

## Leveraging Inefficient and Failing Infrastructure to Accomplish Capital Improvements

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### ABSTRACT

The Hiram G. Andrews Center, a 585,000 s.f., 600-person residential educational and rehabilitation center located in Johnstown, PA, completed a total renovation of its failing central plant through the combination of life cycle repair/replacement funds and by capturing future labor and energy savings which were possible by replacing the existing central plant. Typically, energy savings projects are funded solely through energy and operational savings with little thought given to the future reinvestment that might be required, regardless of the implementation of a performance contract. The synergy that takes place when capital funds are combined with the quantified and guaranteed savings that are available through a performance contract can provide improvements and technology that could not be accomplished via either funding mechanism on its own.

This paper will look at the HGA case study including an analysis of the capital funds, energy savings and operational savings utilized to fund the project. While this project involved upgrades to lighting, HVAC, and controls within the facility, this paper will only detail the issues at the central plant.

### INTRODUCTION

In June of 2000 the Hiram G. Andrews Center (HGAC) faced the same challenges as many state owned facilities this age, failing systems and infrastructure and a cumbersome process for achieving improvements. It was at this time that the Department of General Services was implementing a process to allow state agencies to take advantage of the recently adopted Guaranteed Energy Savings Act (GESA, then Act 57 now Act 77 in the Commonwealth of Pennsylvania) which would allow energy based performance contracting. The Business Manager for HGAC attended an informational meeting and recognized the challenges and opportunities that existed at her facility. Specifically, major repairs were needed on one coal fired boiler in order to allow continuing operation. This need for repairs was following on the heels of previous repairs and investment in the other boilers. Essentially, the boiler plant was failing beyond normal repair, the

exterior lighting fixtures were operational but structurally unsound, and the under-floor radiant heating system was developing leaks and proving unreliable in many areas. The major question became; was there sufficient energy savings available to pay for all of the deferred maintenance needs at HGAC? The short answer was no.

Many performance contracts have resulted in dissatisfied owners or in extreme cases in litigation due to inflating projects beyond a reasonable scope through the use of "non-energy" savings. The HGAC project is an example of a project where funding streams were available from multiple sources. The leadership of HGAC and its governing agency, the Department of Labor and Industry, chose to: recognize the need to invest capital in the central plant regardless of the implementation of an energy savings project; identify the energy savings that would result through the construction of a new plant; identify the potential energy generation capacity that could be implemented in a newly designed plant; and identify the potential labor savings through the natural reduction in central plant operating staff through near term retirement plans of the existing workers if a less cumbersome plant design were implemented. The result was a project scope that could not have been achieved with the existing funding from the using agency alone or by utilizing energy savings and generation capacity which would be accomplished through the performance contract. Essentially, the sum of the individual funding streams resulted in a more effective solution than could have been accomplished by energy savings or capital improvement dollars alone.

### PRE-PROJECT CONDITIONS

HGAC, which is completely barrier-free, covers 12 acres or 522,370 square feet under one roof. This residential center conducts a comprehensive program of services featuring the integration of education, counseling, evaluation, medical maintenance, and therapy in a barrier-free environment.

#### Conditions at Time of Proposal

The condition of the existing heating plant was a major driving factor in this project, especially since it

provides both heating and cooling (via steam absorption chillers). The three existing coal fired boilers, installed in 1957, were still in their original condition. These boilers and the supporting balance of plant (BOP) were critical to the facility. Much of the BOP was in poor condition and was maintained in operating condition at great expense (and with much scavenging of parts). Apart from the 24 hour per day, 7 day a week nature of HGAC's core function, the facility also houses the Crichton Center (facility SIC Code 8069 – Specialty Hospitals, except Psychiatric). Loss of steam at the plant would require evacuation of The Crichton Center and, depending on time of year, perhaps all of HGAC. At a minimum, it would shut down all heating, cooling, and much of the kitchen. Thus, the importance of making good decisions about the heating plant was critical. There were both short- and long-term considerations to be evaluated, the most critical of the short-term considerations was that Boiler #1 was inoperable and would require extensive re-tubing before it could be operated again. Equally important, the main building pressure reducing valve (PRV) station and the deaerator (DA) tank / feed water systems were very old and staff was using scavenged parts to keep them operational. All of these systems needed work that had been deferred pending the outcome of the Guaranteed Energy Savings Program process.

