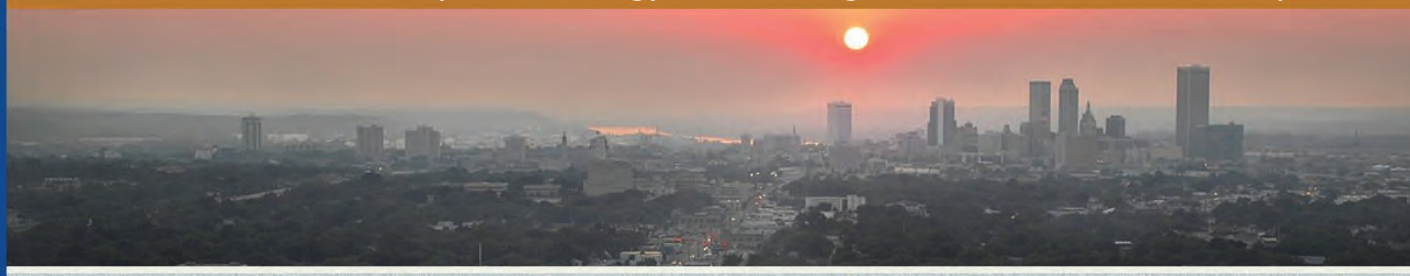
City of Tulsa Sustainability Plan

Resource Efficiency, Clean Energy, and Leading Growth in the New Economy



City of Tulsa
A New Kind of Energy

Prepared by:

URS

Message from the Mayor

October 27, 2011

The City of Tulsa is working to become an organizational model for our community by creating our first sustainability plan, which will define our actions for reducing energy costs, increasing efficiencies, improving air quality and becoming a leader in sustainable government.

The plan is essentially a list of recommendations based on extensive research and background information development, which will allow the City of Tulsa to reduce energy and resource consumption and save money in our processes while continuing to provide high levels of service to our citizens. The switch to alternative fuels will help us meet many of our goals in terms of air quality and emissions, as well as lowering overall fuel costs. The continued expansion of our alternative fuel fleet is one of the main recommendations made in the plan. We are also performing energy audits on COT facilities and pursuing many energy efficiency initiatives.

In order to ensure future success, cities must look for energy solutions that will save money and diversify energy sources. Adding alternative energy to traditional energy will reduce operational expenses, save taxpayer dollars, and lessen our impact on air quality. It is our goal to be an example for other organizations within our city and to be a catalyst for job creation and expansion in energy industries.

Mayor Dewey F. Bartlett Jr.

City Officials

Dewey F. Bartlett, Jr.
Mayor

Councilors:

Jack R. Henderson, District 1

Rick Westcott, District 2

Roscoe H. Turner, District 3

Maria Veliz Barnes, District 4

Christopher E. Trail, District 5

James S. Mautino, District 6

John Eagleton, District 7

William L. Christiansen, District 8

G.T. Bynum, District 9

Jim Twombly
City Manager

Brett Fidler
Director, Office of Sustainability

Released October 27, 2011

Contents

Exhibits

Acronyms List

15-CIP	Capital Improvement Plan
AEP	American Electric Power
AHU	Air handling unit
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BEES	Building for Environmental and Economic Sustainability
BMP	Best Management Practice
C&D	Construction and demolition
COT	City of Tulsa
CNG	Compressed natural gas
CRS	Community Rating System
DDC	Direct Digital Controls
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSM	Demand Side Management
EASA	Electrical Apparatus Service Association
ECM	Energy conservation measure
ECST	Energy Conservation & Sustainability Team (City of Tulsa)
EEC	Environmental Education Committee
EECBG	Energy Efficiency and Conservation Block Grant
EMD	Equipment Management Department
EPA	U.S. Environmental Protection Agency
FMA	Flood Mitigation Assistance
FUSS	Fleet Utilization Scoring System
FY	Fiscal year
GDP	Gross domestic product
GHG	Greenhouse gas
HP	Horsepower
HMGP	Hazard Mitigation Grant Program
HUD	U.S. Department of Urban Housing and Development
HVAC	Heating, ventilation, and air conditioning
IBC	International Building Code
IDL	Inner dispersal loop
ISO	International Organization for Standardization

IP	Intellectual property
IT	Information technology
KPI	Key Performance Indicator
kWh	Kilowatt-hour
LED	Light emitting diode
LEED	Leadership in Environmental Energy and Design
LID	Low impact development
MG	Million gallons
MGD	Million gallons per day
mg/L	Milligrams per liter
MMBtu	Million British thermal units
mpg	Miles per gallon
MW	Megawatt
NACWA	National Association of Clean Water Agencies
NAICS	North American Industrial Classification System
OCC	Oklahoma Conservation Commission
ONG	Oklahoma Natural Gas
OPMUG	Oklahoma Predictive maintenance Users Group
OWRB	Oklahoma Water Resources Board
PACE	Partners for a Clean Environment
PACE	Property Assessed Clean Energy
PCSSC	Professional Consulting Services Selection Committee
PR	Public relations
PSO	Public Service Company of Oklahoma
PV	Photovoltaic
QECB	Qualified Energy Conservation Bonds
RFID	Radio frequency identification
ROI	Return on investment
R&D	Research and development
SAM	Strategic Asset Management
SCADA	Supervisory Control and Data Acquisition
SEF	Solar energy factor
SF	Square feet
SSAC	Standards, Specification, and Awards Committee
STEM	Science, Technology, Engineering, and Mathematics
SWMP	Stormwater Management Plan

TDS	Total dissolved solids
TMDL	Total maximum daily load
TMUA	Tulsa Metropolitan Utility Authority
USGS	United States Geological Survey
VMT	Vehicle miles traveled
WRAS	Watershed Restoration Action Strategies
WWTP	Wastewater treatment plant

Acknowledgements

The City of Tulsa would like to thank the following City personnel for the time and effort they offered in developing this Sustainability Plan.

Energy Management Committee

- Dan Crossland
- Thomas Chandler
- Kerry Rowland
- Mark Brown
- Graham Brannin

Water Management Committee

- Ken Hill
- Graham Brannin
- Mary Kell
- Joan Arthur
- Bill Robison
- Ray West

Solid Waste / Recycling Committee

- Darren Stefanek
- Eric Lee

Sustainable Fleet Committee

- Brent Jones
- John Reel
- Brian Franklin
- Wanda Fisher

Sustainable Procurement Committee

- Larry Hood
- Marsh Hinds
- Jim LaCourse
- Britt Vance
- Priscilla Brown

Other Contributors

- Brett Fidler
- Chris Benge
- Kim McCleod
- Jack Page
- Rick Lisenbee
- Theron Warlick
- Bill Cartwright - Metropolitan Tulsa Transit Authority General Manager
- Meredith Webber - Indian Nations Council of Governments, Office of Energy Management, Tulsa Clean Cities Coordinator

Executive Summary

Tulsa's vision for a sustainable future

The City of Tulsa Sustainability Plan is designed to be more than a reference document. It is designed to evolve with the City as new technologies, new economics, and new people redefine what is feasible. The core of the Sustainability Plan is the integration of sustainable design into all aspects of the City's operations, and it includes sections dedicated to the following areas:

- Energy Management
- Water Management
- Solid Waste and Recycling
- Sustainable Fleet Management
- Sustainable Procurement
- Renewable Energy
- Economic Development

The product of several months of research, data analysis, interviews, and writing by dozens of City staff and consultants, the City of Tulsa Sustainability Plan represents a new way of thinking about how the City consumes energy, water, and other resources. It includes over 60 specific sustainability initiatives and a dozen case studies supporting the recommendations. It contains energy conservation measures that were identified as part of comprehensive energy audits conducted at seven City facilities. Finally, the Plan links sustainability planning with sustainable economic development by highlighting Tulsa's unique positioning to be at the cutting edge of the "Clean Tech" economic revolution. Tulsa ranks 8th in the country for annual rate of green jobs growth (8.3%) and this Plan will strengthen that momentum in the direction of long-term economic expansion.

Plan Highlights

The City of Tulsa's vision for its Sustainability Plan is a plan that directs its growth in a manner that minimizes waste, minimizes consumption, reduces dependence on foreign oil, optimizes existing systems and programs, and maximizes the City's opportunities for sustainable economic development. The Plan addresses this complex set of objectives from many different angles, an approach made possible by the innovations and ideas born of cross-discipline brainstorming sessions and involvement from many different City entities.

Highlights of the Plan development process include:

- **Revitalized Energy Conservation and Sustainability Team (ECST).** The Plan re-establishes a team of City leaders and personnel known as the ECST that is assigned to lead the development of the City's sustainability planning process, a process that originally began several years ago but never took root. The Plan covers the logistics such as defining roles within existing protocols, establishing clear accountability, and dedicating necessary City resources for the Team. It also provides recommendations regarding how and where this Team functions within the existing City hierarchy.
- **Centralized and web-based energy and water data management**. The Plan emphasizes the importance of up-to-date electricity, natural gas, fuel, water and waste data to inform strategic decision making regarding where the City should concentrate its resources to minimize costs and maximize savings and results. With a new web-based sustainability data management platform developed as part of this project, the City now has centralized, instant access to utility data and can conduct real-time energy data analytics.
- **A systematic approach to conservation and cost savings.** The Plan incorporates guidance from the International Organization for Standardization (ISO) 50001 Standard for Energy Management Programs to define the process that the City and its Energy Conservation and Sustainability Team will use to identify, evaluate, prioritize, and measure energy and water conservation initiatives. URS worked with the City to lay out a methodology that the Sustainability Team will use to evaluate, prioritize, and measure sustainability initiatives based on cost, feasibility, and expectation of financial, social and/or environmental results. A defined and documented planning methodology strengthens accountability and transparency in the allocation of City resources to this effort.
- **A dynamic plan that grows with the City.** The team's approach to developing the City of Tulsa Sustainability Plan was to create a dynamic process--not just a static plan document--that evolves and changes with new technologies, new personnel, and new data.
- **Prioritization of initiatives based on cost effectiveness.** The systematic approach to evaluating and prioritizing the implementation of sustainability initiatives that forms the basis of this Plan is designed to maximize the impact of every dollar spent. This framework ensures the efficient allocation of City resources (based on financial metrics primarily and other sustainability metrics secondarily) in a transparent and accountable manner. The Plan is structured to facilitate and encourage the continuous improvement of the City's processes for identifying, implementing, measuring, and communicating results of its sustainability initiatives and programs.
- **Link Sustainability Planning with Economic Development.** Tulsa has the opportunity to leverage its historic position as a leading region for production, manufacturing, and services in the oil and gas industry to become a leading region in clean energy and many of the other industries that compose the Clean Tech industry cluster. To build on this momentum, Tulsa could create a CleanTech Tulsa initiative. This Initiative would involve an analysis of the potential Clean Tech Cluster in Tulsa, build on the compressed natural gas (CNG) sub-cluster that already exists, create a Clean Tech Inventory, and start a Clean Tech Network, which could facilitate the start up of clean tech companies in Tulsa. There are other initiatives that Tulsa could pursue to further economic development opportunities in sustainability. One is exploration of city ownership of the local electric utility franchise. City ownership allows a city to align the policies and economic power of the local utility with local needs and opportunities, including economic development opportunities. This is a major decision for a community, and has its advantages and disadvantages.

Background

Precedents and drivers for sustainability

How the City of Tulsa Defines Sustainability

Sustainability is a term that means different things to different people, but to the City of Tulsa it means "the responsible use of resources to meet current needs without compromising the ability of future generations to meet theirs." From the viewpoint of local government, this means continuing to offer the level of service our citizens deserve while using fewer resources and producing less waste. Sustainability is about doing more with less, not doing without. It is about being more efficient in our processes, more thoughtful in our decisions, and realizing that those decisions have long term implications. It is about realizing we are part of a regional, national, and global community, and that our actions and policies can have wide ranging effects well beyond our borders. It is about recognizing the benefits of community awareness and involvement in local government and knowing these are keys to the City's sustainability. It is about realizing that environmental quality, economic health, and social equity are mutually dependent. It is simply being responsible.

