Richard S. Armstrong, PE, LLC
Mechanical/Electrical Engineer

Comprehensive Energy Audit
of
C Street Shop Warehouse
3425 C Avenue, Barrow
Project # ASRC-BRW-RSA-03A

Prepared for:
The North Slope Borough
Department of Public Works
August 27, 2011

Prepared by:
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Submitted by:

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Richard S. Armstrong, PE, CEM, CEA

Date: 9-4-2011

REPORT DISCLAIMERS

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Payback periods may well vary from those forecast due to the uncertainty of the final installed design, configuration, equipment selected, operational schedules, operational methods, and installation costs of recommended Energy Efficiency Measures (EEMs), or the maintenance provided by the owner. Furthermore, EEMs are typically interactive, so implementation of one EEM may impact the cost savings from another EEM. Neither the auditor, Richard S. Armstrong, PE, LLC, AHFC, or others involved in preparation of this report will accept liability for financial loss due to EEMs that fail to meet the forecasted payback periods.

This audit meets the criteria of an Investment Grade Audit (IGA) per the Association of Energy Engineers definition, and is valid for one year. The life of the IGA may be extended on a case-by-case basis, at the discretion of the AHFC.

IGSs are the property of the State, and may be incorporated into AkWarm-C, the Alaska Energy Data Inventory (ARIS), or other state and/or public information system

Investment Grade Energy Audit
C Street Shops Warehouse

1. **Executive Summary:** The C Street Shop Warehouse is estimated to have been originally constructed in 1983. The facility contains an open warehouse area. The gas for this building is fed from the adjacent building, at 3427 C Street. There is an electric meter on this building, #81790907, but no actual consumption data is available on this meter number. The *average* utility data reported for all four of the C Street Shops is presented below:

Table 1

	2009	2009	2010	2010
Utility	Consumption	Cost/Year	Consumption	Cost/Year
Power & Gas	3,969,167	$20,152	3,856,155	$18,614
	kBTU/yr		kBTU/yr	

A benchmark measure of energy use relative to other similar function buildings in the area is the Energy Use Index (EUI), which takes the total annual energy used by the facility divided by the square footage area of the building, for a value expressed in terms of kBTU/SF. This number can then be compared to other buildings to see if it is about average, higher or lower than similar buildings in the area. Likewise, the Energy Cost Index (ECI) is the cost of all energy used by the building expressed in $/SF of building area. The comparative values for the subject building are listed in Table 2 below:

Table 2

	C Ave Shops	Barrow Avg	NSBSD Bus Barn
Energy Use Index (EUI) kBTU/SF	162	211	183
Energy Cost Index (ECI) $/SF	$.80	$1.68	$.95

Various Energy Efficiency Measures (EEMs) have been analyzed for this building to determine if they would be applicable for energy savings with reasonably good payback periods. Those EEMs that have a Savings to Investment Ration (SIR) of 1 or greater, or those that are recommended for code compliance, life cycle replacement, or other reasons are also included. Also, where a lighting upgrade is

recommended from T-12 lamps with magnetic ballasts to T-8 lamps with electronic ballasts, then the entire facility should be relamped and reballasted to maintain a standard lighting parts inventory, regardless of the payback. For example, a storage room that is infrequently used may not show a very good payback for a lighting upgrade, but consistency dictates a total upgrade. The estimated annual consumption of gas and electric for this building was modeled along with the forecast consumption after incorporating the recommended retrofits. The recommendations forecast a savings of $808/year in energy costs. Modeled and forecast energy consumption cost is presented below:

Table 3

Annual Energy Cost	Existing Building	With Proposed Retrofits
Total	$3,955	$2,553

Specific EEMs recommended for this facility are detailed in the attached AkWarm Energy Audit Report along with specific payback times, as well as estimated installation costs and estimated energy savings. The higher priority items are summarized below:

a. Lighting Upgrades: In general, all of the T-12 flourescent lamps, and all of the magnetic ballasts should be replaced with new T-8 lamps with electronic ballasts. Typical savings in power consumption varies up to 10-30% with this upgrade.
b. Lighting Control Upgrades: Occupant controls can sense the presence of workers, and turn the lights on. The controller can then turn the lights off after a programmed time period of no occupancy. These controls can reduce total kWh consumption for the lighting in the order of 30-90%, depending on the amount of time the lights are manually left on. In this case, lights in aisles of the warehouse can be on a motion sensor so those areas remain unlit until a worker enters the area.
c. Furnace upgrade: The existing system utilizes four gas fired 100 MBH input forced air furnaces to heat the space.

