# Sustainability Plan for DNCS Academy

January 30, 2009

Performed By:

MMA MSFM Cohort #6

David Henson, Nicole Phifer, Chuck Rowe, Skip Bigelow

# Table of Contents

## Background and Client Requirements

DNCS Academy is an engineering educational facility. The campus, established in 1970 and currently operating under the original conditions, covers 35 acres and is comprised of 12 individual buildings including an administrative building, a full service cafeteria, a central utilities building, 4 dorm buildings, 2 classroom buildings, a laboratory building, a library, and a gym. The central utilities building houses 3 boilers used for steam heating, the electrical distribution equipment, and 2 diesel backup generators. All rounds made on the equipment associated with building support are done on paper and filed accordingly. Water, sewer and electrical services to the campus are supplied from the city. DNCS Academy is aware of the necessity for system upgrades for both the survivability of operations and is also interested in making improvements to their existing systems to better position themselves from a business sustainability standpoint. DNCS Academy has requested that these areas be addressed in the Sustainability Plan:

- Fossil Fuel Use (Reduction in Use, Alternate Fuels)
- Electrical Power Use (Reduction, Alternate Sources)
- Lighting (Motion, Alternatives)
- Water Usage (Reductions)
- Waste Generation as a Result of Reduced Water Use
- Paper Use Reduction (Electronic logs)
- Recycling

The sustainability project as a whole will seek out potential use reductions in the above areas of focus, and furthermore seek out alternate sources and or products to further advance both the environmental benefits as well as financial savings.

Phase I of this sustainability project will focus upon use reductions of fossil fuels including natural gas and fuel oil, reductions in the use of electrical power, upgrades to campus lighting, and reductions in water usage. Comparisons will be made to show energy and cost savings as well as reduction upon environmental impact.

DNCS Academy realizes the fact that reductions in use of services such as natural gas, fuel oil, water, and electrical services will show a large benefit with little or no initial investment. Equally, DNCS Academy is anticipating the probability that these benefits gained with little or no initial investment will minimize the financial requirements of lighting upgrades in order to maximize those benefits in a short period of time.

# Recommended Initiatives (Phase 1)

## Fossil Fuel / Energy Usage Reduction:

DNCS Academy's Central Utilities Building (CUB) houses among other utilities systems and equipment, three boilers for heating, and two diesel generators for the purpose of backup or emergency power needs. The school utilizes three (3) fifty-five thousand pound Cleaver Brooks fire tube boilers for the purpose of steam heating and system operations. Under normal operations, these boilers are fired on natural gas in a lead lag manner and due to average load demands, fire at a relatively low rate. The boilers are also able to be fired on fuel oil, however this is typically only done in the event of a loss of natural gas service availability. As a result of the ability to fire the boilers on both fuels, DNCS Academy has in the past included in their annual opacity testing while on natural gas the same testing while on #2 fuel oil. The following suggested options (Option #1 and Option #2, which should not be taken as "either-or" options, but in conjunction with one another) for sustainability will offer savings calculations, both financial and from the standpoint of service dependency, as well as show the resulting improvements upon the impact to the environment. A suggested alternative to the use of fuel oil will also be made in this report's conclusion for the purpose of future options.

### Option #1 – From May 01 to October 31, Run One Boiler as Lead with No Lag

This option includes an operational change being made to the boiler control system which is as simple as programming the automation to call for only one boiler to fire instead of two to run in tandem. This change would be made during the months of warmer weather from May through October. The following research information was conducted based upon the previous operational year, and included assumptions will be noted. The aspects of reduction and savings focused primarily upon the operational requirements of a boiler in the forms of electrical and natural gas requirements.

### Electrical Consumption Savings Calculations

Assumptions:

1) One boiler will be operating 26 weeks per year.
2) Electrical Service Rated @ $0.13 per Kilowatt-Hour
3) The electrical savings calculations were taken at a firing rate of 25%. It is recognized that the augmenting fan speed is constant. The main combustion fan is driven by a VFD. A firing rate of 25% is used in this calculation as an average rate that a second boiler would be firing at throughout the 26 week period, if two boilers were in operation.

Augmenting Fan Amperage: 5 amps @ 460 VAC
Main Forced Draft Fan Amperage: 35 amps @ 460 VAC

Boiler Feed Water Pump: 33.5 amps @ 460 VAC
Total Amperage Draw for Boiler: 73.5 Amps
Total Power Consumption for Boiler: (73.5A) (460VAC) = 33,810 Watts

Total Kilowatt-Hours Saved Per Boiler for 26 Weeks of Operation:
(811.44 Kilowatt-Hours / Day) (7days / Week) (26 Weeks) = 147,682.08 Kilowatt-Hours

Total Cost Savings for Electricity to Not Drive One Boiler for 26 weeks:
(147,682.08 Kilowatt-Hours)(0.13cents / Kilowatt-Hour) = $19,198.67

Total Environmental Impact from Electrical Reduction:
Source: http://www.carbonify.com/carbon-calculator.htm
147,682.08 Kilowatts = 110.76 Tons of $CO_2$ = 553.81 Trees to Sustain

## Natural Gas Consumption Savings Calculations

Assumptions:

1) One boiler will be operating 26 weeks per year.
2) The ambient climate conditions were similar.
3) The total gas bill charges for 2008, as related to gas flow through the CUB meter set was $5,212,765.
4) One review was facilitated with two boilers in operation. The review period was 6 days, ranging from 1000 hours 05/01/08 through 1000hours 05/07/08. The ambient temperature average was 54*F during this period. The total steam production during this timeframe was 4,136,938 pounds of steam @ 120 PSIG. The total gas consumption during this time was 50,970 SCF. The boilers operating in tandem under these conditions produced 81.16 pounds of steam @ 120 PSIG / SCF of natural gas.

5) A second review was facilitated with one boiler in operation, after the plant steam generation system master control program change was accomplished. The review period was 6 days, ranging from 1000 hours 05/14/08 through 1000hours 05/20/08. During this period of time, the ambient temperature average was 57.4*F. The total steam production during this timeframe was 3,920,867 pounds of steam @ 120 PSIG. The total gas consumption during this time was 46,320 SCF. One boiler operating under these conditions produced 84.65 pounds of steam @ 120 PSIG / SCF of natural gas.

