Recreation Centers of Sun City West
R.H. Johnson Campus

SUN CITY WEST, AZ

Renewable Energy System Feasibility Study – Final Report

February 21, 2014

Affiliated Engineers

4742 N. 24th Street
Suite 100
Phoenix, AZ 85016
(602) 429.5800

AEI Project No. 13180-00

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1.0 Executive Summary

Affiliated Engineers Inc., (AEI) is pleased to submit this Final Report of the feasibility study of options for energy conservation measures (ECMs) and renewable energy systems for the R.H. Johnson campus.

Based on recent utility bills, existing drawings, site assessment walks and discussions with facilities management and maintenance personnel, an energy audit of electrical end-use components was developed and an energy model of the campus was constructed. After calibration of the energy model to simulate the actual energy consumption of the campus, various proposed options for ECMs and renewable energy systems were modeled to determine potential energy savings. Then based on their reduced estimated net capital cost after available incentives and tax credits, the simple payback for each recommendation was calculated.

<u>The following are the proposed recommendations and associated payback periods:</u>

ECM Recommendations	**Estimated Net Capital Cost**	**Payback Period**
ECM 1: Selected Zone Temperature Reset	$ 500	0.7 years
ECM 2: Lighting Occupancy Sensors	Test basis of $ 1,000 per zone	7.2 years
ECM 5: Increase Efficiency of AC units	additional 10% of unit cost	3.6 years

Renewable Energy Recommendations	**Estimated Net Capital Cost**	**Payback Period**
Men's Club Solar Thermal System	$ 4,200	5.5 years
Men's Club PV Array System	$ 113,541	16.1 years
Library Solar Thermal System	$ 2,800	4.1 years
Pool/Exercise building/swimming pool Solar Thermal System	$ 36,000	1.9 years

TABLE 1 Proposed Recommendation

The goals of this project were modest, but the results are promising. Depending on the acceptable payback periods and funding available, several options for the implementation of ECMs and the provision of renewable energy systems are possible. Design services for these systems may be contracted through a professional engineering firm or included in a complete design/build installation from a system manufacturer. By first providing both a solar thermal and PV array system for the Men's Club with the PV arrays on top of the new shaded parking structures, a highly visible showcase of the commitment to these sustainable technologies to members, guests and the public at large will be achieved.

2.0 Introduction

Affiliated Engineers Inc., (AEI) was contracted by the Recreation Centers of Sun City West, Inc to perform an energy audit and develop a feasibility study of options for renewable energy systems for the R.H. Johnson campus located at 19803 R.H. Johnson Blvd, in Sun City West, AZ.

The formal project <u>Kick-off Meeting</u> was held on Wednesday, March 20, 2013, during which the project's goals, phases, and deliverables were discussed. In addition, various options for energy conservation measures (ECMs) and renewable energy systems were outlined.

During the <u>Investigation Phase</u> of the project, the campus 2012 APS electric and Southwest Gas bills as well as the mechanical, plumbing, electrical and architectural drawings including HVAC equipment schedules, and electrical site plans were reviewed, and site assessment walks were performed. In addition, an energy audit of the existing electrical energy end-use components including the air conditioning/heating units, lighting and electric water heaters was developed along with documenting the operating efficiencies, design setpoints and hours of operation based on the various occupancies and uses of the buildings served.

In the next <u>Analysis Phase</u>, the electrical energy end-use components were analyzed with the intent of determining any low-cost energy conservation measures or ECMs that could be implemented to reduce the electrical energy consumption of the campus.

In discussions with Facilities Maintenance personnel, it was discovered that some of the initial ECM ideas proposed, such as automatic HVAC unit controls based on occupancy schedules with night setback setpoints, "cooler" white polyurethane membrane roofing, exterior lighting controls by timers and photocell sensors, and replacement of AC units with higher efficiency units, had already been provided/implemented. With kudos to the Facilities Maintenance personnel, these provisions were thus documented as existing conditions.

The options for <u>energy conservation measures</u> include ECM 1 for a higher indoor temperature setpoint reset of selected space thermostats on the hottest summer days, ECM 2 for lighting controlled by occupancy sensors, ECM 3 for roofing insulation upgrades, ECM 4 for the provision of Demand Controlled Ventilation (DCV) to reduce the outside air required to be conditioned, and ECM 5: for an increase in the Energy Efficiency Ratio (EER) of the rooftop AC units.

By first understanding, and hopefully decreasing, the electrical energy consumption of the campus by implementation of the ECMs any proposed renewable energy systems could then be "right-sized" to meet the reduced electrical demands of the campus. To better understand, benchmark and analyze the electrical energy consumption of the campus, an <u>energy model</u> was constructed. This model, after calibration to be within acceptable tolerance of the actual energy usage per the energy bills received, became a powerful tool to analyze and predict the energy savings that could be realized with implementation of the various ECMs. The inputs and assumptions utilized to construct the energy model are included in Section 11.0 Appendix.

The options for renewable energy systems include solar photovoltaic (PV) panels arranged in arrays to provide electrical energy to the electrical distribution systems at the campus, and solar thermal systems to provide the hot water to the swimming pool and spas as well as the domestic hot water to selected buildings. As there are three existing electrical meters serving the campus including the main meter at the Sports Pavilion (Bldg. C), and smaller dedicated meters for the Men's Club (Bldg. H) and Library (Bldg. B), a study of the PV system for each meter and electrical distribution system was performed. Included in the solar thermal studies are the gas-fired heaters for the swimming pool, spas and domestic hot water for the showers and locker rooms serving the Pool/Exercise building (Bldg. D), adjacent to the Sports Pavilion as well as the domestic hot water systems for the Men's Club and Library.

In the Conceptual Design Phase of the project, the ECM and renewable energy options proposed were further analyzed and refined with components, capacities, and system layout schematics defined.

This level of design was the basis for the cost estimating performed in the Financial Evaluation Phase. In addition, the available and applicable incentives and tax credits for the proposed renewable energy system were investigated and studied to determine the reduced net capital costs for each option proposed. Based on the reduced net capital cost and annual energy savings of each option, the associated simple payback was determined.

A Progress Presentation was delivered to the Executive Board and members of the Recreation Centers of Sun City West on May 10, 2013 in the Lecture Hall on the campus. In the presentation, the estimated costs and payback calculations of most of the proposed options were presented and discussed. Based on feedback and additional information received earlier this year, including preferences to showcase renewable energy systems within a limited budget, this Final Report was developed.

The next step is to contract for the associated design, permitting and construction administration services through a professional engineering firm, or consult with system manufacturers who provide a complete design/build installation.

Affiliated Engineers wish to take this opportunity to thank the staff at the Recreation Centers of Sun City West, including Larry Griffith, Project Superintendent, Russ Boston, Facilities Maintenance Operations Manager, and Cindy Knowlton, Recreation Activities Manager, for all of their assistance. Their help in obtaining the requested information regarding equipment, controls and building operations, as well as communicating their ideas and preferences for renewable energy systems was invaluable to the success of the project.

3.0 Site Assessment

Site assessment walks were completed during the months of March and April 2013. Information from these assessments, along with annual utility usage, architectural drawings, mechanical drawings, building schedules and information gathered during operational discussions with facilities personal were used to develop an energy conservation measure (ECM) analysis and renewable energy system assessment.

3.1 Annual Utility Summary

Electricity and natural gas are the utilities used by the RH Johnson campus. The below table summarizes 2012 metered data.

