

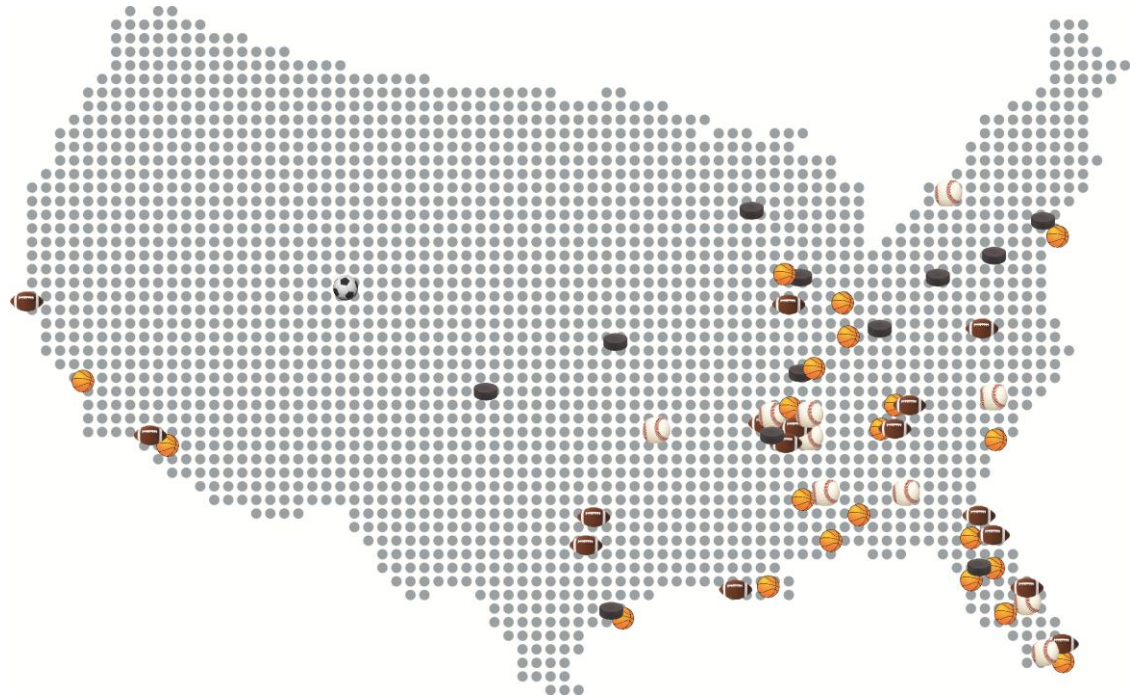


# **STADIUM & ARENA RETRO-COMMISSIONING FINDING THE \$\$ IN GREEN**



## **Presented by:**

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Steve Harrell, CEM, CxA



A vertical strip on the left side of the slide contains two black and white photographs. The top photograph shows a close-up of stadium seating, with rows of seats and a metal railing visible. The bottom photograph shows a close-up of a baseball field, focusing on the pitcher's mound and the bases.

# Agenda

Introduction

Retro-commissioning –  
Unique Considerations for Venue

Case Studies

Bridgestone Arena

Phoenix Cardinal Stadium

# Approach to EBCx

1. Analyze current energy usage
2. Document Current Facility Requirements
3. Conduct a site investigation
4. Identify energy-saving facility improvement measures
5. Develop an Implementation Plan and provide implementation assistance
6. Verify measure implementation and document savings





# Best Practices

- Develop and maintain database on realistic costs
- Understand how the HVAC and lighting systems work, and need to operate
- When possible, work with available utility incentives programs
- Advocacy and training



# Unique Considerations for Stadiums & Arenas

1. Multiple uses = multiple heating, cooling, and lighting challenges and operating procedures
2. Each event requires a unique operational strategy to fulfill both comfort requirements and energy efficiency  
Challenging balance!