A review of this data details that operating one boiler as compared to two boilers in tandem, under the above noted conditions, yielded a 4.30% efficiency gain. The following details the projected energy and monetary savings:

Total Cost Savings through the Reduction of Gas Usage:
Operating the plant steam generation system for a period of 26 weeks per year under these conditions will yield a savings of 2.15% of the current natural gas consumption or a monetary savings of $112,074.45.

Total Volume of Natural Gas Saved:
In calendar year 2008, the plant steam generation system consumed 4,290,309 SCF of natural gas. A 2.15% reduction in this gas volume equates to 92,241.64 SCF.

Total Environmental Impact from Natural Gas Reduction:
Source: http://www.carbonify.com/carbon-calculator.htm
92,241.64 SCF of Natural Gas = 1.51 Tons of CO2 = 7.56 Trees

### Total Savings and Environmental Footprint Reduction Review from Not Operating One Boiler for 24 Weeks

By not operating one boiler for a period of 26 weeks during the warmer months of the year, DNCS Academy stands to save a substantial amount of money through service use reduction, and at the same time, reduce their environmental footprint at no additional operational cost. From the previously noted research and calculations, DNCS Academy can reduce their dependency upon their electrical and natural gas providers by 147,682.08 Kilowatt-Hours and 92,241.64 SCF respectively, which results in a total cost savings of $131,273.12 with no investment. The implementation of this option alone would reduce the schools carbon emissions by 112.27 tons, and that equates to the equivalent of 561.37 trees required to sustain the operation under normal operations.

### Option #2 – Discontinue Opacity Testing On Fuel Oil

During the annual opacity testing of the schools boilers, DNCS Academy has in the past made three runs per boiler on both natural gas and fuel oil. This test is run with the boiler firing at 100% and this condition is held for one hour per run. Assuming that fuel oil is purchased at $3.25 per gallon, each boiler averages a consumption of 400 GPH at a firing rate of 100%, and that each boiler requires a thirty minute warm up prior to the three test runs, the discontinuing of the fuel oil testing would result in a significant cost savings and reduction in their environmental footprint. It is also understood that by eliminating half of the testing operations, that the contract cost for the testing company would be reduced by 50% or $10,000.00. The following shows these results.

Reduction of Fuel Oil Dependency and Associated Cost Saving:
(400 GPH)(10.5 Hours)($3.25 per Gallon) = 4,200 Gallons and $13,650.00
Labor Savings (Assuming $75.00 per Man Hour, for 3 Operators)
(3)($75.00 per Hour)(12 Hours) = $2,700.00

Total Environmental Impact from Fuel Oil Reduction:
Source: http://www.carbonify.com/carbon-calculator.htm
4,200 Gallons of Fuel Oil = 46.81 Tons of CO2 = 234.05 Trees

### Total Savings and Environmental Footprint Reduction Review from Not Testing On Fuel Oil

By not conducting opacity testing of the three boilers while firing on fuel oil, DNCS Academy stands to reduce their environmental footprint by 46.81 tons, decrease their fuel oil dependency by

4,200 gallons and realize an operational cost saving of $26,350.00 overall. Again, it should be noted that these reductions and cost savings can be realized with no investment required.

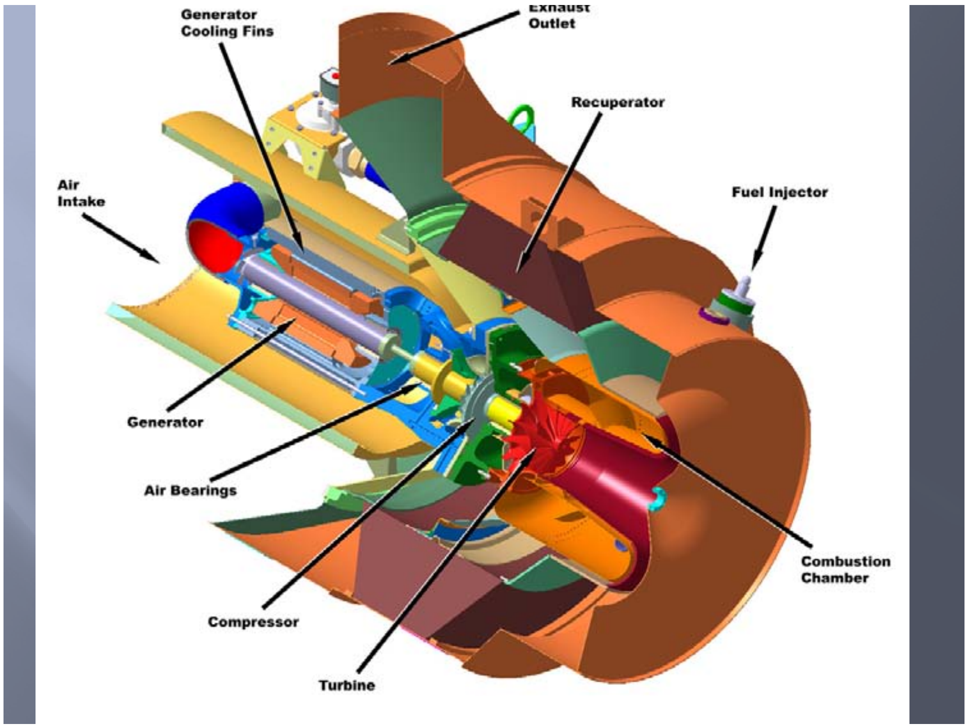
## Electrical Initiatives:

## The Vision for 100% Efficient Electrical Dependency for DNCS Academy:

DNCS Academy uses about 1.5 MWs at Peak load time. The total cost per year is 633,862.90 dollars. A good long term plan for DNCS Academy will be to head in the direction of improving efficiency, and renewable energy. This plan will include adding new equipment to older systems and to add some new stand alone sustainable electrical energy producers. The intention of this plan is to turn DNCS Academy into a power producer at times of availability while at the same time develop a rock solid cost effective and responsible plan for long term sustainability.