Under the direction of Mayor Dewey F. Bartlett, Jr., the City of Tulsa has committed to becoming more sustainable and reducing our ecological impact by increasing energy and resource efficiency, moving toward renewable energy sources for our buildings and alternative fuels for our fleet, and promoting smart growth within Tulsa. To provide a roadmap for the path toward these goals, and to provide a standard by which to gauge progress, Tulsa has developed this Sustainability Plan as a first step toward becoming a regional leader in sustainable government. Tulsa's Office of Sustainability will oversee the initiatives outlined in the Plan, which are designed to reduce costs, decrease environmental impacts, and positively affect the quality of life for Tulsans through changes in the way the City does business.

We are operating in an environment of decreased financial resources, increased infrastructure and maintenance needs, and increased public scrutiny. While this may sound negative, it provides us with an incentive to look closely at our operations and identify economic cost savings and opportunities to minimize our ecological footprint through the implementation of our Sustainability Plan. The issues that we face will motivate us to do better—better by the environment, better by our citizens and better in our role as stewards of the public trust.

Brief History of Sustainability at the City of Tulsa

Until recently, energy efficiency and sustainability efforts within the City of Tulsa have been driven by individual employees and have applied only to a single process or facility. In 2008, Mayor Kathy Taylor assembled a group of City employees with job duties related to energy use, water treatment, and environmental operations. The Energy Conservation and Sustainability Team's (ECST) focus was to develop goals, objectives, and strategies for sustainability and energy conservation.

This group worked together for about a year, and in March 2009 submitted the ECST Operational Plan to the Mayor. This operational plan focused on energy efficiency, resource conservation, and renewable energy opportunities at City facilities. Although the plan was never implemented, it served as the foundation for Tulsa's sustainability efforts moving forward.

In December 2008, before the final submission of the ECST Operational Plan, the decision was made to make sustainability a larger focus of the Mayor's Office and a City employee was appointed Special Advisor for Sustainability. The position was to exist for four months, and building on the work of the ECST, was to ultimately produce a comprehensive outline for sustainability that stretched across all departments and included goals and initiatives to help reach them. In April 2009, the final version of this outline was completed. Like the original ECST plan, this outline was not widely implemented, mainly due to budgetary restrictions and lack of funding for projects above basic services. However, the Special Advisor position remained in the Mayor's Office, and in June 2009 the City received nearly $4 million in federal stimulus funding from the Department of Energy's Energy Efficiency and Conservation Block Grant (EECBG) program. This money was to be used specifically for energy efficiency and sustainability projects.

Mayor Dewey Bartlett took office in December 2009, nearly two years after the first attempts at establishing a City-wide sustainability and energy efficiency plan. He recognized the need for such a plan, as well as a City department to manage EECBG funding and oversee the resulting projects. By February 2010, he had established the Office of Sustainability and appointed its first director. The Office is funded through EECBG and currently oversees six EECBG-funded projects, including the development of this Sustainability Plan, the first truly comprehensive energy efficiency and sustainability plan in Tulsa's history. Other notable sustainability projects implemented through the Office of Sustainability include:

- A $1.4 million energy efficiency retrofit of patient care critical systems at the OSU Medical Center.
- Retrofitting of nearly 1,700 downtown traffic and pedestrian crossing signals with LED units.
- Replacement of all taxiway lighting at both Tulsa airports with LED technology.
- Retrofitting of City facility lighting with LED fixtures.
- A renewable energy feasibility assessment of several City facilities.
- Establishment of an Environmental Education Committee.
- Participation in the Public Service Company of Oklahoma's (PSO) Model Cities Program.

Office of Sustainability's Guiding Principles

- We have a responsibility to use resources efficiently.
- We depend on the health of our environment.
- Environmental quality, economic health, and social equity are mutually dependent.

- Solutions to energy and environmental issues must be collaborative; the City is part of a regional, national, and global community.
- Sustainability should guide City policies; City decisions have long-term implications.
- Community awareness, responsibility, participation, and education are key to our sustainability.

Office of Sustainability Mission Statement

The Office of Sustainability provides leadership and resources to support City departments, elected officials, Authorities, Boards and Commissions, and the citizens of Tulsa in their efforts to increase economic growth and improve social equity while reducing their impact on the environment. The Office promotes and coordinates energy efficiency, renewable energy, and environmental protection initiatives through advocacy, legislation, partnerships, planning, and education programs.

Vision Statement

Over the next several years, the City will operate in an environment of limited financial and natural resources, increased transparency of operations, increasingly strict environmental regulation, and a heightened awareness of environmental impacts. We will meet these challenges with progressive thought and action, integrating emerging and existing technologies, increased resource use efficiency, involvement at the regional, state, and national levels, and comprehensive education programs.

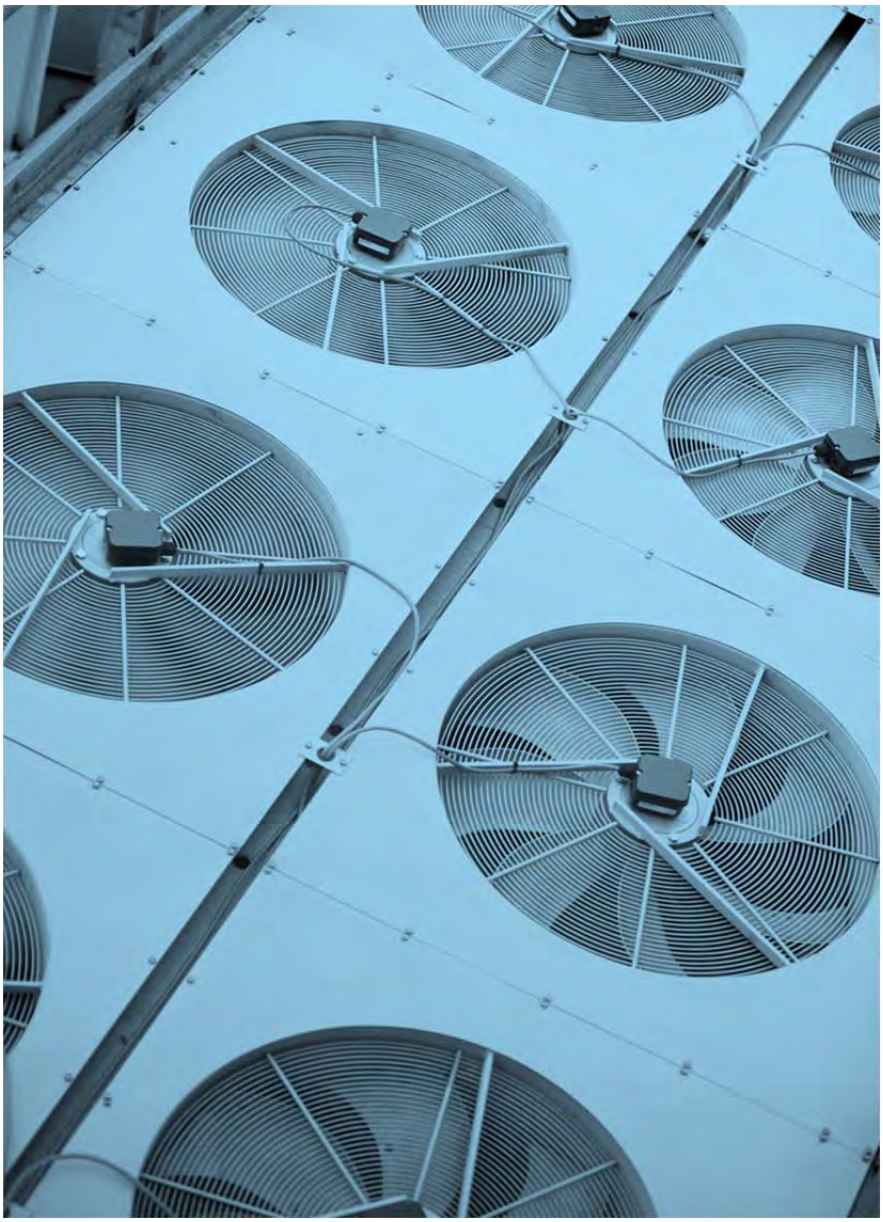
General Strategies

- Focus on internal efforts first, and then expand these efforts externally.
- Identify measures to be taken immediately that will have a financial benefit.
- Record, track, benchmark and report key indicators such as energy use.
- Identify, communicate, and enforce existing sustainability policies.
- Advocate for, and participate in, comprehensive Demand Side Management (DSM) programs with local utilities.
- Remain up-to-date concerning sustainability legislation at the local, state, and federal levels.
- Be aware of potential funding sources outside of COT revenues to support sustainability initiatives.
- Progressive thought and action will be hallmarks of the Office of Sustainability. The willingness to try emerging technologies and revisit past ideas will lead to the success of the Office and its programs.

Committed to Sustainability

Recently the City of Tulsa made a renewed commitment to sustainability and energy management. In fact, energy innovation is one of Mayor Bartlett's five strategic priorities and objectives. The City is committed to promote sustainable energy usage and conservation measures at City buildings and property, support the deployment of energy innovation to private and commercial property owners, and promote the economic development of both traditional and alternative energy industries. This will be accomplished by:

- Decreasing energy usage costs in public buildings and on public property through the application of emerging energy technologies.
- Developing opportunities to encourage energy efficient improvements on private property.
- Investing in energy efficiency through performance-based energy contracting.
- Controlling energy costs and usage through the application of energy use audits and reviews of energy purchase processes and agreements, and negotiation of lower energy rates with existing and other energy providers.
- Promoting economic development to attract alternative energy jobs while continuing to support existing energy industries.



Energy Management

Find and implement energy cost saving opportunities

According to the City of Tulsa Fiscal Year 2011-2012 Annual Budget and Capital Plan, Mayor Bartlett identifies energy innovation as one of the City's top strategic priorities. Specifically, the City strives to:

- Promote sustainable energy usage and conservation measures on City of Tulsa buildings and property.
- Support the deployment of energy innovation to private and commercial property owners.
- Decrease energy usage and energy costs in public buildings and on public property through the application of emerging energy technologies and energy auditing.

238

Number of buildings owned and operated by the City of Tulsa

$20M

Total annual energy costs for City of Tulsa operations, representing 3.6% of the total budget

The Energy Management section of this Plan provides specific guidance on how the City can take steps toward achieving these objectives. The approach laid out in this section contains two parts. The first is the design and implementation of a formal and permanent Energy and Water Management program within the City that is built around a new and improved Energy Conservation and Sustainability Team (ECST), with outside department support and Mayoral direction. The second part of this section details specific energy efficiency and conservation initiatives that will form the starting point for the ECST's FY 2012 Action Plan.

The recommendations provided in this section are not part of a "vision for the future," but rather an operational plan that will produce measurable energy savings over the next 6-12 months and beyond. The integration of the ECST into the City's governance and the broad acceptance of energy innovation as a strategic priority will generate energy savings and foster energy security and greater energy independence over the next 25 years. The combined approach offers both the mechanism and the ideas that will allow the City to achieve its energy innovation objectives and lead the greater Tulsa community by example toward a more energy efficient future.

PART I: ESTABLISH A CITY-WIDE COMPREHENSIVE APPROACH TO ENERGY MANAGEMENT

Baseline Energy Data

The first step in designing a comprehensive approach to energy management is to gain a full understanding of how much energy is being used, who is using it, how it is being used, and how much it costs. This baseline assessment of the City of Tulsa's energy use also serves as a basis for comparison for future energy reductions.

Exhibit 1 provides an overview of the total amount of money that the City has spent on different types of energy over the past four years. The City spent $20 million on energy in 2011 out of a total

budget of $560 million, or about 3.6%. Exhibit 2 breaks out the percentages of the City's total energy costs for Fiscal Year 2011.

