy used in all non industrial buildings. Approximately 70% of all energy used in residential and commercial buildings is electricity, used for heating, cooling, lighting, and plug-in loads. Much of this energy is wasted, both by misuse and inefficiency. Lights left on in rooms fall into the category of misused electricity, while improperly sealed buildings can only be air-conditioned inefficiently. Cutting these out while retaining the level of usage is essential.

Regulation

This country is in the process of deregulating and decoupling its utilities, especially electric utilities, which will be described later. However, generally, electric utilities are monopolistic corporations that both generate and transmit electricity. Utilities are allowed to make a profit, as they are usually private companies, but, because of their monopolistic nature, governments step in to ensure that prices do not rise to far above costs. Utilities charge by the kilowatt-hour, and the government sets the rates that they charge. This has created a fairly efficient and fair system for delivering power, but it also encourages utilities to produce and sell more power. With prices set per kWh, the only way of recovering investments and profiting is to sell more.

New ideas for power

In order to reduce power usage, many different systems and products have been introduced. These can help to reduce waste and increase reliability at the production, transmission, or end use. However, these have been adopted slowly, largely because electricity remains relatively inexpensive in the US, while these products often have large up-front purchase and development costs. Also, the current economic model for electricity generation has generally cast utilities as barriers to efficiency in any usage, as their profit is based on continued usage. Therefore, in order to reduce usage, new products and systems must be used in tandem with regulations and incentives that will actually encourage efficiency.

Products and Systems

Production

Many products have been introduced that give utilities more information and control over their plants. There has also been a continuous series of improvements to plant efficiency. SCADA (Supervisory Control and Data Acquisition) systems allow utilities to digitally control mechanisms throughout their grids to avert failure. Combined with this, utilities can provide proprietary appliances to consumers that can be partially controlled by the utility. Some districts have offered discounts to users who connect air conditioners that can be remotely turned off during power peaks.

Technology such as combined cycle gas generators and steam recovery systems are starting to help power plants produce more electricity out of the same amount of raw materials. Also, technologies to store power are starting to come onto the market. Battery systems may soon be able to help utilities deal with daily spikes in electricity demand. Ice blocks have also been used for decades to lower peak demand while providing air conditioning to local buildings. Lastly, cogeneration is being developed as a way to use waste steam to heat buildings in the winter, potentially reducing the overall energy load.

Transmission

IIT is currently researching and implementing a series of transmission retrofits known as the Perfect Power system. This system is advocating smaller electricity grids that will have far greater control over their operation than the current nationwide grid system. With small grids, SCADA systems can be efficiently implemented, giving systems operators detailed knowledge of electricity use, possibly even down to the room level. With that could come the control to turn off unnecessary lights, detect disproportionately large users, and tailor the system to the smallest possible power usage. Smaller grids could also allow for easier implementation of renewable resources. With more monitoring and control systems, there would no longer be any problem with accepting power generated from decentralized sources such as solar panels and small wind turbines.

There is also some argument for DC (Direct Current) power systems. Appliances have always run on alternating current, but all electronics must run on DC, requiring a transformation that wastes a lot of power. Also, although power is generally generated in AC, and can only be transmitted for long distances using AC, users are starting to install solar panels and other renewable sources, which generally create DC power. With a small DC power grid, waste, in the form of alternators and rectifiers, would be cut out.

End Use

End users can reduce their power usage through high efficiency products, control systems, sealed building construction, or green, decentralized power generation. Probably the most important new product that has come out recently is the compact fluorescent light bulb. This, and other products like it, has the potential to drastically lower the energy usage of buildings if properly implemented.

Control systems will help people monitor and control their energy usage without having to be focused on it constantly. Utilities across the country are starting to install digital power meters that can feed information to an interior panel. This will be able to tell a building manager how much power is being used by what appliances at what times. It will also be able to shut off power to an appliance or schedule power as needed.

Energy consumption can be drastically lowered in the summer by designing buildings that can either take advantage of natural cooling or that are insulated well enough to require only small amounts of air conditioning. Buildings have been designed without the aid of AC for hundreds of years; only in the last fifty years have sealed, air conditioned buildings become popular. There are also ways of sealing and insulating buildings easily available to those willing to make the investment. These are starting to be required in new construction, however, it is very costly to add insulation into an existing building.

Lastly, methods for consumers to generate their own electricity are starting to become common. Utilities are often resistant to pay for power from consumers, but often solar panels and wind turbines only can reduce a buildings load. These have been improving at a rapid pace, and especially small scale wind power is becoming more practical.

Operation Practices

Deregulation

During the 1990's, there was a movement to introduce free-market competition to the electricity industry. Although the transmission system will always continue to be a highly regulated monopoly, power production is now competitive among many companies in several states. In Chicago, the power utility, Commonwealth Edison, split into a transmission company, ComEd, and a production company, Exelon. After a couple of unsuccessful starts, especially in California, deregulation has reduced power prices in almost all markets where it has been introduced.

Decoupling

Decoupling directly addresses the problem that utilities require maintained usage to remain profitable. This system of regulation cuts the link between revenue and kWhs sold. Instead of requiring utilities to charge a set rate for electricity, the state allows the utility to charge more per kWh if usage goes down. The overarching idea is that the utility would invest money to improve their customer's electricity efficiency, and would therefore both reduce power usage and continue to profit. When implemented successfully, with lowered power usage, the consumer's bill can either stay consistent or be reduced, while the utility can continue to make the same or a slightly higher profit, while the total electricity consumption drops.

Carbon Taxes and Trading

There have been recent efforts to limit the emissions of carbon dioxide emitted, which, in a field dominated by fossil fuels, would directly affect energy production. The more conventional scheme has been to tax carbon emissions. However, the scheme gaining more traction has been carbon trading. In this, carbon emissions are capped at a certain level, and industries that need to emit more CO_2 than their set level can buy credits from companies that produce less carbon. The main effect would ideally be less reliance on fossil fuels, but another effect would be higher net efficiency in all electricity use.

Existing IIT service

Production/Supply

IIT currently buys its power from Constellation Energy for an average of 6 to 7 cents per kWh. Our peak usage is during the summer, at 11MW. We use a total of 56,000 MWhs of electricity per year. IIT has a cogeneration plant on its campus, but the generating equipment installed is not efficient enough to make its power competitive with power from the free market. Our plant has the capacity to produce power for approximately 10.5 cents per kWh. Only during peak summer hours does the spot market power rate go above that number.

Transmission

Three feeders from the ComEd grid connect to the IIT campus – one to the north substation next to Herman Hall, and two to the substation located inside the cogeneration plant. There is some redundancy in the west (academic) side of campus, but there are frequently blackouts, particularly on the east (residential) side of campus.

End Use

IIT has analog meters at all of the buildings that it supplies. However, it does not have any system in place that can determine the time of usage or the individual users. Individual buildings can be evaluated as to whether they are more or less efficient than the average building, but it is relatively difficult to pinpoint the exact location of energy being wasted within the buildings. IIT charges the departments that use buildings for their energy usage at a rate of around 10.5 cents per kWh.

IIT improvements

Geothermal

IIT installed a geothermal heating system at Keating hall and disconnected it from the steam system. This does not currently provide electricity, but similar projects could include renewable power generation.

Building improvements (Wishnick Hall)

One of the first buildings to be renovated in a schedule of building renovations at IIT, Wishnick Hall was outfitted with new double-pane windows and had its large open circulation spaces sealed up. Although energy savings were not the reason for the renovation, the decision to add the expense for better windows and insulation cut the heating and cooling loads by more than half. As IIT continues to renovate its 1960's building stock, it will likely continue to push for energy efficient materials.

Perfect Power System

IIT and the Galvin Power Initiative have been researching and implementing the Perfect Power system in IIT's electrical engineering building, Siegel Hall. This will give managers more data and control over where electricity is used in the building, and will help make the building slightly more efficient and far more reliable. This is seen as a test run; if it is feasible and economical, the system of redundancy and advanced controls will be extended throughout campus.

Steam Utilities

Basics of District Heating and Cooling

District heating is a system that is commonly used to heat and cool large areas. Many large office buildings and complexes as well as many college campus's utilize district steam for all their heating and cooling needs. A district heating plant employs a boiler system that uses natural gas as a fuel to heat water that then forms steam. The steam is then transferred to buildings and subsequent spaces through a series of insulated pipes. The steam travels through the pipes by pressurization forces. The steam heats the pipes in a building that then heats the air to a desired temperature. As the steam cools it turns back into a water state referred to as condensate. This condensate is then piped back to the central boiler where it is heated and returned to a steam state.

District heating and cooling systems are also commonly used as cogeneration plants. This refers to the idea that the heat created by the boiler and steam can also be used to create electricity by turning turbines. This is a very efficient use of stream heat. Inefficiencies still exist in this system however. As the steam is transferred through the pipes heat energy is lost and dissipated.

Cogeneration on the IIT Campus

The IIT campus consists of a large cogeneration plant that is located on the southern end of the campus near 35th street. The cogeneration plant employs two new high efficiency Johnston boilers which are capable of producing steam at 85% efficiency. The old boilers that were replaced were only capable of reaching 75% efficiency. The steam is transported through an insulated underground pipe system that also acts as return route for the condensate.

The piping system has issues where it intersects with the city streets. Where these two systems meet a ninety degree elbow is needed to send the pipes under the streets. This bend causes the steam to get trapped and loses much of its speed and heat energy. Thus by the time the steam reaches the buildings on the opposite side of the street there is a great loss in heat energy. The pipe system also has long runs that by the time the steam reaches the northern end of the campus from the southern end a large amount of heat energy is lost before it reaches the buildings.

These inefficiencies in the system have caused the university to implement a 3 phase plan that calls for the creation of 3 new boiler systems to be built on different parts of the campus. This will reduce the length the steam must travel in the pipes resulting in smaller heat losses. The campus also has installed a new geothermal system to use the heat of the earth to heat water before sending it to a boiler.

Billing and Rates on Campus

Currently the IIT campus meters the usage of steam by a buildings monthly consumption. The buildings tenants then pay the university out of their budget. The rate is based on the fixed cost of maintenance and personnel along with the variable cost of water and natural gas. The university currently creates steam at the cost of $25 per 1KLBS. This billing method is based on the economic theory of supply and demand.

Water and Natural Gas Utilities

Water Utility

A typical water system consists of the following components: water sources, water treatment, water distribution system, customer use, and wastewater transport and treatment. Extraction and treatment of water from its source and water distribution are not typically decoupled as is the case with gas and electric utilities. A typical water utility pumps water from its source, treats the water and delivers the water to the customer through its water distribution network. The sewer network and wastewater treatment can be part of the water utility but are often split into separate entities.

Water utilities can be either public or private enterprises. Public municipally owned water utilities serve 85% of the market while privately owned utilities serve the other 15%. Both must supply water that meets EPA standards for safe drinking water. Municipal water utilities are typically owned and operated under the supervision of the town's elected officials and set their own rates. Private water utilities must have their rates approved by a public utilities commission. For a rate increase, the private utility must submit a "water rate case" to the public utilities commission. The rate can be challenged by the commission and customers at public hearings. The utility must demonstrate that it is being run efficiently, its capital improvements are justified and that its proposed rate is appropriate.

Water Utility Infrastructure

The sources of water treated and distributed by the water utility typically come from lakes, streams or wells. Some water utilities are using desalinization plants to treat sea water. Rain water can also be captured, stored and treated for use as a water source. The source water is pumped to a water treatment plant where it is treated to meet safe drinking water standards. The water then enters the water distribution network consisting of a grid of pipes, pumps to maintain water pressure and storage tanks which can supply water during shortages and high usage periods. The water utility ends at the customer's service connection.

Where a sewer system exists, a wastewater utility handles the transport of wastewater to a wastewater treatment plant. The sewer system will often include pumping stations to lift the wastewater and to maintain flow to the plant. The effluent from the wastewater treatment plant re-enters the ecosystem helping to restore the water source. The wastewater utility must also meet strict EPA standards for the treated effluent water.

Water Utility Rate Structure

Water utilities generate revenue by billing their customers in accordance with a rate structure. Additional funds may come in the form of government subsidies to be used for infrastructure improvement. The revenue generated from customer billing and government subsidies is used to cover all of the costs incurred by the utility. These costs include the electricity needed to power their facilities and run pumps, chemicals for water treatment, debt incurred to fund capital improvements, personnel, maintenance and insurance. A well designed rate structure will generate stable and predictable revenue that allows a utility to cover its costs while at the same time promotes the efficient use of water.

Utilities are scrambling to replace a deteriorating and overburdened infrastructure which may not have the capacity to serve a growing population or meet EPA Clean Drinking Water Standards. The replacement of existing infrastructure is very costly and time consuming. Additionally parts of the country are experiencing water shortages as the sources of water are becoming scarce while the population is growing. Therefore, it is in the best interest of both the utility and the customer to use water in a more efficient manner in order to prolong the life of the existing infrastructure and to avoid the need for water rationing.

According to the EPA, the most common rate structures are:

- **Flat Fee** – Customers pay a set rate regardless of how much water they use. This is the simplest rate plan as it does not require metering. However, it does nothing to promote conservation. The EPA recommends this structure for utilities serving a small number of customers with similar usage and when the cost of metering is not justified.

- **Uniform Rate** – Water service is metered and customers are billed for the amount of water used. This rate will often be used along with a flat fee which covers basic connection costs. The uniform rate is easy to implement and is recommended for utilities whose customers have similar usage patterns. By billing the amount of water used, this rate encourages conservation, as lower usage means lower bills.

- **Increasing Block Rate** – Water service is metered and customers are billed increasing rates for increasing blocks of water use. For example, the customer may be billed $7/unit for 0 -10 units and $10/unit for 10 - 20 units. A flat rate will often be used along with this rate to cover basic connection costs. The rate encourages conservation as water becomes increasingly more expensive for the biggest users of water. The EPA recommends this rate for utilities with limited water sources or high water treatment costs.

- **Decreasing Block Rate** – Similar to the Increasing Block Rate, except that the rate starts high for the first block and decreases for higher blocks of usage. The EPA states that this rate would be beneficial for large customers; however it does not promote conservation and may result in revenue shortfalls as a result of higher than forecast water use.

- **Seasonal Rates** – Water service is metered and customers are billed at a variable rate which is greatest during peak usage periods. This structure can be used along with Increasing Block Rates. The EPA suggests using this rate structure if peak usage is much greater than off peak usage which requires an increased capacity. This billing method encourages conservation.

- **Single Tariff Rates** – When a water utility is comprised of several smaller utilities with different operating costs the utility may set different rates for each utility. However, in order to keep rates relatively stable and to keep water more affordable for at the smaller utilities, the utility may charge the same rate for all small utilities. The EPA suggests that this method is less efficient and does not pass the full cost of water delivery to all customers. However, this method helps to reduce any "rate shock" which might occur when a larger utility acquires a smaller utility.

If a rate structure is overly reliant on water usage, a reduction in usage will result in lower revenues. While more efficient water use is good for the utility in the long term, the revenue reduction makes it difficult for the utility to meet its costs and to pay for infrastructure improvements. This situation will result in more frequent rate increases and unstable revenue projections. Rate structures must carefully balance the expected revenue generated from a flat connection fee and the water usage rate.

Water Efficiency Promotion

There are a number of ways for water utilities to promote water conservation and efficiency.

- Rate structure which reflects the full cost of water distribution
- Customer education and rebates for water efficient appliances and devices
- Restrictions and Rationing

Rate Structure

The City of Chicago has begun a program to meter water use at residences and charge the customer for actual water usage rather than charging a flat fee based on size and type. The program guarantees the customer that their water bill will not be greater than their current unmetered rate for 7 years. However, few customers have taken advantage of this program to date.