	2012 Electric		2012 Natural Gas	
	Use (kBtu/yr)	Cost ($/yr)	Use (kBtu/yr)	Cost ($/yr)
Men's Club	272,278	$11,932	-	-
Library	743816	$31,806	-	-
Main	7,711,802	$223,484	3,496,700	$33,990
Total	8,727,896	$267,222	3,496,700	$33,990
Percent of Total	71%	89%	29%	11%

TABLE 2 Annual Utility Usage

Natural gas is used for pool heating, spa heaters and domestic hot water heaters for the shower/ locker rooms at the Pool/Exercise building. All other end-uses are served by electricity.

Energy usage is commonly measured in EUI (Energy Use Index). EUI is calculated by dividing total building energy usage by building square footage. The Electric EUI of the campus is 54.7. The electric and gas EUI of the campus is 76.5.

4.0 Energy Modeling

4.1 Energy Benchmarking

The R.H. Johnson campus was benchmarked against the Commercial Buildings Energy Consumption Survey (CBECS) data set and the energy model constructed for the energy conservation portion of this project. The CBECS data set is sponsored by the US Department of Energy and is the most complete benchmarking public data set available for commercial buildings.

CBECS energy usage can be split up into separate peer groups and building types. Peer groups include floor area, hours of operation, vintage, occupancy type, location-census regions and location-US climates (HDD/CDD). Building types include a variety of building types ranging from high school through laboratory.

Filtering by peer group was the best benchmarking methodology for comparison against the R. H. Johnson total campus meter. The mountain census region was the closest fit within the peer groups. Filtering by building type was the best benchmarking methodology for comparison against the Men's Club meter (Public Assembly: Social/Meeting building type) and the Library Meter (Public Assembly: Library building type). Comparisons are shown in the following chart.

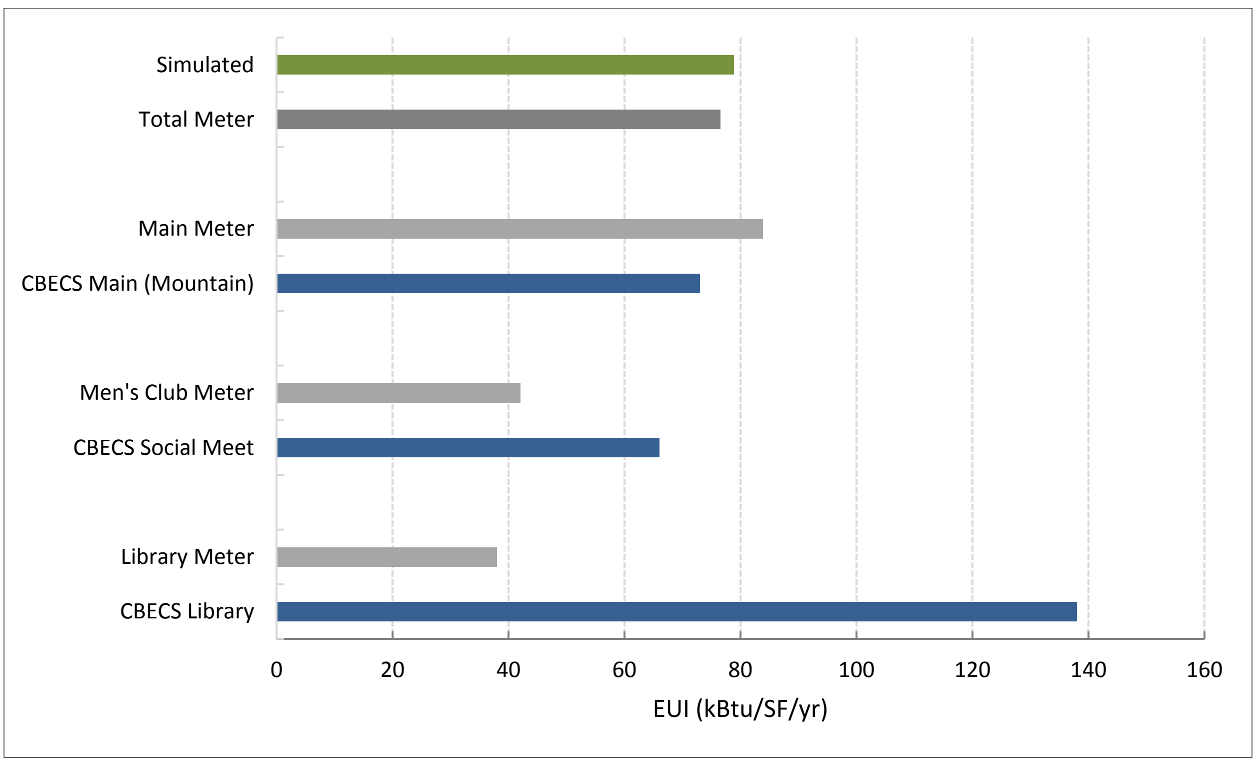

CHART 1 Comparison between Simulated, Actual and Benchmark Energy Usage

As indicated by the chart, the energy usage at the campus and buildings of the R.H. Johnson campus are close to or less than comparative building types. The top comparison (Simulated vs. Total Meter) indicates that the simulated energy usage from the energy model constructed for this project is within acceptable tolerance of the actual total meter readings based on the campus 2012 energy bills. This error of Simulated vs. Total Meter is less than 4% and is discussed in further detail in section "4.2 Energy Conservation Methodology" of this Final Report.

It should be noticed that the "Simulated" and "Total Meter" are electric usage only as no natural gas use was modeled. The "Main Meter" above includes electric and gas usage so it can be benchmarked against the CBECS Main (Mountain) data.

4.2 Energy Conservation Methodology

Energy conservation measure computer simulations were performed using accepted standard engineering calculation procedures and eQUEST version 3.64 building energy simulation software. EQuest software utilizes the DOE 2.2 simulation engine and is a program designed to determine the energy consumption characteristics of buildings utilizing an annual hour-by-hour simulation procedure and historical weather data. The natural gas usage for the outdoor swimming pool, spa and domestic hot water use was not modeled as there were no natural gas ECMs analyzed. Natural gas usage was considered in the solar thermal renewable energy systems of this project.

Basic building geometry, space use characteristics, envelope material characteristics, lighting systems, heating, ventilating, and air conditioning systems were used to create a representative physical model of the building. Occupant, internal load, and operational schedules for the spaces/buildings were used along with local weather data for Phoenix, AZ to drive the hourly simulation.

The inputs and assumptions utilized to construct the energy model are included in Section 11.0 Appendix.

The following is an isometric view of the campus model.