Exhibit 1: Breakdown of City's Annual Energy Costs by Use Category (2008-2011)

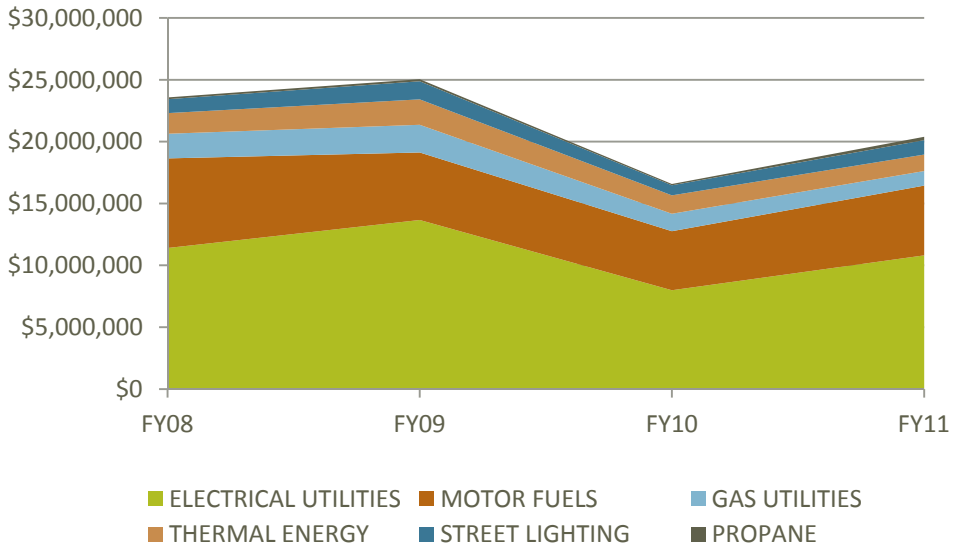
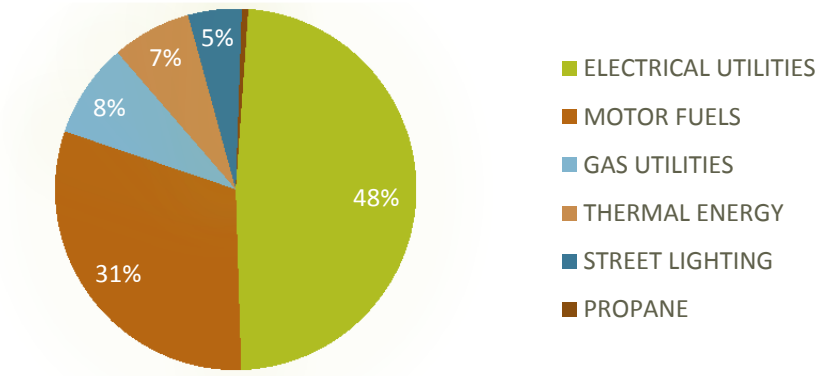
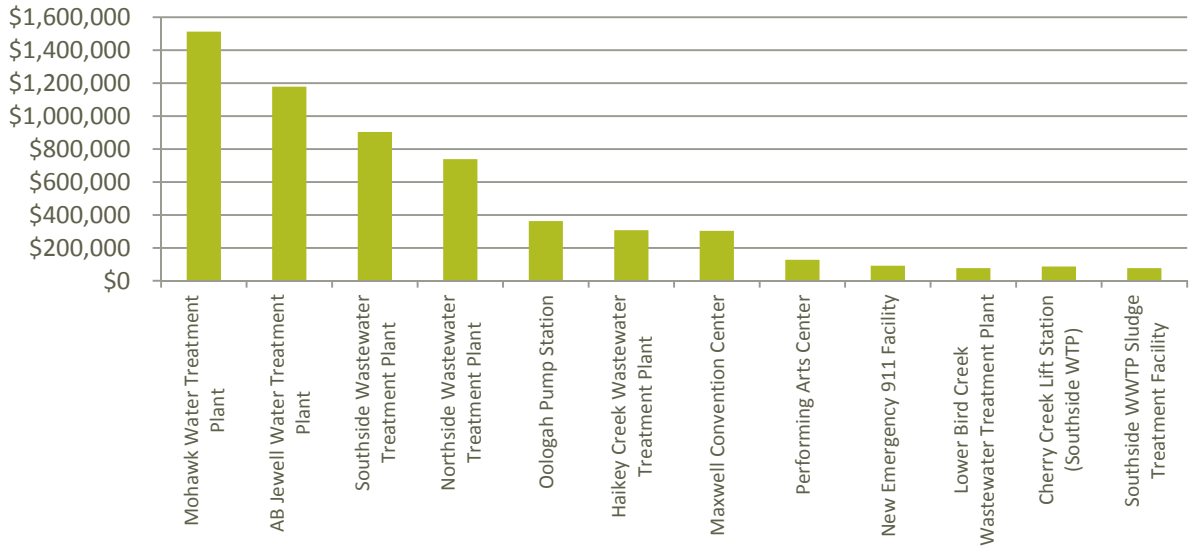


Exhibit 2: City of Tulsa's Annual Energy Costs by Use Category (FY 2011)



Thermal energy includes chilled water and steam sold to the City by third party providers. When the electrical utilities and street lighting categories are combined, the City spent nearly $12 million on electricity in FY11. Of that, about 45% was used by the City for treating and distributing water and wastewater. Exhibit 3 shows the top 12 electricity consumers among City-owned facilities.

Exhibit 3: Top 12 City of Tulsa Electricity Consumers – FY2011



The City of Tulsa has more than 40 fire stations and community/recreation centers. Exhibit 4 shows the total electricity costs by City fire stations in FY 2011 and Exhibit 5 shows total electricity costs for City community and recreation centers. Despite the high number of fire stations and community centers at the City of Tulsa, they collectively account for only 3.5% of the City's total electricity consumption.

Exhibit 4: Electricity Costs for City of Tulsa Fire Stations – FY2011

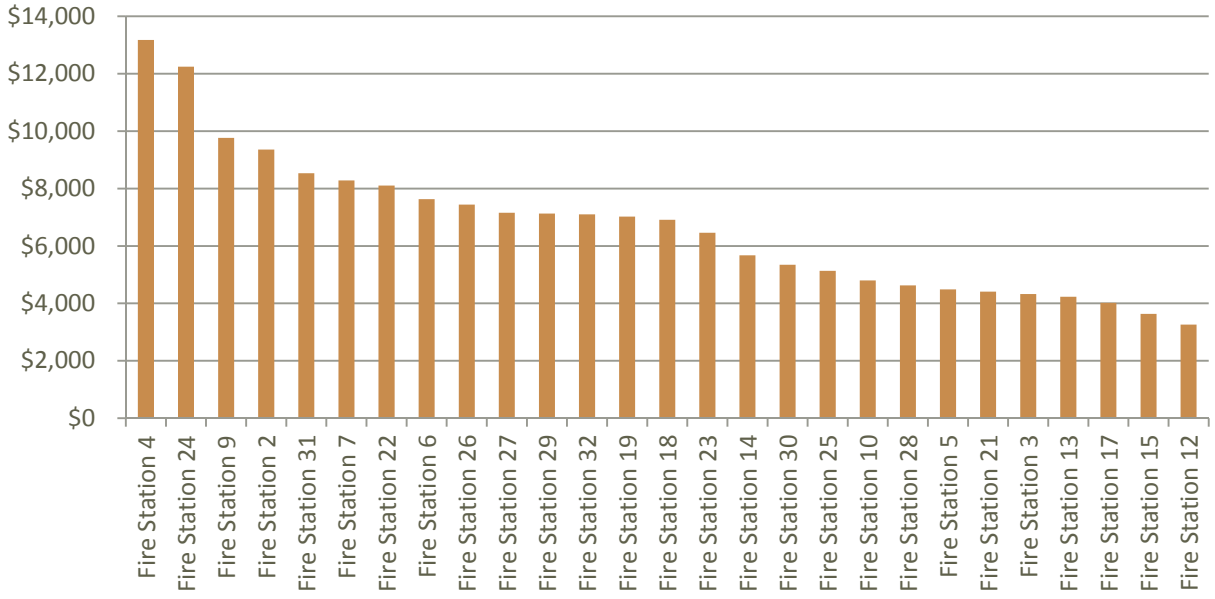
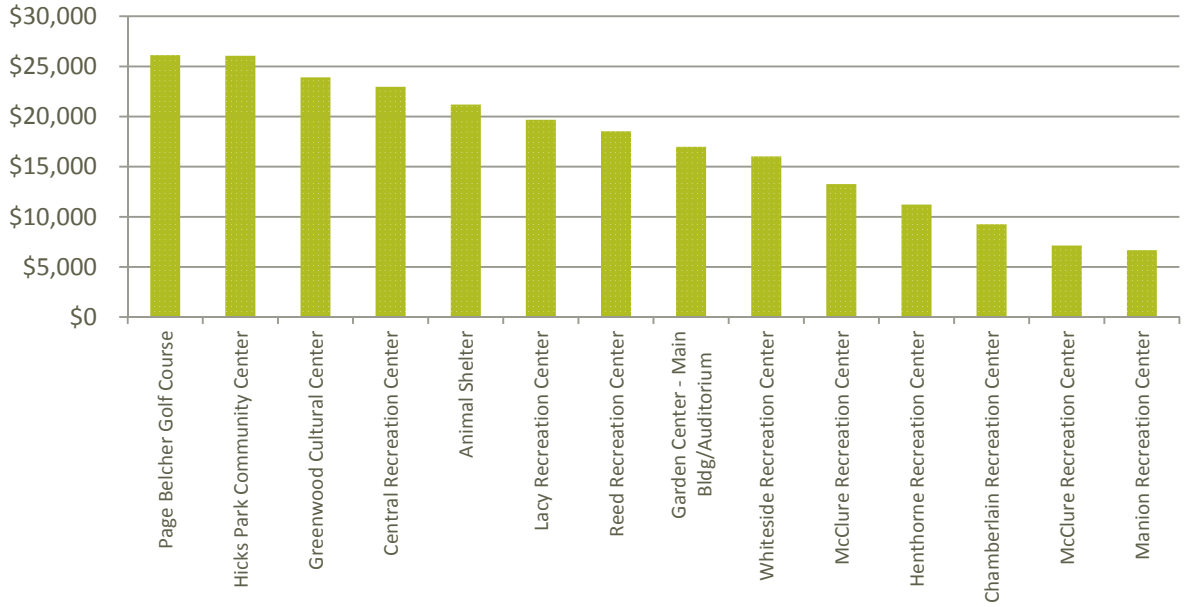


Exhibit 5: Electricity Costs for City of Tulsa Community and Recreation Centers – FY2011



Baseline data specific to water/wastewater and fleet fuel consumption is presented in the relevant sections of this Plan.

Current Structure of Energy Management

The City of Tulsa does not currently have a formal energy management program. Each department within the City is responsible for managing its own energy consumption and budget. Energy management within the energy-intensive departments like the Water and Sewer Department is the responsibility of a select number of City employees with specific expertise related to their operations. The job of managing energy is secondary to their assigned tasks and responsibilities, and therefore does not receive the time and resources necessary to identify, prioritize, implement, and verify energy efficiency and conservation initiatives. Although much has been accomplished with limited resources by those in the City dedicated to energy management, many opportunities for significant cost savings have likely been missed because of the lack of an overarching structure.

The Office of Sustainability currently leads the only coordinated effort in managing the City's energy resources. Over the past three years, this office has identified energy savings opportunities ranging from lighting and HVAC retrofits at City fire stations to replacing downtown traffic signals with high-efficiency light-emitting diodes (LED), all achieving significant cost savings. These projects have largely been funded with grant money, so prioritizing energy conservation initiatives is a function of what types of grants and how much funding are available. There is no formal process within the Office of Sustainability for soliciting energy efficiency and conservation ideas from different departments, validating the ideas, prioritizing the ideas based on estimated costs and annual savings, implementing the ideas, and verifying the energy savings.

> *"The Sustainability Planning process has started a critical city-wide effort to implement all aspects of sustainability within City government and out into the community."*
>
> Graham Brannin
> City of Tulsa

The following list of recommended initiatives was created as part of the Sustainability Plan Workshop held on June 29-30 in the City of Tulsa offices. Out of several ideas that were introduced before the Energy Management Committee, the initiatives detailed in this section were considered to be the highest priority with the greatest opportunity for associated cost savings. This list is not intended to be comprehensive. As new ideas emerge and are cycled through the Energy and Water Management Program described below, this list should continue to grow. See Appendix 1 for a full list of sustainability initiatives associated with the Plan's different sections.

Initiative #1: Re-Establish the Energy Conservation and Sustainability Team

Issue

The City currently has no organized group tasked specifically with energy and water management. In 2008, the inter-departmental group of City employees known as the ECST released an Operational Plan containing recommendations covering topics ranging from energy efficiency to recycling. After 2008, the ECST ceased to function and there has not been a coordinated inter-departmental effort focused on energy management since.