Initially, three options were considered during the preliminary Proposal phase. These can be simply defined as:

- a) Renovate the plant. This involved re-tubing the existing boilers and rebuilding most of the coal transportation system.
- b) Build a new coal-fired plant. This involved replacing the existing boilers in-kind and rebuilding the coal transportation system.
- c) Build a new dual fuel gas and oil plant. This would be a wholesale replacement of the existing boilers and BOP, and would not require rebuilding the coal infrastructure. This option would require the addition of a new natural gas and No. 2 fuel oil delivery infrastructure.

Research done at the time of the Proposal eliminated the new coal-fired plant option. Subsequent research confirmed the non-feasibility of this option for HGAC. Among the reasons for this were:

*Cost:* A new written cost quote for a turn-key project was provided by a separate mechanical contractor.

The sub-contractor cost was estimated at \$5,740,587 and a total project cost of \$7,175,734 (including engineering design, construction management, commissioning, etc).

*Emissions:* Installing new equipment would require HGAC to meet current new source performance standards for emissions (retrofit generally does not). The estimated cost of the emission mitigation equipment was \$1,000,000 to \$1,500,000 (the above coal plant cost did not include this emissions equipment cost, as it could not be determined with certainty that it would be required).

*Permits:* The new emissions permits were estimated to add at least six months to the permitting process - time that HGAC did not have.

*Efficiency:* The resulting plant would not have been significantly more efficient than the existing plant nor would the operating and maintenance costs be significantly reduced.

Therefore, while producing significant gains in reliability, this option was eliminated from consideration due to its cost and minimal gain in operational savings. In summary, HGAC did not have the capital necessary for this option, so it was subsequently eliminated from consideration.

#### Investment Grade Audit Phase

Between the time of the proposal and the preparation of the Investment Grade Audit (IGA), the situation in the plant had deteriorated. As of 01 December 2001, Boiler #3 was also inoperable. The proximate cause was that the stoker had ripped a wear plate loose. These boilers are nearly 45 years old and comprised of mostly original components. All the boilers had very similar run times, and thus there was no reason not to expect the failures that had occurred on Boilers #1 and #3 couldn't have occurred to Boiler #2 at any time.

#### Remaining Options

As a result, two practical options remained to HGAC.

Renovate the existing plant which would allow HGAC to continue to enjoy the extraordinarily low energy costs associated with coal (\$0.16 per therm at the time of the IGA preparation). However, it would not replace all components within the boilers. It would require rebuilding some equipment that was antiquated. It did not address plant emissions which were already more stringent than other areas of the state due to the valley location of the town of

Johnstown. These standards forced HGAC to transport coal significant distances because burning local coal placed them in violation of existing stands. This option did not reduce non-energy operating costs. In many cases, rebuilding the antiquated equipment was more expensive than buying new equipment (the estimate to re-build the stokers was 50% more than new stokers). In such a case, new equipment would be provided rather than re-building. However, in many cases, re-building was the only option. The primary argument for renovating the existing plant was the low energy costs and the existing knowledge base of the operators. The primary argument against it is that it did not replace the boilers in their entirety, nor did it reduce the two major operating costs, fuel and labor.

Building a new dual fuel plant exposed HGAC to the significantly higher energy costs associated with natural gas and No. 2 oil (at the time \$0.63/therm and \$0.42/therm respectively). However, by operating at a higher pressure (250 PSIG), it made a steam turbine generator set operationally feasible to offset electrical costs. This option had the potential to significantly reduce non-energy operational costs. Additionally, it avoided rebuilding equipment that was antiquated already, and provided all new plant equipment and controls. By operating at 250 PSIG, the plant could utilize a steam turbine generator to accomplish pressure reduction and produce power as a by-product of that reduction. This would offset a great deal of the increased cost of boiler fuel. The primary arguments for this option were that it would provide all new equipment and price flexibility with three utilities (gas, oil, and electricity through the turbine), and would allow existing plant staff to be utilized throughout the whole facility. The primary argument against this option was that, even with the turbine generator, it would cost more to provide the fuel to run the new plant than it would to run the rebuilt one.

### **MAKING THE CHOICE**

The choice became fairly clear, in terms of what the institution wanted based upon the information presented. A new plant was preferred over a rebuilt version of what they already had. The challenge was the funding source. When funding an energy savings project, energy savings are expected to pay the finance installments each year for the life of the loan. At the time of this project, Act 57 allowed a maximum of 10 years for a finance period. As mentioned in the previous section, a new dual fuel plant brings many advantages and efficiencies. However, most of the energy related financial benefits are offset by the cost of fuel when an analysis is completed without regard to the issues of

emissions, operational cost, reliability, or lifecycle cost.

A life cycle cost analysis performed using NIST Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program indicated that the dual fuel plant with a steam turbine would carry the lowest life cycle cost of any of the viable options. However, the problem still existed, how do savings cover costs?