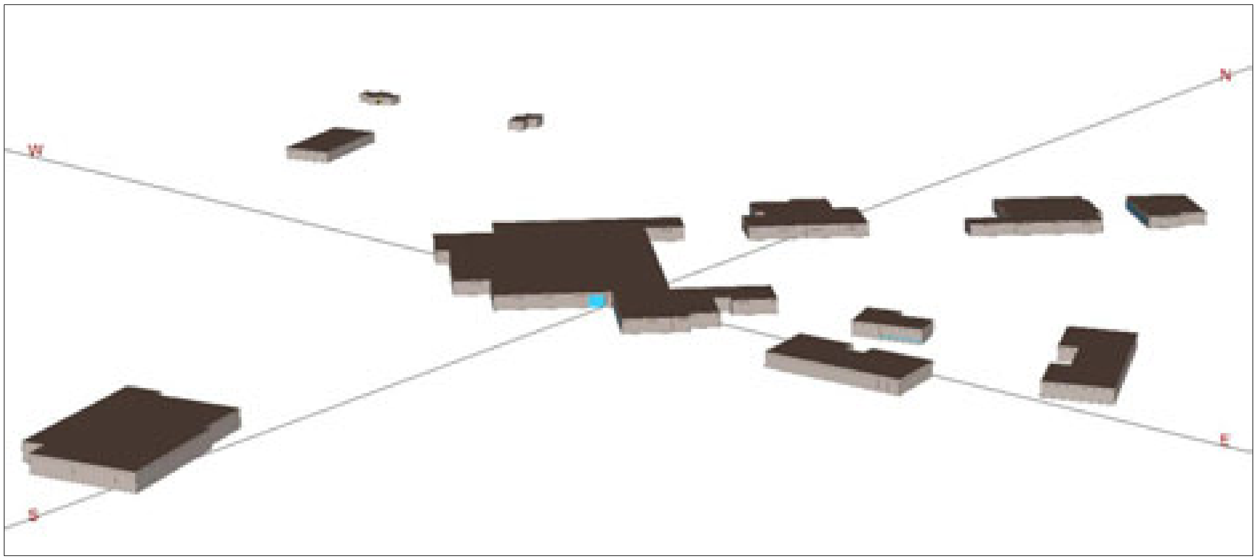

FIGURE 1 Isometric Model of Campus

The following is the floor plan of the Sports Pavilion (Bldg. C), the adjacent part of the Pool/Exercise building (Bldg. D), and the Arts and Crafts building (Bldg. G2) used in the model.

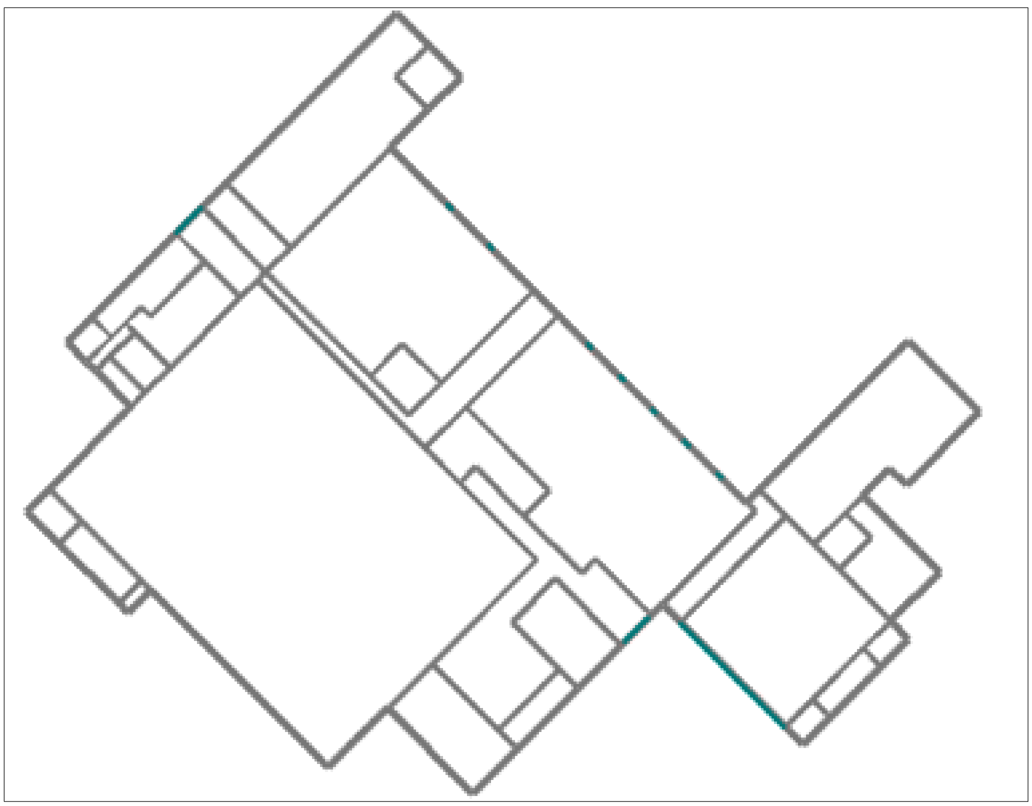

FIGURE 2 Floor Plan Model of the Sports Pavilion

The base model output was compared with annual utility usage to calibrate the model. The following table and graph show model calibration results. The simulated electricity used is well within acceptable tolerance of the actual metered usage.

	Electric Use (kWh)		
	Avg. Meter	eQuest	Error
Jan	191,267	167,473	12.4%
Feb	180,433	164,705	8.7%
Mar	179,310	188,551	5.2%
Apr	171,173	221,853	29.6%
May	194,573	250,818	28.9%
Jun	231,760	260,239	12.3%
Jul	282,507	280,768	0.6%
Aug	266,960	279,765	4.8%
Sep	285,040	251,022	11.9%
Oct	224,080	246,595	10.0%
Nov	174,987	191,122	9.2%
Dec	188,213	162,603	13.6%
TOT:	2,570,303	2,665,514	3.7%

TABLE 3 Comparison between Actual and Modeled Monthly Electric Use

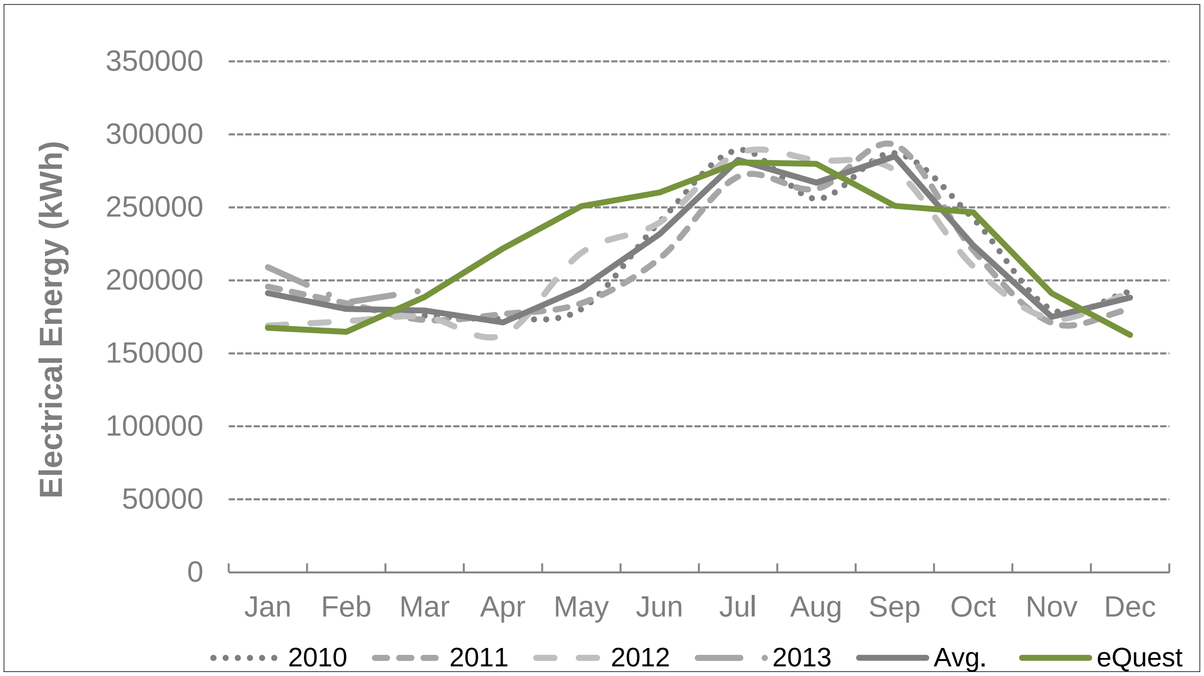

TABLE 3 Comparison between Actual and Modeled Monthly Electric Use

5.0 Analysis of the Energy Conservation Measures

With the identification of all of the electrical energy end-use components, the next step was the brain-storming and analysis of various energy conservation measures (ECMs) that would cost-effectively be implemented to reduce the electrical energy consumption of the campus.