Recommendation

Re-establish ECST with necessary personnel, resources, authority, and budget to lead a coordinated interdepartmental energy management program. One of the key recommendations of the ECST was

to develop a comprehensive strategic plan for energy management including the formation of an energy management team within the City. Using the recommendations of the ECST as a starting point, the City can undertake the following process to develop an integrated and comprehensive energy management program.

- **Step 1: Re-Establish the Energy Conservation and Sustainability Team.** Where the original ECST had a broader approach to several aspects of sustainability, the new mandate of the ECST will be to focus more on energy and water management initiatives. The ECST will prioritize its focus on sustainability initiatives based on return on investment (ROI) with primary attention on energy and water.

  The ECST will be a permanent body within the City of Tulsa comprised of City personnel responsible for coordinating the City's overall energy and water management strategy. The ECST should consist of a core group of 5-7 permanent members with auxiliary members who are brought in for meetings or debriefs as needed. The core group should include representatives from the most energy-intensive departments and include personnel with expertise in energy and water management. Specifically, the ECST should include at a minimum:

  - **One representative from each of the following functional areas**
    - Wastewater treatment
    - Water Operations
    - Equipment Management/Fleet
    - Street Lighting
    - Engineering/Facilities Maintenance
  - **One expert in each of the following areas**
    - Efficiency, performance, and proper maintenance of large pumps and motors
    - Efficiency, performance, and proper maintenance of HVAC and lighting systems
    - Estimated costs and annual savings calculations
    - Energy data analytics
    - Eventually the City may consider creating the position of Energy Manager that would have expertise in all of these areas.

- **Step 2: Assign ECST Chairperson.** The ECST must assign a single person the responsibility to organize meetings, prepare agendas, compile and distribute relevant data, and be accountable for ECST actions.

  The City should designate a single person to be responsible for leading the ECST. Responsibilities of the ECST Chairperson will be to:

  - Organize regular meetings of core ECST members and prepare agendas.
  - Invite other City personnel and community partners to meetings as necessary.
  - Organize and distribute energy data to ECST members.
  - Act as liaison between ECST and Office of Sustainability/Mayor's Office.

The ECST chairperson should be knowledgeable in many different aspects of energy management, from energy data analytics to technical specifications of lighting and HVAC systems. Preferably the ECST leader will be an individual with specific training in the field of energy management, similar to the training provided through the Association of Energy Engineers Certified Energy Manager (CEM) program.

The ECST chairperson will likely be a City employee who will have to balance the work responsibilities of his/her current job description with the added demands of leading this group. Given the importance of this position and the potential for cost savings that can be generated, it is recommended that the City also create a full-time City of Tulsa Energy Manager position within the Office of Sustainability by the end of 2012 to help lead these efforts.

- **Step 3: Integrate ECST into City Governance.** The ECST must have a specific mandate and direction codified in City policy to ensure that participation in ECST meetings is part of participants' regularly assigned tasks and responsibilities.

  One of the main reasons why the original ECST ceased to function as a group and was not able to follow through with many of its recommendations was because the Team was not established as a permanent entity within the City's organizational structure. With $20 million in annual energy spending, a modest goal of a 5% total energy spending reduction assigned to the ECST could generate $1,000,000 in annual savings—funds that would flow directly to the City's General Fund bottom line. A properly organized, supported, and integrated ECST could potentially achieve cost savings of 10-15% annually. To formalize the ECST and fully integrate it into the City's governance, the following steps should be taken:

  - Amend the City's current Internal Energy Policy (Title 12, Chapter 1) to include recognition of the ECST as an energy management coordinating and advisory body.
  - Work with direct supervisors of core ECST members to update Trust and Authorities and adjust the members' annual performance review criteria (PPR) to reflect participation in ECST activities as part of their job description.
  - Require quarterly updates from ECST Chairperson to Mayor's Office, Sustainability Director and City Council that include presentation of energy data and verification of cost savings resulting from implementation of energy efficiency initiatives.

- **Step 4: Grant ECST Required Authority and Resources.** The ECST must have the authority needed to obtain data, gain access to facilities, interview City personnel, and other tasks required to analyze and/or implement energy savings initiatives. The ECST also must have the tools and resources needed to assess equipment, conduct regular meetings, collect, and organize utility data, and implement energy and water conservation initiatives.

  The ECST will serve an advisory role to coordinate energy management efforts City-wide and help quantify and prioritize energy management so that City resources are allocated in the most effective means possible. For the Tulsa Metropolitan Utility Authority (TMUA), the ECST will primarily serve as a partner in providing very specific assistance as needed to the TMUA, including:

  - Assistance quantifying, verifying and reporting savings from TMUA initiatives
  - Serving as a conduit for grants and other incentives of particular interest to TMUA projects

- Facilitation for sharing of Best Practices with other City departments and other City water and wastewater treatment plants.

For all other City-owned facilities, the ECST would identify, prioritize, implement, and measure the results of energy and water conservation initiatives. This would include:

- Making recommendations to city management to allocate energy efficiency funds to the projects with the best ROI
- Providing periodic reports to City management to show quantitative evidence of results.

In this role, the ECST should have the authority to request energy data, project specifications, or other relevant background information pertaining to potential energy or water conservation initiatives from City departments. City departments should be amenable to sending a representative to ECST meetings as requested by the ECST Chairperson with proper advanced notice.

The ECST will need specific tools to take measurements, analyze equipment, detect leaks, or other activities as part of its objective to identify energy and water conservation initiatives. The City should allow the purchase or rental of these tools as part of the Office of Sustainability's budget.

- **Step 5: Allocate Budget for Initiative Implementation.** The ECST should have a "fast-track" approval mechanism at its disposal for approval of funding requests up to a certain dollar amount for implementation of energy and water conservation initiatives. This abbreviated approval mechanism will require the ECST to verify and communicate related cost savings.

  Once the ECST identifies and prioritizes specific initiatives based on life-cycle cost benefit analysis, they will need funding to implement those initiatives and a clearly defined mechanism for accessing those funds. The following recommendations would establish a revolving Implementation Fund that the ECST could use for installing new equipment or upgrading existing equipment, installing advanced controls, hiring third parties to conduct detailed assessments or audits, etc.
- Fund the voter-approved bond for energy efficiency improvements in FY 2012 and allocate money to energy efficiency projects based on ECST recommendations
- Require detailed written project justifications and a thorough review process for all initiatives requiring capital expenditures over $10,000 and define a "fast track" approval process for initiatives costing less than $10,000
- Establish a policy whereby the ECST's available funding is reviewed annually to determine if continued funding of ECST activities is in the City's best interest based on demonstrated results.

Key Performance Indicator	Total percentage of City's energy costs saved due to ECST activities
Target	1% of total City energy costs saved in FY 2012, increasing to 5% by 2015.

Initiative #2: Implement a Systematic Approach to Energy and Water Management

Issue

The City does not currently have an integrated approach to Energy and Water Management. Each department, and in some cases each facility, handles its energy and water consumption independently with only limited and general guidance from the City Energy Policy.

Recommendation

Use guidance from the International Organization for Standardization (ISO) 50001 Standard for Energy Management Programs to define the process that the ECST will use to identify, evaluate, prioritize, and measure energy and water conservation initiatives. The ECST will be responsible for following a well-defined and systematic approach to managing the City's energy and water resources. The City of Tulsa's Energy and Water Management Program will be based on the ISO 50001 Standard for Energy Management Systems. ISO 50001 follows the same "Plan – Do – Check – Act" format that previous management system standards such as 9001 (quality management) and 14001 (environmental management) followed. This systematic approach to identifying, quantifying, prioritizing, implementing, and verifying results of energy and water conservation initiatives ensures that the ECST's resources are allocated in the most efficient way.

> *"The purpose of [ISO 50001] is to enable organizations to establish the systems and processes necessary to improve energy performance, including energy efficiency, use, and consumption. Implementation of this standard is intended to lead to reductions in greenhouse gas emissions, energy cost, and other related environmental impacts, through systematic management of energy."*
>
> Excerpt from ISO 50001

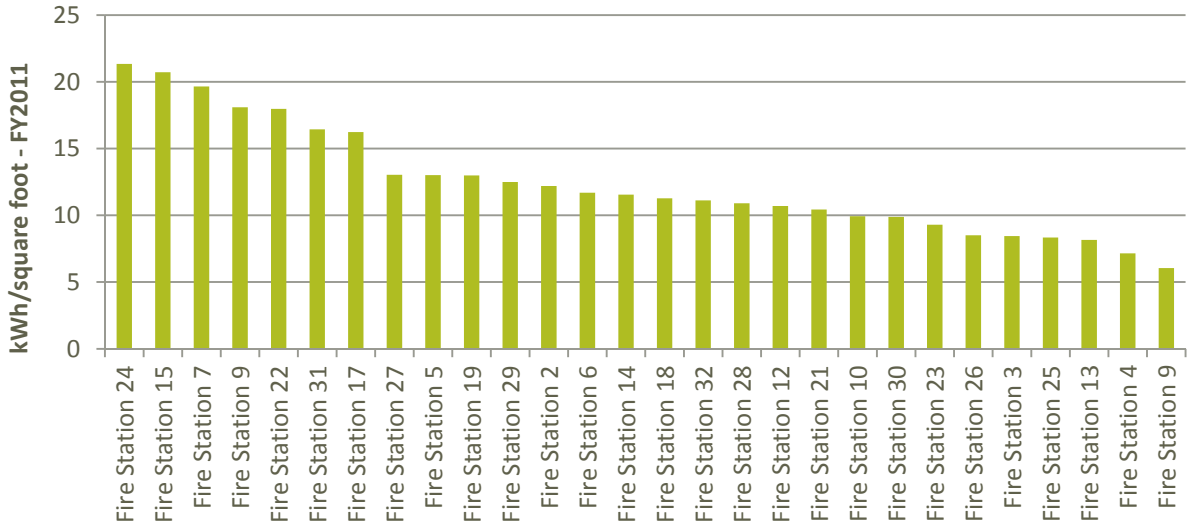
The new Energy and Water Management Program should consist of a seven-part process designed to continuously identify, implement, and verify the savings resulting from new energy and water savings initiatives. These seven steps are described in more detail below, and are represented in Exhibit 7.

- **#1: Compile and analyze energy and water data.** The ECST will collect energy and water consumption and pricing data from energy utilities, third party service providers, City-owned sub-meters, Supervisory Control and Data Acquisition (SCADA) systems, or other sources of energy data, and organize it so that it can be easily analyzed. Relevant data summaries and charts should be made available in electronic format to ECST core members and participating peripheral members at least three days before ECST meetings to allow for adequate review.

- **#2: Conduct benchmarking.** Part of the data analysis process undertaken by the ECST should be to benchmark similar facilities using intensity metrics such as kilowatt-hours (kWh) per square foot, million British thermal units (MMBTU) of natural gas per gallon of throughput, etc. This comparison will indicate which facilities or processes use the most energy relative to similar City-owned facilities. As an example, Exhibit 6 ranks the City of Tulsa fire stations by total kWh

consumed in FY2011 per square foot. The ECST would target the fire stations with the highest kWh per square foot (sf) metric to conduct a more in-depth energy assessment. The City may consider using the Energy Star® Portfolio Manager Program to facilitate this benchmarking process and allow for comparison of City-owned facilities with thousands of similar facilities in the country. Energy Star® Portfolio Manager can also expedite grant applications, increase success in applying for grants, and provide recognition for the City.

Exhibit 6: City of Tulsa Fire Station Electricity Benchmarking (kWh/square foot – FY 2011)



- **#3. ECST core members meet twice a month.** Regular meetings of the ECST would allow a forum for introducing and vetting new ideas, collaborating on data analytics to identify new areas of opportunity, and brainstorming on implementation options. Most importantly, it would maintain the Team's critical mass and momentum.