3. ONE SIZE  FIT ALL

## Current Facility Requirements (CFR)

University of Phoenix Stadium  
Phoenix, AZ

| Requirement                                   | Bowl - NFL                                                         | Bowl - Concerts                                         | Bowl - Dirt Shows                                                     | Bowl - Trade Shows                                                | Concourse                                                 | Storage                   | Kitchen                                                                                     | Offices                                             | Club Level - minor Events                           |
|-----------------------------------------------|--------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------|---------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
| Temperature requirements for cooling season   | 62°F (pre-cool)<br>72°F (during game)                              | Maintain similar to NFL requirements.                   | 72°F                                                                  | 74°F                                                              | Matches conditions for the event in the bowl.             | No cooling                | 70°F                                                                                        | 71°F (85°F)                                         | 68°F                                                |
| Temperature requirements for heating season   | Same as above                                                      | Same as above                                           | 68°F                                                                  | None                                                              | Same as above                                             | No heating                | None                                                                                        | 69°F (60°F)                                         | 68°F                                                |
| Humidity requirements                         | None                                                               | None                                                    | None                                                                  | None                                                              | None                                                      | None                      | None                                                                                        | None                                                | None                                                |
| Dehumidification requirements                 | None                                                               | None                                                    | None                                                                  | None                                                              | None                                                      | None                      | None                                                                                        | None                                                | None                                                |
| Pressure relationship requirements            | Positive                                                           | Positive                                                | Positive                                                              | Positive                                                          | Negative to the bowl, positive to the outside.            | Negative to stadium       | Negative to stadium                                                                         | Positive to outside.                                | Positive to outside.                                |
| Filtration Requirements                       | MERV-8                                                             | MERV-8                                                  | Install a filter media on the return air duct<br>MERV-8 for all AHUs. | MERV-8                                                            | MERV-8                                                    | None                      | MERV-8                                                                                      | MERV-8                                              | MERV-8                                              |
| Ventilation requirements                      | 1,000 ppm                                                          | 1,000 ppm                                               | Open up retractable dome. Full exhaust.                               | 1,000 ppm                                                         | Minimum per ASHRAE 62.1. See Equipment Schedules.         | 100% exhaust              | Hood exhaust.<br>Minimum OA per ASHRAE 62.1. See equipment schedules.                       | Minimum OA per ASHRAE 62.1. See equipment schedule. | Minimum OA per ASHRAE 62.1. See equipment schedule. |
| Air change requirements                       | <i>Talk with T42 about typical requirements.</i>                   |                                                         |                                                                       |                                                                   |                                                           |                           |                                                                                             |                                                     |                                                     |
| Normal operating schedule for occupancy       | 2 hrs prior to kick-off and 1 hr after the end of the 4th quarter. | 2 hrs prior to showtime and 1 hr after show end.        | 2hrs prior to event start and 1 hr after event end.                   | 2hrs prior to event start and 1 hr after event end.               | Same as bowl event schedule.                              | None                      | M - F: 9am to 5 pm.                                                                         | M - F: 7am to 6pm                                   | 5 pm to 9 pm on event day.                          |
| Weekend schedule                              | Same as above                                                      |                                                         | Same as above                                                         |                                                                   | Same as above                                             | Same as above             | None                                                                                        | None                                                | 5 pm to 9 pm on event day.                          |
| Holiday schedule                              | Same as above                                                      |                                                         | Same as above                                                         |                                                                   | Same as above                                             | Same as above             | None                                                                                        | None                                                | 5 pm to 9 pm on event day.                          |
| Other schedule                                | N/A                                                                | 12 - 14 hour days for band crews.                       |                                                                       | Trade show set-up: Load in 1 day prior, and load out 1 day after. | 4 hrs prior to event and 2 hrs after the end of an event. | Same as above             | 6am to 10pm (NFL, Concerts)<br>9am to 5 pm (trade shows)<br>7:30 am to 7:30 pm (dirt shows) | None                                                | 3 pm to 11 pm for event set up.                     |
| Process loads during evening/night time hours | All OFF unless game day.                                           | All OFF except on event.                                | All OFF except on event.                                              | All OFF except on event.                                          | None                                                      | None                      | None                                                                                        | 45% load or less                                    | All OFF                                             |
| Process loads during holiday hours            | All OFF unless game day.                                           | All OFF except on event.                                | All OFF except on event.                                              | All OFF except on event.                                          | None                                                      | None                      | None                                                                                        | 45% load or less                                    | All OFF                                             |
| Process loads during scheduled maintenance    | All OFF                                                            | All OFF                                                 | All OFF                                                               | All OFF                                                           | All OFF                                                   | All OFF                   | All OFF                                                                                     | 45% load or less                                    | All OFF                                             |
| Cleaning Schedules                            | 1 hr after the end of an event until 6 am next morning.            | 1 hr after the end of an event until 6 am next morning. | 1 hr after the end of an event until 6 am next morning.               | 1 hr after the end of an event until 6 am next morning.           | 1 hr after the end of an event until 6 am next morning.   | None                      |                                                                                             | 10 am to 4 pm (1 person) - M - F.                   |                                                     |
| Lighting Levels                               | <a href="#">See email</a>                                          | <a href="#">See email</a>                               | <a href="#">See email</a>                                             | <a href="#">See email</a>                                         | <a href="#">See email</a>                                 | <a href="#">See email</a> | <a href="#">See email</a>                                                                   | <a href="#">See email</a>                           | <a href="#">See email</a>                           |
| Other Requirements:                           | Process loads: Scoreboard, advertising ribbon.                     | Not many concerts at this stadium.                      | Process loads: Scoreboard, advertising ribbon.                        | Advertising ribbon.                                               |                                                           |                           |                                                                                             |                                                     |                                                     |