In discussions with facilities maintenance personnel, it was discovered that some common and relatively low-cost energy conservation measures, such as automatic HVAC unit controls based on occupancy schedules with night setback setpoints, "cooler" white polyurethane membrane roofing, exterior lighting controls by timers and photocell sensors, and replacement of AC units with higher efficiency units, had already been provided/implemented by facilities maintenance personnel.

Thus, other additional ideas for evaluation and analysis were investigated. Based on the construction of the buildings, types of HVAC equipment and lighting, operating controls for the HVAC equipment and lighting, and discussions with facilities personnel regarding the usage and operations of the various spaces at the RH Johnson campus, the following five Energy Conservation Measures (ECMs) were developed and analyzed.

5.1 ECM 1: Selected Zone Temperature Reset

Zone temperature reset reduces electric cooling consumption during days with high outdoor heat (excess of 95 ^{o}F). During these days, indoor occupied zone temperatures which are currently 72-74 ^{o}F are reset to 78 ^{o}F. This ECM is not being considered for exercise and active activity areas and is only implemented in the Library (Bldg. B), Social Hall (Bldg. F), the Men's Club (Bldg. H), Ceramics (Bldg. G1) and Metal Crafts (Bldg.G3).

Installed costs include only labor to reprogram the automatic setpoints as the controls system has this capability. Labor cost estimates are $500.

5.2 ECM 2: Lighting Occupancy Sensors

Limiting zone lighting to times when a space is occupied reduces the electrical energy use by the lighting system. Installing occupancy sensors limits zone lighting without space occupants needing to take action. This ECM recommends the installation of sensors for office and office support areas, restrooms, activity areas and skill areas. Infrared sensors are recommended in zones where occupants have limited movement. A 10% savings in lighting energy are expected where zones of this type exist.

Installed costs of $1,000-$2,000 per zone ($170/sensor) are based on a typical zone size and the number of infrared sensors required. Initial costs would be less if existing infrastructure can be reused (ie., fixtures and fixture locations are unchanged, occupant controls are unchanged, etc.). $1,000/zone is used in this analysis. A total of 53 zones are included in this ECM.

5.3 ECM 3: Roof Insulation Upgrade

Well insulated roofs reduce both heating and cooling energy required for a building. As roofs on campus are replaced, this ECM recommends increasing the R value of roof insulation. Campus existing roofs have an approximate R value of 7.3. This ECM recommends increasing the roofing R value to 20.0 which meets AZ state code for new construction requirements. Roofs are not expected to be replaced any time soon as they have received white polyurethane membrane retrofits to reduce solar heat gain.

A complete demolition and roof replacement would cost $15/SF. However this ECM is not recommended unless a roof has reached end of life and a roofing project is already scheduled. This ECM analyzes the incremental cost of adding insulation to a roof system to meet code. The incremental costs of additional insulation would be approximately $2/SF.

5.4 ECM 4: Demand Controlled Ventilation (DCV)

Outside air is supplied to occupied building spaces to dilute the carbon dioxide (CO_2) exhaled by building occupants as well as other chemical and biological elements present in the air. CO_2 levels in spaces are considered an indicator of the number of occupants in a space, allowing active control to reduce the outdoor air requirements of a space to the code-required minimums. Reducing outdoor air supplied to a zone reduces both heating and cooling energy required for a building. [SS1]This ECM reduces overall outside air supplied to spaces by an average of 40%. It should be noted that CO_2 sensors require annual or semiannual calibration to achieve full effectiveness.

An installed cost of $2,000 per rooftop unit are based on one CO_2 sensor and associated controls upgrades.

5.5 ECM 5: Increase EER of Rooftop Units

Utilizing high efficiency HVAC equipment reduces the heating, ventilating and cooling energy required to operate a building. The rooftop AC units on campus are heat pump units that provide both heating and cooling with energy efficiency rating (EER) values ranging from 9 through 11.9. This ECM recommends that when units reach the end of their service life they are replaced with higher efficiency heat pumps with an EER of at least 13.

As facilities maintenance personnel have been replacing the units with high efficiency units with an EER of 12, the installed costs for this EECM are 10% higher for a heat pump with an EER of 13 compared to an EER of 12, translating to $1,430/ton vs $1,300/ton respectively. Thus, the installed costs of this ECM are based on the incremental increase of providing new replacement heat pumps with an EER of 13 (compared to 12).

5.6 Percentage of Energy Savings of the Energy Conservation Measures

The following chart shows the percentage reduction of electric end-use for each ECM.