### Capstone Micro Turbine

First, DNCS Academy can add the new Capstone Micro turbine model C200 which can assist with producing heat, hot water in the winter time, and Air Conditioning, hot water in the warmer weather along with producing 200 KWs of electricity 24/7. This unit can be used as a standalone power source for times of peak load. It also can be connected to the main grid and be used to send power out during times of low load when the unit needs to stay in service. The turbine is air-cooled and supported on air-lubricated compliant foil bearings. The compressor impeller, turbine rotor, and generator rotor are mounted on a single shaft, which comprises the only moving part in the engine. Power electronics are solid-state, double conversion type, producing three-phase alternating current output from the high-frequency alternating current. The Micro Turbine can use landfill gas, digester gas, natural gas, bio diesel, diesel, or pure bio as fuel. The acoustic emission is at 65dbs. The heat recovery modular is capable of 980 MBTUs/Hr to be used as heat, hot water, or to produce chilled cooled water for air conditioning. Four of the C200 should be used in a parallel configuration to produce 800 KWh of electricity alone with 3920 MBTUs/Hr of heat energy.




## Geothermal Heat Pump Technologies

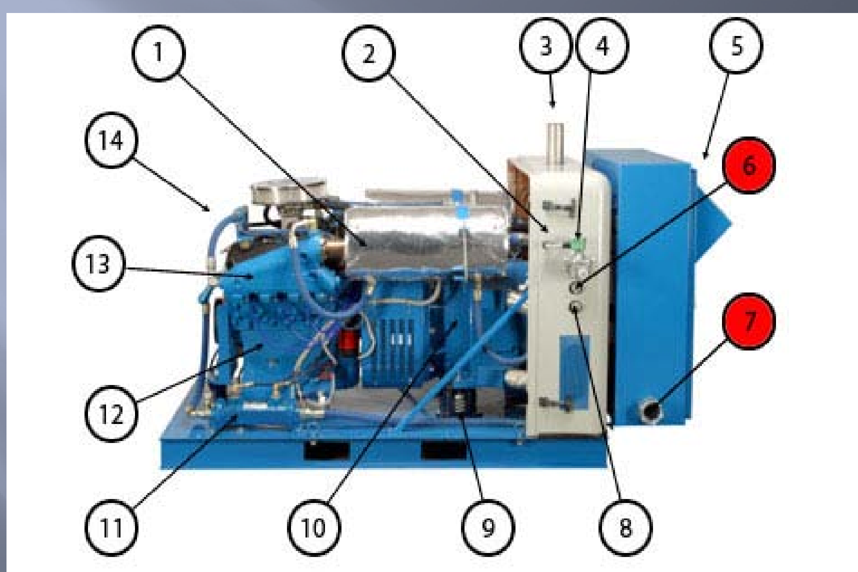
A geothermal heat pump system can and should be added to the system to improve the efficiency for both heating and cooling. This would help the overall efficiency of the co-generation system to be a triple generation. A geothermal heat pump is both reliable and efficient. With the addition of this system you would be able to warm the water for heat and hot water. The heat pump can be then used to reverse the process and be used for cooling. This geothermal heat pump system will help in raising the efficiency of the overall system. The location of this equipment would be in the different mechanical rooms located though out the campus. Geothermal heat pumps are similar to ordinary heat pumps, but use the ground instead of outside air to provide heating and air conditioning. Because they use the earth's natural heat, they are a very efficient heating and cooling technology.

## Cogeneration Bio-Diesel, Gas / Diesel Generators

Located in the Central Utilities Building for DNCS Academy are three Cleaver Brooks boilers which have the option to run on oil or gas. Along with the boilers are all the auxiliary pumps, valves, and controls. Outside of the building are two underground and up to date oil tanks. The tanks can hold diesel fuel, biodiesel, or pure bio fuel. The plan here is to remove one of the boilers to be replaced with two heat and power cogeneration biodiesel / gas / diesel generators. The combined output power from the two generators would be 150 KWs along with heat energy to be used for heating and cooling though out the campus. The Diesel Generators would be used to produce electric power and assist the larger Cleaver Brooks boilers to heat though out the campus. This power cogeneration system includes a microprocessor control panel, a protective switchgear, and heat recovery equipment. They are also enclosed in a sound attenuated cover.

# Heat and Power Cogeneration Bio-Fuel Diesel Generator

1. Exhaust gas heat exchanger
2. Sound attenuation enclosure
3. Engine exhaust
4. Natural gas input
5. U.L. Listed control panel & switchgear
6. Hot water output to DHW and boiler systems
7. Electrical output to building
8. Return water input
9. Vibration isolation
10. Induction generator
11. Oil cooler heat exchanger
12. Engine jacket heat recovery
13. Water jacketed manifold heat exchanger
14. Natural gas and Bio-Diesel fueled engine



**1.8 MW Wind Turbines**

The addition of a 1.8 MW wind turbine from Vestas would complete the vision of a sustainable energy efficient campus. This wind turbine can produce 1.8 MWs of electricity, offers high availability, outstanding grid compatibility and proven technology. Vestas has already installed more than 35,500 wind turbines with proven success. Vestas has 23% of the world's market share making them the world leader. Vestas will install the wind turbine and all of the controls needed to operate the equipment. They also offer several long term maintenance agreements. There are several reasons why wind power is an important source of energy. Wind is an unlimited resource, wind power contributes to a high degree of self-sufficiency, wind power makes it possible to establish a large number of MW in a relatively short time, wind power is a $CO_2$ neutral form of energy and is proactive in reducing greenhouse gas emission. This wind turbine will operate seven days a week 24 hours a day. I believe the average MWs produced will be 600 KWs. The output will range between 0 and 1800 kWs of power. When the Academy is producing more power than it can use the power will be sent out to the main Grid through a step-up transformer and will get equal credit for any power it uses during periods of high load and low power output from the Academy's electrical producing equipment. The savings of one 1.8 MW wind turbine is estimated to be 10,000 barrels of oil in one year. The estimated electrical cost savings is about 400,000 dollars a year following an initial investment of $1.5 million or approximately $185,000 per year under financing. DNCS Academy will also earn NOX and $CO_2$ credits in which it can sell on the open market. This money it receives can be used in pursuing more sustainable energy ideas.