# CASE STUDY: UNIVERSITY OF PHOENIX STADIUM

Year Built – 2006 | Construction Cost – \$412M | Size – 1.7M SF

Capacity –

Football - 63,500 to 72,800

Other – Varies by type & size

Space Types –

Bowl – 27%

Concourse – 47%

Storage – 18%

Offices – 8%

Avg. Energy Data –

17,643,207 kWh/yr

\$1,194,445/yr







# PHOENIX STADIUM

## Project Details

- Retrocommissioning Project through the SRP Powerwise RCx Program
  - Project is divided into three (3) phases
    - **Planning** (complete)
    - Implementation (In progress)
    - Verification (In progress)



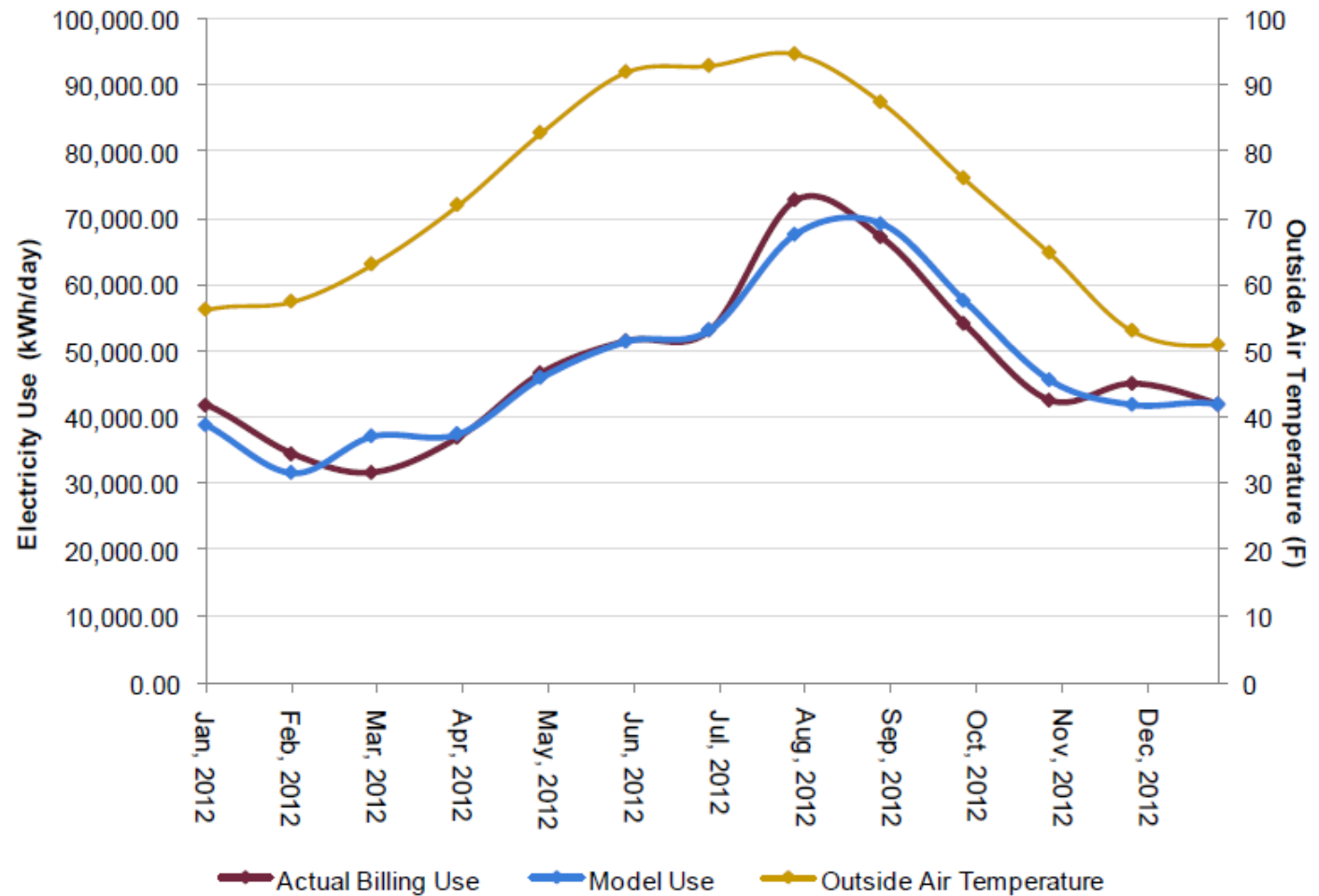
# PHOENIX STADIUM

- Central Plant
  - Two (2) 1,000 ton Chillers
  - Four (4) 1,500 ton Chillers
  - Six (6) variable flow variable speed CHW pumps
  - Six (6) 1,567 ton Cooling Towers
    - Two (2) Cooling Towers have VFDs
    - Six (6) constant speed CW pumps
- Airside Systems
  - 20 Bowl AHUs
  - 15 single-duct variable volume AHUs
  - 9 single-duct, single-zone constant volume AHUs
  - 2 single-duct constant volume AHUs with terminal reheat



# PHOENIX STADIUM

$$E_{ELE} = -35,880.52 + 536.86T_{OA} + 2,692.88N_{Pre-Cool\ Events} + 5,160.33N_{NFL\ Games} + 1,263.89N_{Dark\ Days} + 1,261.12N_{Trade\ Shows} + 729.82N_{Competitions} + 1,059.63N_{Graduations}$$



# RECOMMENDATIONS

Table ES-1. Preliminary RCM Estimates

| RCM No.             | RCM Description                                            | Annual Energy Savings (kWh/yr) | Peak Demand Savings (kW) | Annual Electric Energy Cost Savings (\$/yr) | Implementation Cost (\$) | Simple Payback (years) |
|---------------------|------------------------------------------------------------|--------------------------------|--------------------------|---------------------------------------------|--------------------------|------------------------|
| 1                   | Reset CHW Supply Temperature                               | 365,802                        | 252                      | \$24,765                                    | \$11,000                 | 0.4                    |
| 2                   | Reset CW Supply Temperature                                | 144,634                        | 0                        | \$9,792                                     | \$13,000                 | 1.3                    |
| 3                   | Raise the space cooling temperature set points             | 418,953                        | 195                      | \$28,363                                    | \$11,000                 | 0.4                    |
| 4                   | Raise the Scoreboard Room cooling temperature              | 2,502                          | 0                        | \$169                                       | \$0                      | 0.0                    |
| 5                   | Change the office, ticketing, and team store AHU schedules | 71,148                         | 0                        | \$4,817                                     | \$16,000                 | 3.3                    |
| 6                   | Lower the duct static pressure high limit set point        | 176,631                        | 17                       | \$11,958                                    | \$22,000                 | 1.8                    |
| Total (interactive) |                                                            | 1,179,670                      | 464                      | \$79,864                                    | \$73,000                 | 0.9                    |