The budget structure of the HGAC allowed them to recognize and utilize capital funds that would be required to “do something” at the central plant in order to stay in operation. As mentioned previously, throughout the proposal and Investment Grade Audit (IGA) portions of this project, the boilers continued to deteriorate. Finally, after the IGA was completed, conditions dictated that a temporary oil fired boiler be brought on site at a cost of \$15,000 per month. These conditions emphasized the point that, even if a guaranteed energy project were not implemented, investment would need to be made at the central plant in order to keep HGAC in operation.

Additionally, given the retirement options for the unionized labor force at HGAC, a number of plant employees expressed an interest in leaving. These planned retirements opened the door to see actual savings from the reduction of operational staff required to operate an oil/gas fired plant verses a coal fired installation.

The final piece of the decision lies in the construction delivery method. Act 57 was a part of the first modification of procurement law in the Commonwealth of Pennsylvania in decades. The overall thrust of the modification, aside from the GESA, was to allow best value procurement. The specific benefit as it relates to energy projects is that by utilizing the GESA process, HGAC could avoid the low bid procurement process. This opened the door to the concept of designing a state of the art central plant with electrical generation capacity which would end up being built with the parts and pieces that were the best value for the institution rather than low bid or part of an “or equal” specification. The final product would be installed and commissioned and guaranteed to perform as designed, a requirement of performance contracting.

The administration agreed that, figuring conservatively, they would likely spend nearly six million dollars to bring the plant into some sort of reliable form if they were to complete this work on their own. Additionally, they performed an internal

analysis and determined that eliminating the coal fired plant and reducing their operational staff and their materials budget would provide an annual savings of nearly four hundred thousand dollars per year. These sources of funding coupled with expected electrical generation from the turbine of 1,437,777 kWh per year made the project economically feasible. Additionally, the agency chose to fund this project with cash on hand so that there were no finance costs involved or payments to be made on finance agreement.

## THE RESULTS

The dual fuel plant includes a new skid-mounted steam turbine/generator that generates approximately 400-425 kilowatts of power, at peak load, at the existing primary distribution voltage of 4160 Volts, 3-phase, 3-wire. The generator operates in parallel with the utility. Generated power will be used on site and will not be sold back to the utility. Electrical switchgear and controls interface the generator with the existing power distribution system, providing for a safe and reliable system while meeting the stringent requirements of the serving electrical utility (GPU Energy). A diesel standby generator set, rated at 60kW, 208 Volts, 3-phase, 4-wire was installed at the Boiler Plant. This generator, and associated automatic transfer switch, provides standby power for the new mechanical equipment in the Boiler Plant. This allows the boiler plant to operate in the event of a loss of both preferred and alternate power.

Two new 600 BHP firetube dual fuel boilers (natural gas and No. 2 oil) were installed. Boiler rating is 300 PSIG, max operating pressure is between 250 PSIG and 265 PSIG. These boilers have high turndown, low NOx burners. These burners greatly reduce the existing plant problems with turndown (venting steam when the boilers cannot turn down fast enough) and emissions. These burners will meet all current emissions standards. Even chiller plant performance will be smoother. Prior to installation of the new plant, the steam absorption chiller plant controls would give the boiler plant 30 minutes notice before bringing an absorption chiller on line. This time was needed to build up enough pressure to keep the boiler going when the chiller started. The response time of the new boilers eliminated the 30-minute warning period (during which the building space temperatures were rising).

New breeching up through the roof, one per boiler was installed. This avoided the need to repair the existing failed breeching.

Stack economizers were added in each stack for added efficiency. With stack economizers, total system fuel to steam efficiencies now exceed 86 percent at peak (No. 2 oil).

New natural gas infrastructure was installed, which includes a new line from the property line to the plant, code approved gas trains, metering, and venting. The gas is metered at the property line by the utility, but each boiler will also has a gas meter, tied into the DDC control system to allow continuous efficiency monitoring.

New No. 2 oil infrastructure was installed, including a 20,000 gallon above ground double wall or containment tank, oil pumping station, fuel oil supply and return meters, and day tank.

A new (DA) Tank and boiler feedwater pumps was included.

All new unit-mounted boiler controls, and DDC interface panel were installed. Steam is metered, and the information passed back to the DDC system. The system has the ability to signal the boiler alarms to the DDC system, email, pager, etc, as requested by the Owner.

New steam header and distribution lines were added as required by the higher operating pressures (ahead of the turbine) and the lower operating pressures (downstream of the turbine).

A new flash economizer is utilized to recover surface blowdown heat.