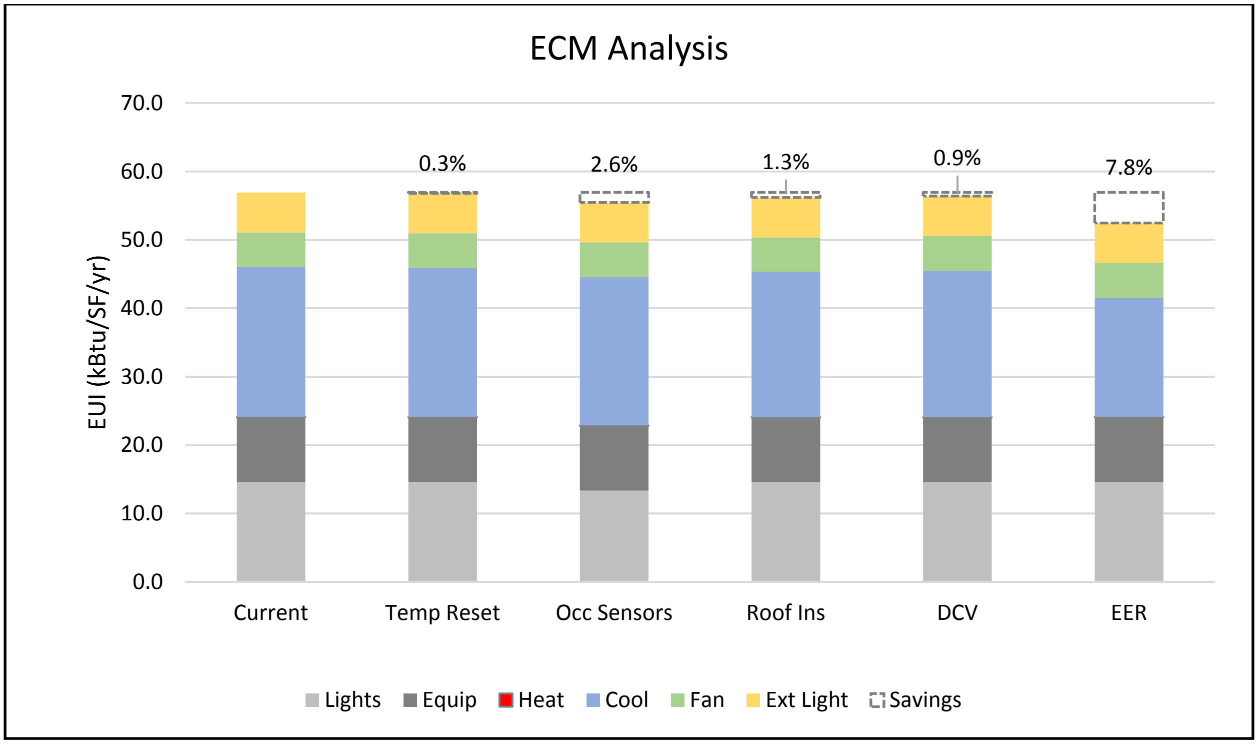

CHART 2 Percentage Energy Reduction for each ECM

Savings associated with each energy conservation measures (ECM) were calculated by the energy model. While the predicted energy use and cost results are meant to be representative of actual building energy use and cost, the simulated energy consumption should not be interpreted as actual usage. Actual energy use and cost may differ from the original assumptions due to unpredictable variables such as changes in the occupancy schedules, actual equipment efficiencies, building operation, utility rate changes, and weather variations from a typical year.

5.7 Installed Costs and Paybacks of the Energy Conservation Measures

The following table shows modeled energy usage, costs and savings; implementation costs; and simple paybacks for each of the ECMs.

	Modeled Electric Usage (kWh)	Modeled Electric Savings (%)	Modeled Energy Cost ($)	Modeled Cost Savings (%)	Modeled Annual Savings ($)	Estimated Installed Cost ($)	Simple Payback (years)
Existing Campus	2,665,513		$281,212				
ECM1: Temp Reset	2,658,495	0.3%	$280,471	0.3%	$741	$500	0.7
ECM2: Occ Sensors	2,596,085	2.6%	$273,887	2.6%	$7,325	$53,000	7.2
ECM3: Roof Ins	2,624,419	1.5%	$276,876	1.5%	$4,336	$319,400	73.7
ECM4: DCV	2,640,624	0.9%	$278,586	0.9%	$2,626	$164,000	62.5
ECM5: Unit EER	2,456,561	7.8%	$259,167	7.8%	$22,045	$79,000	3.6

TABLE 4 Modeled Electric Usage, Savings, Costs and Payback for each ECM.

6.0 Renewable Energy System Incentives

There are a number of photovoltaic (PV) and solar thermal system incentives available for commercial scale renewable energy projects. The following table summarizes common incentives and applicability to the campus.

Source	Incentive Name	Applicability	Description
Federal	Business Energy Investment Tax Credit	R.H. Johnson campus meets requirements	PV and Solar thermal 30% of first cost tax credit.
Federal	EPACT 2005	Expired Dec 31, 2013.	tax deduction of $1.8/SF or $0.6/SF of project area
Federal	Renewable Energy Production Tax Credit	Minimum system size is 5MW, R.H. Johnson campus is not large enough.	Tax credit of $0.01-0.04/kWh/year for 10 years
State of AZ	Non-Residential Solar & Wind Tax Credit	R.H. Johnson campus meets requirements.	Tax credit of 10% of installed cost, up to $25,000.
State of AZ	Solar and Wind Equipment Sales Tax Exemption	R.H. Johnson campus meets requirements	First cost sales tax is 0% for these systems.
Arizona Public Service	Solutions for Business Financing Program.	No longer an APS program.	Low interest loan
Arizona Public Service	Renewable Energy Incentive Program	No longer an APS program.	$0.1/W up to 25 kW incentive
Arizona Public Service	Feasibility Study Incentives	No longer an APS program.	Incentives up to $10,000
Arizona Public Service	Net metering and buyback program	R.H. Johnson campus meets requirements for net metering. Buyback program is no longer financially beneficial.	APS no longer purchases REC at a premium price.
Southwest Gas	Smarter Greener Better Solar Water Heating Program	R.H. Johnson campus meets requirements	$15/therm up to 50% of system cost

TABLE 5 Renewable Energy Systems Incentives

It should be noted that Arizona Public Service (along with other electric utilities in the state of AZ) recently started charging a flat monthly fee to customers with PV. The flat fee is $0.7/kW of installed PV, monthly. This fee is to cover transmission and distribution infrastructure that is in place to serve load but is not being utilized.

7.0 Photovoltaic Renewable Energy System Studies

Multiple solar photovoltaic (PV) studies were conducted for the R.H. Johnson campus. As three separate electric utility meters serve the campus, a study was performed for each of the three electrical systems. The main electrical meter serves the R.H. Johnson campus and is located on the exterior of the Sports Pavilion, adjacent to the back delivery entrance to the Strike Zone restaurant. Smaller dedicated electrical utility meters serve the Men's Club and the R.H. Johnson Library.

PV technology converts solar energy into electricity for use on campus. Three PV array options were sized for 100% of the electric use requirements without any reduction due to ECMs or solar thermal installations.

A solar PV systems requires a number of components. Required components of each system include;

- High efficiency monocrystalline-Si Solar PV panels
- A structure for the panels (either a roof or a constructed platform)
- Premium DC to AC inverters
- Electrical infrastructure associated with tying the system into campus
- Electrical infrastructure associated with tying the system into the Arizona Public Service electric distribution system

While the primary function of the R.H. Johnson campus PV system is to offset electric use on campus, the secondary function of the parking lot PV system is to provide shaded parking for members and guests of the Recreation Center. The following photographs are examples of PV systems above parking structures.

FIGURE 4 PV Panels on Structure

FIGURE 5 PV Panels on Shade Structure

The orientation of solar PV systems can optimize annual electricity generation. A parametric study to optimize panel orientation was conducted for each of the PV array options. For each study, three panel orientations were investigated: horizontal panels, panels tilted 30º facing south, and panels tilted 30º with half facing south and half facing southwest.

Individual summary tables for each PV array study indicate the space requirements for each PV system. These areas of shaded parking structure are shown on the campus site map below.