- **#4. Prioritize initiatives based on life-cycle cost benefit analysis.** The ECST would evaluate ideas brought to the Team for minimum performance requirements and for technical and economic feasibility. For those initiatives that the ECST determines are able to meet the minimum performance threshold and that are deemed to be technically feasible, the ECST would conduct an in-depth cost benefit analysis of the initiative. This analysis will take into account:
    - Upfront installed costs
    - Financing costs over project's expected life
    - Land/lease costs over project's expected life
    - Operations & Maintenance costs over project's expected life
    - Equipment disposal costs
    - Upfront grants, rebates, or other incentives available to offset installed cost

- Sum of estimated annual energy cost savings over project's expected life (as compared to business-as-usual alternative)
- Sum of performance-based incentives available for project over its expected life
- Estimated disposal value of equipment
- Quantitative and qualitative environmental and social costs/benefits

- **#5. Implement initiatives.** During this phase, the ECST would prepare a detailed implementation plan for the next initiative currently in the queue on the prioritized list and work to get the project completed. This would involve coordinating with the right people within the relevant department, requesting funding, obtaining the necessary equipment, tools, and resources, and performing the work according to existing City quality and safety standards.
- **#6. Monitor and verify savings.** As initiatives are completed, the ECST should identify Key Performance Indicators (KPIs) for each initiative based on the available data. The KPI for any given initiative should be one for which data is readily available that will clearly demonstrate the impact that the initiative has on total or normalized energy consumption. For facilities equipped with meters that allow the City to collect and analyze interval data (i.e., frequent meter readings throughout the day to give a more detailed profile of energy consumption patterns) or that have SCADA or sub-metering of individual processes or equipment, the ECST should compare the interval data profile before implementation and after implementation to look for significant shifts in energy usage. For projects that have a relatively minor impact on a facility's total energy utility meter profile and for which monitoring and verification with real data is not possible, energy savings calculations should be documented and maintained as a record of the initiative's estimated savings.
- **#7. Communicate Results.** The ECST Chairperson should meet regularly with the Office of Sustainability, the Mayor's Office, the City Council, and the Communications Department to share project details and specific data demonstrating the program's success. This should be a regular requirement of the ECST and the basis for approving future allocations of funding.
- **Continuous Improvement.** The key feature of the Energy and Water Management Program is that it is designed to allow for continuous improvement. Once the team has completed one project, the ECST will gain more insight into new opportunities that inform the analysis and prioritization of new initiatives.

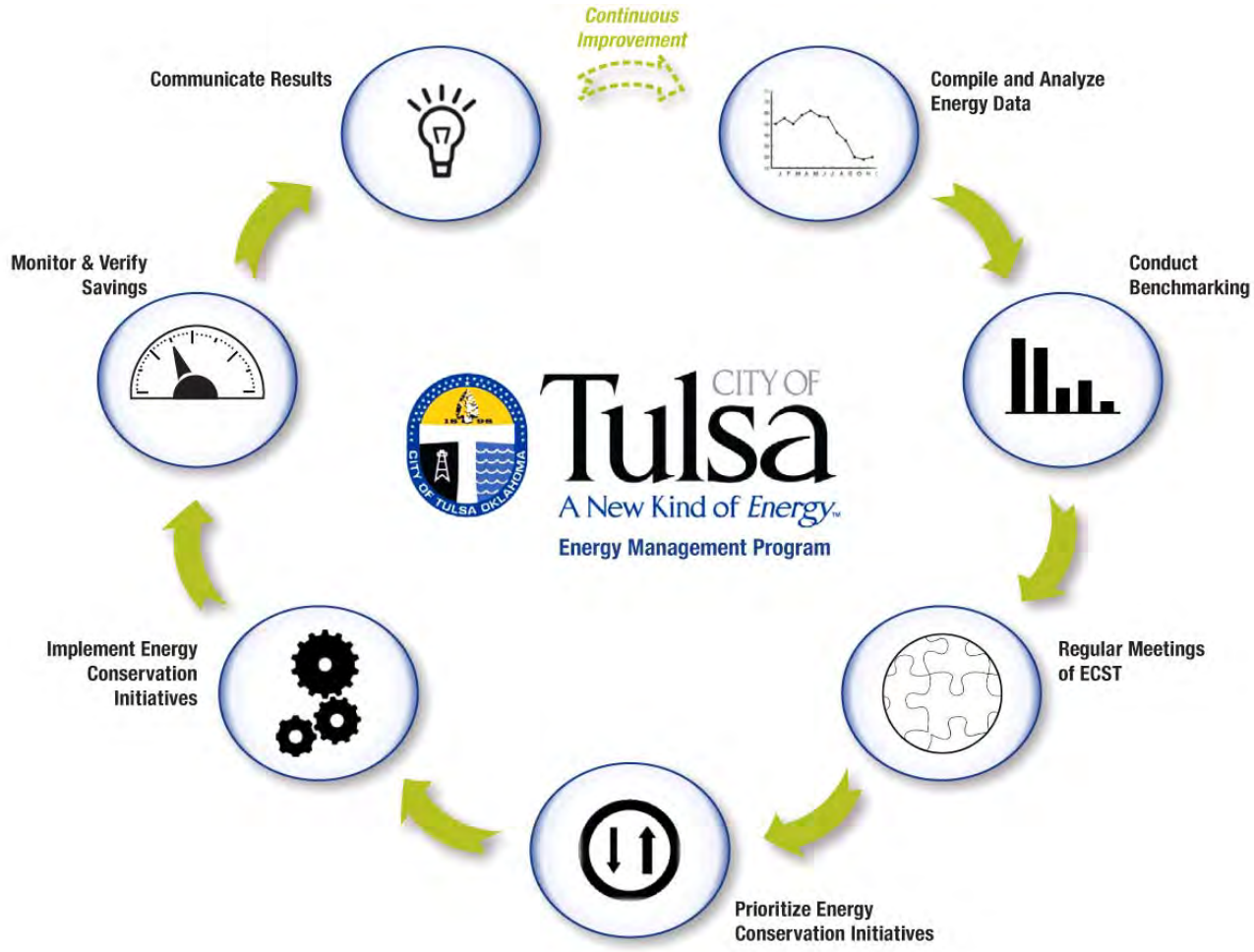
Key Performance Indicator

Certifiability of City Energy and Water Management Program under ISO 50001. The City does not need to expend significant resources to evaluate the City's compliance with ISO 50001, but the ECST should understand the major elements of the ISO standard and attempt to integrate those elements as Best Practices into its approach. Tulsa would likely be the first city in the country to have an energy management program that meets the requirements of this standard if it does choose to formally adopt ISO 50001.

Target

City's Energy Management Program capable of certification (but not necessarily certified) under ISO 50001 by the end of FY2013. This would be determined by an internal ECST audit of its program against ISO 50001 requirements, the results of which should be summarized in a memorandum and presented to the Office of Sustainability.

Exhibit 7: Systematic Approach to Energy and Water Management (Initiative #2)



Initiative #3: Establish Streamlined Energy Data Management System

Issue

Energy data is scattered, inconsistently organized, and not readily available. The City of Tulsa does not currently have a system in place for conducting a detailed analysis of what it spends on energy. The data is available but is not readily accessible and is not being benchmarked or monitored for identification of potential cost savings opportunities.

Recommendation

Organize and consolidate energy data in a consistent format and make it widely available to City departments. Since accurate and reliable energy data is a crucial component of any energy management program, the City of Tulsa should establish an energy data management system that collects and organizes energy data in a format that is readily available and easily accessible to the ECST and other City departments. The following list contains the energy and water data sets that the City of Tulsa should collect and specific recommendations on how to collect and organize it:

- **Monthly electricity bills.** The City purchases electricity from a few different electric utilities, but most of it comes from Public Service Company of Oklahoma (PSO). PSO sends hard copies of monthly electricity bills that contain total consumption, rate information, and peak demand (where applicable) to the City of Tulsa where the bills are distributed to different City departments.
- **15-minute kilowatt load interval data.** The City currently has specialized meters installed on 16 of its facilities that collect and transmit 15-minute readings of the kilowatt (kW) load. This data can be accessed directly by City personnel via phone line using a specially equipped computer terminal with MeterMate™ software installed. The facilities that are configured for electricity interval data collection are:

Performing Arts Center	BOK Center
AB Jewell Water Treatment Plant	400 Civic Center
Mohawk Water Treatment Plant	Oologah Pumping Station
Southside Wastewater Treatment Plant	Apache Street Pumping Station
Northside Wastewater Treatment Plant	Catoosa Flow Line Pumping Station
Haikey Creek Wastewater Treatment Plant	North Cherokee Pumping Station
Lower Bird Creek Wastewater Treatment Plant	Southside Wastewater Treatment Plant (2)
Convention Center	e-911 Center

  Together, these electricity accounts comprise about 65% of the City's total electricity budget, or around $5.8 million in electricity payments annually.

- **Natural Gas Monthly Bills.** The City purchases the majority of its natural gas from Oneok and Oklahoma Natural Gas (ONG). Monthly natural gas invoices are distributed to the appropriate City departments for payment.

The energy data listed above will be uploaded into a software application that the City has licensed to manage its energy data called Hara EEM. City personnel with appropriate login credentials can review this software application at any time. It is best if only a handful of City employees receive access to the Hara EEM database. Those individuals can develop custom reports and charts for other City employees as requested.

Key Performance Indicator

Percentage of total energy costs represented by readily available energy data. This metric will consist of the total dollar amount spent on electricity, natural gas, thermal energy, and motor fuels that the ECST can easily access for analysis as a percentage of the City's total energy costs. The baseline for this KPI is not currently available, but is estimated to be about 25%.

Target

90% of total energy costs (electricity, natural gas, thermal energy, motor fuels) accounted for in Hara EEM and/or other readily accessible databases.

Initiative #4: Prioritized Replacement List for Motors Larger than 10 HP

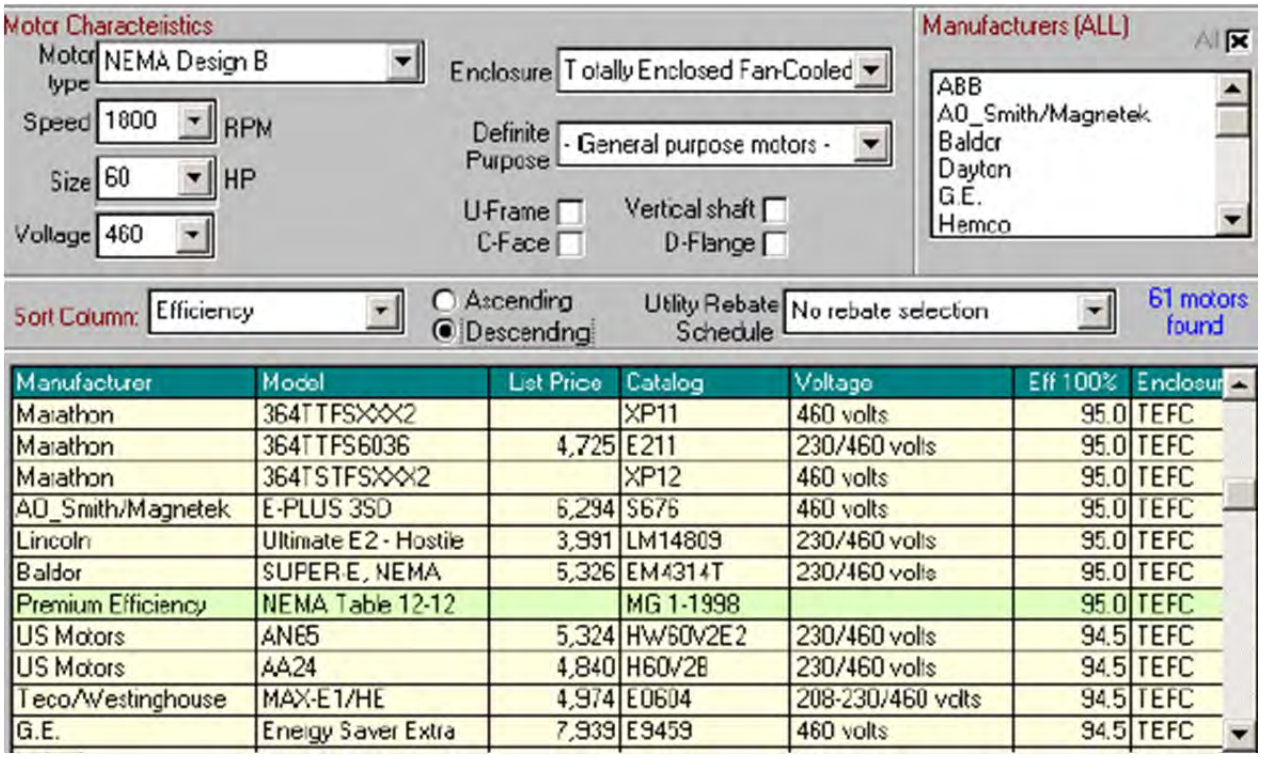
Issue

The City does not have a systematic approach to identifying and replacing inefficient motors in its water and wastewater treatment and distribution systems. Motors account for 90% of the electric energy consumed in a typical water and wastewater plant. Efficient motor selection, design, operation, and maintenance are critical components to energy management at the City's six water and wastewater treatment facilities. In coordination with the City's Asset Management Plan and planned replacements, the remaining useful life and cost to operate should be included in the evaluation in addition to the purchase costs and energy savings.