The flat fee rate actually encourages the customer to use more water because their bill is the same no matter how much water they use. Flat fee pricing is unfair to water efficient customers as they pay the same fee as a customer who is wasteful. The flat fee also discourages the use of water efficient devices because the higher investment cost will not result in rate savings. By charging the customer the full price of water, the financial incentive is created for efficient use.

Rebates and Education

The San Diego County Water Authority has been investigating customer education and rebate programs for smart weather based irrigation controllers. The Weather based controllers can provide more efficient water use by using real time weather data, plant watering requirements and sprinkler system output. However, the controllers must be properly installed and calibrate to realize any water savings.

The first program tried was to provide a $65 voucher for the purchase of a smart controller by customers with at least 2000 square feet of landscaped area. This program had very limited marketing and was not successful. Only 13 vouchers were redeemed.

The Agency next provided free controllers in exchange for the customer's old controller and the customer attending a 1 hour training class. A total of 950 controllers were distributed for which the agency performed a follow-up inspection of 434 installations. The agency found that only 51% were properly installed and configured and that some of the customers actually experienced an increase in water use.

The agency is now promoting a $350 dollar rebate for the purchase of the smart controllers and is placing a greater emphasis on the inspection of customer installed controllers. However, they are having problems with controller availability at 'big box' stores and the lack of resources for home inspections.

Restrictions and Rationing

The City of Chicago limits lawn watering to weekends, and during the morning and evening hours during the week (5 to 8 am and 7 to 10 pm). This restriction reduces water loss due to evaporation and eases the burden on the water system during peak hours. However, this restriction is difficult to enforce without real time usage monitoring.

Southwestern states are facing exploding populations and decreased water availability due to drought conditions. This has forced states such as California to impose mandatory water rationing on its residential, industrial and agricultural customers. The Contra Costa Water District has banned hosing down driveways and is discussing tripling the rate for customers who use more than 1000 gallons a day. South Bay City, CA has restricted lawn irrigation and bars restaurants from serving water unless it is requested. The Central Valley of California has cut farmers off from the federal water supply and has restricted their supply of state water to 20% of normal levels. The result of the drought and necessary restrictions will cost the state billions in tax revenue and drive many small farmers out of business.

The City of San Francisco has begun promoting rainwater harvesting and grey water use to avoid having to impose mandatory rationing on its constituents.

Water Efficiency Practices

The most common water efficiency practices include the installation of water efficient fixtures and making the use of renewable water sources such as rain water and grey water.

Rain Water Harvesting

Rain water can be used as an alternative water source. Rain water is typically collected on the rooftop, where it is diverted from the down spouts through a filtration system to remove rooftop debris into a storage cistern. The water can then be distributed from the cistern with pumps for non-potable applications such as lawn sprinkler systems.

Grey Water

Grey water is the waste water generated from washing hands, bathing or laundry. Grey water can be used for non-sprinkler irrigation systems or for flushing toilets. In Chicago both City and State approval are required for grey water installations; however, there are no formal grey water regulations for the City of Chicago or State of Illinois.

Water Efficient Fixtures

Several states have moved to require High Efficiency fixtures for restrooms and have placed limits on flow rates for commercial washing machines and pre-rinse spray valves. The California standards for high efficiency fixtures are:

- Toilets that use less than 1.3 gallons per flush
- Urinals that use less than 1 gallon per flush
- Waterless Urinals
- Washers which use 35% to 50% less water than standard washers
- Pre-rinse spray valves used in restaurant dish washing which have flow rates less than 1.6 gallons per minute.
- Showerheads with flow rates less than 2.5 gallons per minute.
- Sink faucets which use less than 2.2 gallons per minute.

According to the US EPA, the average home can save 30,000 gallons of water and $170 a year by replacing water fixtures with high efficiency fixtures.

Present IIT Water System

The City of Chicago Water Department supplies water to each building at IIT. The City meters and bills each building based on a uniform rate structure. IIT is responsible for the water infrastructure within the buildings and for the campus's landscaping system. IIT has installed sub-meters to monitor landscape water usage and has moved to weather based sprinkler controllers.

Natural Gas Utilities

As its name implies, natural gas is a natural resource found beneath the earth's surface in cavities of porous rock. It is a very efficient energy source, because unlike electricity, it retains most of its potential energy between its extraction point and its point of use.

Natural gas is a tradable commodity which is traded on the open market. The commodity price is decoupled from the transportation charge. In many states, the customer can choose their natural gas supplier. Natural gas Utilities or Local Distribution Companies (LDCs) can be either public or privately owned. The distribution of natural gas makes up the majority of the cost charged to the customer according to the Energy Information Agency.

Natural Gas demand is cyclical in nature due to its seasonal usage pattern and it use in electricity generation. Natural gas is heavily used in residential and commercial heating and therefore demand spikes in the winter months. Because of the greater reliance on natural gas in electrical generation, higher electricity demand in summer months cue to the use of air conditioning systems is causing a spike during the summer months as well.

Natural gas commodity pricing is also prone to the laws of supply and demand. If prices for natural gas exceed the threshold at which natural gas electricity generation is cheaper than coal generation, power plants may switch to coal generation. This leaves greater supply than demand, bringing the price of natural gas down.

The health of the US economy also plays a role in natural gas pricing. Recessions and periods of growth can cause great fluctuations in the price of natural gas.

Because of the fluctuations in the supply and demand of natural gas, Natural gas utilities must carefully structure their distribution rates to account for this.

Natural Gas Utility Infrastructure

Natural gas is pumped from underground reservoirs through interstate pipelines which are owned and operated by pipeline companies. There are storage reservoirs within the network which can be used to meet peak demand. Natural gas is delivered to the utilities at City Gate Stations where it is distributed through its local network. The City Gate Station is also a marketing center where prices are determined.

Natural gas is distributed through a network of low pressure small diameter pipes. At the city gate, natural gas is typically scrubbed and filtered. Mercaptan, which gives the commodity its rotten egg smell, is added to aid in leak detection. Because of the expense associated with installing a local natural gas distribution system, LDCs are awarded local distribution rights and treated as regulated natural monopolies. State public utility commissions provide oversight in ensuring that the LDC provides reliable and efficient natural gas distribution.

Natural Gas Efficiency

The use of natural gas can be made more efficient through the use of High Efficiency (HE) Appliances and the use of building techniques and technologies to reduce the heating load of buildings.

Energy Performance Contracting

Energy Performance Contracts (EPCs) are part of the US Environmental Protection Agency's (USEPA) Energy Star program. An Energy Service Company (ESCO) implements water and energy efficiency projects while guaranteeing that the savings due to lower demand will be adequate to pay for the capital investment. The contractor assists the customer with obtaining long term financing for the project, backed by the contractor guaranteed energy and water cost savings. The contract typically consists of an Energy/Water audit, followed by a design-build efficiency project. The savings are verified through the use of 'International Performance Monitoring and Verification Protocols' (IPMVP). These protocols establish the methodology for measuring savings for complex systems which require high precision monitoring.

ESCOs are typically subsidiaries of building and control manufacturers although independent ESCOs do exist. ESCOs are typically conservative in their approach due to the fact that they are guaranteeing energy savings. For this reason, EPCs are not typically used to implement new or unproven technologies. Because the ESCO assumes the risks involved in what are large capital investment efficiency projects, an EPC is an excellent tool for upgrading a facility's infrastructure to more efficient systems.

The University of Massachusetts Amherst has completed a $43 million dollar Energy Performance Contract funded by its projected utility savings over 10 years. Meters have been installed to establish baseline usage and to perform post project metering to ensure the contractor meets the agreed upon 28% energy reduction. To date their reductions from 2004 baseline energy and water usage are:

- Steam – 24% reduction
- Electricity – 9% reduction
- Water – 36% reduction

Because of the reductions in steam and electricity usage, UMASS Amherst will also realize a reduction in greenhouse gas emissions.

3. Objectives

Main Purpose and Goal

Our purpose is to develop an operational utility model including pricing, utility integration and consumer involvement that will encourage efficiency and promote sustainability. To do this we must be willing to consider alternatives to the current centralized utility models, distribution systems and regulatory structures.

The utility must promote sustainability

Somehow, the utility must be set up in such a way as to make it profitable or worthwhile for some entity to reduce the amount of energy being produced or used. There are three groups who can be given the incentive to lower usage: consumers, utilities, and intermediaries. If the consumer is charged exorbitantly or given incentives based on the level of power usage, they could change their usage patterns. Similarly, utilities can be taxed or offered incentives to reduce their power generation. Lastly, the utility and consumer can be disconnected from each other, and an intermediary with a vested interest in sustainability can be employed to deliver resources to the consumer.

The utility must be able to finance its operations

We must remember that we cannot allow the utility to go bankrupt. We can transfer the incentives to reduce energy usage to the consumer or a third party, but the utility must still make enough money to continue to run. We can make it unprofitable for the utility to continue providing the same excessive amount of resources that it does today, but in our final model, the utility must remain financially viable. Running a utility into debt would probably reduce energy usage, but it would also drastically reduce the quality of life.

The service level to the consumer must not be lowered

There are three ways that utility usage can be lowered: we can produce energy from more sustainable resources, we can cut actual used energy, or we can cut waste. Ethically, we do not want to reduce the resources being used effectively and efficiently; we want to instead maximize the sustainable resources while minimizing the waste. Therefore, we believe that the current level of service must be maintained. IIT needs to have well lit and well heated rooms for classes. This is something that cannot be cut. However, the light and heat can be generated sustainably, and the waste of heating and lighting a room when it is not in use can be recovered.

The utility model must be specific to IIT

We do not have the time or expertise to tackle all of the energy problems of the United States. Our utility is specific to IIT, and must be designed around IIT's circumstances. We are a small campus in the city, not a nationwide power grid. Also, although IIT is a consumer of power, it can also act as a utility in providing service and billing individual buildings for their resources. This utility system will be based largely on research done on situations with very different circumstances. The system that we generate must fit IIT's needs and problems.

We are creating a utility model

We are not studying all of the buildings on campus to determine whether they are inefficient. We are also not creating a plan to implement energy or resource saving devices. That is not our goal. The buildings at IIT have been inefficient for decades, and products to retrofit these building have existed almost as long. So far, however, it has not been profitable or worthwhile for anyone in control to make changes. That is what we are addressing. We are creating an operational model for a utility that will provide an opportunity for some party to benefit from using resources more efficiently.

Research

Our IPRO largely revolved around research. The main way that we will start to understand our goal is through researching how utilities work right now and what has stopped them from promoting efficiency. Then we can look into how IIT's utilities operate specifically.

Operation of the current utility system

Most of the students in this IPRO have little to no experience with utilities, let alone how they are managed. Although the current utility system may set a bad example of how to promote sustainability, this is the only place we can start. We have to understand what the basic definition of a utility is, and the market forces operating on them. Utilities sell metered resources, and are generally monopolies, but have historically been heavily regulated by state governments in order to ensure that service is reliable and affordable. These definitions are starting to be bent in current operation, and our team needed to know about current developments in utility operational models.

Factors preventing sustainability in the current utility system

One important thing to recognize is that it does not encourage moderating usage. The system was set up decades ago, in the general model of supply and demand. The only difference was that utilities are usually not allowed to set their own rates. Therefore, the only way that a utility running in the classic rate-based model could raise money was by selling more of its resource. If a utility faces even a relatively small drop in demand, it can easily go into the red. Under the current system, there is an incentive to continue raising production of resources.

Sustainable measures that have been implemented around the world

Over the past twenty years, many products that can either generate resources renewably or that can reduce waste have come into the market. In our subgroups, we must learn what standards of efficiency can be achieved by using these new systems. More importantly, we need to research what utility pricing and operation practices have been tried elsewhere, and see how effective they have been.

IIT's existing utility system

Through our IPRO professor Joseph Clair, we can get all of the data we need on IIT's existing system. Using the figures of IIT's current usage patterns with the research on new sustainable products, we can come up with a rough estimate of how much energy and money IIT could save on its campus. IIT has already done some upgrades, such as a geothermal heating plant and a series of building retrofits, and we can judge the success of these programs.

Creation and Documentation

We have to use our research to come up with a new utility model for IIT. This research has to be synthesized, scaled down, and adapted to IIT's campus. Following this, we need to report our findings to Joseph Clair at the IIT Office of Sustainability, the customer of our research and thought.

Creating new ideas

First, we need to use our knowledge of utility systems and IIT's unique problems to come up with an individualized solution for our campus. The solutions can be scaled-down versions of new national utility practices, or can be totally unrelated to solutions being developed in the rest of the world. We can also utilize business practices that have not traditionally been associated with utilities.

Testing new ideas

Our ideas will have no credibility or basis for judgment until there are some statistics that can illustrate the potential energy and monetary savings provided. Through our research on IIT's current utility system, we can set a baseline. From our research into renewable production and sustainable products, we can set an achievable goal for usage. Past that, we need to determine how much each scheme will cost IIT per unit of the resource saved, and how much money that investment will save in the long run. We can then choose either one scheme to present, or a combination of elements from multiple ideas.

Documenting
Our results are going to be presented and used by the IIT Office of Sustainability at the end of the semester. We are presenting it to Joseph Clair in the form of a report. In this report, we have to clarify the costs and benefits of our final proposed solution.

4. Methodology

Energy utility companies have operated largely as monopolies, with some government oversight, in the past century. Society greatly valued the access to energy and strong infrastructure afforded by this model. However, in recent years, governments have started deregulating utilities due to the demands of people; they wanted the regulation-determined cost of power to be replaced by prices determined by market forces. The companies are still monopolistic but respond to a combination of regulatory prices and market forces. The infrastructure and transmission have largely remained unchanged. The current utility model is to be tested against new models that will be determined through research throughout the project. The model to be compared against was the current IIT self-generated electricity and steam utilities. Then, the best model was presented. This model when implemented will ideally allow for a better hold on energy costs while encouraging efficiency and investment in renewable resources and providing reliable infrastructure.

To create a solution to the problem, the team members were divided into three sub-teams. One sub-team was responsible for finding a solution specific to the steam utility; one for the water utility as well as natural gas; and one for the electric utility. Each sub-team worked parallel to each other.

First, each sub-team gathered knowledge in order to understand the state of the current utility model, and to get an idea of the range of possible solutions. This has been done by touring utility plants, interviewing experts in the field, calculating the benefits and costs of the current model, studying the current infrastructure, and researching market forces and government regulations related to the utility.

Next, research was conducted to find potential solutions. New technologies and methods for handling the resources have been identified and documented. The costs associated with updating and maintaining infrastructure has been calculated as well.

After all the research and calculations were complete, the best solution was determined by comparing the costs, benefits, and feasibility of the potential solutions. Barriers and obstacles to efficiency, market forces, and regulations were all taken into account.

In order to meet all the IPRO deliverable deadlines, the team members were again divided into deliverable sub-teams: Ethics, Reports, Presentation, and Exhibits. For deliverables involving more work, such as the reports, the same team members were once again divided into sub-teams to efficiently accomplish all the necessary tasks. All work was then be compiled and reviewed by the entire group prior to submission. In addition, a person was assigned the role of Team Leader, while another person was assigned the role of Secretary, which involved taking minutes and doing other administrative work.

The evenly distributed workload among the group and subgroups allowed the team to be able to accomplish all the required tasks in a timely manner.

The potential solutions have been tested and discussed through analysis simulations, group discussions on the pros and cons of each as well as thought modeling processes. Taken into account were the costs, benefits, barriers, market forces, and regulation, the short-term and long-term effects of the new model.