One of the four furnaces is not operational. The furnaces appear to be 1990 vintage, and are estimated to be 70% efficient. This report recommends replacing all four furnaces with new 95% efficient condensing gas furnaces. This upgrade will provide more reliable equipment, in addition to replacing equipment that is near the end of its useful life. The marginal cost of the furnace replacement needs to consider that fact that the furnaces are near the end of their useful life, with one already failed.

d. Setback Thermostats: It is recommended that lockable setback thermostats be installed and programmed for occupied temperatures of 72 deg F, and unoccupied temperatures of 55 deg F. This has an estimated payback of 1.1 years.

The 3 priority recommendations in the detailed report estimate to save $1,402/year, with an installed cost of $17,450. This does not include design or CA services, but overall it does indicate a cost effective energy savings program if one considers that the furnaces need to be replaced due to age, and the T-12 lamps will no longer be in production in another year.

2. Audit and Analysis Background:

a. Program Description: This audit included services to identify, develop, and evaluate energy efficiency measures at the subject building. The scope of this project included evaluating the building shell, lighting, other electrical systems, and heating, ventilating, and air conditioning (HVAC) equipment.

b. Audit Description and Methodology: Preliminary audit information was gathered in preparation for the site survey, including benchmark utility consumption data, floor and lighting plans, and equipment schedules where available. A site visit is then performed to inventory and evaluate the actual building condition, including:

i. Building envelope (roof, windows, etc)
ii. Heating and ventilating

iii. Lighting systems and controls
iv. Building specific equipment
v. Plumbing systems

c. **Method of Analysis:** The information gathered prior to the site visit and at the site visit is entered into AkWarm-C, an energy modeling developed for Alaska Housing Finance Corporation (AHFC) specifically to identify forecasted energy consumption which can be compared to actual energy consumption. AkWarm-C also has some pre-programmed EEM retrofit options that can be analyzed with energy savings forecasted based on occupancy schedules, utility rates, building construction type, building function, existing conditions, and climatic data that is already uploaded to the program based on the zip code of the building. When new equipment is proposed, energy consumption is calculated based on manufacturer's cataloged information.

Cost savings are calculated based on the historical energy costs for the building. Installation costs include labor and equipment to estimate the full up-front investment required to implement a change, but design and construction management costs are excluded. Costs are derived from Means Cost Data, industry publications, experience of the auditor, local contractors and equipment suppliers. Maintenance savings are calculated were applicable and are added to the energy savings for each EEM.

The cost and savings are applied and a simple payback and simple return on investment (ROI) is calculated. The simple payback is based on the number of years that it takes for the savings to pay back the net installation cost (Net Installation divided by Net Savings.)

A simple life-time calculation is made within AkWarm-C for each EEM. The life-time for each EEM is estimated based on the typical life of the equipment being replaced or altered. The energy savings is extrapolated throughout the life-time of the EEM. The total energy savings is calculated as the total life-time multiplied by the yearly savings.

d. **Limitations of the Study:** All results are dependent on the quality of input data provided, and can only act as an approximation. In some instances, several methods may achieve the identified savings. This report is not intended as a final design document. A design professional, licensed to practice in Alaska and in the appropriate discipline, who is following the recommendations, shall accept full responsibility and liability for the results. Budgetary estimates for project management, engineering and design of these projects in not included in the cost estimate for each measure, but these costs generally run around 15% of the cost of the work.