Recommendation

Work in conjunction with parallel efforts through Asset Management Planning to compile an inventory of all City-owned and operated motors larger than 10 Horsepower (10 HP) and prioritize motor replacements based on life-cycle costs. This inventory should include data on motor type, speed (RPM), size (HP), voltage, frequency of use, and enclosure type. This data can be fed into the U.S. Department of Energy MotorMaster+ Version 4.0 software to determine the potential costs and savings associated with replacing a specific motor with a newer, higher efficiency alternative. MotorMaster+ Version 4.0 (Exhibit 8) analyzes motor system efficiency by analyzing the nameplate data, operating profile, and field measurements. Once this data is collected, the program determines which motors are inefficient or oversized, and computes the energy and demand savings associated with the selection of an energy efficient replacement. The software is free, so the only cost to implement would be the labor hours needed to collect and input the data.

Exhibit 8: Screenshot of US DOE MotorMaster+ Version 4.0



Manufacturer	Model	List Price	Catalog	Voltage	Eff 100%	Enclosur
Marathon	364TTFSXXX2		XP11	460 volts	95.0	TEFC
Marathon	364TTFS6036	4,725	E211	230/460 volts	95.0	TEFC
Marathon	364TSTFSXXX2		XP12	460 volts	95.0	TEFC
AO_Smith/Magnetek	E-PLUS 3SD	6,294	S676	460 volts	95.0	TEFC
Lincoln	Ultimate E2 - Hostile	3,991	LM14809	230/460 volts	95.0	TEFC
Baldor	SUPER E, NEMA	5,326	EM4314T	230/460 volts	95.0	TEFC
Premium Efficiency	NEMA Table 12-12		MG 1-1998		95.0	TEFC
US Motors	AN65	5,324	HW60V2E2	230/460 volts	94.5	TEFC
US Motors	AA24	4,840	H60V2B	230/460 volts	94.5	TEFC
Teco/Westinghouse	MAX-E1/HE	4,974	E0604	208-230/460 volts	94.5	TEFC
G.E.	Energy Saver Extra	7,939	E9459	460 volts	94.5	TEFC

The ECST would initiate a project to replace the motor that is highest on the prioritization list. This effort will need to be coordinated with the 15-Capital Improvement Plan (15-CIP). The ECST can make recommendations and prepare the cost/benefit analysis, but it should be the department's decision regarding when the replacement occurs, especially for larger motors that require significant capital expenditures and long lead times. In many cases, there is no data on specific equipment's current running efficiency; this should also be included with the criteria for maintenance and/or replacement. The prioritization list should be updated annually to reflect new motor purchases and all replacements. Although City departments would still have the option of replacing their motors as they see fit, the ECST should coordinate the implementation of this initiative with those departments with the largest motors, especially the water and wastewater plants. The ECST can consolidate prioritized lists from Asset Management Plans into an overall priority list.

Key Performance Indicator

Simple payback (in years) for the total cost of replacing inefficient motors. The ECST should collect electricity load data for the motor that is scheduled to be replaced (either from the 15-minute interval data available from PSO for main meters, from an internal SCADA platform, or from a clamp-on style electricity meter/data logger like the Fluke 345 Power Quality Clamp Meter). The ECST should then collect the same data after the installation of the new motor to compare the load profile and verify savings. If either of the motors is a variable frequency drive, the team should collect data over a period of at least 24 hours to facilitate a more accurate comparison of the profiles. This data can be used to cross-check the savings estimate provided by the MotorMaster+ software.

The KPI for this initiative is the total cost of motor replacements divided by the verified total annual reduction in money spent on electricity compared to the business-as-usual scenario of not changing any of the motors. This calculated value is known as "simple payback" because it indicates how many years it will take for the savings generated by the investment in new motors to pay for itself without taking into account the time value of money.

Target

The simple payback for the oldest and most inefficient motors that will be at the top of the list will be very short. As the ECST moves down the list, the paybacks will get longer. For this reason, this initiative has a sliding target over the next five years:

- **Year 1: Simple payback less than 2 years**
- **Year 2: Simple payback less than 2.5 years**
- **Year 3: Simple payback less than 3 years**
- **Year 4: Simple payback less than 4 years**
- **Year 5: Simple payback less than 5 years.**

The simple payback calculation requires the cost of the electricity in $/kWh. The ECST should understand the electricity costs of the City's different rate structures and use the appropriate cost in its calculations. As a default, the City pays about $0.08/kWh for its general service electricity accounts.

The motor replacement prioritization list should be re-evaluated annually to gauge whether the estimated paybacks for the replacement of those motors next in the queue justifies the continued allocation of resources to this effort.

Initiative #5: Consider "Soft-Starter" Systems on Motors Larger than 25 HP

Issue

Many of the City's largest motors are constant-speed drive motors that cycle on and off regularly. This frequent starting and stopping of large motors tends to add to "peak" energy demand (with higher associated peak demand charges) with large spikes in electricity consumption as the motor starts up. It can also reduce the expected life of the motor and increase associated maintenance costs.

Recommendation

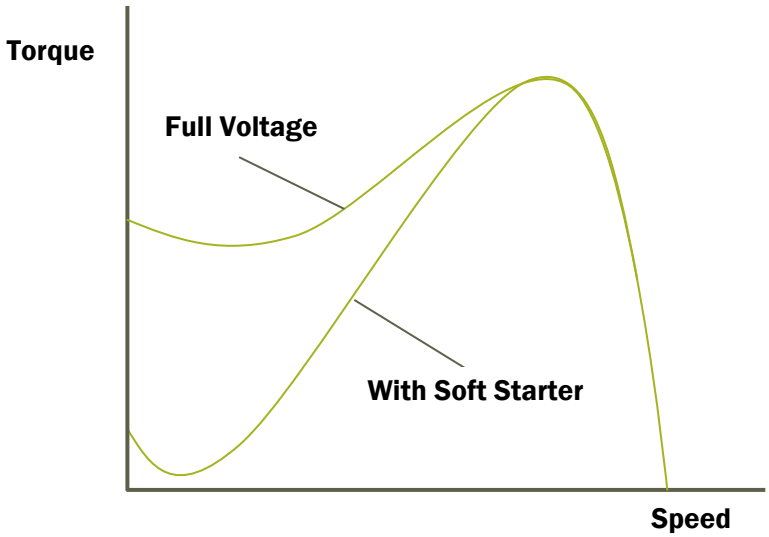
Identify motors that are good candidates for the use of a "soft-starter" system. This process can be done concurrently with the replacement prioritization inventory described in Initiative #4. Motor soft starters are devices that temporarily reduce the load and torque in the powertrain of a motor during startup (see Exhibit 9). This reduces the stress on the motor, shaft, and electrical distribution systems and therefore decreases maintenance costs and increases the useful life of the motor. It also minimizes the load peaking associated with motor startup. For electricity meters that pay a demand charge, this peaking can significantly impact the total electricity invoice.

Good candidates for retrofitting with a motor soft starter system would have the following characteristics:

- AC motor
- Greater than 25 HP
- Constant Speed Drive

- Regularly (at least a few times a day) cycles on and off

Exhibit 9: Soft Starter Speed Torque Curve[1]



The ECST should conduct a thorough performance and life-cycle cost analysis using the specific system characteristics before purchasing and installing a motor soft starter. The soft starter should not negatively impact the intended performance of the motor and should have a simple payback of less than five years.

Key Performance Indicator

Percent reduction of total consumed electricity in kWh for motors equipped with soft starter systems. This metric can be measured using 15-minute interval data available from PSO for some main meters, from an internal SCADA platform, or from a clamp-on style electricity meter/data logger. The ECST should take measurements of the motor during startup before and after installation of a soft starter system, and compare the results.

Target

10% average reduction of total estimated annual electricity consumption in kWh. This target should be converted to total annual kWh of electricity consumption reductions once data and calculations are available.

[1] http://electricalsolution.wordpress.com/2011/07/26/soft-starter-working-principle/

Initiative #6: Institute Large Motor Performance Testing & Efficiency Commissioning (O&M Procedure)

Issue **Large motors, specifically those at the water and wastewater treatment plants, are very high energy users. If large motors are not properly operated and maintained, it can result in significant excess energy use.**

Recommendation **Large motors should be tested and commissioned often to ensure that they are working at maximum allowable efficiency.** Motors should be repaired according to the standards of the Electrical Apparatus Service Association (EASA), specifically EASA Standard AR100-2010 "Recommended Practice for the Repair of Rotating Electrical Apparatus." Additionally, the EASA published a document entitled "The Effect of Repair/Rewinding on Motor Efficiency" that offers a guide to maintaining motor efficiency. The City should hold its motor repair shop accountable to EASA standards. A list of motor repair shops that are members of EASA in the Tulsa area is available on EASA's website. Large motors should be tested regularly to ensure that their efficiency is maintained; this can be accomplished by using data loggers.

Key Performance Indicator **Motor efficiency should be tested on all motors larger than 50 HP.**

Target **Test motors larger than 50 HP, maintain rated efficiency, and ensure that the efficiency of the motor is within +/- 2% of the labeled efficiency.**

Initiative #7: Use an Inventory and Replacement Prioritization of Lighting and HVAC Systems

Issue

No systematic approach to replacing inefficient lighting or HVAC (heating, ventilation and air conditioning) equipment. As shown in Exhibit 10, 50% of the electricity consumed in a typical commercial office building is for cooling and lighting. New, high-efficiency HVAC and lighting equipment can provide the same or better performance as existing systems while using a fraction of the electricity.

Recommendation

Implement a systematic approach to identifying and replacing old and inefficient lighting and HVAC equipment.

- **Lighting**. The ECST should complete a lighting system assessment of all City of Tulsa facilities beginning with the largest facilities. The assessment should include a three-phase process:
  - Assess current lighting conditions
  - Provide recommendations to improve lighting
  - Installation of new equipment.

  This assessment will require collecting data on the current illumination, bulb and fixture type, lumens, color index, and temperature. This must include information on the lighting load, room dimensions, the proper illumination level for the task, and hours of use. An analysis will be conducted using the optimum lumens per square foot using the most current illumination standards of the Illuminating Engineering Society (IES). Priority will be given to projects that reduce watts with increased bulb life, but provide the best light quality with little or no mercury-filled tubes. The assessment report will contain technical drawings of the room that show the foot-candles for the retrofit of new equipment as well as specific information about the type of bulb and ballast required.
- **HVAC.** HVAC consumes up to 30 percent of energy used in commercial facilities.[2] Exhibit 10 shows the breakout of electricity consumption for an average commercial office building. A complete HVAC assessment will provide a component by component, system by system evaluation of all HVAC equipment with the focus on making systems work properly and efficiently. The HVAC audit will require basic information such as type and number of units, hours of use, and dimensions of a building. The analysis will be conducted using standards by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).

  The result of these two studies will be a prioritized list of recommended replacements based on the life-cycle costs and expected electricity cost savings of each replacement. This list will allow the ECST to allocate equipment replacement funds in a systematic manner that maximizes the City's Return on Investment (ROI). Special attention should be made to take full advantage of existing rebate/incentive programs available through PSO to offset the cost of energy efficient system retrofits.