The research has been documented by each member of the team keeping a record of websites, books, and articles that they have read and found useful for the project. This list was then uploaded to the Google groups website, and finally placed as an appendix in this report. The testing has been documented by writing down all potential solutions as well as the expected results obtained from the thought modeling simulation.

The results of the tests and analysis of the new model have been compared side-by-side to the state of the current utility model. The incentives of the new model will be clearly documented.

Gantt Chart located in Appendix A

5. Team Structure and Assignments

- **Utility Sub Groups**
  - Electric
    - **Ryan Murphy**- Leader
    - Alok Kashyap
    - Fatima Chippo
    - Nizar Zhani
  - Gas/Water
    - **Juliana Masci** – Leader
    - Pat Becker
    - Tim Baldwin
  - Steam Team II
    - **Sam Martin** – Leader
    - Jeffrey Burke
    - Nathan Lee
    - Yomola Shonekan
- **Deliverables Sub Groups**
  - Reports
    - Pat Becker (Gas/Water rep)
    - Jeffrey Burke (Steam Team rep)
    - Ryan Murphy (Electricity rep)
  - Presentation
    - Nathan Lee (Steam Team rep)
    - Timothy Baldwin (Gas/Water rep)
    - Alok Kashyap (Electricity rep)
  - Ethics
    - Sam Martin
  - Exhibit
    - Juliana Masci (Gas/Water rep)
    - Fatima Chippo (Electricity rep)
    - Yomola Shonekan (Steam Team rep)
- **Meeting Roles**
  - Minute Taker
    - Juliana Masci
  - Agenda Maker
    - Jennifer Guilfoyle
  - Time Keeper
    - Jennifer Guilfoyle
- **Status Roles**
  - Timesheet Collector Administrator
    - Jennifer Guilfoyle/ GoogleGroups
  - Master Schedule Maker
    - Juliana Masci/ GoogleGroups
  - GoogleGroups Administrator
    - Juliana Masci

6. Budget

As part of the team building process the entire group gathered for a meeting that included 3 pizzas. Our guest speakers were able to come in but the meetings did not require food and refreshments as was proposed in the initial project plan

- $16 price of a large pizza (national Average) 3 pizza's per guest speaker= $48
- $3.99 price of 100 count paper plates (CVS Price), donated to group

Our project also required a great deal of research. Thus it was important for printouts to be made and dispersed to the group of all relevant research and information. This was imperative to ensure the project shared information and was continually on the same page. The estimated printing cost is $20.00.

7. Code of Ethics

We will examine the ethics of our problem/solution along with the ethical dynamics of our own team. Ethical considerations are important because people often become so focused on a solution or getting a task done that they forget to look at the big picture.

The main ethical dilemmas that come into play when considering our solution is where do we draw the lines for what is best for the common person versus the community. If we subscribe to the belief of John Stuart Mill's Utilitarianism, we could determine what is best for all parties involved. Using a system of hedonic calculus, putting arbitrary numbers on something that cannot necessarily be measured (happiness, natural environment, etc…), we can assign values to the different phenomena inherit to our problem. It would be convenient to continue to allow all Americans the opportunity to purchase inexpensive energy even though it may be environmentally damaging. It is much harder to force people to change, which can lead to economic suffering, for an ideal that does not necessarily have short term results. Where is the line between corporate and personal responsibility? A real ethical dilemma this team will encounter will be how to make a populace become responsible while still ensuring that the utility is acting in a responsible fashion.

Ethical considerations within the team are thankfully less daunting. Whenever working in groups a problem of some members committing more to the team than others is an issue. Our team has worked to solve this by splitting the problem into several manageable sub-sections. Sub-team leaders communicating back to the group leader helps to ensure all personnel remain on task. Another issue within the team is the problem of direct and indirect communication: sometimes group members can be left in the dark when much of the communication must be electronic due to the physical separation of the majority of the commuter students. The team has worked on this by ensuring that communication flows neatly up and down from the lowest possible level to the highest.

8. Results

Steam Utility Solution

The plan calls for the creation of a new billing system that allows customers to buy a certain amount of steam for each month. The steam company will suggest to the customer how much they should purchase at the beginning of each month. Along with this recommended amount the company will suggest the options of buying more or buying less steam. To promote efficiency the three amounts suggested will have differing price ranges. For example the recommended amount will be the base line charged per unit of steam, the larger amount of steam will have a higher cost per unit of steam while the lower amount will have a lower charge per unit of steam. If a customer uses more steam then they purchase in a given month they are charged a Luxury Tax.

The suggested purchase of steam amounts will be based on historic usage figures. The amount will also take into account other factors such as heating degree days, occupancy type as well as square foot space of a building. During the winter months a buffer zone will be added to the recommended amount for abnormally cold conditions.

The rate will be based on past usage figures, the cost of natural gas and water as well as the fixed rates that are included in the creation and transportation of steam. The rate will be set to ensure the economic feasibility of the utility company.

Pros

- Customer has knowledge of what exactly they are paying for each month
- Customer has the choice of what they want to pay each month.
- Utility company gets a rough estimate on the amount of steam that will need to be created each month.

Cons

- May under produce steam and possibly lose money during an unusually cold month that requires more steam use.

Concept of this model

Old system based on old supply and demand economics which promotes consumption. (Pay less when there is great supply and low demand, Pay more when there is low supply and high demand.)This model works when a product is wanted by consumers and not necessarily needed.

Our system based on the idea that paying less for fewer products and more for more products will increase customer efficiency. This model works when a product is not just wanted by a customer but needed.

Supporting Numbers

Currently the campus uses 57,473 BTU/SF per year, while the efficiency goal is 13,600 BTU/SF per year (per Efficient Building Standards). Need to cut 43,873 BTU/SF per year in steam use to reach efficiency mark. Actual steam use varies greatly from building to building.

Example: Current model rates based on $25 per 1Klbs used.
New Model offers three choices each month
$30 per 1Klbs – High range
$25 per 1Klbs – Recommended range
$20 per 1Klbs – Low range
$40 per 1Klbs – Overage charge

Water and Natural Gas Utility Solution

The Water and Natural Gas subgroup proposed that an IIT Water and Gas Efficiency Utility be created whose purpose is to provide reliable, fairly priced and efficient water and gas services to the IIT community. The City of Chicago provides metered water and sewer service to each campus building, while Peoples Gas provides Natural Gas metered service. IIT is responsible for the interior plumbing and piping, wastewater and landscaping sprinkler systems. IIT does not distribute water or gas between campus buildings. The bulk of the true cost of the commodities is covered by the City of Chicago and People's rate; therefore we will not be treating our utility like a traditional utility who traditionally delivers a metered commodity from a seller to the customer. Instead, our utility will focus on providing water and gas efficiency solutions as well as providing the 'last mile' of distribution.

The utility will have its own maintenance staff. One advantage of the maintenance staff working under the utility is better communication of potential problems. Another advantage is that the Utility can ensure that the maintenance staff has adequate training and education regarding the new efficient systems. If this is not politically possible, the maintenance staff will use codes to identify work performed on behalf of the utility and bill the utility for its services.

The utility will be responsible for all parts of IIT's water and gas infrastructure, including faucets, toilets and sprinkler systems as well as high efficiency natural gas appliances. The Utility will reduce water and natural gas use. As a result, the campus will reduce costs by using sustainable water sources when possible and upgrading to efficient fixtures.

The utility will either implement efficiency solutions on its own or by employing Energy Performance Contracting (EPC). We recommend the use of an Energy Performance Contract. An Energy Performance Contract allows the University to finance the high up front costs incurred from the installation of high efficiency appliances against energy and water savings over time. The EPC guarantees the University water savings. If the water savings specified in the contract are not realized, the contractor is obligated to pay for the excess usage.

The City of Chicago Water Department has substantially increased rates since 2004. The combined water and sewer rate has gone from $17.68 in 2004 to a projected $27.90 in 2010. We have projected IIT's 2004 water usage (not including steam) to 2013 as either remaining the same or increasing an average of 1% each year. The yearly water costs increase from $336,426/year to $530,965/year in the present usage remains unchanged. If water usage increases 1%/yr from 2004 to 2013, the yearly costs jumps from $336,426/yr to $ $574,959/yr.

Maintain Present Usage for 10 years

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1000 cuft Water	19031	19031	19031	19031	19031	19031	19031	19031	19031	19031
Water Rate	$9.66	$9.95	$9.95	$9.95	$11.44	$13.16	$15.00	$15.00	$15.00	$15.00
Sewer Rate	83%	83%	83%	83%	84%	85%	86%	86%	86%	86%
Water Bill	$336,426	$346,526	$346,526	$346,526	$400,595	$463,329	$530,965	$530,965	$530,965	$530,965

10 year Water Cost $4,363,787

Usage increases 1%/yr

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1000 cuft Water	19031	19221	19414	19608	19804	20002	20202	20404	20608	20814
Water Rate	$9.66	$9.95	$9.95	$9.95	$11.44	$13.16	$15.00	$15.00	$15.00	$15.00
Sewer Rate	83%	83%	83%	83%	84%	85%	86%	86%	86%	86%
Water Bill	$336,426	$349,991	$353,491	$357,026	$416,861	$486,963	$563,630	$569,266	$574,959	$580,708

10 year Water Cost $4,589,322

To illustrate how water efficiency projects can yield tremendous cost savings and lead to cost stability, we considered three scenarios.

1. Through minor infrastructure improvements and campus awareness projects, IIT is able to decrease water usage an average of 1% a year for the next 10 years.
2. By implementing efficiency methods over the next 10 years and reducing usage by 5% each year for a total of 37% over 10 years.
3. Implementing an energy performance contract with 10% usage reductions for the first 3 years and financing the project cost against the projected 10 year savings.

CASE 1: Usage Decreases 1%/yr

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1000 cuft Water	19031	18841	18652	18466	18281	18098	17917	17738	17561	17385
Water Rate	$9.66	$9.95	$9.95	$9.95	$11.44	$13.16	$15.00	$15.00	$15.00	$15.00
Sewer Rate	83%	83%	83%	83%	84%	85%	86%	86%	86%	86%
Water Bill	$336,426	$343,061	$339,630	$336,234	$384,810	$440,621	$499,893	$494,894	$489,945	$485,046
Savings 0%	$0	$3,465	$6,896	$10,292	$15,785	$22,708	$31,072	$36,071	$41,020	$45,919
Savings 1%	$0	$6,931	$13,861	$20,792	$32,051	$46,342	$63,737	$74,372	$85,014	$95,663

10 year Water Cost	**$4,150,559**
10 year Savings vs. Present Usage	**$213,228**
10 year Savings vs. 1%/yr Increase	**$438,763**
Total Usage Reduction	**9%**

CASE 2: Usage Decreases 5%/yr

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1000 cuft Water	19031	18079	17175	16317	15501	14726	13990	13290	12626	11994
Water Rate	$9.66	$9.95	$9.95	$9.95	$11.44	$13.16	$15.00	$15.00	$15.00	$15.00
Sewer Rate	83%	83%	83%	83%	84%	85%	86%	86%	86%	86%
Water Bill	$336,426	$329,200	$312,740	$297,103	$326,287	$358,515	$390,308	$370,793	$352,253	$334,640
Savings 0%	$0	$17,326	$33,786	$49,423	$74,308	$104,814	$140,657	$160,172	$178,712	$196,325
Savings 1%	$0	$20,792	$40,751	$59,923	$90,574	$128,448	$173,322	$198,474	$222,706	$246,068

10 year Water Cost	**$3,408,264**
10 year Savings vs. Present Usage	**$955,523**
10 year Savings vs. 1%/yr Increase	**$1,181,058**
Total Usage Reduction	**37%**

CASE 3: Usage Decreases 10% 1st 3 yrs

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1000 cuft Water	19031	17128	15225	13322	13322	13322	13322	13322	13322	13322
Water Rate	$9.66	$9.95	$9.95	$9.95	$11.44	$13.16	$15.00	$15.00	$15.00	$15.00
Sewer Rate	83%	83%	83%	83%	84%	85%	86%	86%	86%	86%
Water Bill	$336,426	$311,873	$277,221	$242,568	$280,416	$324,330	$371,675	$371,675	$371,675	$371,675
Savings 0%	$0	$34,653	$69,305	$103,958	$120,178	$138,999	$159,289	$159,289	$159,289	$159,289
Savings 1%	$0	$38,118	$76,270	$114,458	$136,444	$162,633	$191,955	$197,591	$203,283	$209,033

10 year Water Cost	**$3,259,537**
10 year Savings vs. Present Usage	**$1,104,251**
10 year Savings vs. 1%/yr Increase	**$1,329,785**
Total Usage Reduction	**30%**

For *Case 1*, where usage is reduced 1% a year for 10 years, IIT will save $41,000 a year compared to maintaining 2004 usage levels billed at the 2013 rate. The 10 year savings amount to $213,000. Compared to the case where usage increases 1% a year, IIT will save $96,000 a year by 2013 with total savings of $438,000.

For *Case 2*, where efficiency methods are implemented to reduce usage an average of 5% a year for 10 years, IIT will save $196,000 a year compared to maintaining 2004 usage levels billed at the 2013 rate. The total 10 year savings amount to $956,000.

For *Case 3*, where a Energy Performance Contract is employed and usage is reduced by 10% for the first 3 years of the project. Usage has dropped by 30% by 2007 and the yearly savings at year 10 are $159,000. Because of the early usage reductions, the 10 year savings are $1,104,000. When compared to the scenario where usage increases 1% a year for 10 years, IITs yearly savings are $159,00 by year 10 and the total savings are $1,330,000.

While we can show the financial advantages of water and gas efficiency, dedicating the funds necessary for the project can be problematic for an educational institution. That is the advantage of an Energy Performance Contract. The Energy Performance Contractor helps the institution obtain financing backed by the projected savings. In our Case 3 example, we have projected a 10 year savings of $1.1 million if present usage is maintained. These savings can be used to back financing and spread the capital costs over 10 years while yielding the immediate benefits. Additionally, the University can apply for government grants to help fund the project.

Rate Structure

The utility rate structure will be based on billing the customer for the full cost of water service. The operational costs will be decoupled from the City of Chicago's commodity cost. The rate structure will be composed of an operational flat fee; the City of Chicago metered usage fee and a maintenance rate.

IIT Operational Fee – A flat fee based composed of prorated campus wide costs and customer specific costs.

- Campus wide costs will be prorated based on the historical usage of the customer.
  - Administration and maintenance salaries, wages and benefits
  - Insurance, legal, engineering and other professional services
  - Administrative costs such as billing, telephone, computer
  - Debt service of campus wide projects

- Costs which can be attributed to individual customers will be directly billed to that customer.
  - Debt service for customer specific projects
  - Asset depreciation

Water and Gas Provider Fee – Calculated from metered use. Where more than one customer uses water or gas measured by the same meter, a submeter will be installed. The customer will be billed the Provider's rate based on the sub metered usage.

IIT Uniform Maintenance Rate – To cover maintenance costs, a percentage of the City of Chicago Rate will be charged to cover anticipated maintenance costs. A yearly maintenance cost will be projected based on historical costs. Past years will be examined to determine the ratio of maintenance to usage. For instance if for a typical year the campus paid $400000 for water and spent $10000 on maintenance and repair costs, the rate will be 2.5% of the City of Chicago fee.

This solution offers greater rate stability for the customer by reducing water/gas usage and provides revenue stability to the utility by decoupling operational cost recovery from the usage rate.