## LIGHTING:

There are many different types of lighting on campus. While fluorescent is the most common type of general purpose lighting, we found other types used in the initial construction almost forty years ago! As mentioned, tubular fluorescent lamps are the most common and efficient sources of lighting in older buildings and are the most numerous upon campus. The new generation of lamps, T-8 is particularly efficient. It is important to understand that lamps and ballasts work as a system and the overall efficiency of a lighting fixture is dependent on the lamp / ballast combination. Traditional magnetic ballasts are less efficient than modern electronic ballasts. Ballasts today are required by the government to meet minimum efficiency standards. Fluorescent lamps last up to 20,000 hours of use!

Incandescent lamps (regular light bulbs) have relatively short lives (typically 1000 to 2000 hours of use) and are the least efficient of common light sources. Several locations on campus have these types of bulbs. In fact, only about 15 percent of the energy they use comes out as light – the rest becomes heat. However, these bulbs produce a pleasant color that is similar to natural light. Incandescent bulbs are the least expensive to buy, but the most expensive to operate. Reduced wattage incandescent bulbs produce nearly the same light (lumens), but consume less energy than standard bulbs.

High-intensity-discharge (HID) lamps are high output light sources that include mercury vapor, metal halide, and high-pressure and low-pressure sodium. As with fluorescent lamps, HID lights require ballasts for proper lamp operation. The efficiency of HID sources varies widely from mercury vapor with an efficiency almost as low as incandescent bulb to low-pressure sodium which is among the most efficient light sources. Most of the exterior building lighting on campus is of the older inefficient mercury vapor type; by replacing these fixtures with low-pressure sodium fixtures, substantial energy savings will be immediately recognized!

Tungsten-halogen lamps are a type of incandescent lamp that has become increasingly popular in recent years. They produce a whiter, more intense light than a standard incandescent bulb and are typically used for display and accent lighting. Halogen spotlights also have good focusing in small areas. They are about twice as efficient and last two to four times longer than most incandescent bulbs. They would make excellent low cost replacement for the sign lighting about the campus!

Compact fluorescent lamps (CFLs) are similar in operation to standard tube fluorescents but are manufactured to produce colors similar to incandescent bulbs. They are available in a range of types and sizes to meet most applications including down lighting and general space lighting. CFLs are about four times as efficient as incandescent bulbs and last up to ten times longer. However, lamp/ballast combinations that replace incandescent bulbs are more expensive than their incandescent bulb counterparts. Life expectancy, labor changing expense savings, and energy savings make CFLs perfect for replacement of most of the incandescent bulbs on campus!

Fluorescent ballasts are devices that control the starting and operation of fluorescent lamps. The lamps and ballast form a system and their overall performance is a function of the lamp/ballast combination. (Note: HID lamps also require ballasts for operation) The old standard energy-consuming magnetic ballast, such as the ones in most of the fluorescent fixtures on campus, for four-foot and eight-foot lamps are no longer available due to the federal minimum efficiency standards. Energy-saving fixed-output electronic ballasts are thirty percent more efficient than the old magnetic ballasts. Couple the energy savings of the fixed-output electronic ballast with the T-8 lamps and you will benefit from almost fifty percent energy savings from all of the retrofit able fluorescent fixtures on campus!

Control of lighting systems range from the most basic and familiar manual wall switch to sophisticated computer controlled lighting management systems. Modern advances on occupant sensing and day lighting add additional cost-effective options for managing lighting systems. A combination of time clocks and photocells will provide simple, reliable, and cost effective methods of controlling exterior lighting around campus. Occupancy sensors, whether sound, motion, or heat sensing, are used to detect the presence of people in a space and turn off lights when spaces are unoccupied. They include delays and logic systems to avoid false or too frequent turning off of light and are perfect for restrooms and infrequently used hallways and rooms on campus. Day lighting controls adjust light output levels from fixtures in perimeter areas next to windows or under skylights in response to natural outdoor lighting entering the building, perfect for the cafeteria, library, gym and the glass corridors!

The lighting schedule, cost analysis and return-on-investment (ROI) tables, based on $0.13/KWH and $75.00/hr labor rate are located at the end of this report, as Attachment A. Substantial savings are available by performing the first stage. The second and third stages are listed, as well.

## Water Reductions:

By evaluating water usage and implementing water conservation practices anyone can realize reduced operating expenses through energy savings, and reduced water and sewer costs. At the DNCS Academy, we looked at changing out the older, less efficient models of faucets, shower heads, and toilets with the newer more environmentally friendly models of today. The average toilet uses 3-7 gallons per flush, and a 5 minute shower can use anywhere between 25-50 gallons. Things like brushing your teeth and washing your hands with the tap running uses 2 gallons per minute. One of the first steps we took was to identify unnecessary uses and fix any leaks. A tap leaking one drop of water per second wastes more than 6.5 gallons of water per day, or 2,372.5 gallons a year. It is important to educate the faculty, staff and students, as well as involve them in the water efficiency effort.

When we looked into shower heads for the showers on campus we found two models of low flow shower heads, the Aerating model and the Non-aerating model. The Aerating model mixes air into the water stream. This maintains steady pressure so the flow has an even, full shower spray. Because the air is mixed in with the water, the water temperature can cool down a bit towards the floor of the shower. This is the most popular model. In the Non-Aerating model the air is not mixed into the water stream. This maintains the temperature well and delivers a strong spray. The water flow pulses with non-aerating shower heads, giving more of a massaging effect. A typical, simple shower head is a perforated nozzle that distributes the water over a large solid angle. Less water can be used to wet the same area. Low flow shower heads can use water more efficiently by aerating the water stream. We chose to replace existing shower heads at the academy with a chrome plated 1.6 gpm high efficiency shower head. This shower head delivers the performance of a regular 2.5 gpm spray but requires only 1.6 gpm. The spray technology controls the waters shape and velocity, allowing the spray to satiate with a full-body spray that feels like a high-flow shower, while using less water. The spray surpasses standard showers using thermal technology that produces a larger spray droplet which stays warmer longer. Some of the key benefits are easy installation, 36% water savings pays for investment in as little as six months, and great spray performance. Each shower head costs $29.99.

