EXERCISE 5: Reviewing Audit Results and Selecting Appropriate Measures

Student Instructions for Exercise 5:

ECM descriptions, savings and costs have been provided by the ESCo following a detailed audit of the properties identified in your RFP. Review the audit results, develop a list of questions to ask your ESCo representative (a.k.a. Exercise Leader), and work with the ESCo to finalize your project's scope.

While reviewing your audit and finalizing your measures, consider the following issues:

- because audit results contain both technical and financial information, are you sure that your team members have the background necessary to assess the accuracy and feasibility of recommendations? If not, you may want to involve a consultant.
- are enough details provided with the economic data, particularly savings valuation rates and escalation assumptions?
- are the assumptions used in the savings calculations as accurate as possible?

ENERGY CONSERVATION MEASURES

Lighting Retrofit

Approach:
Each building's lighting system was evaluated individually, as well as the project being evaluated as a whole. Inventories and schedules of existing lighting equipment located in common areas were collected during the audit. Lighting ECM's were selected by reviewing a combination of issues including: wattage saved, hours of operation, cost effectiveness, and system wide product uniformity to reduce inventory diversity. A detailed inventory of impacted fixtures and corresponding energy savings is located in Appendix B.

Summary of Lighting ECM's:
Valley Ridge. A total of 88 fixtures were identified for retrofit. Predominant fixtures (67%) containing 4' T-12 fluorescent lamps powered by standard magnetic ballasts will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Thirteen exit signs containing incandescent lamps will be retrofitted with LED kits.

McLain Village. A total of 175 fixtures were identified for retrofit. Predominant fixtures (82%) containing 4' T-12 fluorescent lamps powered mainly by standard magnetic ballasts will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Thirteen exit signs containing incandescent lamps will be retrofitted with LED kits.

Elena Gardens. A total of 604 fixtures were identified for retrofit. Approximately 25% of these fixtures contain 4, 4', T-12 fluorescent lamps powered mainly by standard magnetic ballasts and will be delamped to 2-lamp fixtures using T-8 lamps (CRI 80) and low-power electronic ballasts. Another 45%, containing 4' T-12 fluorescent lamps powered mainly by standard magnetic ballasts, will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Approximately 79 exit signs containing incandescent lamps will be retrofitted with LED kits.

Bradley Tower. A total of 542 fixtures were identified for retrofit. Approximately 8% of these fixtures contain 4, 4' T-12 fluorescent lamps powered mainly by standard magnetic ballasts and will be delamped to 2-lamp fixtures using T-8 lamps (CRI 80) and low-power electronic ballasts. Another 31%, containing 4' T-12 fluorescent lamps powered mainly by standard magnetic ballasts, will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Approximately 67 exit signs containing incandescent lamps will be retrofitted with LED kits.

Matthew Blvd. A total of 250 fixtures were identified for retrofit. Predominant fixtures (60%) containing 4' T-12 fluorescent lamps powered mainly by standard magnetic ballasts will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Approximately 24 exit signs containing incandescent lamps will be retrofitted with LED kits.

Roosevelt Park. A total of 308 fixtures were identified for retrofit. Most (72%) eligible fixtures contain high wattage incandescent lamps which will be replaced with compact fluorescent lamps providing similar light output. Approximately 24% of the fixtures contain 3' or 4', T-12 watt saver fluorescent lamps powered mainly by energy efficient magnetic ballasts, which will be retrofitted with T-8 lamps (CRI 80) and low-power electronic ballasts. Another 31% containing 4, 4' T-12 watt saver fluorescent lamps powered by energy efficient magnetic ballasts, will be delamped to 2-lamp fixtures using T-8 lamps (CRI 80) and low-power electronic ballasts. Approximately 46 exit signs containing incandescent lamps will be retrofitted with LED

kits.

Assumptions:

- Wattage used for various existing and proposed technologies are based on ratings provided by manufacturers or by an independent test laboratory
- Improvements are limited only to common areas (offices, corridors, etc.)
- Where appropriate, light levels will be adjusted to meet Illuminating Engineering Society (IES) standards
- Hours of operation for various fixtures were determined by monitoring usage over a period of 1 week
- Blended electric rate of $0.0712/kWh (Averaged from actual US Electric rates, demand charge=$6.60/kW with 12 month demand ratchet, consumption charge=$0.06/kWh)

Calculation Methodology:

The following relationship was used to calculated consumption savings associated with the proposed lighting retrofit. A detailed inventory of impacted fixtures and corresponding energy savings is located in Appendix B.