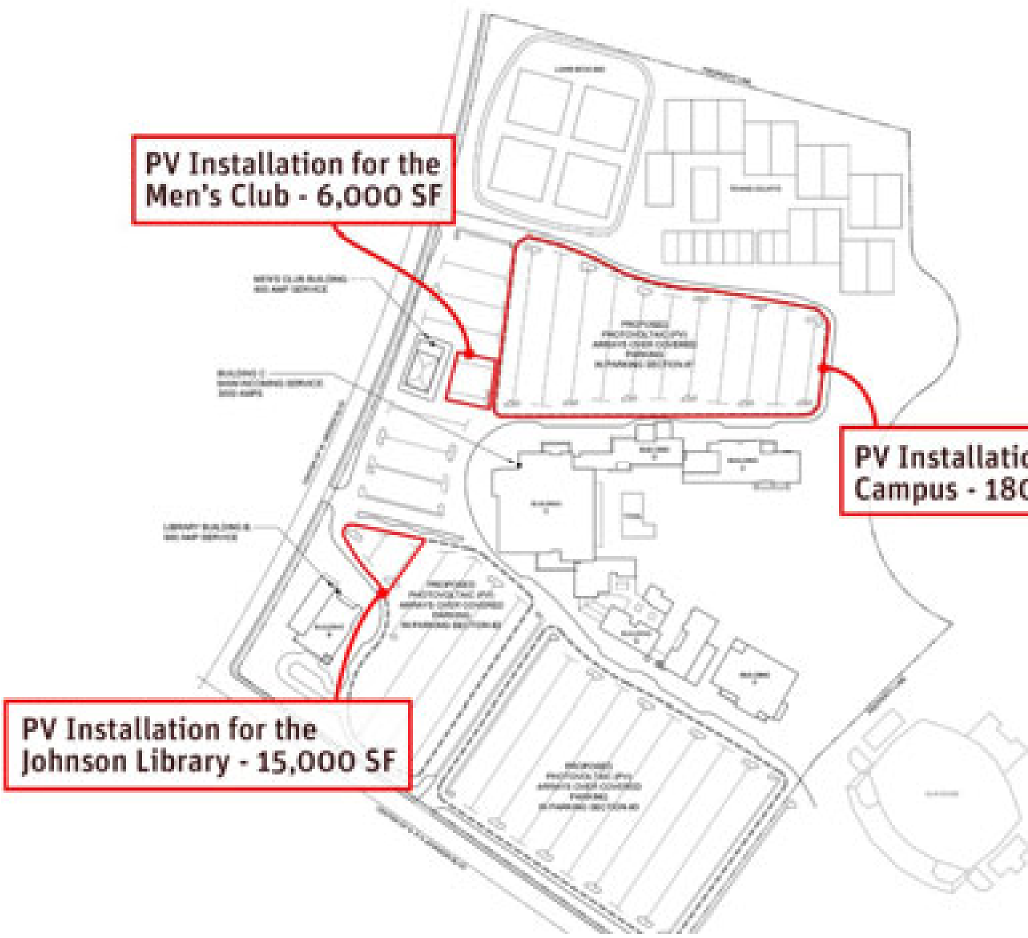

FIGURE 6 Campus Plan indicating Proposed Areas for PV Array

For the PV array studies, hourly weather data files were used to generate accurate results.

Incentives from the federal Renewable Energy Production Tax Credit and the state of Arizona non-residential solar and wind tax credit are available.

A first cost of $4/W is estimated for the R.H. Johnson campus PV array and $4.5/W is estimated for the smaller PV arrays at the Men's Club and R.H. Johnson Library.

7.1 RH Johnson Campus PV Array

The first PV study was performed for the main campus electrical meter.

RH Johnson Campus	Horizontal Panel	30º, South	30º, South & SW
Array Capacity [kW]	1,500	1,300	1,350
No. of Modules	4,915	4,125	4,280
Total Module Area [sf]	86,300	72,420	75,130
Panel Efficiency	20%	20%	20%
Electricity Generation [kWh/yr]	2,447,228	2,436,454	2,458,543
Packing Ratio [sf]	2:1	2:1	2:1
Installation Area [sf]	173,000	145,000	151,000
Capital Cost [$/W]	$4.0	$4.0	$4.0
Tie-In Costs	$125,000	$125,000	$125,000
Total Capital Cost [$]	$6,000,000	$5,325,000	$5,525,000
State Tax Credit [$]	$25,000	$25,000	$25,000
Federal Incentive [$]	$1,837,500	$1,597,500	$1,657,500
Net Capital Cost [$]	$4,262,500	$3,702,500	$3,842,500
Annual Savings [$]	$258,183	$257,046	$259,376
Annual Rate Increase [$]	$12,600	$10,920	$11,340
Net Savings [$]	$245,583	$246,126	$248,036
Simple Payback [yrs.]	17.4	15.0	15.5

TABLE 6 RH Johnson Campus PV Study

The campus parking lot (900,000 SF) is large enough for the installation of a shaded parking structure sized to meet all electric demands of the main campus electrical system (less than 200,000 SF).

Note that the above simple payback figures have decreased significantly from those included in the previous Progress Presentation. This is due to the recent reduction in costs for PV arrays as well as full utilization of the available incentives and tax credits. The tie-in costs ($125,000) are included in the above table and include a new Service Entrance Switchboard (SES) in the main electrical room and the associated wiring to connect the proposed PV system to the main electrical distribution system. Costs associated with the shade structure are also included. Any fees for the design of the PV system are not included in the Net Capital Cost.

7.2 Men's Club PV Array

A second study was conducted for the Men's Club.

Men's Club	Horizontal Panel	30^o, South	30^o, South & SW
Array Capacity [kW]	49	42	44
No. of Modules	159	133	138
Total Module Area [sf]	2,792	2,343	2,430
Panel Efficiency	20%	20%	20%
Electricity Generation [kWh/yr]	79,162	78,814	79,528
Packing Ratio [sf]	2:1	2:1	2:1
Installation Area [sf]	5,600	4,700	4,900
Capital Cost [$/W]	$4.5	$4.5	$4.5
Tie-In Cost [$]	$25,000	$25,000	$25,000
Total Capital Cost [$]	$243,348	$214,235	$221,513
State Tax Credit [$]	$24,335	$21,423	$22,151
Federal Incentive [$]	$73,004	$64,270	$66,454
Net Capital Cost [$]	$146,009	$128,541	$132,908
Annual Savings [$]	$8,352	$8,315	$8,390
Annual Rate Increase [$]	$408	$353	$367
Net Savings [$]	$7,944	$7,962	$8,023
Simple Payback [yrs.]	18.4	16.1	16.6

TABLE 7 Men's Club PV Study

There is enough surface parking adjacent to the Men's Club for an array sized to meet all electric demands of the Men's Club. (less than 6,000 SF)

Note that the above simple payback figures have decreased significantly from those included in the previous Progress Presentation. This is due to the recent reduction in costs for PV arrays as well as full utilization of the available incentives and tax credits. Tie-in costs ($25,000) are included in the above table and include the service modifications and associated wiring to connect the proposed PV system to the Men's Club electrical distribution system. Costs associated with the shade structure are also included. Any fees for the design of the PV system are not included in the Net Capital Cost.

7.3 R.H. Johnson Library PV Array

A third study was conducted for the R. H. Johnson Library.

R.H. Johnson Library	Horizontal Panel	30^o, South	30^o, South & SW
Array Capacity [kW]	129	112	116
No. of Modules	424	356	369
Total Module Area [sf]	7,446	6,248	6,482
Panel Efficiency	20%	20%	20%
Electricity Generation [kWh/yr]	211,137	210,207	212,113
Packing Ratio [sf]	2:1	2:1	2:1
Installation Area [sf]	14,900	12,500	13,000
Capital Cost [$/W]	$4.5	$4.5	$4.5
Tie-In Cost [$]	$25,000	$25,000	$25,000
Total Capital Cost [$]	$607,362	$529,714	$549,126
State Tax Credit [$]	$25,000	$25,000	$25,000
Federal Incentive [$]	$182,209	$158,914	$164,738
Net Capital Cost [$]	$400,154	$345,800	$359,388
Annual Savings [$]	$22,275	$22,177	$22,378
Annual Rate Increase [$]	$1,087	$942	$978
Net Savings [$]	$21,188	$21,235	$21,400
Simple Payback [yrs.]	18.9	16.3	16.8

TABLE 8 RH Johnson Library PV Study

There is enough surface parking adjacent to the R.H. Johnson Library for an array sized to meet all electric demands of the R.H. Johnson Library. (Less than 15,000 SF)

Note that the above simple payback figures have decreased significantly from those included in the previous Progress Presentation. This is due to the recent reduction in costs for PV arrays as well as full utilization of the available incentives and tax credits. Tie-in costs ($25,000) are included in the above table and include the service modifications and associated wiring to connect the proposed PV system to the Library's electrical distribution system. Costs associated with the shade structure are also included. Any fees for the design of the PV system are not included in the Net Capital Cost.