3. **Acknowledgements:** We wish to acknowledge the help of numerous individuals who have contributed information that was used to prepare this report, including:

   a. **Alaska Housing Finance Corporation (Grantor):** AHFC provided the grant funds, contracting agreements, guidelines, and technical direction for providing the audits. AHFC reviewed and approved the final short list of buildings to be audited based on the recommendation of the Technical Service Provider (TSP).

   b. **North Slope Borough (Owner):** The NSB provided building sizing information, two years energy billing data, building schedules and functions, as well as building age.

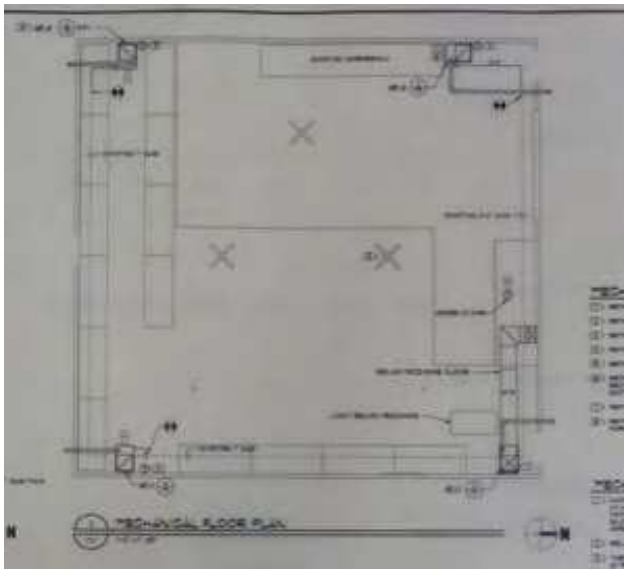
   c. **Nortech Engineering (Benchmark TSP):** Nortech Engineering compiled the data received from the NSB and entered that data into the statewide building database, called the Alaska Retrofit Information System (ARIS).

   d. **Richard S. Armstrong, PE, LLC (Audit TSP):** This is the TSP who was awarded the projects in the Arctic Slope Regional Corporation, Bering Straits area, and the Nana area. The firm gathered all relevant benchmark information provided to them by Nortech, cataloged which buildings would have the greatest potential payback, and prioritized buildings to be audited based on numerous factors, including the Energy Use

Index (EUI), the Energy Cost Index (ECI), the age of the building, the size of the building, the location of the building, the function of the building, and the availability of plans for the building. They also trained their selected sub-contracted auditors, assigned auditors to the selected buildings, and performed quality control reviews of the resulting audits. They prepared a listing of potential EEMs that each auditor must consider, as well as the potential EEMs that the individual auditor may notice in the course of his audit. Richard S. Armstrong, PE, LLC also performed some of the audits to assure current knowledge of existing conditions.

4. **Building Description and Function:** The subject building is called the 3425 C Street Shop Warehouse. It was originally constructed in 1983. The total size of the building is 1,200 SF. The building has one story.

   a. **Heating System:** The building heating system consists of four Thermal Pride Model ICC7-100N natural gas forced air furnaces. The discharge of the furnaces is upward with very limited ductwork. The heating system was upgraded to the furnaces in 1993, as the plan indicates.



   b. **Ventilation System:** There is no outside air ventilation system at this building. Natural infiltration provides adequate outside air since only two occupants are typically present.

   c. **Plumbing System:** There is no plumbing system in the building.

   d. **Domestic Hot:** There is no domestic hot water in the building.

e. **Lighting:** Typical lighting throughout the building is comprised of T-12 fluorescent fixtures, using magnetic ballasts. Exterior lighting utilizes one 250 watt (estimated) high pressure sodium (HPS) wall pack.

5. **Historic Energy Consumption:** Energy consumption is modeled within the AkWarm-C program. The program analyzes 12 months of historical data when available. There was no energy consumption data available for this building, as the heat is provided as a sub-feed from the 3427 C Street Building.