There are many faucet aerators out in the market today. We chose the standard faucet aerator. A 1.0 gpm flow rate which is best suited for bathrooms. This particular faucet is also available in 1.5 and 2.0 gpm. Basically Faucet aerators break water flow into fine droplets to maintain "wetting effectiveness" while using less water. These faucets are water saving, they increase spray velocity, and reduce splash. They are water efficient, save money and the energy used to heat hot water. Less water used means less stress on septic systems or reduced cost associated with waste water treatment. The cost of this type of faucet is $1.39.

A low flush toilet is a flush toilet that uses significantly less water than a normal flush toilet, using as little as 6 liters, or 1.6 gallons per flush as opposed to the usual 13 liters, or about 3.4 gallons was put into use in the U.S. in the 1990s. Installing a low-flush toilet, which uses 6 liters or less per flush, or placing a toilet insert or weighted plastic bottle filled with water in the water tank can conserve water. Toilets use over 40% more water than needed. Low-flow toilets are available at places like Lowes and Home Depot. The Pegasus Cottage Collection 1.28 gallons per flush all-in-one HET Flapper-less elongated toilet is sold at Home Depot for $149.00. This toilet uses Niagara Flapper-less flush technology which eliminates flappers or any other type of seal in your toilet. The 1.28 gallons per flush cannot be increased. If the cost of changing out these toilets is a concern, one might consider the Toilet Tummy. The Toile Tummy is effective, low in cost, maintenance free and user friendly. It is the least complex and easiest to use toilet tank water saving product. All you have to do is fill the tummy with water and hang it on the inside of the toilet tank wall and forget about it. It saves an approximate 80 to 160 oz of water per flush depending on whether one or two are used. It never needs maintenance.

For the laundry rooms in the dormitories, we want to replace the washing machines with front loading washing machines. Front loading washers save the amount of energy and water consumed. Front loading washers will use around 10 gallons of water per full load, while top loading washers use 40 gallons per full load.

The following calculations show the water saving potential and cost versus monetary benefits of the previously mentioned options. These calculations were made having made the assumptions that all showers were used daily an average of 12 times for 15 minutes, the toilets were all used daily an average of 24 times, and the washing machines were all used daily an average of 6 times. Sink usage was not included due to the variances in time used. It should also be assumed that the school pays a water charge of $5.50 for every 1,000 gallons used and a sewer charge of $7.50 per 1,000 gallons.

| **Item Description** | **Dollar Amount** | **Water Saving** | **Cost Benefit** |
|---|---|---|---|
| 56 toilets at $149.00 | $8,344.00 | 2,849 gallons / day | $37.04 / day |
| 34 Showers at $29.99 | $1019.66 | 5,508 gallons / day | $71.60 / day |
| 16 Washing machines at $600.00 | $9,600.00 | 2,880 gallons / day | $37.44 / day |

It can be seen that the noted changes have greatly lessened the dependency upon the water and sewer services. On a daily basis, the school stands to decrease its water and sewer usage by 11,237 gallons. This will result in a monetary savings of $146.08 per day. Although this value may seem small, when compared to the initial investment of $18,963.56, the return on investment is achieved in only 130 days or 4.5 months. On an annual basis and following the initial investment, DNCS Academy stands to save $53,319.

## Change Management

In accompaniment of the previously mentioned suggestions, a degree of change management will also be required for optimal benefit realization. It is our recommendation that senior leadership hold a "roll out" meeting in order to fully communicate the results and findings of this report, the schools intentions, and actions to be taken. We also recommend that a departmental lead be assigned the role of reporting back to senior leadership at regular intervals the progress and results of actions being taken in the form of a cost versus benefit metrics. These reports should include initial investments, costs of implementation, benefits and savings realized, as well as potential hurdles and actions taken as a result. Ongoing operations and projects should also be communicated throughout the community via the schools web site, and community awareness should be emphasized through inclusion on a volunteer basis, in parallel with regular reporting of accomplishments and obstacles through town newsletters and meetings. Inclusion of the students in these programs is also highly recommended. We suggest that DNCS Academy align its goals for these projects with an offering to the student curriculum in the form of environmentally sustainable classes, labs, and potentially extracurricular programs for various types of either monetary of class credit rewards.

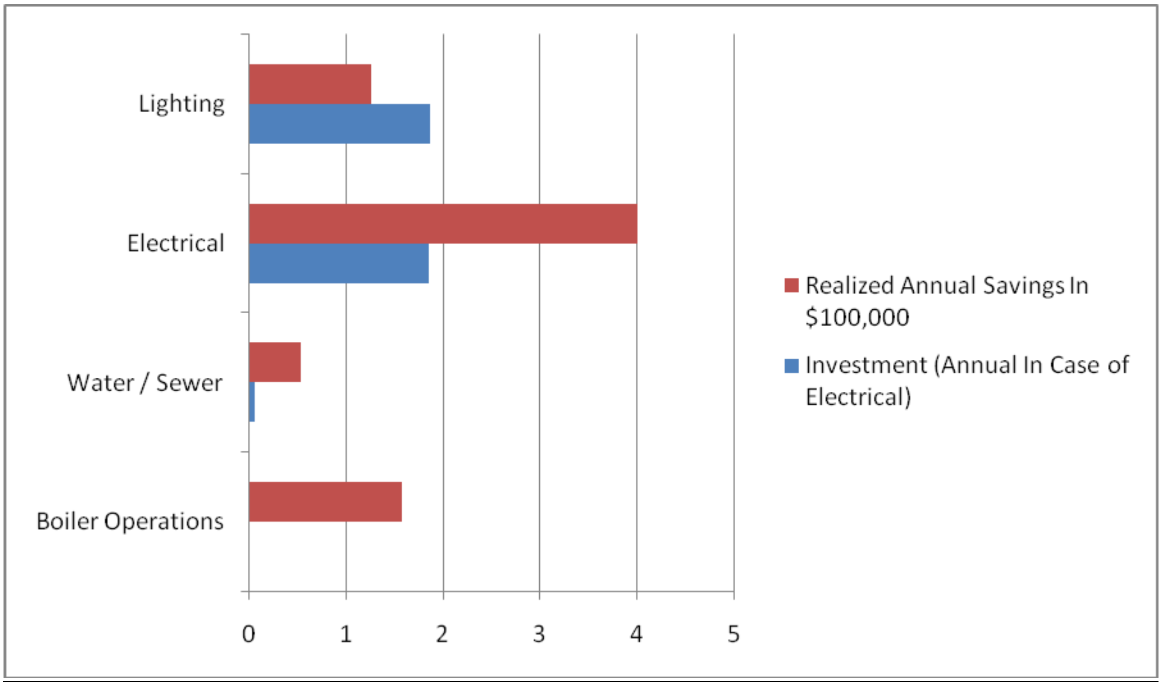
The alignment of everyone's efforts that are affected either directly or indirectly by the schools efforts to become more environmentally sustainable is not only a good idea, but it will prove to be essential. Through constant and clear communication, the utilization of a diverse set of ideas and skill sets, and the support and drive of the project by constituents, this effort is sure to be a success.