8.0 Solar Thermal Renewable Energy System Studies

Solar thermal renewable energy studies were conducted for the RH Johnson campus. Three solar thermal array options were sized based on the following buildings and hot water equipment loads:

- Pool/Exercise (Building D)/ Swimming Pool- Natural gas-fired heaters including;
  - Hot water heaters for shower/locker rooms: (2) 100 gallons /199 kBtu each
  - Pool heater: 2,100 kBtu
  - Indoor and outdoor spa heaters: (2) 264 kBtu each
- Men's Club - Electric hot water heater for domestic hot water: 50 gallons
- R.H. Johnson Library - Electric hot water heater for domestic hot water: 15 gallons

Solar thermal systems require a number of components. As represented in the schematic diagram, the components of each system include;

- High efficiency glazed flat plate collectors
- A structure for the panels (either a roof or a platform/parking shade structure)
- A premium efficiency pump
- Hot water storage tank
- Heat exchanger
- Plumbing infrastructure associated with system

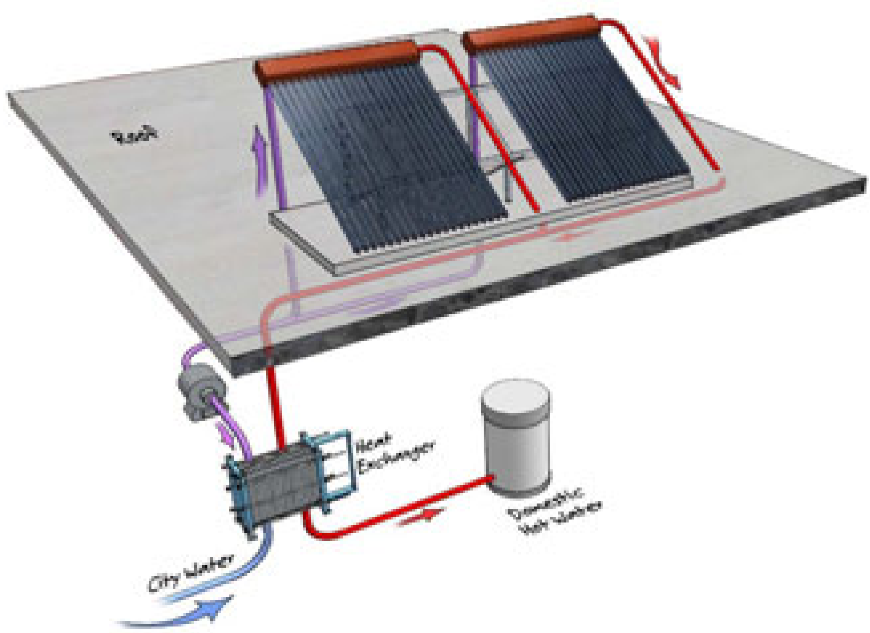

FIGURE 7 Schematic of Solar Thermal System

As natural gas is used to heat the Pool/Exercise building aquatics areas, incentives from Southwest Gas are available for this system.

The Renewable Energy Production Tax Credit is available for all three systems, but the state tax credit is not available for solar thermal systems.

The following table summarizes the size of the solar thermal systems, their net capital costs after incentives and tax credits, and their associated energy cost savings and simple payback.

	Pool/Exercise Swimming Pool	**Men's Club**	**Library**
Water heater type	Gas	electric	electric
Total energy saved [MMBtu]	1,863	24.6	12.8
Total therms saved [therms]	18,630	NA	NA
Total electric saved [kWh]	NA	7,200	6,428
No of Panels required	90	3	2
Tank Capacity [gal]	tankless system	135	120
Capital Cost [$]	$180,000	6000	4000
SW Gas Incentive [$]	$90,000	NA	NA
Federal Business Energy Investment Tax Credit [$]	$54,000	$1,800	$1,200
State Tax Credit [$]	NA	NA	NA
Net Capital Cost [$]	$36,000	$4,200	$2,800
Annual Energy Savings [$]	$18,630	$760	$678
Simple Payback [yrs.]	1.9	5.5	4.1

TABLE 9 Solar Thermal System Study

Note that any fees for the design of the solar thermal systems are not included in the Net Capital Costs.

9.0 Recommendations

9.1 Energy Conservation Measure Recommendations

Utilizing a payback duration of less than 8 years as a threshold, ECM 1 for the select zone temperature reset is recommended for implementation immediately and ECM 2 for lighting occupancy sensors is recommended for implementation on a limited test basis immediately as well. Though the payback period was calculated for many various types of spaces, the implementation of ECM 2 in the larger zones with high wattage lighting such as the Lecture Room or Social Halls would result in the quickest payback periods.

ECM 5 for the increased EER of the rooftop units is recommended whenever a rooftop heat pump unit reaches the end of its service life and needs replacement.

ECM 3 for roof insulation upgrade to an R-value of 20 is not recommended due to the lengthy payback period, but insulation with greater R-valves than existing should be considered when roofs are replaced.

ECM 4 for Demand Controlled Ventilation (DCV) is not recommended due to the long paybacks of the measure, but may still be considered for the largest of the spaces on campus including the Lecture Room and Social Halls, especially if these spaces are usually only partially occupied. If this ECM was only implemented for these spaces, the simple payback would be much more favorable. The estimated net capital cost indicated in the table below assumes the eight (8) units serving these areas are retrofitted.

ECM Recommendations	Estimated Net Capital Cost	Implementation
ECM 1: Zone Temperature Reset	$ 500	Immediately
ECM 2: Lighting Occupancy Sensors	$ 1,000 per zone	Immediately on a limited test basis
ECM 5: Increase EER of new AC units	additional 10% of unit cost	Upon scheduled unit replacement
ECM 4: DCV for Lecture Rm and Social Halls	$ 16,000	After additional study and if budget allows
ECM 3: Roof Insulation Upgrades	TBD based on project	As project budget allows

TABLE 10 ECM Recommendations

9.2 Renewable Energy System Recommendations

In general, shorter paybacks are associated with the smaller PV systems tilted 30º facing south. This is because small systems are able to take greater advantage of state incentives (which grant as maximum of $25,000) and systems tilted 30º facing south optimize sun exposure to the panels.

Thus, the installation of a photovoltaic array with panels facing 30º south and a solar thermal system for the Men's club is recommended at this time. Installing a system the smallest size for the Men's Club would offer multiple benefits.

1. Smaller system allows a limited upfront investment for the first renewable system.
2. The Men's Club incurs the least cost of any of the studied PV systems.
3. While the Men's Club does not have the lowest payback of any of the solar thermal systems, it is still has a relatively short payback (5.5 years) and requires a relatively small initial investment after incentives ($4,200)
4. The Men's Club PV system is the only system that can receive the maximum State of Arizona tax credit as it does not reach the upper limit.

It should be noted that if a solar thermal systems is first provided for the Men's Club, it will offset electric usage for the building and thus the PV system could be downsized accordingly.