   Energy consumption was analyzed using two factors: the Energy Cost Index (ECI) and the Energy Use Index (ECU).

   The energy cost index takes the average cost of gas and electrical energy over the surveyed period of time (typically 2 years) and averages the cost, divided by the square footage of the building. *The ECI for this building is not available, so the energy consumption for the group of four shops in the area was used for an average ECI of $.80/SF, and the average ECI for all buildings in Barrow that were surveyed is $ 1.68/SF. This data could be understated, however, due to the lack of metering in the subject building, and potential incorrect data being provided.*

   The energy use index (ECU) is the total average electrical and heating energy consumption per year expressed in thousands of BTUs/SF. *The average ECU for all buildings in Barrow that were surveyed is 211 kbtu/sf, and the EUI for this building is 207 kbtu/sf, compared to 162 for this building.*

6. **Energy Efficiency Measures considered or recommended:** The building was examined for application of a multitude of potential EEMs that are discussed below. Those EEMs that appear to have an application for the subject building are further analyzed for estimated payback periods, either within the AkWarm-C program or separately within this report. The accuracy of the cost estimates and paybacks varies significantly due to a multitude of conditions, but is estimated to be approximately +/- 25%. Assumptions made regarding energy costs and the life of the EEM, noting that post-

construction measurement and verification are based on energy savings, not energy cost savings.

All of the selected EEMs are analyzed within the AkWarm-C program using the schedules and estimated costs input into the model.

7. **Interactive Effects of Projects:** The AkWarm-C program calculates savings assuming that all recommended EEM are implemented. If some EEMs are not implemented, savings for the remaining EEMs will be affected, in some cases positively, and in others, negatively. For example, if the fan motors are not replaced with premium efficiency motors, then the savings for the project to install variable speed drives (VFDs) on the fans will be increased.

   In general, all projects were evaluated sequentially so that energy savings associated with one EEM would not be attributed to another EEM as well. For example, the night setback EEM was analyzed using the fan and heating load profile that will be achieved after installation of the VFD project is completed. By modeling the recommended projects sequentially, the analysis accounts for interactive effects between the EEMs and does not "double count" savings.

   Interior lighting, plug loads, facility equipment, and occupants generate heat within the building. When the building is in cooling mode, these contribute to the overall cooling demands of the building; therefore lighting efficiency improvements will reduce cooling requirements on air conditioned buildings. Conversely, lighting efficiency improvements are anticipated to increase heating requirements slightly. Heating penalties are included in the lighting project analysis that is performed by AkWarm-C.

8. **Loan Program:** The Alaska Housing Finance Corporation (AHFC) Alaska Energy Efficiency Revolving Loan Fund (AEERLF) is a State of Alaska program enacted by the Alaska Sustainable Energy Act (senate Bill 220, A.S. 18.56.855, "Energy Efficiency Revolving Loan Fund). The AEERLF will provide loans for energy efficiency retrofits to public facilities via the Retrofit Energy Assessment for Loan System (REAL). As defined in 15 AAC 155.605, the program may finance energy efficiency improvements to buildings owned by:

a. Regional educational attendance areas;
b. Municipal governments, including political subdivisions of municipal governments;
c. The University of Alaska;
d. Political subdivisions of the State of Alaska, or
e. The State of Alaska

Native corporations, tribal entities, and subsidiaries of the federal government are ***not*** eligible for loans under this program.