Lighting Savings = $[\sum_u[(kW/fixture_{baseline} * Qty_{baseline} - kW/fixture_{post\text{-}retrofit} * Qty_{post\text{-}retrofit})*Hours\ of\ Operation]_u*Rate$

where,

Savings=Yearly cash savings realized during the post installation time period (yearly)
$kW/fixture_{baseline}$ = Lighting baseline demand per fixture for usage group u
$kW/fixture_{post\text{-}retrofit}$ = Lighting demand per fixture during post-retrofit period for usage group u (yearly)
$Quantity_{baseline}$ = Quantity of affected fixtures before the lighting retrofit for usage group u
$Quantity_{post\text{-}retrofit}$ = Quantity of affected fixtures after the lighting retrofit for usage group u
Hours of Operation = Total number of post-retrofit operating hours for usage group u
Rate = Blended rate per kWh, assumed to be $0.0712/kWh

Energy and Cost Savings Summary:

	Annual Pre-Retrofit		Annual Post-Retrofit		Annual Savings			Constr. Cost	Simple Payback
Estate	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**Total $**	**$**	**Years**
Elena Gardens	71.9	485,253	29.9	201,817	42.0	283,436	$20,180	$104,936	5.2
Bradley Tower	64.4	398,299	31.9	167,675	32.5	230,624	$16,420	$83,742	5.1
Valley Ridge	10.8	27,402	5.5	12,934	5.2	14,468	$1,030	$7,004	6.8
Matthew Blvd	31.1	217,590	15.1	99,424	16.0	118,166	$8,413	$51,319	6.1
Roosevelt Park	51.9	302,760	34.6	166,818	17.3	135,942	$9,679	$56,138	5.8
McLain Village	16.7	144,475	8.2	71,108	8.5	73,367	$5,224	$32,389	6.2
Total	**246.9**	**1,575,779**	**125.3**	**719,776**	**121.6**	**856,003**	**$60,947**	**$335,528**	**5.5**

WATER CONSERVATION MEASURES

Water Services Retrofit and Replacement

Approach:

Both retrofit and replacement options were considered, based on replacement fixture and retrofit component prices, water supply and wastewater costs, and overall project costs. We recommend toilet fixture replacement in three buildings (McLain Village, Roosevelt Park, Valley Ridge) and fixture retrofits in the remaining three estates. Toilet replacement is recommended whenever the payback allows. Replacement toilets run at 1.6 gallons per flush. When paybacks are extended, toilets will instead be rebuilt to save approximately one gallon per flush. Rebuilt toilets will run at 3.3 - 3.5 gallons per flush. Showerhead replacements will run at 2.5 gallons per minute and bathroom sink faucet aerators will flow at 1.5 gallons per minute. Replacement aerators on kitchen sinks will run at 1.8 gallons per minute. Detailed inventories and savings calculations are presented in Appendix A.

Summary of Water Service Measures:

Valley Ridge Estates. Replace 270 toilets, 270 bathroom sink aerators, and 250 kitchen sink aerators

McLain Village Estates. Replace 474 toilets, 94 flanges, 474 bathroom sink aerators, and 469 kitchen sink aerators

Elena Gardens. Replace 289 toilets, 284 angle stops, 279 bathroom sink aerators, 280 showers, and 280 kitchen sink aerators

Bradley Tower. Replace 274 toilets, 267 bathroom sink aerators, 267 showers, and 267 kitchen sink aerators

Matthew Blvd. Replace 123 toilets, 123 bathroom sink aerators, 120 showers, and 120 kitchen sink aerators

Roosevelt Park Estates. Replace 322 toilets, 64 flanges, 322 angle stops, 322 bathroom sink aerators, 320 showers, and 320 kitchen sink aerators

Assumptions:

- Flow rates used for various existing and proposed fixtures are based on manufacturers ratings or by an independent test laboratory
- Each occupant flushes toilet 5 times per day, over approximately 350 days per year
- Each occupant showers for 5 minutes per day, over approximately 350 days per year
- Each kitchen sink is used for 10 minutes per day, over approximately 350 days per year
- Blended water/sewer rate of $4.49/1000 gallons (Averaged from water rate of $1.82/1000 gallons and sewage rate of $2.67/1000 gallons)

Calculation Methodology:

The following relationship was used to calculated consumption savings associated with the proposed water services measures. Detailed inventories and savings calculations are presented in Appendix A.