Electric Utility Solutions

In order to create an organization that will do anything, it must have both incentive and control. There is no shortage of energy-saving devices on the market today, but there has not been large implementation of them. The reason is that few groups that have the desire to change the status quo have any authority to do so, and even fewer groups that have control over the situation have any need to change. Any solution that attempts to fix this problem has to give incentive to organizations with control, authority to organizations with incentive, or both to a new organization. Our solutions are looking at ways to create incentives for reduction where they do not currently exist, as well as assigning control to the groups that will benefit from the incentives.

One of the hardest parts of reducing demands for resources, including electricity, is putting a value on reduction. There is an easy way of calculating the value of use, specifically the amount of profit that can be made off of each kilowatt-hour. However, reduction is not that simple. There can always be a monetary value placed on reduction, but it is not always purely based on the kilowatt-hour. In some cases, power reduction can be seen in marketing terms, as a form of advertising a new and forward-looking campus. Sometimes the value of energy reduction is in avoiding exorbitant fees for usage, as was the case during the gasoline price spike in 2008. In almost all cases, however, the final value of an energy-reduction strategy is based on the amount of time it will take to repay its investment. Although any energy reduction will theoretically pay for itself in the long run, an investment that pays for itself within two years of reduced energy is worth far more to an institution than one that takes ten years to pay off. Once it starts to take twenty years to pay off an investment, the value of reducing power usage comes into question.

Total Electrical Contracting

One of the main reasons that IIT has not invested in power and energy reduction is that although the amount IIT pays for energy is in the millions of dollars; it is a drop in the bucket of IIT's budget. If the potential for profit inherent in energy reduction were to be separated and assigned to a different organization, there would be a much higher chance of improvements being made. This model gives responsibility for IIT's electricity system to an independent contractor. The contractor can be paid a flat rate for electricity service rather than based on a number of kilowatt-hours provided, giving them all profit for any energy savings.

Along with the right to charge a rate for electricity service rather than kilowatt-hours, the contractor would also have to receive the right to replace or fix any device that uses electricity on IIT's campus. The contractor would be able to enter any room and install occupancy sensors, compact fluorescent light bulbs, and other energy savers. However, the responsibility that comes with this right is that the contractor must sustain the same level of service that all rooms on the campus received before the contract. For example, the contractor would have the right to isolate and turn off air conditioning to any room that was not being used, but once that room is used, it must have the same level of AC that it had before. The contractor would be allowed to profit off of reducing waste and inefficiency, but not by reducing actual user service levels. These would have to be precisely determined before the contract by IIT.

Before IIT hires anyone to lower its energy usage, it must first find a baseline usage that it wants to achieve. Energy reductions that could reduce IIT's power consumption to 75% of its present value would be fairly easy to implement, while reducing energy consumption to 25% of its present value would be obviously more desirable, but far harder to achieve. With enough investment in the next decade or so, it is feasible that net power consumption levels could be reduced to zero, using photovoltaic and geothermal generation systems. In order to set the value of its contract with any outside company, IIT must know its required baseline usage.

Once the baseline consumption is known, IIT has to compare that to the current usage, and find a way to put a monetary value on that reduction. This can be figured primarily by the length of the contract. The investment made in reduction can be evaluated by the amount of time it will take for energy savings to pay back the investment. Therefore, simple changes needed to cut the school's usage by 25% may be cheap enough to be paid back in 3 years; while the more in-depth investments required reduce the university's usage by 75% might take 15 years.

From there, it is necessary to determine how the contract will be paid. For the three-year return, 25% reduction, the contract could be set so that the contractor was paid the initial amount of energy usage for three years, plus some amount for profit. However, the same contract could be structured so that the contractor could be paid the initial amount for electricity the first year, then a rate that decreased by 16.7% every year for the next six years. This would return the same amount of money. This system would be beneficial, as it would show the same profit for the contractor, while realizing monetary savings for IIT by the end of the first year. The only trade-off is that the contract must last for twice the original duration.

In order to bid for this contract, IIT would work through the Request for Proposal process. IIT would advertise its intention to let someone else take over its power system for a period of time, and mention the diminishing payment structure. The desired baseline power consumption would be the determining factor, and electrical services companies would bid based on the amount of time it would take them to repay their investment and return the campus power service to IIT, with the required reduced power consumption.

Performance Contracting
The Energy Performance Contract solution described in the Water and Gas Utility section was also an option considered for the Electric Utility. This model for power reduction uses largely the same economics as the total electricity contract, but leaves both the control of the IIT power system in IIT's hands. In this case, IIT would still solicit ideas for energy reduction from outside contractors, but it would leave the opportunity open for many different organizations to profit by incrementally improving IIT's campus.

Basic Implementation
This solution is the base case, or control solution, with which to judge all of the other solutions. This model proposes allowing IIT's facilities department to create and implement changes to IIT's system on their own. This model is essentially how our campus energy system works now. We would certainly hope that one or all of our other solutions work better than the status quo, but it is a good basis for comparison. The facilities department has almost total control over what gets added to the campus electricity system, but it has no more motivation to change the system than IIT in general. IIT has some desire to reduce their power consumption, and it is branding itself as a frontrunner in sustainability research. However, the actual amount of money spent on utilities at this school is small in comparison with the total budget, and IIT has clearly had some trouble converting this small financial saving into a set of sweeping changes on campus. This model assumes that the IIT facilities and campus energy departments would run the same value comparisons on improvements from the previous model, but it would also require IIT to come up with the ideas and implement them.

Taxing/Capping
All of the previous solutions have focused on giving control over energy use to outside groups. Two of them even require that electricity management on campus is switched to a flat fee for electricity service, rather than a rate for kilowatt-hour usage. Both of those solutions also require that all devices that use electricity essentially come under the jurisdiction of the organization implementing power reduction schemes. This leaves the end user with little control over their energy usage, likely with a correspondingly small amount of interest in the subject. The end user would not be able to pick their light fixture, but he would also not have to pay extra money if the supplied light fixture were inefficient.

This is not necessarily an ineffective way of creating power reduction on campus, but it is not the only way.

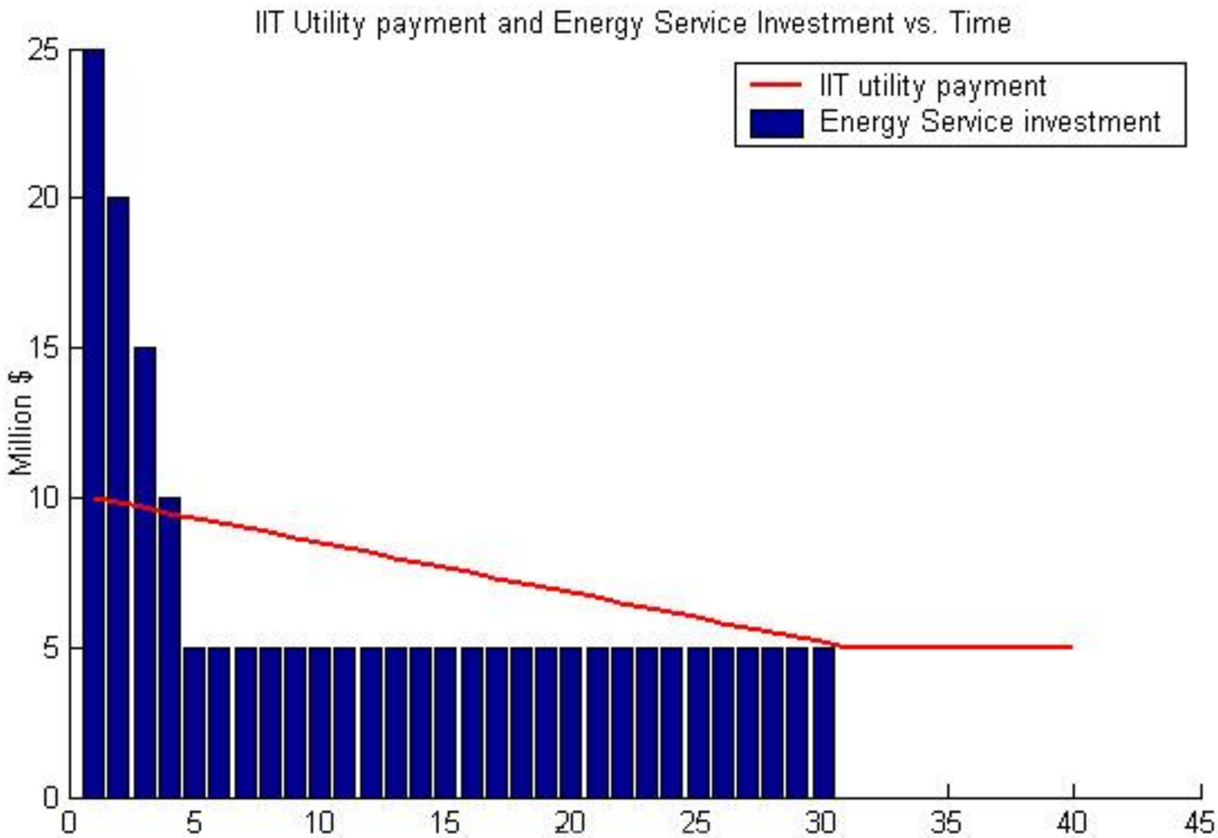
In this solution, IIT gives all control and incentive for power reduction to small groups of users. In order to provide a financial stimulus to change current patterns, some sort of tax, cap, or incentive must be provided. In the cases of taxes and incentives, the money either collected or spent must be accounted for. A tax will not be popular unless the money from the electricity tax is clearly redistributed among those paying the tax. Similarly, incentives for lowering power usage might be popular, but the money for those has to come out of some other part of the budget.

The actual group taxed must also be considered. With enough digital meters and complex sensors, individual rooms could be metered and taxed per kilowatt-hour, with the tax being distributed among the professors or departments that use the room. It would probably be more practical, however, to tax entire buildings or departments based on their energy usage. Along with this tax, however, the departments or buildings must receive more control over the facilities that they use. In order to do this, the facilities department might be broken up into smaller groups that would be assigned to either a department or a set of buildings. The departments themselves could run cost-benefit analyses of various investments in their electrical infrastructures, and then call in their representative of the facilities department to implement it. In this way, the departments or buildings receive the control to change their environment along with the impetus to do so. The profit from any tax, after paying for any equipment required for it, would be redistributed to the groups paying it at a flat rate. Those departments or buildings using the least amount of power would likely receive more of the redistributed funds than they paid, while those using excessive amounts of power would pay far more in taxes than would be returned to them.

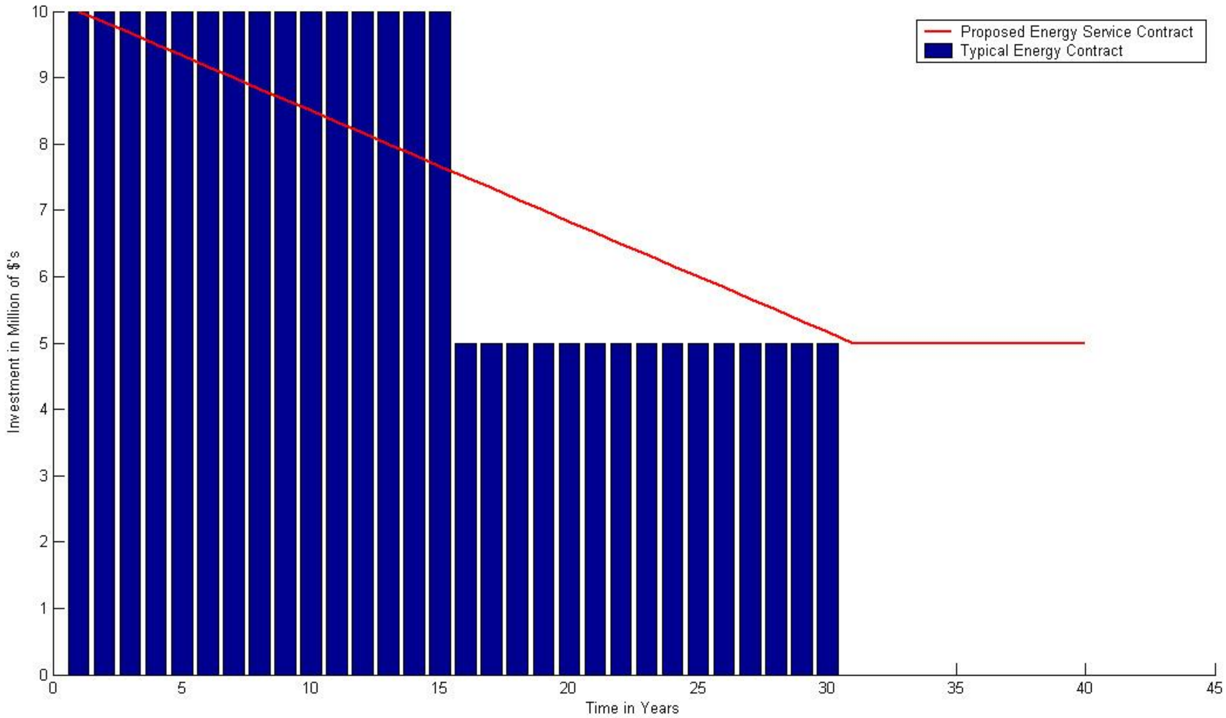
A similar alternative to a tax on electricity usage is a cap and trade system. In this system, a cap or baseline is set for energy consumption for each building or department, and those that use less energy than they are allotted can sell their credits for energy to others, while those exceeding their posted baseline would have to purchase the right to use power from the more energy-conscious departments. This system is often seen as more acceptable than a tax system, since there are clearly as many groups benefiting from the system as there are groups being penalized for excess consumption. In both cases, capping and taxing, the campus can be induced to become increasingly more sustainable by either gradually increasing the tax per kilowatt-hour on electricity or by gradually lowering the baseline applied to the cap and trade system.

Transferring Control to ECE Department

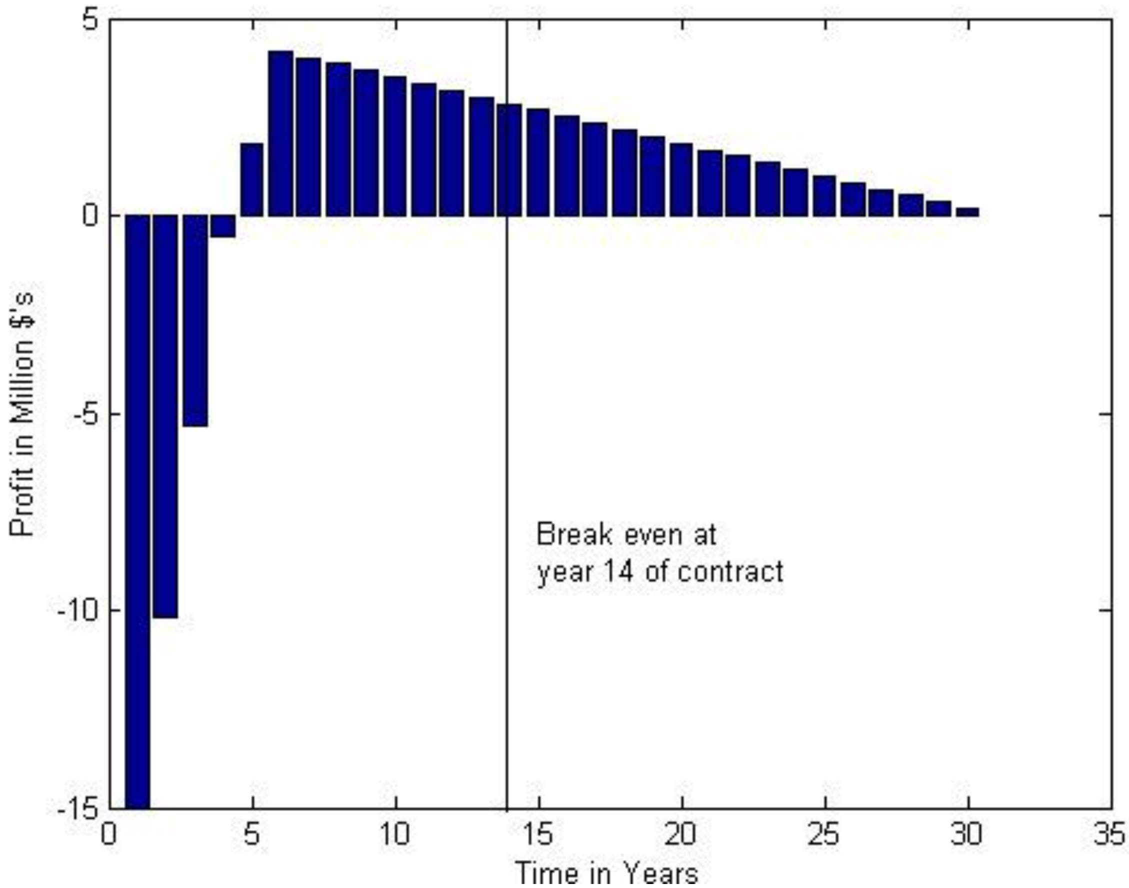
This last solution for electricity reduction looks at another way of valuing that drop in usage. All of the other solutions have looked primarily at the amount of money that can be saved through a drop in kilowatt-hours, but there is also money to be made in marketing IIT as a sustainable university. Specifically, the Electrical and Computer Engineering Department would have a large financial stake in advertising itself as a cutting edge institution for green technology. IIT could potentially receive grants to develop methods and devices for energy savings. It could also get many more students paying tuition if it could parlay its sustainability into a new department. Farther down the road, those same students would be alumni contributing money to the college, and that same research would have turned into profitable patents.