## Recommendations for Future Initiatives

Following the implementation of this reports phase 1 suggestions, DNCS Academy has further opportunities available to them that will continue to further their independency upon services, add to their monetary savings, and continue to diminish their environmental footprint. Examples of future initiatives that have already been discussed include further advancements in the electrical department with the purchasing of a Capstone Micro Turbine and or a Cogeneration Biodiesel Generator, further improvements upon campus lighting which has been shown to have an average return on investment of 2.5 years, and further water and sewer usage reductions while targeting campus sinks. Other suggestions that this report will support are the transfer to a paperless system for logging of operational systems, as well as the purchasing and use of a biodiesel processor. A paperless logging system would show substantial cost savings not only in the decrease of paper purchasing, but also from the decreased need for printing and administrative work. Purchasing a biodiesel processor would allow DNCS Academy to actually produce their own fuel to run diesel fueled equipment and automobiles. Biodiesel can be processed for less than one dollar per gallon while at the same time, reducing their cafeteria oil waste which they currently pay to have removed.  Biodiesel fuels are biodegradable, non toxic, and they produce between eighty and ninety percent less carbon emissions when burned.


## Cost Versus Benefit Analysis

This sustainability report has shown that DNCS Academy has a number of opportunities to improve upon its environmental impact while at the same time reducing its dependency upon local service providers and as a result save monetary funds.  The majority of these opportunities will require little or no initial investment to implement, and have a dramatically favorable impact.  Operational modifications made to the boilers will require no investment and will result in an annual savings of $157,623.  Modifications made to the water systems, including campus washing machines, toilets and showers, following an initial investment of $18,964 will result in an annual savings of $53,290.  Phase 1 lighting modifications will show an overall return on investment of 1.5 years following the initial investment of $186,913 which will generate an annual savings of $125,333.  The initial investment, realizing that approximately half would be covered by state and federal grants, for the purchasing and construction of the schools 1.8 megawatt wind turbine would be $1.5 million.  This results in a return on investment of 3.75 years, however when the investment is spread out over time through financing, approximately $185,000 per year, the annually estimated $400,000 electrical savings results in an annual profit of $215,000.  The following graphical representation shall show an alternative cost versus benefit visualization on the first year’s basis.




## (Attachment B) - Lighting Schedule, Cost Analysis and (ROI) Tables

**LIGHTING SCHEDULE (Quantity of FIXTURES)**

### ADMINISTRATION

| | | | |
|---|---|---|---|
| Hallways/Stairwells | 2 lamp - 8' T-12 fluorescent tube | Qty | 32 |
| Restrooms (4) | 1 lamp - 2' T-12 fluorescent U tube | Qty | 24 |
| Kitchenette | 2 lamp - 4' T-12 fluorescent tube | Qty | 2 |
| Lobby/Reception | 2 lamp - 8' T-12 fluorescent tube | Qty | 12 |
| Conference Room | 4 lamp - 4' T-12 fluorescent tube | Qty | 7 |
| Admissions/Bursar | 4 lamp - 4' T-12 fluorescent tube | Qty | 5 |
| Dean's Suite | 4 lamp - 4' T-12 fluorescent tube | Qty | 7 |
| Faculty Offices (32) | 4 lamp - 4' T-12 fluorescent tube | Qty | 32 |
| Basement/Mechanical | 2 lamp - 8' T-12 fluorescent tube | Qty | 20 |
| Exterior Doors (6) | 1 lamp - 150W mercury vapor | Qty | 12 |

### CAFETERIA

| | | | |
|---|---|---|---|
| Entryways (3) | 2 lamp - 8' T-12 fluorescent tube | Qty | 6 |
| Kitchen area | 2 lamp - 8' T-12 fluorescent tube | Qty | 16 |

| | | |
|---|---|---|
| Serving/Clearing | 2 lamp - 8’ T-12 fluorescent tube | Qty 10 |
| Dining Area | 2 lamp - 8’ T-12 fluorescent tube | Qty 32 |
| Rest Rooms (2) | 1 lamp - 2’ T-12 fluorescent U tube | Qty 24 |
| Basement/Mechanical | 2 lamp - 8’ T-12 fluorescent tube | Qty 14 |
| Exterior Doors (3) | 1 lamp - 150W mercury vapor | Qty 6 |