Savings = $(Gal_{baseline} - Gal_{post\text{-}retrofit})*(Rate/1000gal)$

where,

Savings=Yearly cash savings,

$Gal_{baseline}$ = Baseline water usage,

$Gal_{post\text{-}retrofit}$ = Post-retrofit water usage,

Rate/1000gal = $4.49/1000 gallons

Water Consumption and Cost Savings Summary:

	Pre-Retrofit Annual Consumption	**Post-Retrofit Annual Consumption**	**Annual Consumption Savings**	**Annual Cost Savings**	**Constr. Cost**	**Simple Payback**
Estate	**Gallons**	**Gallons**	**Gallons**	**$**	**$**	**Years**
Elena Gardens	7,960,400	5,782,000	2,178,400	$9,781	$38,146	3.9
Bradley Tower	7,523,355	5,463,500	2,059,855	$9,249	$47,170	5.1
Valley Ridge	15,568,000	9,828,438	5,739,562	$25,771	$121,124	4.7
Matthew Blvd	3,696,000	2,856,000	840,000	$3,772	$19,237	5.1
Roosevelt Park	15,348,480	9,206,400	6,142,080	$27,578	$129,617	4.7
McLain Village	26,241,351	11,506,236	14,735,115	$66,161	$305,664	4.62
Total	**76,337,586**	**44,642,574**	**31,695,012**	**$142,312**	**$660,958**	**4.6**

ENERGY CONSERVATION MEASURES

Mechanical Upgrades, Boilers and Distribution Systems

Approach:
Space heating systems and domestic hot water systems in McLain Village and Bradley Tower will be upgraded with new heating hot water boilers and domestic hot water heaters. Distributions systems will be repaired where necessary, and all steam equipment will be eliminated. Using a PC-based controller, control and operation of mechanical equipment will reside at the central maintenance office.

Summary of Mechanical Upgrades:
McLain Village. Decentralized space heating water and domestic hot water systems will be provided in 8 modules, each serving 6 to 8 contiguous buildings. This decentralization will allow 50 buildings to be removed from the central steam and domestic hot water systems. Each heating module will consist of two cast iron heating water boilers, and a low mass, copper tube domestic hot water heater and hot water storage tank. Circulating pumps and all ancillary accessories will also be installed. Control and operation of each new boiler room will reside locally, and will have capabilities of central monitoring. New underground gas lines will be designed and installed to support the gas load for the new boilers. New underground piping, for heating hot water and domestic hot water, will be installed between each building within a heating module. Finally, new heating water wall convectors will replace existing steam radiators.

Bradley Tower. A parallel heating source will be provided to existing steam systems (heating hot water and domestic hot water heat exchangers). This will provide a heating source redundancy and will allow Bradley Tower to take advantage of less expensive rates by switching their reliance from steam to natural gas. Hydronic cast iron boilers, circulating pumps, and all ancillary accessories will be installed and piped into the existing distribution system, downstream of the existing steam to water heat exchangers. A separate domestic hot water boiler will be installed and tied into the existing domestic hot water system downstream of the existing steam to domestic hot water heat exchanger. Valves will be installed that allow these new systems to be primary sources and the existing steam system to act as a back up. The major mechanical components of this new system will be controlled and monitored at a central maintenance office. New underground gas lines will be designed and installed to support the gas load for the new boilers.

Assumptions:
- Average natural gas rate at McLain Village of $4.42/MCF
- Average natural gas rate at Bradley Tower of $5.50/MCF
- Average steam rate at Bradley Tower of $15.09/Mlbs
- 1 lbm of steam is equivalent to 950 Btu

Mechanical Upgrades Energy and Cost Savings Summary:

	Estimated Annual Consumption Savings	Annual Cost Savings	Constr. Cost	Simple Payback
Estate	**MCF**	**$**	**$**	**Years**
Bradley Tower Boiler/DHW	0	$109,440	$1,294,608	11.83
McLain Village Boiler/DHW	42,676	$188,628	$2,547,380	13.5
McLain Village Piping	0	0	$2,282,858	∞
Total	**42,676**	**$298,068**	**$6,124,846**	**20.5**

PURCHASED GAS MEASURES

Approach:
We will utilize our resources and partnerships with various natural gas marketing services companies to offer a purchased gas option for all qualifying meters.