Key Performance Indicators

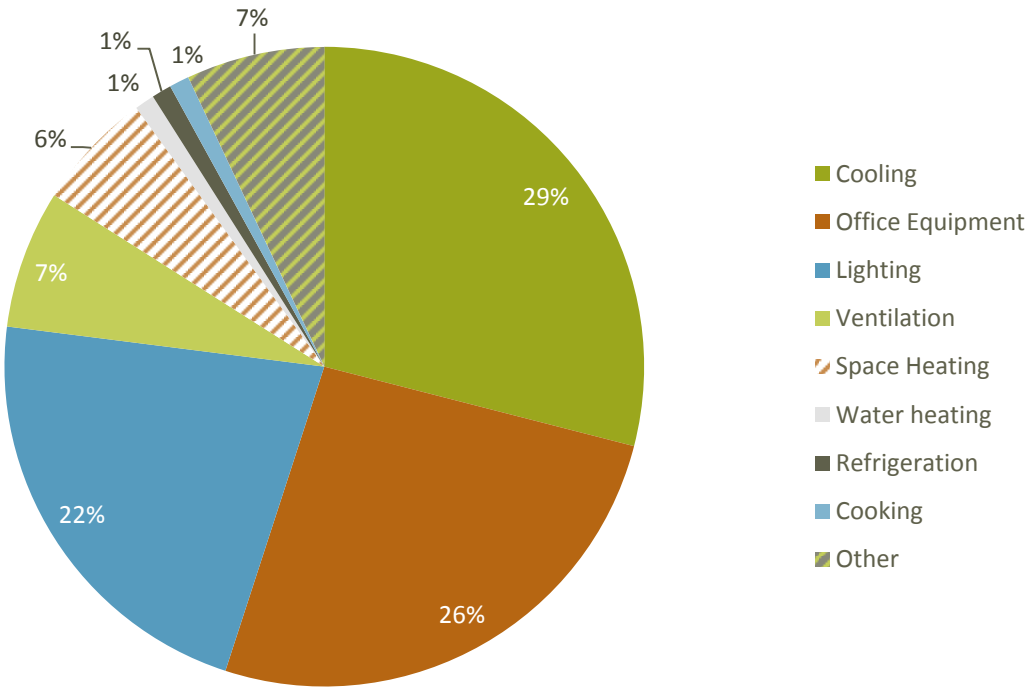
Simple payback (in years) for the replacement of lighting and HVAC equipment. When possible, the ECST should measure

[2] US Energy Information Association

the electricity load of both the old equipment being replaced and the new equipment to calculate estimated annual savings. The simple payback calculation requires the cost of the electricity in $/kWh. The ECST should understand the electricity costs of the City's different rate structures and use the appropriate cost in its calculations. As a default, the City pays about $0.08/kWh for its general service electricity accounts.

Target **Two-year simple payback for lighting retrofits and five-year simple payback for HVAC replacements.**

Exhibit 10: Breakout of Electricity Consumption for Average Office Building[3]



[3] U.S. Department of Energy

Issue

The City pays the electric bills for highway lighting but these lights are not the most efficient option currently available. The City of Tulsa Streets & Stormwater Department is responsible for the maintenance and electricity bills of all highway lighting on state, U.S., and interstate highways in the corporate limits of Tulsa, approximately 6,500 luminaires. This responsibility is relegated by the Oklahoma Department of Transportation (ODOT) in bilateral agreements. In FY 2011, the City spent $1,159,000 on electricity for the operation of highway lighting and another $245,000 annually for maintenance. Seventy-two percent of the highway lighting is 200, 250, and 400 watt high-pressure sodium (HPS) lamps and the remainder are metal halide (MH) and mercury vapor (MV) lamps. Alternative highway lighting options could save the City significant amounts of money each year in electricity and maintenance costs.

Recommendation

Work with ODOT to move away from replacement with like type fixtures/ballasts to a more energy efficient and similar light output fixture. In these cases, there is a significant up front cost associated with the new fixtures, as detailed below. However, this upfront cost is tempered by two factors: the energy efficiency itself and the longevity of these new products. Here is a comparison:

Standard HPS Fixture at 250W:

- Bulb lifetime is approximately 18 months (for output required by AASHTO or similar)
- Fixture lifetime is approximately 15 years
- Ballast lifetime is approximately 5 years
- CRI (color rendering index-measurement of how true a color looks under this light which affects nighttime response for drivers) is approximately 21 (out of 100 for daylight)
- Energy Consumption = 3.6 kWh per day (12 hour burn), 1314 kWh per year
- Bulb replacement cost = $80 + labor
- Fixture replacement cost = $180 + labor

Induction Fluorescent Fixture at 150W:

- Bulb/Fixture/Ballast lifetime is approximately 100,000 hrs (22.83 yrs)
- CRI is approximately 70
- Energy Consumption = 1.8 kWh per day (12 hour burn), 657 kWh per year
- Fixture cost = $495 + labor

LED Fixture at 126W:

- Bulb/Fixture/Ballast lifetime is approximately 60,000 hrs (13.7 yrs)
- CRI is approximately 85
- Energy Consumption = 1.512 kWh per day (12 hour burn), 551.9 kWh per year
- Fixture cost = $890 + labor

As shown in these calculations, induction lighting is more cost effective than LED. Induction fixtures work well to replace streetlights in neighborhoods, underpass lighting, and car parking lot lighting. However, they do poorly when compared with LED fixtures for roadway lighting where cars depend upon the lighting to aid in vehicle safety. The distribution of light coming out of an LED fixture is much more uniform which is a beneficial quality for roadway lighting.

The City should work with ODOT to phase in the use of LED lighting as a replacement to existing HPS, MH, and MV lighting. The City could save up to 60%, or nearly $700,000 annually, on electricity costs by switching to the more efficient LED lights. Additionally, due to a significantly longer fixture life, maintenance costs would be much lower for the LED lights.

Key Performance Indicator **Total percentage of existing highway lights replaced with high-efficiency LED highway lights**

Target **25% by end of FY 2013, 100% by end of FY 2016**

Initiative #9: Upgrade Interior Lighting, Occupancy Sensors, and Exit Signs

Issue

The City of Tulsa still uses inefficient luminaires with T12 lamps and magnetic ballasts. The 1992, 2000, and 2005 amendments to the Energy Policy and Conservation Act established energy conservation standards for certain classes of general service fluorescent lamps and magnetic ballasts. The amended energy conservation standards, which are performance-based, do not explicitly prohibit the sale of T12 lamps; however, based on a Department of Energy analysis, most commercially-available T12 lamps are too inefficient to meet the amended standards and can no longer be manufactured for distribution in commerce after July 14, 2012. Additionally, the manufacture of magnetic ballasts was phased out beginning January 1, 2010. The T12 linear fluorescent lamps and magnetic ballasts used throughout many City buildings are inefficient compared to the newer technology. Converting these fixtures to 28-watt, T8 (or more efficient T5) lamps and electronic ballasts could reduce energy consumption and re-lamping cost while improving light quality.

In addition, incandescent lamps are slowly being phased out; therefore, incandescent lamps should be retrofitted with the screw-in compact fluorescent lamps (CFL). CFLs offer the same, often better, light output as incandescent lamps but at a lower wattage. Due to the increased efficiency of CFLs over incandescents, not only do CFLs reduce required input wattage, but they also dramatically reduce the amount of waste heat generated.

Upgrading incandescent or fluorescent exit signs to LED is an effective way of reducing energy consumption and maintenance. LED light production yields relatively low amounts of heat and most of the energy goes into producing visible light. LED exit signs have a lifespan as high as 100,000 hours and consume far less power than incandescent light bulbs and even fluorescent light bulbs. CFLs and LEDs also reduce replacement frequency and therefore maintenance costs.

High-intensity discharge (HID), high-bay luminaires could be replaced with T8 or T5 fluorescent high-bay luminaires. T8 and T5 fluorescent high-bay luminaires offer the same light output as HID luminaires and operate at a lower wattage, therefore reducing energy costs. Also, they are instant-on which allows luminaires to be turned off when not in use. HID luminaires require a cool-down period before they can be re-started; therefore, they are typically left on.

Occupancy sensors enable lights to come on when an occupant enters the room and automatically turn off 15 to 30 minutes after the space is vacant. Spaces throughout the buildings could be outfitted with these sensors, such as the restrooms, small offices, storage rooms, etc.

Recommendation

A lighting upgrade program should be implemented that consists of an assessment of all of the City of Tulsa's facilities beginning with least efficient facilities as identified through benchmarking. This assessment should include a three-phase process:

- Assess current lighting conditions.
- Provide recommendations to improve lighting.
- Install new equipment.

The lighting study will require collecting data on the current illumination, bulb and fixture type, lumens, color index, and temperature. This must include information on the lighting load, room dimensions, the proper illumination level for the task, and hours of use. An analysis will be conducted using the optimum lumens per square foot using the most current illumination standards

by IES. Priority will be given to projects that reduce watts with increased bulb life, but provide the best light quality with little or no mercury-filled tubes.

A main goal of this program will be to eliminate the use of T12 fluorescent luminaires, magnetic ballasts and incandescent bulbs, and to limit the usage of lights to only when they are needed.

Key Performance Indicator **Percentage of T12 luminaires replaced by high efficiency alternatives**

Target **100% of T12 luminaires replaced by end of FY2013.**

Initiative #10: Re-Commission Lighting Control at One Technology Center

Issue **One Technology Center (OTC) has a lighting control system that may not be optimized to provide only the minimum amount of lighting required for occupant egress.** The OTC lighting control system allows Security to control the lights on all floors throughout the building. The original intent was for the lights to be turned off after normal business hours. If an occupant needed to be in a part of the building after hours or on a weekend, he/she would check in with Security who would turn on the lights for the floor that was to be occupied. According to the 2006 International Building Code (IBC) Section 1006.1, all means of egress must be illuminated by artificial lighting during the entire time a building is occupied, so that the paths of exit travel are always visible and available for evacuation of the occupants during emergencies.

Although much has already been done to reduce the lighting load at OTC, it may be possible to adjust lighting levels on 24/7 occupied floors down to the minimum required for safe egress under the IBC.

Recommendation **The lighting control system for OTC should be re-commissioned to ensure that only the minimum amount of light required for safe egress during emergencies is turned on during the nights and weekends.** It may also be possible to optimize cleaning service to be performed on a floor-by-floor basis to minimize the amount of floors illuminated during unoccupied times, but only if this does not add to other costs. Seasonal fluctuations of lighting requirements should also be taken into account.

An estimate for total potential electricity cost savings can be calculated assuming the following:

- 20% of the building square footage is area that is not controlled by the lighting control system, or is emergency lights, corridors, stairwells etc. and as a result would not be affected by the reduction in run-time.

- 0.9 Watts per square foot (W/SF) lighting density, slightly lower than the ASHRAE 90.1 required maximum level of 1.0 W/SF.
- Four out of the 15 floors are areas that require 24/7 illumination.
- The lighting can be reduced 5 hours per weekday minus 1 hour per day for cleaning.

This calculation shows a reduction in electricity use of 384,516 kWh/year (or $28,000 using a blended electricity rate of $0.072/kWh). This is an approximately 22% reduction in the annual electric consumption (1,774,500 kWh). It should be noted that the building receives chilled water from the district cooling system so the electric consumption of the building only accounts for lighting, miscellaneous plug loads, fans, and pumps.

Key Performance Indicator **Total electricity costs for OTC**

Target **15% reduction of total electricity costs in FY2013**

Initiative #11: Replace Building Exterior Lighting with High-Efficiency Alternatives

Issue **Exterior lighting is typically provided by high-intensity discharge lamps, which are often high wattage.** Prevalent HID lighting includes mercury vapor, high-pressure sodium, and metal halide types ranging from 70 to 1,000 watts. Some HID light types are more inefficient than others, but all HID lighting is less efficient than LED lights.

Exterior lighting is typically automatically controlled by timers and photocells. When exterior lighting is controlled by a simple timer (i.e., scheduled to turn on and off at set times every day), lights are often on when they are not needed due to the changing times of the rising and setting sun. When exterior lighting is controlled by a simple photocell, lights can come on when they are not needed due to over-sensitive photocells that switch lights on during inclement weather with dark cloud cover or before the sun sets.

Recommendation **Replacing HID wall packs and flood lights with LED typically reduces energy consumption by over 70%, reduces re-lamping cost, and limits night light pollution.** Complete fixture replacement is typically required for this energy conservation measure, which may result in a relatively high up-front cost. LED luminaires are more efficient in the colder temperatures and offer the same light output as HID luminaires at a lower wattage, which reduces energy costs. LED luminaires have a significantly longer life than HID luminaires and therefore will not need to be replaced as often, which could offer significant Operation and Maintenance (O&M) savings.