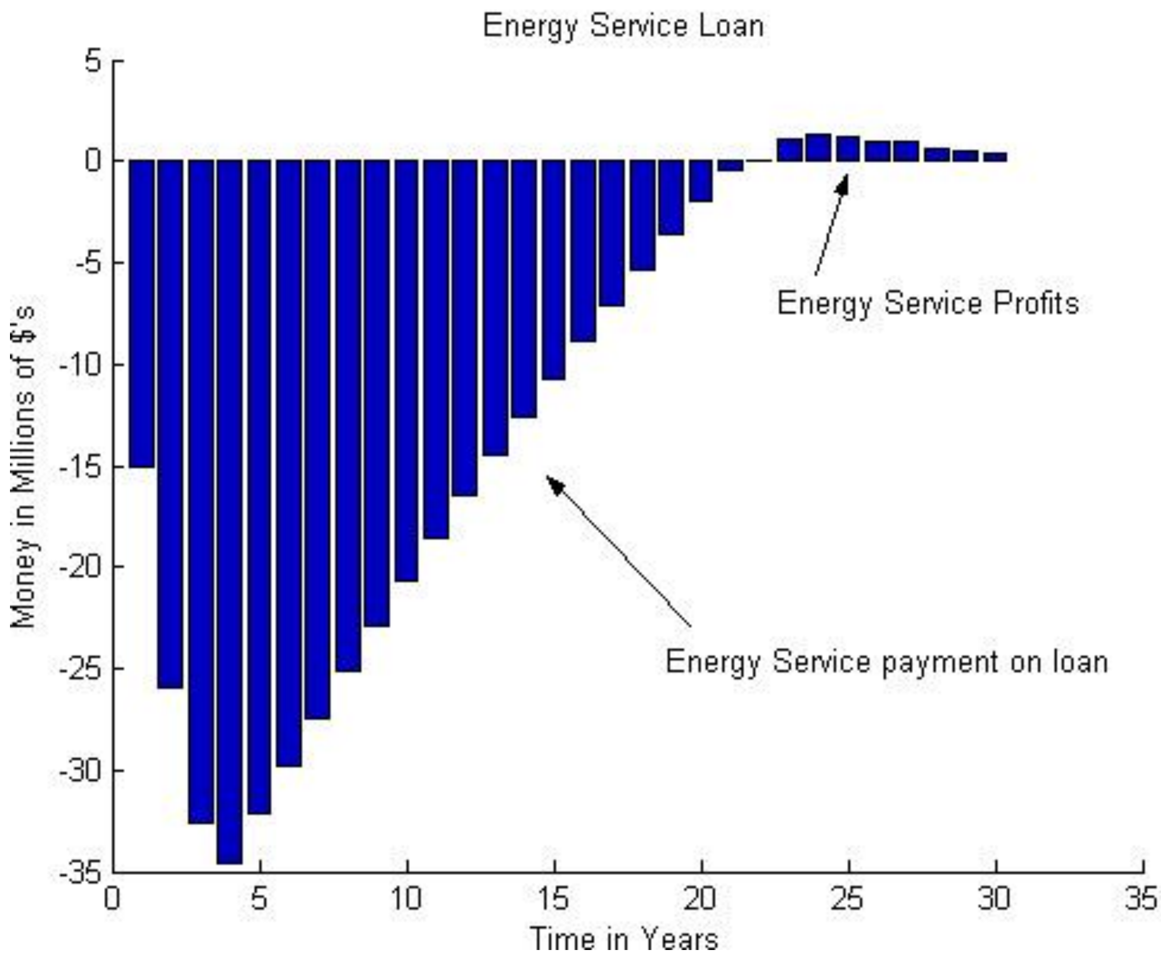
The energy service company invests heavily in efficiency measures during the first 4 years of the contract. By year five, the company's investments level off. Heavy front end investments yield more immediate cost savings.



Payments to the contractor can either be structured as tiered flat fee with payments halved at the midpoint of the contract or as a diminishing flat fee.



The large front end investment by the contractor sets the break even point at year 14.



Overall profits for the contract will be realized in year 23.

Unified Solution

All sub-group solution advantages and disadvantages were discussed by the team. It was decided that it would be best to present a single solution for all IIT utilities. It was decided that the "Total Energy Contracting" solution proposed by the Electrical sub-group would best address IIT's needs. There are several advantages by turning all utility operations over to a contractor and paying them a diminishing rate. IIT gains rate certainty and its energy use is greatly reduced. The contractor has the incentive to maximize energy efficiency as it leads to greater profits. Although originally discussed as an electricity solution, the plan can be applied to all utilities.

9. Obstacles

Certainty of Scope
When the project began, there was uncertainty over the scope of the problem and the project goals. After question and answer sessions with our advisor Joseph Clair and an outside consultant John Kelly, we gained clarity on the problems we needed to solve.

Enormity of the task
The enormity of the project became apparent once the problems were defined. We decided to divide the team into subgroups to research individual utilities. It was decided that there would be 3 research subgroups: Electricity, Steam and Water/Natural Gas. Water and Natural Gas utilities were grouped together because the delivery, storage and metering methods of the commodities were similar. To share the burden of preparing the deliverables, we divided our team into parallel deliverable subgroups. One member from each utility research subgroup was assigned to a deliverable subgroup when possible to help with information exchange.

Team Communication
Because team members have different class and work schedules there where limitations on how often we could meet outside of class. We needed to agree on standard tools for information exchange. The team decided to use Google Groups as an online discussion forum. Google Groups was chosen over iGroups because the majority of our team had experience and a comfort level with it. However, not everyone was familiar with Google Groups. Those who had problems joining the discussion group and navigating the site met with out team leader, who conducted informal training sessions and ensured that everyone was up to speed on Google Groups.

Research Sources
There is a wealth of information, both published and online, regarding utilities and utility management. However, the research subgroups needed to filter through this information to find reliable and reputable sources of information. The research subgroups were able to find information available on the websites of professional organizations. The subgroups also took advantage of campus tours and presentations to gain knowledge on campus generation and distribution operations.

Scope Creep
Because of the variety of the regions that utilities serve worldwide, our team needed to avoid losing focus in our research and allowing the boundaries of the project scope to creep into areas not applicable to the environment IIT Campus Energy Services operates. While researching problems faced by utilities worldwide, the research subgroups needed to remain focused on how the solutions could be scaled to solve IIT's challenges.

Time Constraints – 1 semester IPRO
Because this is a one semester IPRO, with nothing to build on from previous IPROs, our team needed to build a foundational understanding of utilities before we could begin to think of solutions to the problem. Being outsiders to the industry, the team had the advantage of not being invested in the old paradigms which need to be broken to solve problems faced by a modern utility. The disadvantage was the loss of time that was spent educating ourselves on utility functions and needs. The team decided to approach the IPRO as though we were outside consultants hired by the university to present solutions within the limited 16 week time frame. We used the fact that there would not be another IPRO to continue our work as motivation in keeping focused.

10. Recommendations

The University must now determine what it is they are looking for in an agreement from an energy contractor. To do this, the University must go beyond the research and conclusion of this IPRO and perform feasibility studies of the suggested performance contracting model. First, differing levels of investment from the contractor should be explored. An estimate with a fair amount of accuracy should be completed to determine the amount of finances that will be needed by the contractor to reach a higher level of efficiency on campus. Second, the length of the contract should be analyzed. The shortest time frame as possible should be determined to ensure the university reaches its efficiency goals quickly. A shorter time frame will also make it more appealing for contractors from a monetary standpoint as they will have the possibility of making a profit sooner. The rate of return, or the fee paid by the university each year, should be determined. An accurate fee will ensure the university is paying a fair amount and that the contractor is receiving a fair sum each fiscal year.

The next step for the University should be to take the information from the feasibility studies and make contact with energy contractors to determine interest in the project. A private bid system could then be setup so the university can choose the best offer. As part of the agreement with the contractor of choice, a small scale implementation should be utilized to determine the effectiveness of a performance contract on the IIT campus. A small scale implementation should comprise a single building or even a few buildings if desired with a short contract length. If successful, the information and knowledge gained from the small scale implementation could be used to plan an implementation campus wide. However, if the small scale implementation is not successful, the University will need to look at the data and determine why it failed and what the next best course of action is.

11. References

Steam Team Research

Websites visited

http://www.conservationsolutions.com
http://www.buildinggreen.com
http://www.eeba.org
http://www.energycodes.gov
http://www.mwalliance.org
http://www.energysolutionscenter.org
http://www.illinoisbiz.biz
http://egbconference.com/market-data
http://usa.autodesk.com/company/sustainable-design/articles
http://www.steamingahead.org
http://www.cbboilers.com/Energy/Energy%20Tips/Return%20Boiler%20Condensate.pdf
http://www.cleaver-brooks.com/cb_aware-energy.htm
http://memagazine.asme.org/articles/2009/February/Technology_Focus.cfm
http://livebuilding.queensu.ca/building_systems/heating_cooling_system/steam_heating
http://www.ncseonline.org/nle/crsreports/energy/eng-80.cfm?&CFID=11262148&CFTOKEN=7028302
http://oee.nrcan.gc.ca/publications/commercial/m144-7-2003e.cfm
http://hpac.com/popular/district_steam_design/
http://www.usgbc.org
http://findarticles.com/p/articles/mi_m3601/is_n31_v40/ai_14921434/
http://www.modbs.co.uk/news/fullstory.php/aid/2943/University_tests_identify_the_most_efficient_stea
m_trap_.html
http://www.smart-energy-alliance.com/
http://www.gepower.com/prod_serv/plants_td/en/td_network.htm
http://livebuilding.queensu.ca/
http://pepei.pennnet.com/
http://iuep.org/
http://www.eeivt.com/
http://utilityexchange.org/
http://eei.org/Pages/default.aspx
http://naruc.org/
http://www.erec.org/projects/finalised-projects/sustainable-communities.html
http://www.exeloncorp.com/corpresponsibility/environment/
www.eere.energy.gov/geothermal/powerplants.html
www.allianteenergygeothermal.com/HowitWorks/OpenLoopSystems/index.htm
www.iit.edu/~ipro301s05/knowledge/reports/s0i301-Final%20Report.pdf
www.pubmedcentral.nih.gov/articlerender.fgci?artid=2199292edis.ifas.ufl.edu/FY1033#TABLE_1

PUBLICATIONS

Rise of the 'Super Boiler'. Heating/Piping/Air Conditioning HPAC Engineering; Jun2008, Vol. 80 Issue 6, pBSE6-BSE9

Russell, Christopher. Return on steam efficiency investment. Plant Engineering; Jan2004, Vol. 58 Issue 1, p58-60

Checket-Hanks, B. Steam Boilers And Their Wild Load Swings. Air Conditioning Heating & Refrigeration News; 9/23/2002, Vol. 217 Issue 4, p10

Russell, Christopher. MANAGEMENT SIDE OF ENGINEERING. Plant Engineering; Sep2000, Vol. 54 Issue 9, p30

Cogeneration. Chemical Market Reporter; 03/17/97, Vol. 251 Issue 11, pSR6

Perenc, Jeff. Green Means: SAVING. Heating/Piping/Air Conditioning HPAC Engineering; Sep2008, Vol. 80 Issue 9, p5

Bugliarello, George. The Engineering Challenges of Urban Sustainability. Journal of Urban Technology; Apr2008, Vol. 15 Issue 1, p53-83

Itano, Nicole. A model of energy-efficient building. Christian Science Monitor; 1/14/2008, Vol. 100 Issue 34, p13-13

Perry, Tekla S. The Zero-Zero Hero. IEEE Spectrum; Sep2007, Vol. 44 Issue 9, p12-14

Wagner, A., et al. Thermal comfort and workplace occupant satisfaction—Results of field studies in German low energy office buildings. Energy & Buildings; Jul2007, Vol. 39 Issue 7, p758-769

Insurance Rebates For Owners of Energy-Efficient Buildings. Energy Design Update; Jan2007, Vol. 27 Issue 1, p6-7

Hewitt, David. Energy-Efficient Buildings Needed. Heating/Piping/Air Conditioning HPAC Engineering; Aug 2006, Vol. 78 Issue 8, p11-13

Profit in green offices. Estates Gazette; 7/8/2006 Issue 627, p35-35

Berg, Joel. 'Green' Loans Touted as Profit Opportunity. American Banker; 5/9/2006, Vol. 171 Issue 88, p9

Sakraida, Vincent A. District-Steam Design for University Campuses. Heating/Piping/Air Conditioning HPAC Engineering; Mar2008, Vol. 80 Issue 3, p24-33

Hicks, Jason. Calif. cleaners receive $100K in rebates. American Drycleaner; Dec2006, Vol. 73 Issue 9, p88

Tremmel, A. and Hartmann, D. Efficient steam turbine technology for fossil fuel power plants in economically and ecologically driven markets. VGB Powertech 2004, vol.84, no.11, pp. 38-43

Meters Aid Allocation of Energy Costs, Pinpointing of Maintenance Problems. Heating/Piping/Air Conditioning HPAC Engineering; Jan2005, Vol. 77 Issue 1, p66-67

Langston, Lee. campus heat and power. Mechanical Engineering; Dec 2006, Vol. 128 Issue 12, p28-31

Decentralized boiler system schools campus in efficiency. Consulting-Specifying Engineer; Aug2008, Vol. 44 Issue 2, p54-55

Water and Gas Team Research

Websites Visited

American Water Works Association – AWWA
http://www.awwa.org/

Sustainable Infrastructure for Water and Wastewater | Water | US EPA
http://www.epa.gov/waterinfrastructure/

Environmental Protection Agency - Water & Wastewater Pricing Introduction
http://www.epa.gov/waterinfrastructure/pricing/index.htm

Setting Small Drinking Water System Rates for a Sustainable Future
http://www.epa.gov/ogwdw/smallsystems/pdfs/guide_smallsystems_final_ratesetting_guide.pdf