**CENTRAL UTILITIES**

| | | |
|---|---|---|
| Offices (6) | 2 lamp - 4’ T-12 fluorescent tube | Qty 9 |
| Machine Shop | 2 lamp - 8’ T-12 fluorescent tube | Qty 8 |
| Shop | 2 lamp - 4’ T-12 fluorescent tube | Qty 4 |
| Locker Room | 2 lamp - 4’ T-12 fluorescent tube | Qty 4 |
| Storage Rooms (4) | 2 lamp - 8’ T-12 fluorescent tube | Qty 8 |
| Power House | 1 lamp - 250W mercury vapor | Qty 25 |
| Exterior Doors (5) | 1 lamp - 150W incandescent bulb | Qty 5 |
| Exterior Building Floods (6) | 1 lamp - 250W mercury vapor | Qty 6 |

**DORMITORIES (FOUR IDENTICAL)**

| | | |
|---|---|---|
| Entryways (2 ea, 8) | 2 lamp - 8’ T-12 fluorescent tube | Qty 8 |
| Hallways/Stairwells | 2 lamp - 8’ T-12 fluorescent tube | Qty 48 |
| Common Areas (3 ea, 12) | 4 lamp - 4’ T-12 fluorescent tube | Qty 48 |
| Rooms (96 ea, 576) | 2 lamp - 4’ T-12 fluorescent tube | Qty 2304 |
| Showers/Rest Rooms (6 ea, 24) | 2 lamp - 4’ T-12 fluorescent tube | Qty 288 |
| Laundry Rooms (1 ea, 4) | 2 lamp - 8’ T-12 fluorescent tube | Qty 12 |
| Exterior Doors (2 ea, 8) | 1 lamp - 150W mercury vapor | Qty 32 |
| Mechanical Room (1 ea, 4) | 2 lamp - 4’ T-12 fluorescent tube | Qty 16 |

**CLASSROOM BUILDINGS (TWO IDENTICAL)**

| | | |
|---|---|---|
| Entryways (4 ea, 8) | 2 lamp - 8’ T-12 fluorescent tube | Qty 12 |
| Hallways/Stairwells | 2 lamp - 8’ T-12 fluorescent tube | Qty 24 |
| Class Rooms (20 ea, 40) | 1 lamp - 300W incandescent bulb | Qty 600 |
| Lecture Halls (2 ea, 4) | 1 lamp - 300W incandescent bulb | Qty 96 |
| Rest Rooms (8 ea, 16) | 1 lamp - 2’ T-12 fluorescent U tube | Qty 128 |
| Exterior Doors (4 ea, 8) | 1 lamp - 150W mercury vapor | Qty 16 |
| Mechanical Room (1 ea, 2) | 2 lamp - 4’ T-12 fluorescent tube | Qty 8 |

**LABORATORY BUILDING**

| | | |
|---|---|---|
| Entryways (4) | 2 lamp - 8’ T-12 fluorescent tube | Qty 6 |
| Hallway | 2 lamp - 8’ T-12 fluorescent tube | Qty 12 |
| Labs (6) | 2 lamp - 8’ T-12 fluorescent tube | Qty 144 |
| Class Rooms (4) | 1 lamp - 300W incandescent bulb | Qty 60 |

| | | | |
|---|---|---|---|
| Rest Rooms (4) | 1 lamp - 2’ T-12 fluorescent U tube | Qty | 32 |
| Basement/Mechanical | 2 lamp - 8’ T-12 fluorescent tube | Qty | 20 |
| Exterior Doors (4) | 1 lamp - 150W mercury vapor | Qty | 8 |

**LIBRARY**

| | | | |
|---|---|---|---|
| Entryways (2) | 4 lamp - 4’ T-12 fluorescent tube | Qty | 2 |
| Rest Rooms (2) | 1 lamp - 2’ T-12 fluorescent U tube | Qty | 16 |
| Study/Meeting Rooms (12) | 4 lamp - 4’ T-12 fluorescent tube | Qty | 18 |
| Offices (6) | 4 lamp - 4’ T-12 fluorescent tube | Qty | 9 |
| Library Hall | 1 lamp - 250W mercury vapor | Qty | 32 |
| Mechanical Room | 2 lamp - 4’ T-12 fluorescent tube | Qty | 4 |

**GYMNASIUM**

| | | | |
|---|---|---|---|
| Front Entryway | 4 lamp - 4’ T-12 fluorescent tube | Qty | 5 |
| Display Cabinets (8) | 1 lamp - 100W incandescent bulb | Qty | 32 |
| Side/Rear Exits (3) | 4 lamp - 4’ T-12 fluorescent tube | Qty | 6 |
| Locker Rooms (2) | 2 lamp - 8’ T-12 fluorescent tube | Qty | 14 |
| Rest Rooms (4) | 4 lamp - 4’ T-12 fluorescent tube | Qty | 4 |
| Exercise Room | 2 lamp - 8’ T-12 fluorescent tube | Qty | 10 |
| Weight Room | 2 lamp - 8’ T-12 fluorescent tube | Qty | 10 |
| Assembly Room | 2 lamp - 8’ T-12 fluorescent tube | Qty | 16 |
| Gym/Track | 1 lamp - 250W mercury vapor | Qty | 35 |
| Mechanical Room | 2 lamp - 4’ T-12 fluorescent lamp | Qty | 10 |

**PARKING LOT and AREA LIGHTING**

| | | | |
|---|---|---|---|
| Single Lamp Poles (24) | 1 lamp - 300W mercury vapor | Qty | 24 |
| Double Lamp Poles (20) | 2 lamp - 300W mercury vapor | Qty | 20 |

## PHASE ONE - LIGHTING UPGRADE SCHEDULE

**ADMINISTRATION**

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Hallways/Stairwells 24hr | 128 | 864 | 900 | $ 2396 | 0.8 |
| Restrooms 24hr | 144 | 552 | 900 | 1348 | 1.2 |
| Kitchenette 12hr | 8 | 46 | 150 | 115 | 1.8 |
| Lobby/Reception 24hr | 96 | 324 | 300 | 899 | 0.8 |
| Conference Room 12hr | 56 | 210 | 525 | 265 | 3.0 |
| Admissions/Bursar 12hr | 80 | 150 | 375 | 188 | 3.2 |
| Dean’s Suite 12hr | 56 | 210 | 525 | 265 | 3.0 |

| | | | | | |
|---|---|---|---|---|---|
| Faculty Offices 12hr | 256 | 960 | 2400 | 2396 | 1.5 |
| Basement/Mechanical 8hr | 160 | 560 | 750 | 499 | 3.0 |