## CASE STUDY: BRIDGESTONE ARENA

Year Built – 1996 | Construction Cost – \$144M

Capacity –

Basketball 19,395

Ice Hockey 17,113

Concert varies up to 20,000

Average Energy Figures –

158,999,358 kBTU per year

\$2,856,134 per year



# PROJECT SNAPSHOT

## Bridgestone Arena Energy Audit

| Current Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Energy Conservation & Affect                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                 | Cost Effectiveness & Financing                                                                     |                                                                                                                 |                                                                                                         |                                                                         |                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Findings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Recommendations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Site Energy Savings (MBtu/yr)                                                   | Energy Cost Savings (\$/yr)                                                                        | Implementation Cost (\$)                                                                                        | Commissioning (\$)                                                                                      | Simple Payback (yrs)                                                    | ROI (%)                                                                         |
| <b>Lighting control system is one (1) failure away from causing an emergency</b><br>Current system incapable of advanced lighting scheduling<br>Current system incapable of supporting daylight harvesting controls<br><b>The bowl units do not have sufficient dehumidification capacity</b><br><b>HVAC control system is obsolete and cannot be updated</b><br>No Airside economizer functionality<br>Suboptimal AC unit schedules<br>No heating water supply temperature reset<br>14 AC units without supply air temperature reset<br>5 AC units without night setback controls<br>10 AC units with faulty discharge static pressure sensors<br><b>HVAC system loads are high and indoor air quality (IAQ) is poor</b><br>Bowl units need to be rebalanced<br>10 VAV AC units use inlet guide vanes to control air volume<br>5 CAV AC units have constant speed fans<br>AC 4-4E serves the Register of Deeds and is CAV<br>5 AC units have closed outside air dampers<br><b>Lighting loads and energy use is higher than necessary</b><br>Inefficient lamps are used throughout the arena<br>Lighting levels in the tower retail space is higher than recommended<br>Stairwell lighting is on more than required by local code<br>Event Services office space is overlit<br>Event level interview rooms are overlit<br>Sirius XM Radio tenant space is overlit<br><b>HVAC operations &amp; maintenance (O&amp;M) issues exist throughout the arena</b><br>Missing filters & broken static pressure gauges<br>Dirty / clogged cooling and heating coils<br>Holes in supply air ducts near AC 1-3H and AC 1-4E | <b>Replace the lighting control system</b><br>Occupancy-based lighting controls to applicable spaces<br>Daylight harvesting in main concourse near front doors<br><b>Design+install dehumidification system</b><br><b>Upgrade/replace HVAC control system</b><br>Enthalpy-based economizer control for all AC units<br>Occupancy-based AC unit controls<br>Heating water supply temperature reset<br>Supply air temperature reset for 14 identified AC units<br>Night setback controls for applicable AC units<br>Recalibrate/replace discharge static pressure sensors<br><b>Reduce HVAC system loads &amp; improve IAQ</b><br>Rebalance the bowl AC units<br>Install VFDs to VAV AC units<br>Install VFDs to CAV AC units<br>Convert AC 4-4E to variable air volume<br>Open outside air dampers to the 5 identified AC units<br><b>Reduce lighting loads and use</b><br>Install efficient lamps to identified fixtures<br>Turn off security lighting during business hours<br>Implement bi-level lighting controls to stairwells<br>Redesign event services office lighting<br>Redesign event level interview room lighting<br>Implement daylight harvesting to Sirius XM Radio<br><b>Existing Building Commissioning</b><br>Address HVAC O&M issues<br>Identify additional energy-savings measures<br>Provide ongoing commissioning services | 16,149<br><br><br>N/A<br>29,614<br><br><br>803<br><br><br>558<br><br><br>25,440 | \$212,620<br><br><br>N/A<br>\$388,456<br><br><br>\$16,015<br><br><br>\$12,513<br><br><br>\$296,930 | \$1,000,000<br><br><br>\$2,100,000<br>\$1,600,000<br><br><br>\$133,642<br><br><br>\$44,289<br><br><br>\$403,100 | \$116,000<br><br><br>\$100,000<br>\$116,000<br><br><br>\$38,200<br><br><br>\$7,800<br><br><br>\$403,100 | 5.2<br><br><br>N/A<br>4.4<br><br><br>10.7<br><br><br>4.2<br><br><br>1.4 | 19.1%<br><br><br>N/A<br>22.6%<br><br><br>9.3%<br><br><br>24.0%<br><br><br>73.7% |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 61,680                                                                          | \$787,554                                                                                          | \$4,877,931                                                                                                     | \$735,200                                                                                               | 7.1                                                                     | 14.0%                                                                           |