Water Billing - NMHC.org
http://www.nmhc.org/Content/BrowseContent.cfm?IssueID=132&siteArea=Topics

TCEQ Regulatory Guidance: Rain Water Harvesting: Guidance for Public Water Systems
http://www.tceq.state.tx.us/files/rg-445.pdf_4447778.pdf

HarvestH2O.com – Simple Rainwater Harvesting Design
http://www.harvesth2o.com/simple_system.shtml

Federal Energy Management Program: Purchasing Renewable Power
http://www1.eere.energy.gov/femp/program/utility/utilityman_renew.html

Water Billing - NMHC.org
http://www.nmhc.org/Content/BrowseContent.cfm?IssueID=132&siteArea=Topics

Redwood City Public Works Water Services | Water Use Allocation Program
http://www.redwoodcity.org/publicworks/water/wapoverview.html

City of Petaluma - Water Resources and Conservation – Home
http://cityofpetaluma.net/wrcd/index.html

Bloomberg.com – Las Vegas Running out 2/26/09
http://www.bloomberg.com/apps/news?pid=email_en&refer=home&sid=a_b86mnWn9.w

Water Utility Regulation
http://www.reason.org/news/show/127744.html

NaturalGas.org
http://www.naturalgas.org/naturalgas/distribution.asp

ACEEE – Natural Gas Price Effects of Energy Efficiency and Renewable Energy Practices
http://www.ef.org/documents/Nat_Gas_ACEEE.pdf

UMass Amherst: Physical Plant: Energy Performance Contract
http://www.facil.umass.edu/~utildept/html/projects/EnergyProject/index.html

EPC Watch - M&V Concepts
http://energyperformancecontracting.org/m-and-v.html

Tools & Resources Library : ENERGY STAR
http://www.energystar.gov/index.cfm?c=tools_resources.bus_energy_management_tools_resources

National Association of Regulatory Utility Commissioners
http://www.naruc.org/

Johnson Controls Inc. | Performance Contracting
http://www.johnsoncontrols.com/publish/us/en/products/building_efficiency/energy_efficiency/performance_contracting.html

Johnson Controls Inc. | Higher Education
http://www.johnsoncontrols.com/publish/us/en/products/building_efficiency/solutions_for_your/higher_ed.html

Regulated Utility News and Content
http://www.utilityregulation.com/

City of Chicago Water
http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?contentOID=536891358&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Cultural+Affairs%2FVenues%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Cultural+Affairs&deptMainCategoryOID=-536883853

Continental Billing System for Windows
http://www.cusi.com/products/cbsw.asp

The Rain Well Products
http://www.therainwell.com/Products.html

The Chicago Center for Green Technology
http://www.cbe.berkeley.edu/mixedmode/ccgt.html

Madison Environmental Group - Project Archive
http://www.madisonenvironmental.com/projectarchive.html

Rainwater Harvesting at NCSU
http://www.bae.ncsu.edu/topic/waterharvesting/overview.html

People's Gas
http://www.peoplesgasdelivery.com/

Capturing Condensate to Conserve Emory's Water
http://atlanta.bizjournals.com/atlanta/stories/2001/07/09/focus7.html

Alternative Water Sources: Supply-Side Solutions for Green Buildings
buildinggreen.com/auth/article.cfm/ID/3903

Grey Water on the Shores of Lake Michigan
http://chicagopublicradio.org/Content.aspx?audioID=25759

The Texas Manual on Rainwater Harvesting
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

Aquabarrel
http://aquabarrel.com/

Rainwater Recovery Incorporated
http://rainwaterrecovery.com/

National Tank Outlet
http://ntotank.com/

Graphical Climatology of Chicago Temperatures, Precipitation, and
Snowfall (1871-Present)
http://home.att.net/~chicago_climo/

Rainwater Club Design Tips
http://www.rainwaterclub.org/design.htm

http://www.eia.doe.gov/oil_gas/natural_gas/info_glance/natural_gas.html

http://www.eia.doe.gov/oil_gas/natural_gas/ngs/ngs.html

http://www.naturalgas.org/naturalgas/storage.asp

http://www.ferc.gov/industries/gas/indus-act/storage.asp

Electricity Team Resources

Buildings Energy Data Book 2008
http://buildingsdatabook.eren.doe.gov/

Power Technologies Energy Data Book
http://www.nrel.gov/analysis/power_databook/

2003 Commercial Buildings Energy Consumption Survey (CBECS)
http://www.eia.doe.gov/emeu/cbecs/

Residential Compliance Manual for California's 2005 Energy Efficiency Standards
http://www.energy.ca.gov/title24/2005standards/residential_manual.html

IIT Perfect Power Prototype
http://www.galvinpower.org/
http://www.galvinpower.org/resources/listall.php?sct=14

Exploring Individual-Level Factors Related to Employee Energy-Conservation Behaviors at Work; Scherbaum, Charles A. and Paula M. Popovich; Journal of Applied Social Psycology. Vol 38(3), Mar 2008. pp. 818-835.

The effect of tailored information, goal setting.; Abrahamse, Wokje, Linda Steg, Charles Vlek, and Talib Rothengatter; Journal of Environmental Psychology 27 (2007) 265–276

PERFECT POWER: How the Microgrid Revolution Will Unleash Cleaner, Greener, More Abundant Energy; Robert Galvin, Kurt Yeager

System Demo: San Diego Gas & Electric and Advanced Control Systems, Inc.

Advanced Control Systems Support and Services: Jeff Smith: Advanced Control Systems , Inc.

Technical Support: Ron powers: Advanced Control Systems, Inc.

New Products: Gary Ockwell: Advanced Control Systems, Inc.

Mc Donnell Group

The Smart Grid: Separating market hype from practical Distribution Company Reality.

System Security: Mary Hester: Intelligent System Solutions

OMS/ DAS map. Live demo: Gary Ockwell : Advanced control Systems, Inc.

12. Resources

Our team did not have any expenses this semester. Our two pizza parties were covered by Professor Clair.

The following pages detail the time spent by each team member during the semester.

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		1: reading project proposal/working on understanding problem		1: initial research visiting utility websites				2.00
Becker, Pat		1.5: research Utility Operation and Management		1.5: Research Utility and Management. Read downloaded presentations.	2: Research Electricity as a tradable commodity.	1: Research Utility Portfolio Management	0.5: Create personal timesheet and document research.	6.50
Burke, Jeffrey								
Chippo, Fatima						1h:reading syllabus	2hs: Reading project propsal	3.00
Guilfoyle, Jennifer						1 hr: Searching and reading websites about utilities and utility management	1.5 hr: Reading proposal for ipro, writing questions, r	2.50
Kashap, Alok		2:Reading Research Paper and start over the project	1:Went Electrical Dept.and discuss to the professor about project	3:Discussion with my team members about our project				6.00
Lee, Nathan				1: Team Building workshop	1: Read project proposal, get understanding of project			2.00
Martin, Sam			3: proposal and going through utilities websites		1: meeting w/ LT Castle (Nuclear) about energy problems/solutions he encountered in the fleet			4.00
Masci, Juliana			1: read syllabus	2: looking up utilities websites	3: Setting up Google groups and forms	3: prelim research on subgroup topic		9.00
Murphy, Ryan			1: read proposal		3: read perfect power	2: read perfect power	1.5: research the power business	7.50
Shonekan, Yomola		1:15h:read proposal		1:15: researched on utilities				3.00
zhani,nizar		1:30going over the proposal		1h:discuss ways to research with the team		2h :research		4.50

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy				1:Get set up on google groups, schedule	2: Researched Chicago water utities			3
Becker, Pat		3: Research sustainable water resources such as gray water and rainwater uses.		1:Research Water Utilities	0: Baby born	0: Baby in hospital	0: Baby in hospital	4
Burke, Jeffrey								
Chippo, Fatima	1H:defining problem and find key words		2hs: objectives and reaserch about some models and strategies		2.5: meeting with and PE freind discussing SCADA strategy to increase efficiency	2hrs:research electricity utilities		7.5
zhani,nizar								
Guilfoyle, Jennifer			.5 hr: responding to emails, created agenda, reviewed deliverable tasks and project plan					
Kashap, Alok		2 Hrs.Research about various aspect of utilities and their features		1.5 Hrs. Went to segal hall to learn more about the consumption and distribution of electricity				3.5 Hrs.
Lee, Nathan		1: Read/Understand Project Proposal	2: Research Thermal Efficiency Methods					3
Martin, Sam	.5 read proposal again	2: research steam energy	1: research history of steam power		1: research modern steam utility			4.5
Masci, Juliana			4: Project Proposal			3: Proj Proposal	3: Create Timesheet Log, Bio	10
Murphy, Ryan			2.5: Research power utility pricing schemes	1: Research microgrid implementation			1: create biography, familiarize with google groups	4.5
Shonekan, Yomola			2h:researched on utilities					

Week 3	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		1.5: Bio, research Chicago water	1: Project Plan Methodology sections A,D,F		5: Sustainability Forum			7.50
Becker, Pat	0.5:Search for info on NatGas Utilities	2: Research Natural Gas and Water Utilities, update bio		0.5: Update timesheet and Bio		2: Research natural gas distribution	2:Research water distribution	7.00
Burke, Jeffrey		1.5 smart grid research, background, budget	1.0 background budget		1.0 internet research on steam distrivution			3.50
Chippo, Fatima	1hr: meeting with subgroup	2hrs. working on project plan			2hrs, learn MS project	2hrs: research on strategies	1h:meet with team member	8.00
zhani,nizar				2:go over the prposal and projec plan	2:getting familiar with ms project	1:research on different strategies		5.00
Guilfoyle, Jennifer	1 hr: sending out emails, uploading bio for myself and Fatima, and wrote bio for myself	1: Met with Fatima and Julie to review sections for project plan, wrote agenda	1.5 hr: Logging back time, reviewing methodology and purpose, emails address book	1.5 hr: Reviewing project plan, minutes sent out emails, created agenda		.5 hr: sent out emails, researched natural gas utilities	1 hr: Revising project plan, sending out emails, reviewing time sheets	6.50
Kashap, Alok	1hr. Meeting with group mates	1.5 hrs. working on project plan			2 hrs. Research on electricity distribution		1 Hr. Again met with group members discussing the issue	5.50
Lee, Nathan	1: Get set up on Google Groups, Update schedule, Create Bio		2: Project Plan Methodology Sections B,C,E		1: Research Thermal efficiency			4.00
Martin, Sam		3: attend arch class buildings are heated	1: plan w/ subgroup about steam plant tour new meeting times	1: project plan	2: research heat distribution			7.00
Masci, Juliana	5: Project Proposal	5: Project Proposal, meeting with jenn and fatima	2: Complile Project Proposal	2: Cont. Compiling, edit group members in proposal			2: Compiling drafts for proposal, editing format	16.00
Murphy, Ryan		1.5: Research California deregulation fiasco	1.5: meeting with electricity group at HUB		2.5: research regulatory practices of power utilities	1: Research SCADA system	.5: revise biography	7.00
Shonekan, Yomola			3h:worked on objective	1h: researched				4.00

Week 4	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		0.5 Water group team meeting/presentation discussion.		2: Rain barrel research-fromTexas			2: Utility regulation research	4.50
Becker, Pat	4: Research Water utilities and sustainability efforts. AWWA downloads	0.5 Water Group Team Meeting. Discussed In class presentation format.	3: Research Natural Gas Distribution and Water Distribution systems and Conservation programs.	1.5: Begin Summarizing Water Gas Research.		2: Research Water Utility rates.	3: Work on water subgroup research presentation.	14.00
Burke, Jeffrey		1.0 budget revisions		1.5 water group team meeting	3 steam research and background revision			5.50
Chippo, Fatima	2h: working on schedule task	1 h: working on expected results	2h: research about strategies to benefits user	0.5: rewrite my bio		2h:meeting EP discussing the project		7.50
zhani,nizar	1:00 work on schedule task	1:00 working on expected results		2:00research on how to improve efficiency	1:00 going over the final plan and the bio	1:00 research on how to improve efficencies		6.00
Guilfoyle, Jennifer	1.5 hr: Review PP rubric, reviewing time sheets, meeting with Fatima and Nizar, emails, agenda, reviewing PP again	1.5 hr: Met with Fatima, reviewed rev 2 of project plan, sent out emails, reviewed new additions to time sheets, revised sections of project plan	1 hr: met with Fatima & Nizar Expected Results, Schedule of Tasks, revised Expected Results, reviewed project plan	2.5 hr: writing expected results, revising project plan, searching for new meeting room, meeting with Fatima and Nizar	1 hr: revisions on project plan, emails			7.50
Kashap, Alok	0.5 Hrs.Rewrite my Bio		2 revise project plan and learn more about utilities			3 went comed office and tallked to supervisor	2.5 meet with IPRO Groups and tallked regarding my project	8.00
Lee, Nathan				0.5: Steam Plant Tour	2: Review and summarize Steam Plant Tour	2: Research transportation of steam		4.50
Martin, Sam		1.5: complete bio, upload documents to google groups, update electronic log		1: Steam Plant tour and prepare brief	1: Research cost benefit analysis of multiple vs single boilers		1: Compile data and research for sub group meeting	4.50
Masci, Juliana	2: editing project plan		2:Research for	2: Research	2: Continue research			8.00

			subgroup					
Murphy, Ryan	1.5: meet with Fatima at MTCC		2: Research electricity regulation methods			3: Research electricity storage, transmission, usage	1: research	7.50
Shonekan, Yomola	2h: research on provision of incentives(to customers) by utilities			0:50: steam plant tour	2:30h: research on hydrothermal power plants and utilty infrastructure			5.00

Week 5	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		2: Water utility rate structure		2: Research gas utility process			1: Gas and water rates, ppt slides	5.00
Becker, Pat			2: Research wastewater management for water utilities	1: Research Rainwater use in the Seattle,WA	2: Research Pricing, in the book "The Theory of Public Utility Pricing"	2: Research Water Utility Sewer Service, Chicago and Madison, WI	2: Research Sustainability Projects of the MWRDGC. Storm Sewer Rehab	9.00
Burke, Jeffrey		2.0 sub group meeting and steam research for solutions		1.0 regulation research, IIT systems research	1.5 post info on google groups and research sustainable communites			4.50
Chippo, Fatima		1:sub group meeting	2: research advanced control system	1: subgroup meeting	2h: working on presentation on tuesday			6.00
zhani,nizar		1h: subgroup meeting	2h research electrical efficiency	1h subgroup meeting		2hrs working on slides		6.00
Guilfoyle, Jennifer	.5 hr: meeting agenda	1.5 hr: review work done, check project plan status, return emails	1 hr reviewing work done		1 hr: deciphering ideas about energy efficiency			4.00
Kashap, Alok		1 Hrs. Sub group meeting	2 hrs. Working on ppt for subgroup presentation	1 Hrs. Sub group meeting		1hrs research	2hrs Discussed with my roommate about utility	7.00
Lee, Nathan		2: Sub group meeting Research steam efficiency methods			1: Research valves on steam pipes for efficiency	1: Review understanding of goals and what we've done		4.00
Martin, Sam		1: Sub group meeting	1: Research Steam efficiency	3: research Speaker Questions				5.00
Masci, Juliana			5: research gas distribution methods	3: research gas marketing	1: research government regulations		2: working on ppt for subgroup presentation	11.00
Murphy, Ryan		1: subgroup meeting	1: research, questions for speaker	1: Subgroup meeting		3: Work on powerpoint, research IIT grid and uses	4: Work on powerpoint for group presentation	10.00
Shonekan, Yomola		0:50: sub-group meeting	2h: research on utility regulations					2.50