Summary of Purchased Gas Measures:
Presently, approximately 50 meters can be placed on brokered gas at this time. The housing authority currently has approximately 1,200 meters, many of which are classified as residential meters. The 50 brokerable meters represent approximately half of the housing authority's entire gas consumption. This proposal addresses cost savings from the 50 brokerable meters alone, a master metering strategy will be needed to broker the remaining meters.

Assumptions:
- Average present natural gas rate of $5.50/MCF
- Average contract natural gas rate of approximately $3.70/MCF

Purchased Gas Cost Savings Summary:

	Present Annual Natural Gas Costs*	Annual Contract Natural Gas Costs	Annual Cost Savings	HUD Qualified Cost Savings	Constr. Costs	Simple Payback
Meters	**$**	**$**	**$**	**$**	**$**	**Years**
50 Brokerable Meters	$1,245,236	$837,704	$407,532	$203,766	$2,500	0.01

* Costs for approximately 50% of the housing authority's total consumption

PROJECT SUMMARY

Estimated Cost of ECM's

The following table identifies the total cost of ECM's installed at each site.

Estimated Project Costs		
Estate	**ECM's**	**Cost**
McLain Village Estates	-Mechanical Upgrades (incl. piping @ $2,282,858) -Lighting Retrofit -Water Services -Building Automation	$5,168,291
Bradley Towers	-Mechanical Upgrades -Lighting Retrofit -Water Services -Building Automation	$1,425,520
Roosevelt Park Estates	-Lighting Retrofit -Water Services	$185,755
Elena Gardens	-Lighting Retrofit -Water Services	$143,082
Matthew Blvd	-Lighting Retrofit -Water Services	$70,557
Valley Ridge Estates	-Lighting Retrofit -Water Services	$128,128
All Estates	-Gas Rate Negotiation	$2,500
	Total	**$7,123,833**

PROJECT SUMMARY I

Cash Flow Analysis

The following tables present the details of the cash flow analysis for a contract period of 12 years.

CASH FLOW ANALYSIS I

Construction Costs (all measures)	$7,123,831	**Financed Project Cost**	$8,584,217	**Base Year Electrical Cost Savings**	$60,947
Engineering Audit (3%)	$213,715	**Finance Term - Yrs**	12	**Electrical Price Escl.**	0
Engineering Design (5%-7%, 5%)	$356,192	**Annual Interest Rate**	0.051	**Base Year Steam Cost Savings**	$109,440
Commissioning (3%-5%,3%)	$213,715	**Construction Months**	12	**Steam Price Escl.**	0
One-Time Training (2%)	$142,477	**Annual Payment**	$973,988	**Base Year Gas Cost Savings**	$188,628
Construct. Management (5%-10%,5%)	$356,192	**Principal**	$8,584,217	**Gas Price Escl.**	0.03
Construct. Interest (2.5%-5%,2.5%)	$178,096	**Interest**	$3,103,637	**Base Year Water Cost Savings**	$142,311
Total Costs (all measures)	$8,584,217	**Base Yr Savings**	$705,092	**Water Price Escl.**	0.04
		Simple Payback	12.2	**Rate Savings**	$203,766
				Ann. M&V, Training Costs (5%-10%, 10%)	$40,341

Year	Electrical Cost Savings	Gas Cost Savings	Water Cost Savings	Steam Conversion Savings	Gas Rate Savings	Total Utility Cost Savings	Annual M&V, Training Costs	Financing Costs	Net Benefit to HA
1	$60,947	$188,628	$142,311	$109,440	$203,766	$705,092	$40,341	$973,988	-$309,237
2	$60,947	$194,287	$148,003	$109,440	$209,879	$722,556	$40,341	$973,988	-$291,773
3	$60,947	$200,115	$153,924	$109,440	$216,175	$740,601	$40,341	$973,988	-$273,728
4	$60,947	$206,119	$160,081	$109,440	$222,661	$759,247	$40,341	$973,988	-$255,082
5	$60,947	$212,302	$166,484	$109,440	$229,340	$778,514	$40,341	$973,988	-$235,816
6	$60,947	$218,672	$173,143	$109,440	$236,221	$798,422	$40,341	$973,988	-$215,907
7	$60,947	$225,232	$180,069	$109,440	$243,307	$818,995	$40,341	$973,988	-$195,334
8	$60,947	$231,989	$187,272	$109,440	$250,606	$840,254	$40,341	$973,988	-$174,076
9	$60,947	$238,948	$194,762	$109,440	$258,125	$862,222	$40,341	$973,988	-$152,107
10	$60,947	$246,117	$202,553	$109,440	$265,868	$884,925	$40,341	$973,988	-$129,404
11	$60,947	$253,500	$210,655	$109,440	$273,844	$908,387	$40,341	$973,988	-$105,942
12	$60,947	$246,117	$202,553	$109,440	$282,060	$901,116	$40,341	$973,988	-$113,213
Total	$731,364	$2,662,026	$2,121,809	$1,313,280	$2,891,853	$9,720,332	$484,097	$11,687,853	-$2,451,619