<u>The following table proposes a chronological order of the recommendations:</u>

Renewable Energy Recommendations	Estimated Net Capital Cost	Implementation
Men's Club Solar Thermal System	$ 4,200	As soon as budgeted
Men's Club PV Array System (30 degree South)	$ 128,541	As soon as budgeted
Library Solar Thermal System	$ 2,800	As soon as budgeted
Pool/Exercise building/swimming pool Solar Thermal System	$ 36,000	As soon as budgeted

TABLE 11 Renewable Energy System Recommendations

Though the solar thermal system for the Pool/Exercise building/ swimming pool has a very attractive payback of less than 2 years, and has a smaller associated net capital cost than the PV array system for the Men's Club, it is recommended that the Recreation Centers of Sun City West implement both the solar thermal and PV array systems at one building to better highlight the goals of providing renewable energy systems for their facilities. Thus, the building for which these systems incur the least cost is recommended to showcase these sustainable technologies to present and future members of the Recreation Centers of Sun City West.

Of course, the above recommendations are dependent on available budgetary funding, and are proposed as a roadmap for future renewable energy system projects. If additional funding is available, the solar thermal systems for the Library and Pool/Exercise building / swimming pool should be strongly considered as their simple paybacks as very attractive.

Alternatively, if near-term funding cannot support the higher cost for the Men's Club PV array system, perhaps the solar thermal systems for all of the buildings could be provided as the first step of the roadmap.

Depending on the nature of the design and delivery methods for these renewable energy systems, fees may be incurred from a traditional professional engineering firm for design, permitting and construction administration services. Alternatively, some manufacturers of these systems provide in-house design, permitting and construction services for a complete design/build installation.

10.0 Conclusion

This Final Report represents the start of the process for the Recreation Centers of Sun City West to realize their dreams and plans for future energy conservation and renewable energy system projects. As noted, both are closely inter-related as the implementation of energy conservation measures (ECMs) and provision of solar thermal systems will reduce the required size, capacity and costs of any photovoltaic (PV) renewable energy systems.

The Recreation Centers of Sun City West should be given credit for embarking on this roadmap towards exploring energy conservation measures and renewable energy systems. Few Owners of similar facilities exhibit the foresight to investigate energy conservation measures and such sustainable design practices. Of course, budget constraints and economic payback are critical as all spending decisions require a solid financial return on investment.

The simple payback periods of the recommended ECM 1 for selected zone temperature reset and ECM 5 for increased unit EER efficiencies are less than 5 years. Facilities maintenance personnel are scheduled to implement ECM 1 immediately and have already been replacing units with high efficient units.

The recommendation for ECM 2 for occupancy sensors for lighting controls should be implemented on a limited test basis, so as to test their operations and acceptance by members and staff. Newer technologies on the market have greatly increased the use and acceptance of these controls.

Though the simple payback periods for ECM 3 for roof insulation upgrades and ECM 4 for Demand Controlled Ventilation (DCV) at the AC units are very long, these measures may still be implemented in the future. When a roof requires replacement, the incremental cost for insulation with a somewhat greater R-value may be considered. Also, based on the occupancy rates of the large assembly areas on campus such as the Lecture Room and Social Halls, the relatively small cost for the DCV controls for these eight units may be considered as well. For the more times that these areas are occupied at only partial occupancies, the less outside air is required by code to be conditioned and delivered to these spaces, thus resulting in less electrical energy consumed by the units and a much shorter payback period.

The recommendations regarding the renewable energy systems take into consideration the need to start "small" but still highlight a commitment to these sustainable technologies for the least possible cost. Though the simple payback for the PV array systems are approximately 16 years, by first providing both a solar thermal and PV array system for the Men's Club, the size of the PV system can be reduced, and the PV arrays on top of the new shaded parking structures will provide a highly visible showcase to members, guests and the public at large.

As noted in the Recommendations section and depending on the funding available, alternate recommendations may be pursued. As the first costs for the solar thermal systems are much less than the PV array systems, all of the proposed solar thermal systems could be provided first, with the added benefit of much shorter payback periods than the PV array systems.

Depending on the nature of the design and delivery methods for these renewable energy systems, fees may be incurred from a traditional professional engineering firm for design, permitting and construction administration services. Alternatively, some manufacturers of these systems provide in-house design, permitting and construction services for a complete design/build installation.

The goals of this project were modest, but the results are promising. Depending on the acceptable payback periods and funding available, several options for the implementation of ECMs and the provision of renewable energy systems are possible. Using this Final Report as the roadmap, the Recreation Centers of Sun City West has more specific information to confidently move forward with the process to put these recommended forward-thinking designs into practice.

11.0 Appendix: Energy Model Assumptions

Item	Model Design Inputs
Weather Data	Climate Zone - Zone 2B TMY3 Weather File, AZ_Phoenix_Sky_Harbor_Int
Utility Rates	Electricity: $ 0.1055/kWh
Building Area	159,700
Space Types	TRANS: Transient OFF: Office STOR: Storage MEET: Meeting/Conference RESTROOM: Restroom EMR: Electrical/Mechanical Room COMP: Server/Computer ACTIVITYACTIVE: Active Activities (also named for function) ACTIVITYNONACTIVE: Non-Active Activities (also named for function) POOL: Pool FOOD: Kitchen/Dining LIBRARY: Library LECT: Lecture Hall
% of Vertical Windows	2.4%
Vertical Glass Selection	1.3 inch framing, Double Pane Grey Tint Glass Center of Glass U=0.57 SHGC=0.61
Exterior Shades	none
Walls	Above Grade Wall U value=Roo0.125 • 6” Concrete • 2” Rigid Insulation • 1/2” Gypsum board
Roof	Roof with insulation entirely below deck 2” Batt insulation U-value: 0.1375
Slab-On-Grade Floor	R Value = 12

Lighting Power Density	Lighting typical W/SF TRANS: 0.5 OFF: 1.1 STOR: 0.8 MEET: 1.3 RESTROOM: 0.9 EMR: 1.5 COMP: 1.1 ACTIVITYACTIVE: 1.4 ACTIVITYNONACTIVE: 1.5 POOL: 1.2 FOOD: 1.2 LIBRARY: 1.7 LECT: 0.9
Lighting Controls (occupancy)	None
Lighting Controls (daylight)	None
Exterior Lighting	89 kW (shuts off at midnight)
Receptacle Loads	EPD- Equipment Power Density (W/SF) TRANS: 0.2 OFF: 1.0 STOR: 0.2 MEET: 1.0 RESTROOM: 0.5 EMR: 0.2 COMP: 4.0 ACTIVITYACTIVE: 0.5 ACTIVITYNONACTIVE: 3.0 POOL: 1.0 FOOD: 1.5 LIBRARY: 1.5 LECT: 1.0
Occupancy	TRANS: 100 OFF: 100 STOR: 333 MEET: 15 RESTROOM: 7 EMR: 666 COMP: 60 ACTIVITYACTIVE: 50 ACTIVITYNONACTIVE: 15 POOL: 15 FOOD: 200 LIBRARY: 100 LECT: 7

Schedules	Per owner input & documentation
HVAC Systems	Rooftop single zone package units Heat pump systems
Perimeter Heating	None
Humidity	No controls
Outside air Volume	25% outside air values noted in building audit
Energy Recovery	None
Fan Power	Supply static pressure: 2"
Supply Air Temperature Reset	Heating/Cooling: NONE
Space Temperature Set points	Occupied Spaces: Cooling/Heating : 72 ºF Pool area: Cooling/Heating : 74 ºF Active Activity Areas: Cooling/Heating : 70 ºF Unoccupied night setbacks of 65 ºF/85 ºF for heating/cooling
Demand Controlled Ventilation	None
Economizer Control	Fixed dry bulb: 70 ºF high limit Shutoff
Cooling/Heating Design	Heat Pumps with EER values per owner input and energy audit (9.0-12.8)