Week 6	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy	2: Research rate structures, work on ppt slides	1.5: Finish up slides, go over presentation before class		1: Presentation skills seminar		2: Presentation meeting		6.5
Becker, Pat	2: Edit Presentation slides. Review Presentation material.	1: Review ppt presentation with sub group before class.			2: Research effectiveness of prior conservation campaigns.	2.5: Research water conservation California water crisis.	2: Research links on the AWWA.ORG page	9.5
Burke, Jeffrey	3.0 subgroup presentation prep.,research on how shipping companies operate	3.0 Sub group meeting and presentation prep.						6
Chippo, Fatima	1: meeting with Joseph Clair discussing power point		3:research iit existing utilitises to increase their efencienty					4
zhani,nizar	2h:working on slides and what murphy should say with my slides		1h:research on water chillers			1h:research new technologies used by campuses to save energy		4
Guilfoyle, Jennifer							.5 hr: reviewing time sheets, email	0.5
Kashap, Alok		2Hrs.Working on power point	1 hrs. Meeting with subgroup people			2 hrs meet Nathan and Timothy regarding presentation	2Hrs Created power point	7
Lee, Nathan		2: Subgroup meeting, presentation prep			1: Research condensate return in steam transmission	2: Midterm Presentation meeting	2: Create slides for midterm presentation	7
Martin, Sam	1: Start reading Perfect Power	2: Presentation and Subgroup meeting	1: Read Perfect Power	1: Read Perfect Power	1: Read Perfect Power		1: Read Perfect Power	7
Masci, Juliana	4: Compiling ppt with pat's, continuing with gas research powerpoint	1: Subgroup meeting to go over the ppt before class		2: researching for IIT utility usage			2: researching marketing techniques and regulation standards for gas	9
Murphy, Ryan	3: Meeting with Joseph Clair, working on powerpoint	2: Working on powerpoint				1: reading perfect power book		6
Shonekan, Yomola	1:30: putting notes	2: meeting with Jeff on				0.5: research underground		4

	together for presentation	presentation subgroup				steam transportatio n		

Week 7	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy	1.5: Created Visio group organization, worked on ppt slides	1: Finish up slides for first run		1: Revised ppt slides				3.50
Becker, Pat	2: Study conservation promotions and their effectiveness.	2: Review slides and think of what	1: Meet with Presentation group to practice presentation	2: Prepare presentation. research rate schedules.	1: Prepare for presentation,	2: Prepare for Presentation.		10.00
Burke, Jeffrey								0.00
Chippo, Fatima	reading some power point that talks about saving energy		2hrs.revising articles posted on google groups					3.00
zhani,nizar			1h : going over the slides for comments	1h subgroup meeting			1h review articles posted on google group	3.00
Guilfoyle, Jennifer	.5 hr: reading some research that has been done and posted on google groups	1 hr: reviewed emails, created agenda, reviewed midterm presentation,	1.5 hr: reviewing posted articles from groups, emailing people	1 hr: reviewing presentation, printing, reviewing sources, emails			1 hr: emails, reviewing presentation, reviewing and replying to messages on google groups	5.00
Kashap, Alok	2 Hrs Worked on creating Power point slide			1hr.Subgroup meeting	1hr.Reviewing presentation			4.00
Lee, Nathan	1: More work on Midterm Presentation slides	0.5: Midterm presentation slides (1st draft) 1: Sub group meeting	2: Fix slides research Geothermal solutions for steam	2: Fix midterm presentation slides	1: Further research on Geothermal solutions for steam			7.50
Martin, Sam		1 - Subgroup meeting	3 - Research Steam practice with Midterm presentation	1 - Research Steam Technology				5.00
Masci, Juliana	1: research for gov't regulations	4: email subgroup for specific questions, researching nat gas			2: researching for questions, compiling questions from sub-group,	1: review presentation, add images		8.00
Murphy, Ryan	1: talking to group, updating time sheets		4: writing IPRO subgroup progress		2.5: Researching psychological aspects of		2:preparing for presentation	9.50

			summary		conservation			
Shonekan, Yomola		1h: sub-group meeting		1:30: reviewing presentation on google groups			1h: research on geothermal technology	3.50

Week 8	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy			1: Assessing feedback from mid term presentation	2: Research utility regulation process				3.00
Becker, Pat	1: Presentation		2: Preliminary ideas for IIT water utility improvements.		2: Research regulatory requirements restrictions for water utilities at IIT (Chicago / Illinois)			5.00
Burke, Jeffrey								0.00
Chippo, Fatima		1 hours goin over midterm presentation feed back						1.00
zhani,nizar	1h:midterm presentation		1.5: talking to Ryan about which problems we have to adress		2:research on ways to conserve energy			4.50
Guilfoyle, Jennifer	3.5 hrs: making phone calls, emails, reviewing practicing slides for presentation (in case back up is needed)	1 hr: agenda making, emails, ipro midterm presentation feed back review		.5 hr: peer review form work, reviewing different peer review methods				5.00
Kashap, Alok	1Hr. Review the midtterm persentation							1.00
Lee, Nathan	1: midterm presentation	1: steam team meeting 2: research on ideal efficient, sustainable buildings		3: research on examples of existing efficient sustainable buildings	2: research on steam usage in other buildings and campuses			9.00
Martin, Sam		2.5 Subgroup meeting prep and Subgroup meeting	3 - Finish Perfect Power	1.5 Begin work on Cost Benefit Analysis of Modern Steam Utility				7.00
Masci, Juliana								0.00
Murphy, Ryan	3: preparing for presentation, giving presentation		1.5: redefining problem	2: coming up with ways to influence and instigate conservation				6.50
Shonekan, Yomola	1h: attended midterm presentation	1h: sub-group meeting						2.00

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		2: sub group meeting, water re-use research						4.00
Becker, Pat	1 Research Water Utility plan	1.5 - Sub group meeting. Research IIT Water Utility plan		2: Work on Water gas/group background	2: Research EPA water utility documents	3: Research EPA water Documents	1 Organize resources	10.50
Burke, Jeffrey		1.0 sub group meeting						
Chippo, Fatima		1.5 compiling research on deliverables		2 agends emails and compiling research	2 hrs: work on tax		1 hours organize resources	6.50
zhani,nizar	2h:brainstorming:ideas to implement					3h:researching and compiling information		5.00
Guilfoyle, Jennifer		1hr: meet with prof, print peer review sheets, set up for meeting	.5 hr: compiling time sheets	1.5 hr: compiling information on deliverables, agenda, emails			1.5 hr: compiling peer review sheets, reviewing emails	4.50
Kashap, Alok								0.00
Lee, Nathan		1: steam team meeting		2: research on effectiveness of "luxury tax"	2: research of effectiveness of "luxury tax"			5.00
Martin, Sam	2 - Research format for Cost Benefit Analysis	1 - Subgroup meeting	2 - Research social implications of Sin Taxes				2.5 - Research warmth and coolth steam systems	7.50
Masci, Juliana								0.00
Murphy, Ryan		1.5: brainstorming ideas for implementation		3 hr: compiling information on ideas	2: emailing people, organizing schedule	1: compiling background		7.50
Shonekan, Yomola		1h: sub- group meeting						1.00

Week 10	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		3: Reviewing utility models from different cities	1: brainstorming solutions for water/gas	1: Working on slide layout for presentation				5
Becker, Pat	1: Work on water utility rate structure	3: Work on water utility rate structure. Write Obstacles section of final report.				2: Work on water utility rate structure options	2: Work on water utility rate structures	8
Burke, Jeffrey		1.0 sub group meeting						0
Chippo, Fatima	2hrs: reading emails regarding IPRO		reviewing research compiled	3 hrs. subgroup meeting		2h compling research		8
zhani,nizar	1:subgroup meeting		2:research and ressources compiled	3h subgroup meeting	2h going over google group documents			8
Guilfoyle, Jennifer	2 hr: reviewing emails and deliverable group schedule, compiling review sheets, reviewing IPRO office emails	1 hr: creating agenda, compiling deliverable subgroup schedule of tasks, reviewing ipro day deliverables, meeting with subgroup leaders	.5 hr: compiling time sheets, emails	1 hr: compiling data, agenda, reviewing obstacles section of paper				4.5
Kashap, Alok								0
Lee, Nathan		1 subgroup meeting	1 slideshow intro		2 analyzing numerical data			4
Martin, Sam	3.5: Begin compiling Steam solutions	1: Subgroup meeting		1.5: Help with Report				5.5
Masci, Juliana								0
Murphy, Ryan	1: subgroup meeting	.5: team leader meeting w/ Jenn	4: Organizing tasks for subgroup, writing first draft of objectives					5.5
Shonekan, Yomola	0:30h: reading Electricity subgroup's progress report	1h: sub-group meeting		3 deliverables sub group meeting				4.5

Week 11	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		0.5: subgroup meeting		2: Pricing options for rainwater capture	2: Outside companies for water, especially rainwater capture installation		2: Rainwater capture large scale feasibility options	6.50
Becker, Pat		0.5: subgroup meeting		1: Work on Water Background for final Report	2: Work on Water Background for final Report	4: Work on Water Background for final Report and Water Solution	2: Work on Water Solution	9.50
Burke, Jeffrey		1.0 Subgroup Meeting						0.00
Chippo, Fatima	1 hour work on brochure	2hrs: organizing resourses	2 hours work on exhibit	3 : work on reserch about taxes	1hr: read emails from Ipro office			9.00
zhani,nizar	1h work on brochure	2h research about schools promoting themselves as research institutes	2hrs on exibit		2h research on federal grants			7.00
Guilfoyle, Jennifer								0.00
Kashap, Alok								0.00
Lee, Nathan		1: steam team meeting	2: work on presentation slides	3: research on EPA's ratings of buildings	3: research on buildings and campuses rated by EPA			9.00
Martin, Sam	2: Write Ethics section for Report	1: Subgroup Meeting	3: Compile Solutions data				1: Revise Ethics section	7.00
Masci, Juliana								0.00
Murphy, Ryan	1: work on report set up		2: research on electrical contracting idea	1.5: objectives section of report	3: objectives section of report		2.5: electricity background compilation	9.00
Shonekan, Yomola	1h: researching on how utilities can provide incentives	3h: sub-group meeting and working on exhibit						4.00

Week 12	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		2.5: Work on background, intro slides for presentation	1: Work on presentation	1: Review slides for presentation				4.50
Becker, Pat	2: Write Water/Gas Background	3: Rework water utility solutions. Research Energy Performance Contracts	3: Research Energy Performance Contracting	2: Write Water Solution			2: Work on Water/Gas Background	12.00
Burke, Jeffrey		1.0 Sub group meeting						1.00
Chippo, Fatima	3 hours working on broshure		3 research on electricity solution	2 hours working on exhibit		1hour researh on taxation		9.00
Zhani Nizar	3h working on brochure		2h on exibit	2h:research on how universities promote themselves as research institutions		2h: ways to get research funds off the state of illinois		9.00
Guilfoyle, Jennifer								0.00
Kashap, Alok								0.00
Lee, Nathan	2: work on presentation slides	1: steam team meeting		1: steam team meeting	3: review other teams' pending solutions			7.00
Martin, Sam		1: Sub group meeting	3: Work on presentation	1: Subgroup meeting		2: prepare for presentation	2: prepare for presentation	9.00
Masci, Juliana								0.00
Murphy, Ryan		4: work on electricity background	2: Research ComEd programs for Thurs presentation				3: Work on electricity solution	9.00
Shonekan, Yomola		1h: subgroup meeting		1h: subgroup meeting				2.00

Week 13	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		2: Work on background, solutions slides	5: Work on presentation with Murph, Sam, Jenn; Type up slides					7
Becker, Pat		2: Water Background		1: Water Solution	1: Water Solution			5
Burke, Jeffrey								0
Chippo, Fatima	1 hour meetin with murphey discussing solutions	3 hours group meeting workng on brochure		3 hours woking on exhibits		2 working on implemeting electricity solution on exhibit		9
Zhani Nizar		3h working on brochure		3h on poster	2h: going through the documents and posts			8
Guilfoyle, Jennifer		.5 hr: making agenda			1 hr: phone calls, emails with group members		1.5 hrs: work on graphs for deliverables	3
Kashap, Alok								0
Lee, Nathan	3: work on presentation slides	1: steam team meeting 1: work on steam solutions						4
Martin, Sam	3: Work on Steam Solution	1: Sub Team meeting	4: Work with Murph, Jenn, and Tim on the presentaton				1: review Presentation	9
Masci, Juliana								0
Murphy, Ryan	1.5: Work on electricity solutions	1: Arranging time to talk to Ty Miller	4: Talk to Ty Miller, work with Sam Jenn and Tim on presentation					6.5
Shonekan, Yomola		3h: working on brochure		3h: working on poster				6

Week 14	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy		3.5: Final touches on presentation	1: prepare for IPRO day	3.5: IPRO day				8.00
Becker, Pat	1: document sources	2: test water solution numbers	1: proofread / correct water background / solution					4.00
Burke, Jeffrey								0.00
Chippo, Fatima	2 hours going over presentation			1 hour going over presentation				3.00
Zhani Nizar		1h going over presentation		2hrs go over presentation and different topics	6h: IPRO day			9.00
Guilfoyle, Jennifer	7.5 hrs: poster, brochure and presentation work	1.5 hrs: presentation work			Ipro Day: 5 hrs			14.00
Kashap, Alok								0.00
Lee, Nathan			2: go through presentation, brochures, poster	1: prepare for IPRO day	6: IPRO day			9.00
Martin, Sam	1: Go over presentation	3: Practice presentation, then go over it with Murph	2: Practice Presentation	7: IPRO DAY				13.00
Masci, Juliana								0.00
Murphy, Ryan								0.00
Shonekan, Yomola		1h: reviewing presentation						1.00

Week 15	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
Baldwin, Timothy								0.00
Becker, Pat	2: Organize Final Report Layout	4: Final Report Abstract and Background intro. Adjust formatting.	3: Final Report	2: Final Report				11.00
Burke, Jeffrey								0.00
Chippo, Fatima								0.00
Zhani Nizar								0.00
Guilfoyle, Jennifer	2 hrs: peer review	.5 hr: gathering ipro day results						2.50
Kashap, Alok								0.00
Lee, Nathan		1: Peer Review online		1: Peer Review online 1: Review final report				3.00
Martin, Sam		.5: Last Sub group meeting	1: Final Report Review					1.50
Masci, Juliana								0.00
Murphy, Ryan								0.00
Smonekan, Yomola								0.00

13. Acknowledgments

We would like to thank the following individuals for their time, guidance and encouragment.