Footnotes: 1) 'Soft Cost' fees include OH&P (20%-30%)
2) 'Hard Costs' are typically 60%-70% of total project costs, soft costs are 30%-40% of total project costs

PROJECT SUMMARY II

Cash Flow Analysis

The following tables present the details of the cash flow analysis for a contract period of 12 years on a project that utilizes Modernization Funds.

CASH FLOW ANALYSIS II

Construction Costs (not incl. Piping)	$4,840,973	**Financed Project Cost**	$6,301,359	**Base Year Electrical Cost Savings**	$60,947
Engineering Audit	$213,715	**Finance Term - Yrs**	12	**Electrical Price Escl.**	0
Engineering Design	$356,192	**Annual Interest Rate**	0.051	**Base Year Steam Cost Savings**	$109,440
Commissioning	$213,715	**Construction Months**	12	**Steam Price Escl.**	0
One-Time Training	$142,477	**Annual Payment**	$714,969	**Base Year Gas Cost Savings**	$188,628
Construct. Management	$356,192	**Principal**	$6,301,359	**Gas Price Escl.**	0.03
Construct. Interest	$178,096	**Interest**	$2,278,266	**Base Year Water Cost Savings**	$142,311
Total Costs (all measures)	$6,301,359	**Base Yr Savings**	$705,092	**Water Price Escl.**	0.04
		SPB	8.9	**Rate Savings**	$203,766
Piping Const. Costs	$2,282,858			**Ann. M&V, Training Costs (5%-10%, 10%)**	$40,341
Engineering Audit	$0.00				
Engineering Design	$0				
Commissioning	$0.00				
One-Time Training	$0.00				
Construct. Management	$0.00				
Construct. Interest	$0.00				
Total Costs (all measures)	$2,282,858				

Year	Electrical Cost Savings	Gas Cost Savings	Water Cost Savings	Steam Conversion Savings	Gas Rate Savings	Total Utility Cost Savings	Annual M&V, Training Costs	Financing Costs	Net Benefit to HA
1	$60,947	$188,628	$142,311	$109,440	$203,766	$705,092	$40,341	$714,969	-$50,218
2	$60,947	$194,287	$148,003	$109,440	$209,879	$722,556	$40,341	$714,969	-$32,754
3	$60,947	$200,115	$153,924	$109,440	$216,175	$740,601	$40,341	$714,969	-$14,709
4	$60,947	$206,119	$160,081	$109,440	$222,661	$759,247	$40,341	$714,969	$3,937
5	$60,947	$212,302	$166,484	$109,440	$229,340	$778,514	$40,341	$714,969	$23,203
6	$60,947	$218,672	$173,143	$109,440	$236,221	$798,422	$40,341	$714,969	$43,112
7	$60,947	$225,232	$180,069	$109,440	$243,307	$818,995	$40,341	$714,969	$63,685
8	$60,947	$231,989	$187,272	$109,440	$250,606	$840,254	$40,341	$714,969	$84,944
9	$60,947	$238,948	$194,762	$109,440	$258,125	$862,222	$40,341	$714,969	$106,912
10	$60,947	$246,117	$202,553	$109,440	$265,868	$884,925	$40,341	$714,969	$129,615
11	$60,947	$253,500	$210,655	$109,440	$273,844	$908,387	$40,341	$714,969	$153,077
12	$60,947	$246,117	$202,553	$109,440	$282,060	$901,116	$40,341	$714,969	$145,806
Total	$731,364	$2,662,026	$2,121,809	$1,313,280	$2,891,853	$9,720,332	$484,097	$8,579,625	$656,610