| Energy Utility Use & Cost |                      |   |                 |
|---------------------------|----------------------|---|-----------------|
| Electricity               | 13,071,455 kWh/yr    | & | \$688,492 /yr   |
| Electric Demand           | 2,183 kW/month       | & | \$536,802 /yr   |
| Natural Gas               | 21,962 Therms/yr     | & | \$18,559 /yr    |
| Chilled Water             | 6,386,381 ton-hrs/yr | & | \$548,362 /yr   |
| Steam                     | 29,788 kWh/yr        | & | \$365,231 /yr   |
| Site Energy Use           | 158,999 MBtu/yr      | & | \$2,157,445 /yr |
| Total Utility Cost        |                      |   | \$2,856,134 /yr |

Energy Use + Demand Cost = \$1,157,445/yr

Total Utility Cost = \$2,856,134/yr

**Site Energy Savings** 61,680 MBtu/yr

**Enerev + Demand Cost Savings** \$787,554 /yr

**Avoided GHG Emissions** 6,359 MtCO<sub>2</sub>e/yr

1247 Cars

551 Homes

35 Railcars of Coal

Current vs. Proposed Energy Use

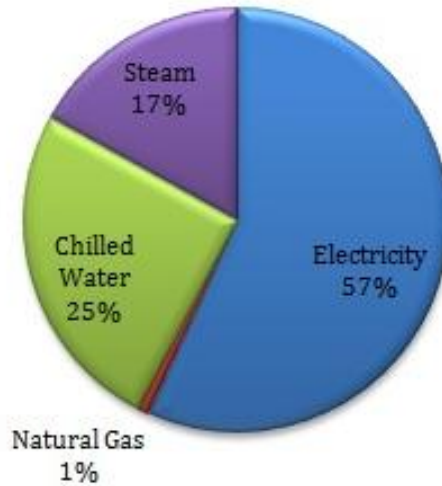
  

ESCO: Energy service companies, such as Siemens, can provide non-lien loans to entities with limited access to disposable income for implementing energy savings facility improvements. There may be a contract currently in place between Siemens and Metropolitan Government of Nashville and Davidson County that could be used to fund implementation of the recommendations listed. An advantage to using an ESCO is they would guarantee the project savings, while not requiring any (or little) capital investment from the arena to implement any energy saving facility improvements.

**TVA EnergyRight Solutions Program** can provide incentives to the arena for implementing qualifying energy saving facility improvements. There are two (2) types of incentives: Standard and Custom. The standard incentive pays a standard incentive per unit installed. For example, replacing T12 lamps with T8 lamps qualifies for a standard incentive. The custom incentive offers \$0.10/kWh saved for all other energy efficiency retrofits that do not qualify as standard incentives. All incentives are capped at \$200,000/yr or 50% of the total implementation cost, whichever is less.

# FINDINGS

Energy Use + Demand Cost = \$2,157,445/yr



Total Utility Cost = \$2,856,134/yr



- Lighting Control & Loads
- Bowl Units
- HVAC System
- O&M

# RECOMMENDATIONS

- Replace the lighting control system
- Design + install dehumidification
- Upgrade HVAC control
- Reduce HVAC loads & improve IAQ
- Reduce lighting loads and use
- Address O&M