Appendix A: Photos
Appendix B: AkWarm-C Report

Warehouse Lighting

Forced Air Furnace, Typical of 4

ENERGY AUDIT REPORT – PROJECT SUMMARY – Created 9/4/2011 7:07 AM

General Project Information

PROJECT INFORMATION	AUDITOR INFORMATION
Building: C Street Shops Warehouse	**Auditor Company:** Richard S. Armstrong PE, LLC
Address: 3425 C Street	**Auditor Name:** Richard S Armstrong
City: Barrow	**Auditor Address:** 2321 Merrill Field Dr. C-6 Anchorage, AK 99501
Client Name: Tom Hatcher	
Client Address: 3427 C Street Barrow, AK 99723	**Auditor Phone:** (907) 229-0331
	Auditor FAX:
Client Phone: (907) 852-2611	**Auditor Comment:**
Client FAX:	

Design Data

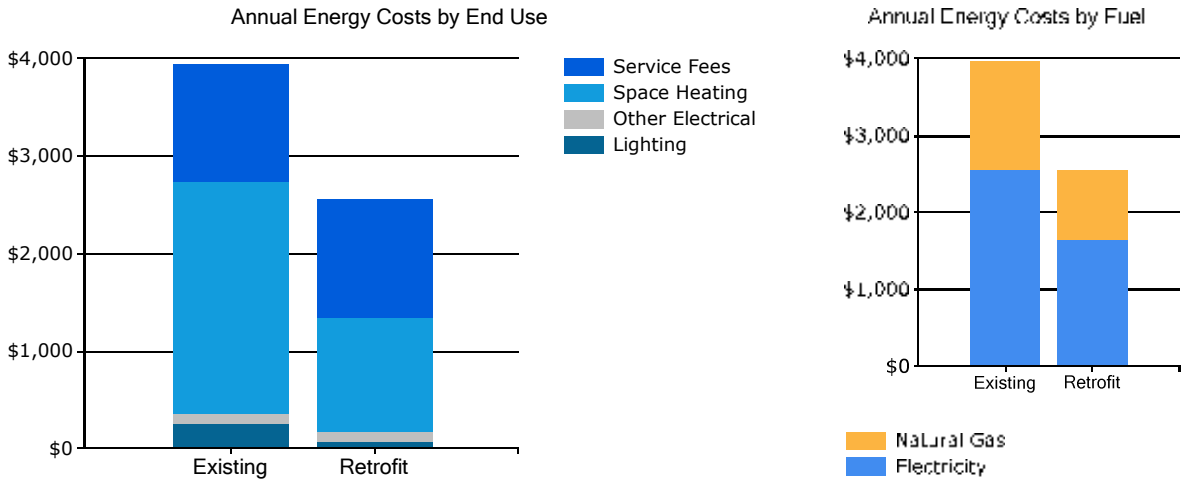
Building Area: 1,200 square feet	**Design Heating Load:** Design Loss at Space: 67,023 Btu/hour with Distribution Losses: 74,470 Btu/hour Plant Input Rating assuming 82.0% Plant Efficiency and 25% Safety Margin: 113,521 Btu/hour Note: Additional Capacity should be added for DHW load, if served.
Typical Occupancy: 1 people	**Design Indoor Temperature:** 70 deg F (building average)
Actual City: Barrow	**Design Outdoor Temperature:** -41 deg F
Weather/Fuel City: Barrow	**Heating Degree Days:** 20,370 deg F-days