“False Loading” Steam vents through the roof allow the Owner to fully load the boilers both upstream and downstream of the turbine (the latter also false loads the turbine). This allows for: testing at full load regardless of weather, training, verification of performance (under all loading conditions, etc).

The performance of the system has provided the required steam for the facility. The turbine has provided significant reduction in electric consumption as illustrated below. Note that all the electricity generated is used to offset the building load and is not sold back to the utility.

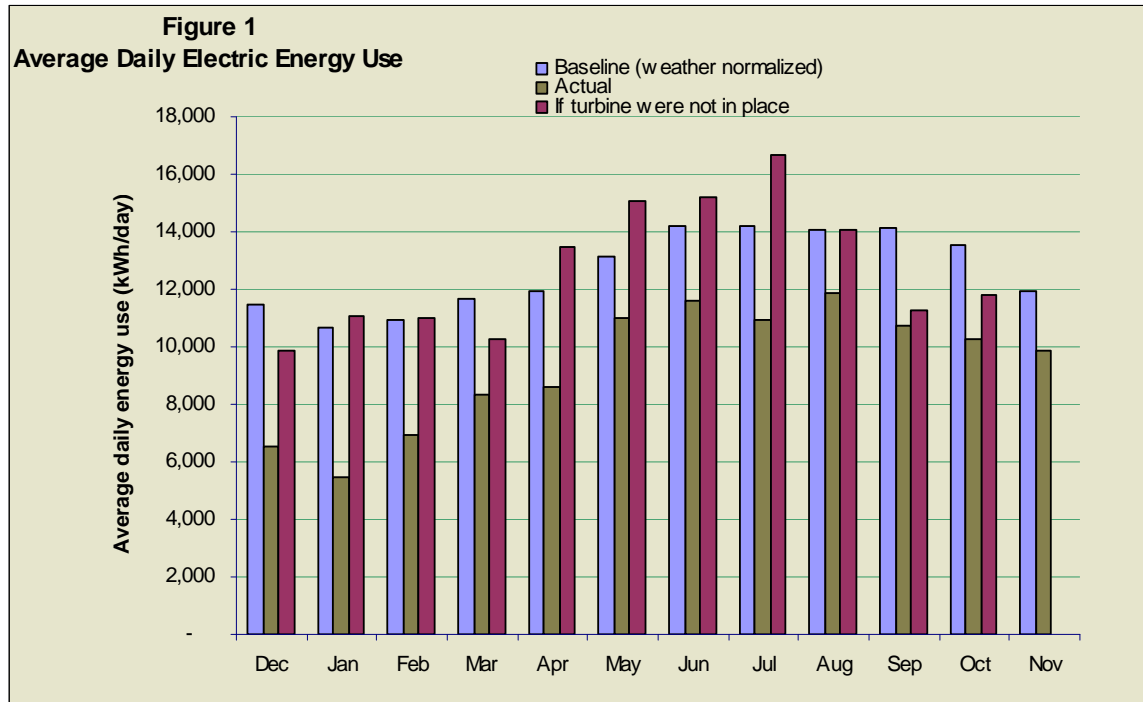


Figure 1: The electrical consumption for the facility prior to the installation of the energy project, the actual consumption now that the turbine is in place, and the project consumption for the facility if the turbine had not been installed.

## CONCLUSIONS

Performance contracting has been around for years. Achieving more energy efficient facilities is the primary goal of these projects and is the best way to provide improvements at little or no financial risk to the client. However, there are situations where simply looking at energy efficiency may not meet the goals and needs of the facility owner. The use of avoided capital and operational savings must be completely understood by the owners and the financial administrators involved because these savings are not guaranteed and often come from budgets other than those used to pay the present utility bills. Use of these funds without complete understanding places an owner at significant financial risk.

However, simply ignoring capital that will need to be invested in a facility during the life of an energy savings project turns a blind eye to the potential to develop the most cost effective installation. In the case of Act 57, now Act 77, the use of capital funds that are designated for specific projects is prohibited. HGAC was allowed to utilize these funds because they were considered unreserved funds by virtue of the way they prepare the budgets.

As we face higher and higher utility costs which are applied to ever-aging systems and infrastructure, serious consideration needs to be given to developing a financial model that allows the use of capital funds, or more accurately re-investment dollars, with energy savings potential to purchase the most cost effective capital improvements. It should be noted that adding capital to an energy savings project is not really “avoided” capital but rather re-distributed capital. In other words, it is money which would need to be spent in the future that is being spent today. In the HGAC example it is a bit easier to understand because the capital that was added to the project would have needed to have been spent in the same time frame with or without an energy project.

**REFERENCES**

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