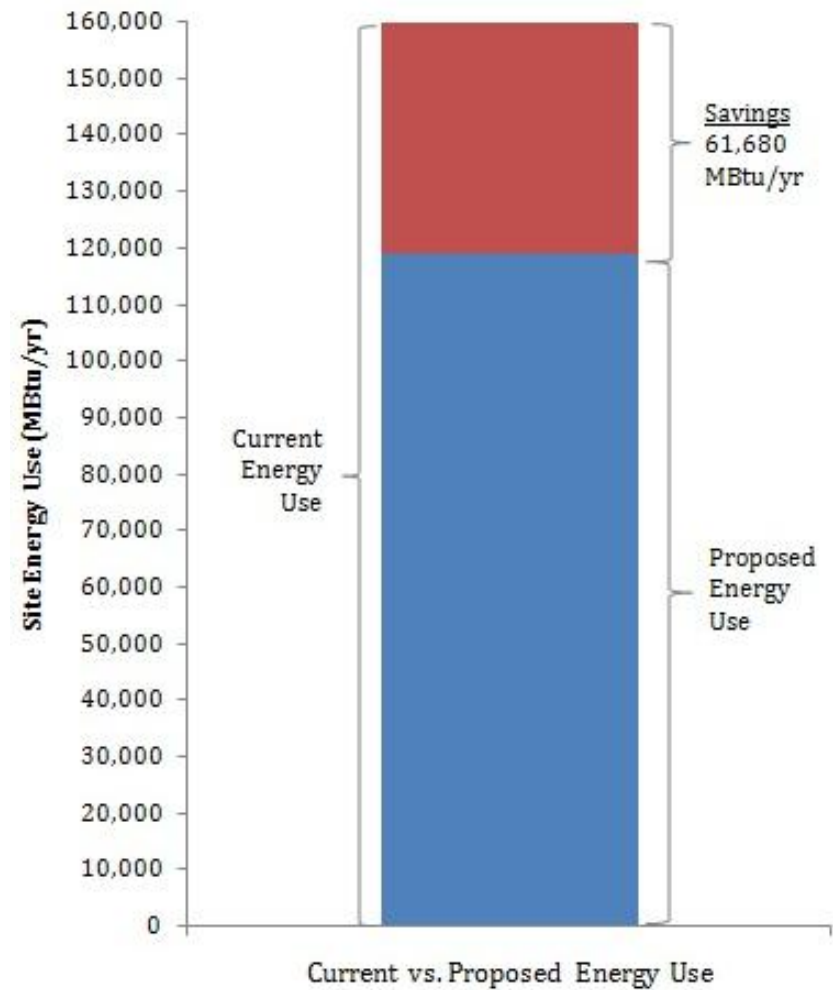






Table 1: Recommended ECMs List

| ECM No. | Description                                                         | Estimated Savings    |                          |                            |                 |                     | Cost Estimate (\$) | Simple Payback (yrs) |
|---------|---------------------------------------------------------------------|----------------------|--------------------------|----------------------------|-----------------|---------------------|--------------------|----------------------|
|         |                                                                     | Electricity (kWh/yr) | Electric Demand (kW/mth) | Chilled Water (ton-hrs/yr) | Steam (klbs/yr) | Energy Cost (\$/yr) |                    |                      |
|         | HVAC-related Measures                                               |                      |                          |                            |                 |                     |                    |                      |
| H-1     | Restore & optimize heating water supply temperature reset           | 0                    | 0                        | 0                          | 4,963           | \$70,943            | \$3,600            | 0.1                  |
| H-2     | Optimize supply air temperature controls for fourteen (14) AC units | 56,896               | 0                        | 27,798                     | 130             | \$8,078             | \$0                | 0.0                  |
| H-3     | Enable unoccupied mode night setback controls for five (5) AC units | 23,116               | 0                        | 11,294                     | 53              | \$3,282             | \$12,000           | 3.7                  |
| H-4     | Open outside air dampers for five (5) AC units                      | 1,401                | 0                        | 685                        | 3               | \$199               | \$3,600            | 18.1                 |
| H-5     | Recalibrate discharge static pressure sensors for ten (10) AC units | 10,299               | 0                        | 5,032                      | 23              | \$1,462             | \$0                | 0.0                  |
|         | Sub-total (interactive <sup>1</sup> )                               | 77,956               | 0                        | 38,087                     | 4,396           | \$71,369            | \$19,200           | 0.3                  |
|         | Lighting-related Measures                                           |                      |                          |                            |                 |                     |                    |                      |
| L-1     | Replace inefficient lamps                                           | 124,559              | 5.0                      | 0                          | 0               | \$8,915             | \$23,424           | 2.6                  |
| L-2     | Turn off security lighting in Tower retail space                    | 3,661                | 1.1                      | 0                          | 0               | \$396               | \$0                | N/A                  |
| L-3     | Reduce stairwell lighting energy use                                | 27,612               | 3.2                      | 0                          | 0               | \$2,261             | \$11,800           | 5.3                  |
| L-4     | Redesign lighting in Event Services Office                          | 3,960                | 0.9                      | 0                          | 0               | \$388               | \$3,600            | 9.3                  |
| L-5     | Redesign lighting in event level interview rooms                    | 2,340                | 1.7                      | 0                          | 0               | \$397               | \$3,120            | 7.9                  |
| L-6     | Reduce lighting energy use in Sirius XM Radio Tenant Space          | 1,513                | 0.4                      | 0                          | 0               | \$156               | \$2,345            | 15.0                 |
|         | Sub-total                                                           | 163,645              | 12.3                     | 0                          | 0               | \$12,513            | \$44,289           | 3.5                  |
|         | Commissioning (All ECMs)                                            | 241,601              | 12.3                     | 38,087                     | 4,396           | \$83,882            | \$32,100           | 0.4                  |
|         | Total (interactive)                                                 | 241,601              | 12.3                     | 38,087                     | 4,396           | \$83,882            | \$69,765           | 0.8                  |