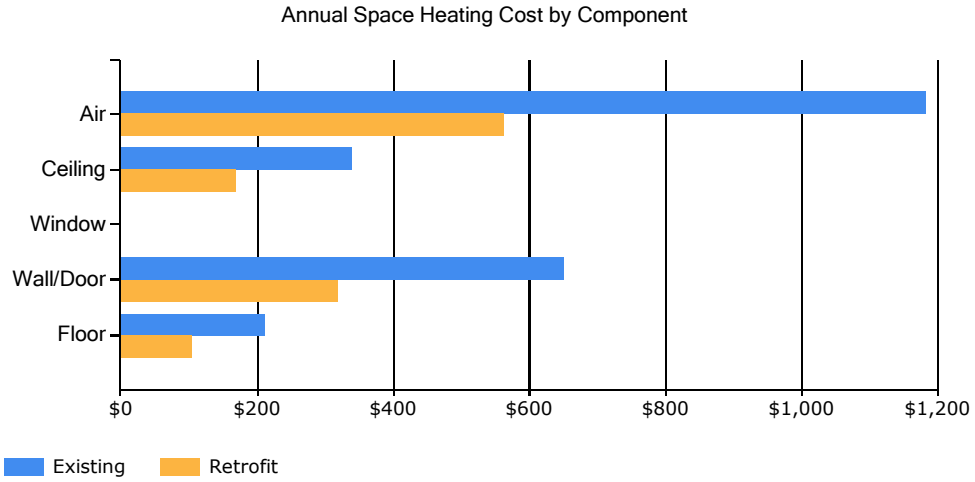
Utility Information

Electric Utility: Barrow Utilities & Electric-elec - Commercial - Lg	**Natural Gas Provider:** Barrow Utilities & Electric-gas - Commercial - Lg
Average Annual Cost/kWh: $0.174/kWh	**Average Annual Cost/ccf:** $0.316/ccf

Annual Energy Cost Estimate

Description	Space Heating	Space Cooling	Water Heating	Lighting	Other Electrical	Cooking	Clothes Drying	Ventilation Fans	Service Fees	Total Cost
Existing Building	$2,382	$0	$0	$243	$107	$0	$0	$0	$1,222	**$3,955**
With Proposed Retrofits	$1,154	$0	$0	$69	$107	$0	$0	$0	$1,222	**$2,553**
SAVINGS	$1,228	$0	$0	$173	$0	$0	$0	$0	$0	**$1,402**


Annual Energy Costs by End Use
$4,000
$3,000
$2,000
$1,000
$0
Existing
Retrofit
Service Fees
Space Heating
Other Electrical
Lighting
Annual Energy Costs by Fuel
$4,000
$3,000
$2,000
$1,000
$0
Existing
Retrofit
Natural Gas
Electricity


Annual Space Heating Cost by Component
Air
Ceiling
Window
Wall/Door
Floor
$0
$200
$400
$600
$800
$1,000
$1,200
Existing
Retrofit

PRIORITY LIST – RECOMMENDED ENERGY EFFICIENCY MEASURES

Rank	Feature	Recommendation	Annual Energy Savings	Installed Cost	SIR	Payback (Years)
1	Setback Thermostat: Warehouse	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Warehouse space.	$268	$200	16.85	0.7
2	HVAC And DHW	Replace all four 100 MBH gas furnaces with new 95% Efficient Lennox G61V High Efficiency Gas Furnaces	$988	$14,000	1.10	14.2
3	Lighting: Warehouse	Replace with 12 FLUOR (2) T5 45.2" F28T5 28W High Lumen (3050 L) HighEfficElectronic and Remove Manual Switching and Add new Occupancy Sensor	$145	$3,250	0.28	22.4
	TOTAL		**$1,402**	**$17,450**	**1.13**	**12.4**

ENERGY AUDIT REPORT – ENERGY EFFICIENT RECOMMENDATIONS

1. Building Envelope

Insulation

Rank	Location	Existing Type/R-Value	Recommendation Type/R-Value	Installed Cost	Annual Energy Savings

Exterior Doors – Replacement

Rank	Location	Size/Type/Condition	Recommendation	Installed Cost	Annual Energy Savings

Windows and Glass Doors – Replacement

Rank	Location	Size/Type/Condition	Recommendation	Installed Cost	Annual Energy Savings

Air Leakage

Rank	Location	Estimated Air Leakage	Recommended Air Leakage Target	Installed Cost	Annual Energy Savings

2. Mechanical Equipment

Mechanical

Rank	Recommendation	Installed Cost	Annual Energy Savings

2	Replace all four 100 MBH gas furnaces with new 95% Efficient Lennox G61V High Efficiency Gas Furnaces			$14,000	$988

Setback Thermostat

Rank	Location	Size/Type/Condition	Recommendation	Installed Cost	Annual Energy Savings
1	Warehouse	Existing Unoccupied Heating Setpoint: 70.0 deg F	Implement a Heating Temperature Unoccupied Setback to 60.0 deg F for the Warehouse space.	$200	$268