Professor Joseph Clair - IIT

Professor Bob Anderson – IIT

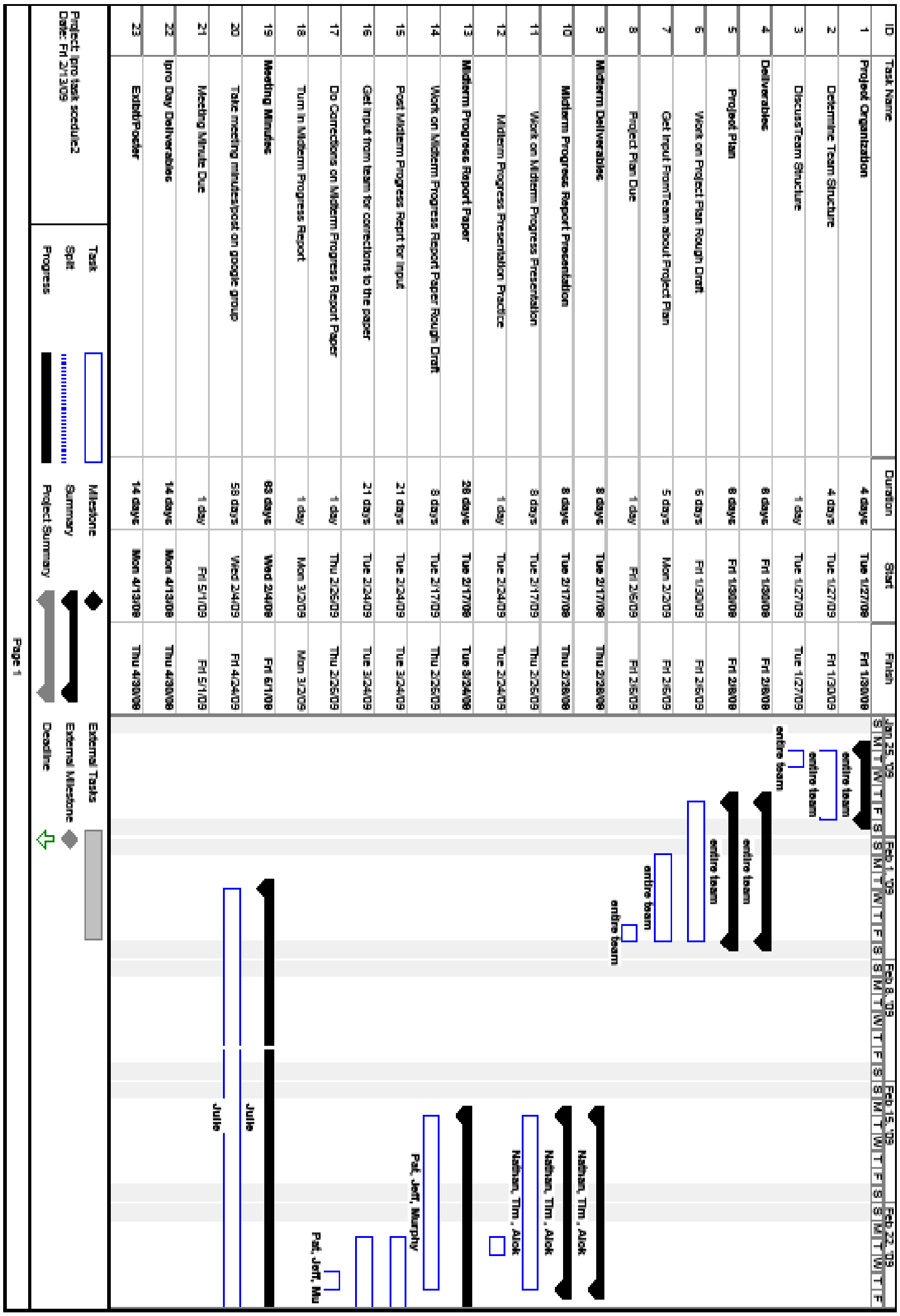
Professor Said Al-Hallaj – IIT

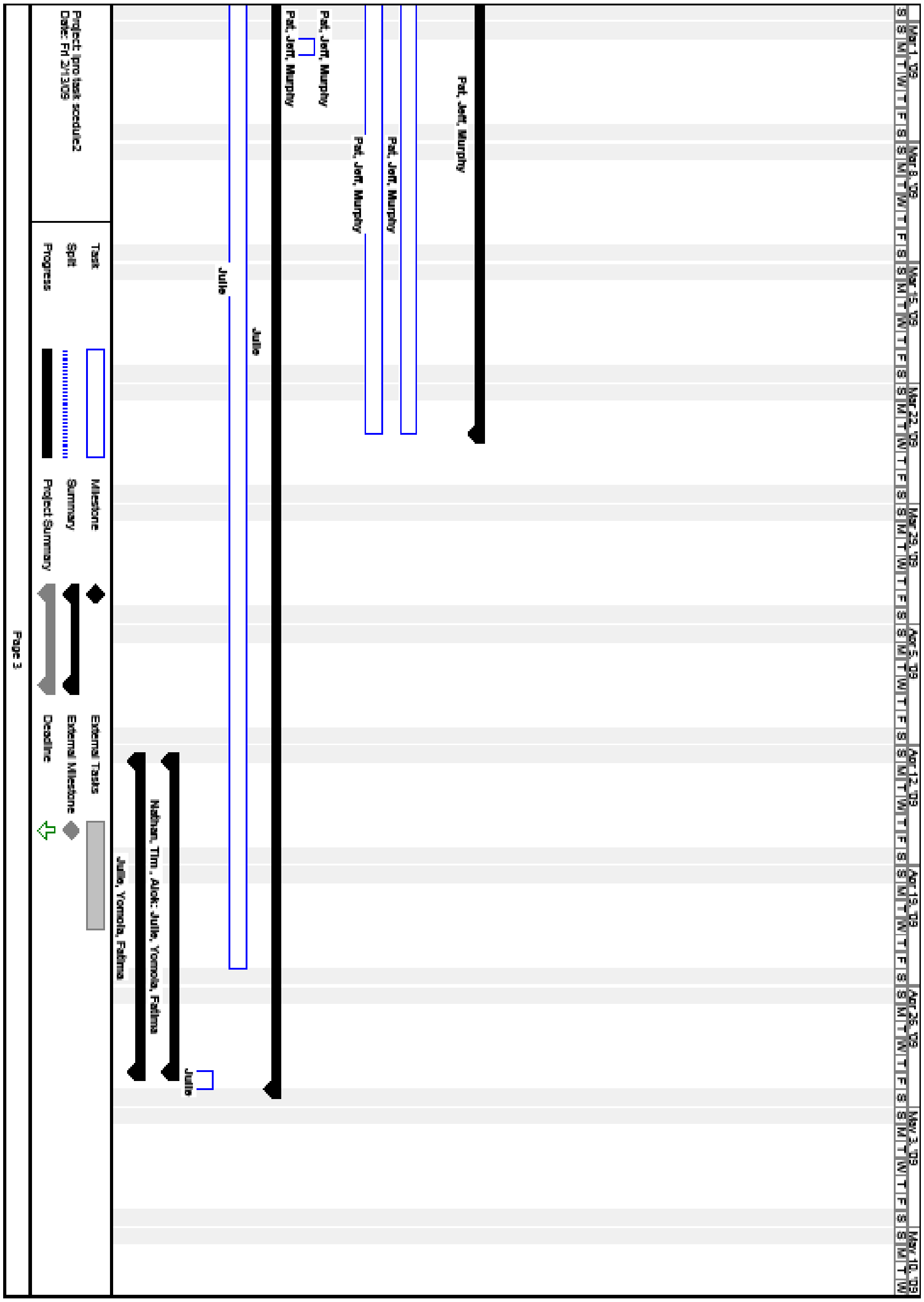
John Kelly - Endurant Energy

Stacie Frank - ComEd

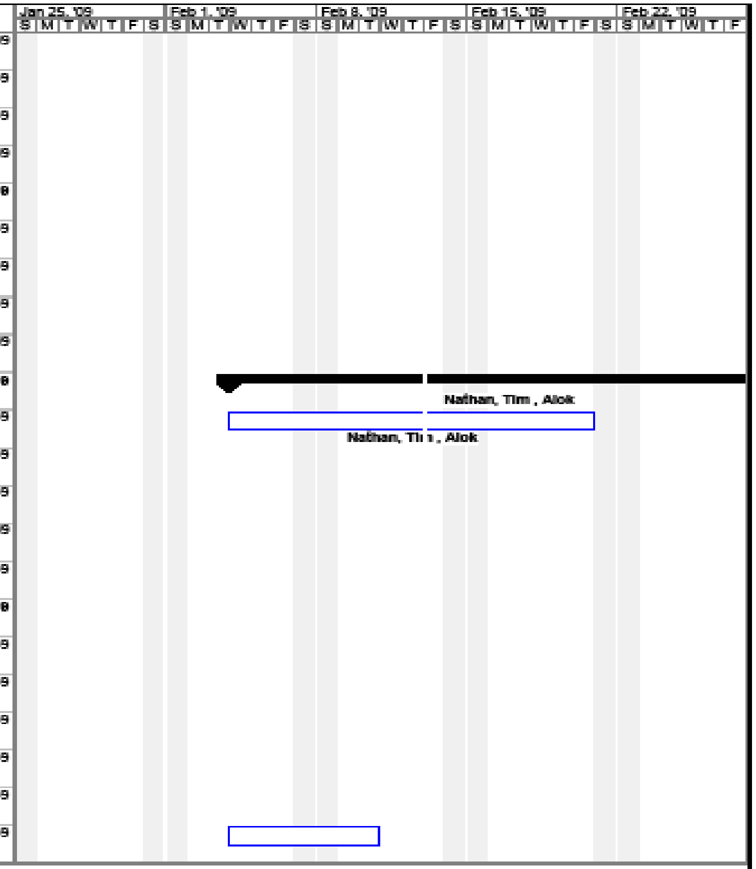
Ty Miller - TAC

APPENDIX A – Gantt Chart




Mar 1, '09
Mar 8, '09
Mar 15, '09
Mar 22, '09
Mar 29, '09
Apr 5, '09
Apr 12, '09
Apr 19, '09
Apr 26, '09
May 3, '09
May 10, '09
Pat, Jeff, Murphy
Pat, Jeff, Murphy
Pat, Jeff, Murphy
Pat, Jeff, Murphy
Pat, Jeff, Murphy
Julie
Julie
Julie
Nathan, Tim, Alok; Julie, Yomola, Fatima
Julie, Yomola, Fatima
Project: ipro task scedule2
Date: Fri 2/13/09
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 3

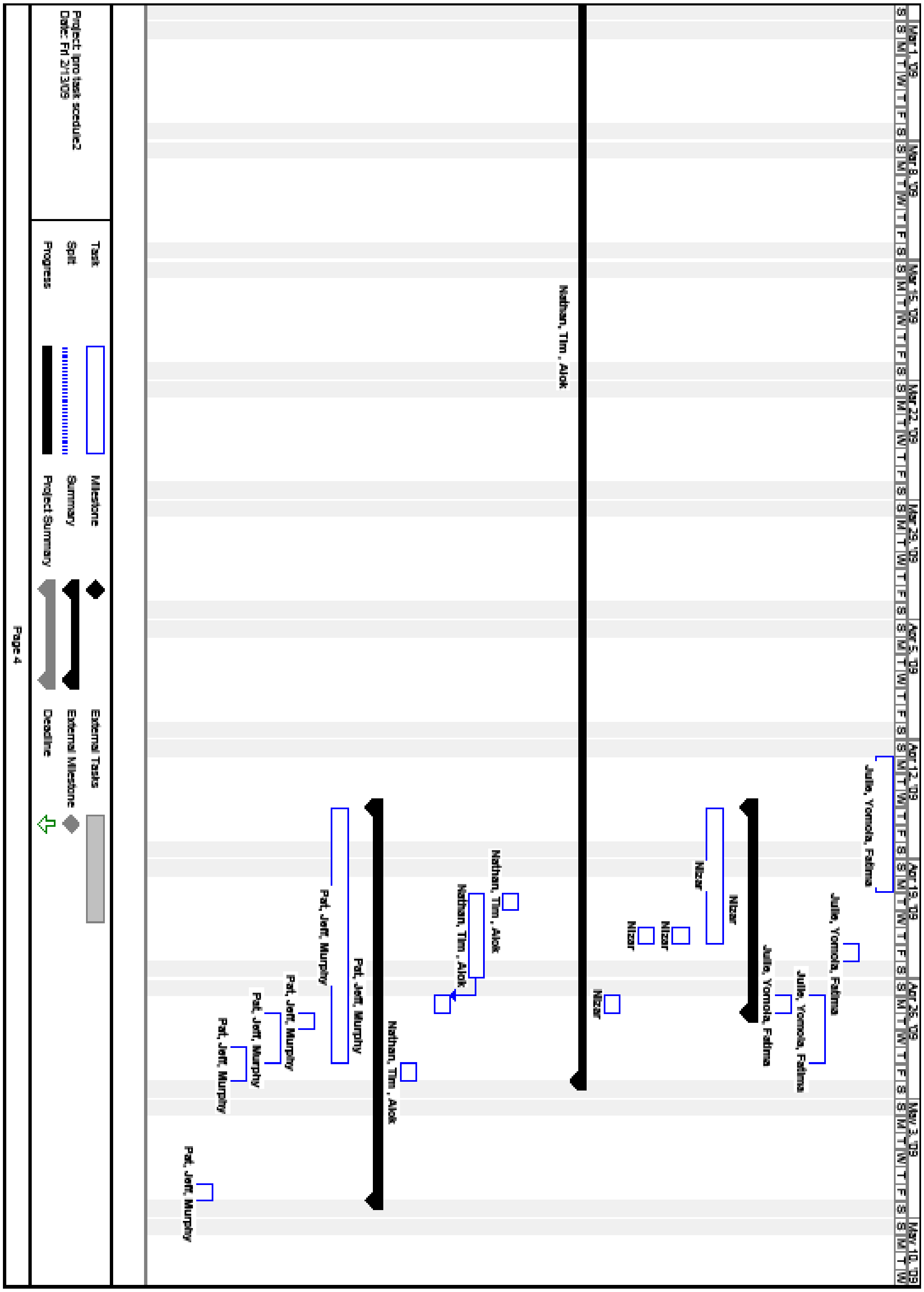
ID	Task Name	Duration	Start	Finish
24	Design Exibit/Poster Rough Draft	6 days	Mon 4/13/09	Mon 4/20/09
25	Post design for input	1 day	Fri 4/24/09	Fri 4/24/09
26	Get input from team for corrections on paper	4 days	Mon 4/27/09	Thu 4/30/09
27	Exibit/Poster Due	1 day	Mon 4/27/09	Mon 4/27/09
28	**Abstract/Brochure**	**8 days**	**Thu 4/16/09**	**Mon 4/27/09**
29	Design Abstract/Brochure	6 days	Thu 4/16/09	Thu 4/23/09
30	Post design for input	1 day	Thu 4/23/09	Thu 4/23/09
31	Get input from team for corrections on paper	1 day	Thu 4/23/09	Thu 4/23/09
32	Abstract/Brochure Due	1 day	Mon 4/27/09	Mon 4/27/09
33	**Final Presentation**	**83 days**	**Wed 2/4/09**	**Fri 6/1/09**
34	Make final presentations rough draft	13 days	Wed 2/4/09	Fri 2/20/09
35	Practice presentations	1 day	Tue 4/21/09	Tue 4/21/09
36	Make corrections to presentations	4 days	Tue 4/21/09	Sat 4/25/09
37	Practice presentation 2	1 day	Mon 4/27/09	Mon 4/27/09
38	Give presentation	1 day	Fri 5/1/09	Fri 5/1/09
39	**Final Report With Table of Content**	**17 days**	**Thu 4/16/09**	**Fri 6/8/09**
40	Make final report rough draft	11 days	Thu 4/16/09	Thu 4/30/09
41	Post final report rough draft for input	1 day	Tue 4/28/09	Tue 4/28/09
42	Get input from team for corrections on paper	3 days	Tue 4/28/09	Thu 4/30/09
43	Make corrections on final report	2 days	Thu 4/30/09	Fri 5/1/09
44	Final report due	1 day	Fri 5/8/09	Fri 5/8/09
45	Spring Break	5 days	Wed 2/4/09	Tue 2/10/09



Project: ipro task scedule2
Date: Fri 2/13/09

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Page 2


Project: ipro task scedule2
Date: Fri 2/13/09
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 4
Nathan, Tim , Alok
Julie, Yomola, Fatima
Nizar
Pat, Jeff, Murphy