Table 2: Potential capital-intensive improvements list

| No.                       | Description                                            | Estimated Savings    |                          |                            |                 |                     | Cost Estimate (\$) | Simple Payback (yrs) |
|---------------------------|--------------------------------------------------------|----------------------|--------------------------|----------------------------|-----------------|---------------------|--------------------|----------------------|
|                           |                                                        | Electricity (kWh/yr) | Electric Demand (kW/mth) | Chilled Water (ton-hrs/yr) | Steam (klbs/yr) | Energy Cost (\$/yr) |                    |                      |
| HVAC-related Measures     |                                                        |                      |                          |                            |                 |                     |                    |                      |
| I-1                       | Restore positive pressure & indoor air quality to bowl | 11,924               | 1.4                      | 5,826                      | 27              | \$1,883             | \$10,000           | 5.3                  |
| I-2                       | Add desiccant dehumidification to bowl units           | N/A                  | N/A                      | N/A                        | N/A             | N/A                 | \$1.7M to \$2.5M   | N/A                  |
| I-3                       | Upgrade/replace HVAC control system                    | 2,468,674            | 272                      | 1,206,132                  | 5,626           | \$388,456           | \$1.6M             | 4.1                  |
| I-4                       | Install VFDs to ten (10) VAV AC units                  | 131,676              | 15                       | 0                          | 0               | \$10,783            | \$92,428           | 8.6                  |
| I-5                       | Install VFDs to five (5) CAV AC units                  | 41,964               | 4.8                      | 0                          | 0               | \$3,437             | \$27,614           | 8.0                  |
| I-6                       | Convert AC 4-4E to variable air volume                 | 16,078               | 1.8                      | 7,856                      | 37              | \$2,539             | N/A                | N/A                  |
|                           | Sub-total (interactive)                                | 2,269,769            | 250.3                    | 1,036,841                  | 4,836           | \$346,034           | \$3.4M to \$4.2M   | 9.9 to 12.2          |
| Lighting-related Measures |                                                        |                      |                          |                            |                 |                     |                    |                      |
| I-7                       | Replace lighting control system                        | 1,346,223            | 153.7                    | 657,731                    | 3,068           | \$212,620           | \$1.0M             | 4.7                  |
| I-8                       | Replace great spectacular and billboard signs          | N/A                  | N/A                      | N/A                        | N/A             | N/A                 | N/A                | N/A                  |
|                           | Sub-total                                              | 1,346,223            | 153.7                    | 657,731                    | 3,068           | \$212,260           | \$1.0M             | 4.7                  |
|                           | Commissioning (All ECMs)                               | 3,414,058            | 381.0                    | 1,595,912                  | 7,444           | \$526,760           | \$300k to \$336k   | 0.6 to 0.7           |
|                           | Total (interactive)                                    | 3,414,058            | 381.0                    | 1,595,912                  | 7,444           | \$526,760           | \$4.7M to \$5.5M   | 8.9 to 10.4          |



| Implementation Costs | Commissioning Costs | Simple Payback | ROI |
|----------------------|---------------------|----------------|-----|
| \$4,877,931          | \$735,200           | 7.1            | 14% |



## Success Factors & Lessons Learned

- Give ample consideration to building use and occupancy. Varied schedule impacts energy usage and needs
- Clearly document the current facility requirements (CFR) with the facility manager/Director of Operations
- Remain focused on Player and Fan Experience – start with the Bowl

A vertical strip on the left side of the slide shows a black and white photograph of a stadium. The top part shows rows of empty seats, and the bottom part shows a portion of the field with white yard lines.

## Questions and Discussion

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**Principal**

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