Ventilation

Rank	Recommendation	Cost	Annual Energy Savings

3. Appliances and Lighting

Lighting Fixtures and Controls

Rank	Location	Existing	Recommended	Installed Cost	Annual Energy Savings
3	Warehouse	12 FLUOR (2) T12 8' F96T12 75W Standard Magnetic with Manual Switching	Replace with 12 FLUOR (2) T5 45.2" F28T5 28W High Lumen (3050 L) HighEfficElectronic and Remove Manual Switching and Add new Occupancy Sensor	$3,250	$145

Refrigeration

Rank	Location	Existing	Recommended	Installed Cost	Annual Energy Savings

Other Electrical Equipment

Rank	Location	Existing	Recommended	Installed Cost	Annual Energy Savings

Cooking/Clothes Drying

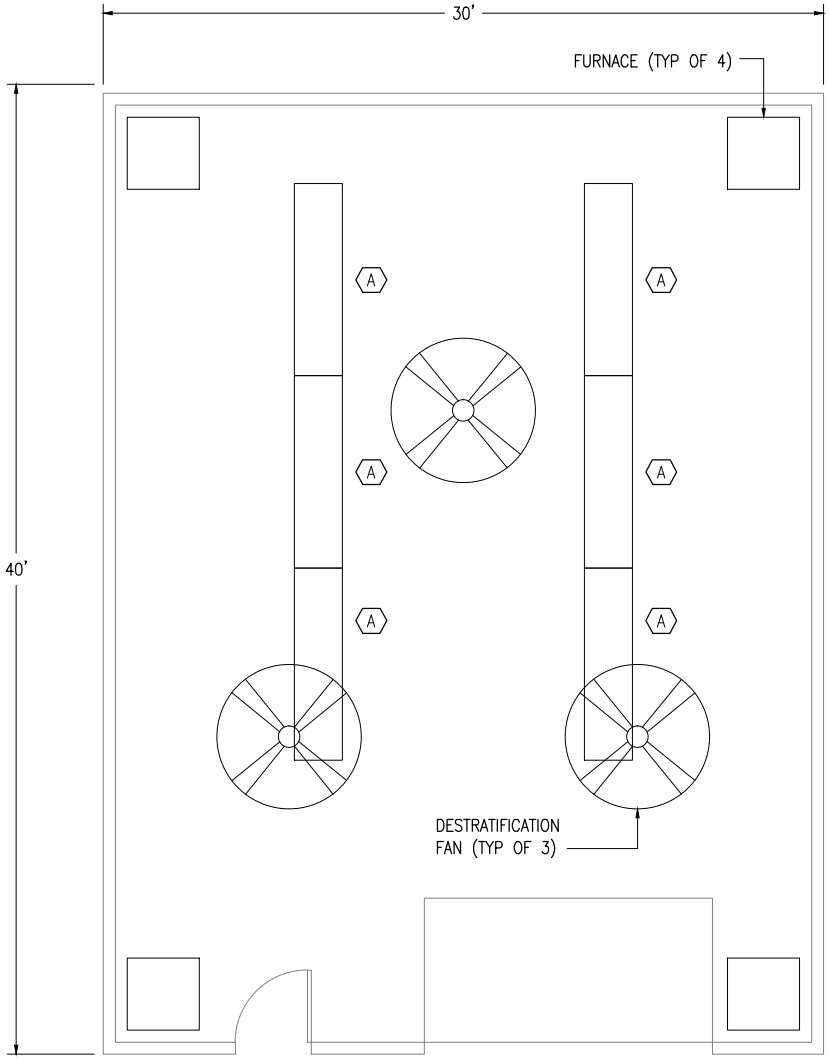
Rank	Recommended	Installed Cost	Annual Energy Savings


Front of building


Connection to heavy equipment shop


T-12 8' flourescent lights

100 MBH gas furnace



LEGEND

DESTRATIFICATION FAN

FURNACE

A — 2 LAMP 8' T-12

1 3425 C STREET PLAN

1/4"=1'-0"