## CAFETERIA

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Entryways 24hr | 48 | 162 | 450 | $ 499 | 1.3 |
| Kitchen area 18hr | 128 | 432 | 600 | 899 | 1.3 |
| Serving/Clearing 18hr | 80 | 270 | 375 | 562 | 1.3 |
| Dining Area 18hr | 256 | 864 | 1200 | 1,798 | 1.3 |
| Rest Rooms 24hr | 144 | 552 | 1800 | 1,348 | 1.8 |
| Basement/Mechanical 8hr | 112 | 322 | 525 | 350 | 2.8 |

## CENTRAL UTILITIES

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Office 12hr | 36 | 207 | 675 | $ 253 | 3.6 |
| Machine Shop 12hr | 64 | 216 | 300 | 299 | 2.0 |
| Shop 12hr | 16 | 92 | 150 | 112 | 2.3 |
| Locker Room 18hr | 16 | 92 | 300 | 170 | 2.4 |
| Exterior Doors 12hrs | 35 | NA | 75 | 245 | 0.5 |

## DORMITORIES (FOUR IDENTICAL)

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Entryways 24hr | 64 | 216 | 600 | $ 599 | 1.5 |
| Hallways/Stairwells 24hr | 384 | 1296 | 1800 | 3,595 | 1.0 |
| Common Areas 24hr | 384 | 1104 | 1800 | 3,595 | 0.9 |
| Rooms 8hr | 9216 | 52992 | 43200 | 43,120 | 2.5 |
| Showers/Rest Rooms 24hr | 1152 | 6624 | 10800 | 16,175 | 1.1 |
| Laundry Rooms 24hr | 96 | 324 | 600 | 899 | 1.1 |
| Mechanical Room 8hr | 64 | 368 | 600 | 300 | 3.5 |

## CLASSROOM BUILDINGS (TWO IDENTICAL)

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Entryways 24hr | 96 | 276 | 900 | $ 899 | 1.4 |
| Hallways/Stairwells 24hr | 192 | 552 | 1800 | 1,800 | 1.4 |
| Class Rooms 12hr | 4200 | NA | 9000 | 16,848 | 0.8 |
| Lecture Halls 12hr | 672 | NA | 1440 | 2,696 | 0.8 |
| Rest Rooms 24hr | 768 | 2944 | 5400 | 7,189 | 1.3 |
| Mechanical Room 8hr | 32 | 540 | 750 | 150 | 8.8 |

### LABORATORY BUILDING

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Entryways 24hr | 48 | 162 | 450 | $ 450 | 1.5 |
| Hallway 24hr | 96 | 824 | 1800 | 899 | 3.0 |
| Labs 12hr | 1152 | 3888 | 5400 | 5,392 | 1.9 |
| Class Rooms 12hr | 420 | NA | 900 | 1,685 | 0.8 |
| Rest Rooms 24hr | 192 | 736 | 1350 | 1,800 | 1.3 |
| Basement/Mechanical 8hr | 16 | 92 | 300 | 50 | 8.1 |

### LIBRARY

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Entryways 24hr | 16 | 60 | 150 | $ 149 | 1.5 |
| Rest Rooms 24hr | 96 | 368 | 1200 | 899 | 1.9 |
| Study/Meeting Rooms 12hr | 144 | 540 | 1350 | 675 | 3.0 |
| Offices 12hr | 72 | 270 | 675 | 337 | 3.0 |
| Mechanical Room 8hr | 16 | 92 | 300 | 75 | 5.5 |

### GYMNASIUM

| LOCATION | LAMP COST | BALLAST COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|---|
| Front Entryway 24hr | 40 | 150 | 300 | $ 375 | 1.3 |
| Display Cabinets 12hr | 192 | NA | 150 | 300 | 1.1 |
| Side/Rear Exits 24hr | 48 | 180 | 450 | 449 | 1.5 |
| Locker Room 18hr | 112 | 378 | 750 | 786 | 2.0 |
| Rest Rooms 24hr | 32 | 120 | 300 | 299 | 1.5 |
| Exercise Room 12hr | 80 | 270 | 750 | 375 | 2.9 |
| Weight Room 12hr | 80 | 270 | 750 | 375 | 2.9 |
| Assembly Room 12hr | 128 | 432 | 1200 | 600 | 2.9 |
| Mechanical Room 8hr | 40 | 230 | 375 | 187 | 3.5 |

## PHASE TWO – LIGHTING UPGRADE SCHEDULE

### MERCURY VAPOR CEILING, EXTERIOR DOORS and WALLPACKS

| LOCATION | FIXTURE COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|
| Admin Exterior Doors 12hr | 1350 | 900 | $ 1,179 | 1.9 |
| Cafeteria Exterior Doors 12hr | 675 | 450 | 590 | 1.9 |
| Utilities - Power House 24hr | 5000 | 3750 | 8,190 | 1.1 |
| Exterior Building 12hr | 1500 | 900 | 983 | 2.4 |
| Dormitories Exterior Doors 12hr | 7200 | 4800 | 3,145 | 3.8 |
| Classroom Exterior Doors 12hr | 3600 | 2400 | 1,573 | 3.8 |
| Laboratory Exterior Doors 12hr | 900 | 1200 | 787 | 2.6 |

| | | | | |
|---|---|---|---|---|
| Library Hall 18hr | 8000 | 7200 | 7,865 | 1.9 |
| Gym/Track 18hr | 8750 | 7878 | 8,600 | 1.9 |

## PHASE THREE – LIGHTING UPGRADE SCHEDULE

### PARKING LOT and AREA LIGHTING

| LOCATION | FIXTURE COST | LABOR COST | ENERGY SAVING/YR | YR-ROI |
|---|---|---|---|---|
| Single Lamp Poles 12hr | 9600 | 7200 | $ 4,717 | 3.6 |
| Double Lamp Poles 12hr | 16000 | 6000 | 7,826 | 2.8 |