Astronomical time clocks, which are devices that track the daily rising and setting of the sun, are the best option for accurately controlling outdoor lighting to come on at dusk and off at dawn.

Key Performance Indicator **Number of HID exterior lighting fixtures replaced with high efficiency alternatives.**

Target **Three buildings with HID exterior lighting by end of FY 2013**

Initiative #12: Implement Retro-Commissioning Program for Existing City Buildings

Issue **Many City buildings, particularly those that have never gone through any type of commissioning or quality assurance process, are typically performing well below their potential.** This is especially true when a group of buildings have multiple uses and are of different ages. Retro-commissioning applies a systematic investigation process for improving and optimizing a building's O&M. Retro-commissioning occurs after construction, as an independent process, and is generally applied to buildings that have not previously been commissioned. It may or may not emphasize bringing the building back to its original intended design. In fact, original design documentation may no longer exist or may be irrelevant, or the original purpose of the building may have changed altogether.

Recommendation **Retro-commissioning is a process that involves a thorough analysis of a facility and its goal is to improve building processes so that they perform, not only the way they were designed to, but in a way that meets current operating needs.** Retro-commissioning works toward maximizing system functionality. It is an inclusive and systematic process intended not only to optimize how equipment and systems operate, but also to optimize how the systems function together.

Although retro-commissioning may result in recommendations to investigate further capital improvements, O&M tune-up activities and diagnostic testing are primarily used to optimize the building systems. The goals and objectives for applying the process, as well as the level of rigor, may vary depending on the current needs of the owner, the budget, and the condition of the existing equipment.

Typically the level of rigor is consistent with an ASHRAE Level 2 energy audit and most often focuses on dynamic energy-consuming systems, with the goal of reducing energy waste, obtaining energy cost savings, and identifying and addressing existing problems. Numerous studies have cited retro-commissioning as one of the most cost-effective ways to save energy. The energy savings from retro-commissioning programs varies widely, and the total operational and maintenance cost savings can be difficult to quantify. However, retro-commissioning typically reduces energy consumption by at least 3 to 5 percent where implemented.

Buildings with air handlers and an automation system should be the prime focus of retro-commissioning.

Key Performance Indicator **Number of City buildings retro-commissioned and percentage reduction of energy use in those buildings**

Target **Three of the City facilities with the highest energy/sf ratios retro-commissioned with 3-5% reduction in energy consumption by FY2013.**

Initiative #13: Enforce City Policies Regarding HVAC Controls, Setbacks and Set Points

Issue **Many HVAC systems throughout City-owned facilities are controlled by facility occupants and are not controlled in compliance with existing City policy.** When occupants are given control of a building's HVAC system, set points and schedules often exceed the range of temperatures and occupied hours ideal for energy efficiency and as a result, systems likely operate more hours than needed. Some buildings throughout the City do not have the ability to automatically adjust temperature set points according to a schedule, but instead are controlled manually. Manually controlled HVAC systems often operate as if the building is occupied 24 hours per day, 7 days per week.

Recommendation **For buildings with no building automation system or zone-level programmable control, programmable thermostats could provide an effective, economical, and easy way to save energy.** Programmable thermostats can save energy and money without sacrificing comfort by offering daily temperature set points. They do this by allowing temperatures to be set according to time and day occupancy schedules in the workplace. When a building is unoccupied, temperatures can be set lower for heating or higher for cooling. Programmable thermostats reduce energy consumption while the building is unoccupied in the evenings, over weekends, and throughout extended holidays. They can save as much as 33 percent of the heating energy and from 10 to 25 percent of the cooling energy by providing better temperature control and more efficient equipment operation.

In buildings that have programmable control through building automation systems or zone-level programmable thermostats, schedules and thermostat set points should be set with consideration of occupant feedback, but with limited occupant control. Limited occupant control can be accomplished through thermostat locks, enforced set point and schedule settings, and/or zone-level set point ranges.

The City's Internal Energy Policy (Title 12, Chapter 1)

sets a target temperature of 72 degrees Fahrenheit as a maximum during heating season and as a minimum during cooling season. Tulsa Parks and Recreation Department has implemented a Thermostat Set Point Policy that is more stringent, as seen in this picture taken at the Central Recreation Center. However, it appears this program is not monitored or enforced, and many of the thermostats were set less conservatively than the Policy indicated.

A reward program should be implemented to promote compliance with the thermostat policy. This could be done with random, unscheduled trips to facilities by ECST members who would verify that the thermostats are set in accordance with the policy.

Key Performance Indicators

The percentage of buildings utilizing programmable control. The percentage of buildings properly utilizing programmable control.

Target

All buildings with non-24/7 occupancy should have programmable control ability. All buildings with current programmable control ability should be programmed to appropriate temperature set points and scheduled setbacks during unoccupied hours. All city-owned facilities shall follow the Thermostat Set Point Energy Management Policy.

Initiative #14: Reset Domestic Hot Water Temperatures

Issue

Domestic hot water heaters are often set to higher temperatures than needed to adequately meet the demand of the hot water system.

Recommendation

Although some manufacturers set water heater thermostats to 140˚F, many domestic hot water systems only require a set point of 120˚F. Reducing water temperature to 120˚F also slows mineral buildup and corrosion in water heater pipes, which improves the lifetime and efficiency of the system. If a commercial kitchen is present that does not have a booster heater, a set point of 140˚F may be required. A series of temperature set point tests may be conducted to locate the optimal temperature that will satisfy the domestic hot water needs while limiting energy waste.

The City should complete an inventory of its hot water heaters and determine which heaters need to be set higher than 120°F. In buildings that are unoccupied, hot water heaters should be set to unoccupied mode as part of the shut-down procedure. Most hot water heaters have an unoccupied mode that reduces the temperature to the lowest setting.

Key Performance Indicators

The percentage of domestic water heaters that are set to the optimal temperature that satisfies hot water needs while limiting energy waste.

Target

All of the city facility domestic water heaters are set to the optimal temperature that will satisfy the domestic hot water needs while limiting energy waste within one year.

Initiative #15: Enforce Existing Policy on Computer Power Controls/Laptop Conversion

Issue

A standard desktop computer consumes about 100 watts on average when it is in use, while standard laptops consume about 30 watts. Out-dated cathode ray tube (CRT) monitors consume as much as 70 watts when in use, while liquid crystal display (LCD) monitors that are LED backlit consume about 15 watts. Additionally, a significant amount of energy is wasted when computers are put in screen-saver mode rather than hibernate or shut down when not in use.

Recommendation

All City-owned desktop computers should be set to go into hibernate mode when not in use for 15-30 minutes and to shut down overnight. If computers are connected to a network where updates are installed after hours, software exists that allows the network administrator to change the power management controls of all PCs on the network. This software can set the PCs to go into hibernate mode when not in use and also allows the administrator to turn on the computer before installing updates. Microsoft offers a majority of these programs at no charge.

When upgrading IT equipment, the City should implement a policy requiring the purchase Energy Star® labeled products, and should also consider purchasing laptops rather than desktops. Laptops consume far less energy than desktops and can be used in combination with an LCD monitor, mouse, and keyboard, similar to a desktop, for ergonomic comfort.

Note: As of July 2011, approximately 1,850 City employee computers had been put on the NightWatchman® PC management system. Shortly after its roll-out, approximately 300 City employees had removed themselves from the program. All City-owned computers should remain on the NightWatchman® system. The City's IT department should monitor the number of employees that are part of the system.

Key Performance Indicator

The percentage of City-owned desktops on the NightWatchman® system.

Target

All City-owned desktops without a valid exemption are on the NightWatchman® system.

Initiative #16: Install Vending Machine Setback Controls

Issue

Refrigerated and snack vending machines can consume large amounts of wasted energy due to their 24 hour/7 days per week operation, regardless of area occupancy or vending machine use. Snack vending machines typically draw at least 100 watts in lighting alone 24 hours per day, 365 days per year. Refrigerated vending machines consume a significant amount of energy to supply cold products. Measurements have shown that a typical machine that dispenses 500 12-oz cans with an illuminated front consumes between 7 and 11 kWh/day in an office environment. For comparison, new Energy Star® certified residential refrigerators use 1-2 kWh/day. One reason for the high energy use is that the manufacturers and owners of the vending machines generally do not pay for the energy to run the machines; therefore,

they have little incentive to improve the energy efficiency of the machines. The building owners, who pay the utility bills, have little choice in the type of vending machine that is deployed at their site.

Recommendation

Install vending and snack misers on beverage and snack vending machines. This load-managing device is a simple plug-and-play device, with tens of thousands of units installed in school districts, colleges and universities, government offices, retail stores, and hospitality facilities. It uses a passive infrared occupancy sensor to turn off the vending machine when the surrounding area is unoccupied and turn it back on when the area is occupied. Additionally, the lighting in vending machines can be permanently reduced or turned off completely.

The load manager also monitors the ambient temperature while the vending machine is off, and it powers up the machine when required to ensure that the product stays cold. In addition, the load manager monitors electrical current used by the vending machine so that it is not shut off while the compressor is running to prevent a high head pressure start from occurring. This process reduces maintenance costs and extends the life of the vending machine by significantly reducing the number of compressor cycles. This equipment is compatible with all types of cold drink vending machines and will not damage the vending machine. This has been validated by acceptance from corporate Coca-Cola, corporate Pepsi-Cola, and machine manufacturer testing. Devices are also available for snack vending machines that simply shut off the lights when the space is not occupied.

In addition to being safe, these devices extend the machine's life and reduce maintenance costs. During standard operation, a cold vending machine's compressor typically cycles three to four times per hour, running each time for about 10 to 15 minutes. In a two-hour period, a compressor will run through as many as eight short duration cycles. While the vending machine area is occupied, it leaves the vending machine powered and the compressor will operate in this same fashion. However, when the area around the machine is vacant, it will typically cycle the compressor only once every two hours for a longer cycle, usually about 20 – 30 minutes in length. This will extend the life of the compressor, allowing it to run fewer and longer cycles. In addition, the replacement frequency of the fluorescent lamps will be reduced. While it is true that power cycling fluorescent lamps will shorten their life, the hours that the machine is powered down greatly exceeds this reduction in burn hours. The net effect is that the lamps will need to be replaced less often. This controller technology reduces vending machine maintenance costs by decreasing the frequency and direct expense of component failures, and thus the number of service calls.

Key Performance Indicator

Percentage of vending machines with installed occupancy controls.

Target

100 % of vending machines have occupancy controls installed over the next three years.

Initiative #17: Use Demand Control Ventilation

Issue

Many City buildings are conditioning more outside air than is necessary, contributing to higher electricity bills. Buildings are designed to promote the health and comfort of their occupants. Part of this design strategy is to provide outdoor air or "fresh air." Often this fresh air is delivered as if the building were at full occupancy regardless of whether or not it is occupied at all. More often than not, this fresh air has to be conditioned to meet indoor temperature set points. The cost to condition this air is a significant portion of the total energy cost for most building HVAC systems. If the amount of outdoor air can be minimized or eliminated when the building has little or no occupancy, energy savings can be significant. Because utilization shifts over a large range in many building spaces, Demand Control Ventilation (DCV) is an excellent energy savings opportunity.

Recommendation

Implement a Demand Control Ventilation control strategy. People generate bio-effluents (ammonia, methane, etc.) which are typically the largest source of indoor air contaminants in a building. Since carbon dioxide (CO_2) is generated by respiration at nearly the same rate as other bio-effluents, CO_2 is an excellent indicator of human respiration, building occupancy level, and indoor air quality. A DCV control strategy varies the amount of fresh air brought into buildings according to indoor CO_2 levels. The volume of outside air introduced through the air handlers is reduced so that the return air CO_2 level is no more than 700 parts per million (ppm) higher than the current outside air CO_2 level.

A comprehensive CO_2 Demand Control Ventilation strategy includes:

- Review of design minimum ventilation rates to ensure compliance with ASHRAE 62.1-2007 and local codes.
- Inspection and testing of outside air dampers to verify proper operation and to ensure that outside air dampers close tight during unoccupied modes such as morning warm-up. Installation of CO_2 sensors to measure return air and outside air CO_2 levels.
- Installation of sensor to measure outside air flow and controls to vary supply fan speed and damper position to meet the required amount of outside air needed to be pulled into the system.

DCV could be implemented in buildings such as offices, convention centers, and recreation centers with air handling units. It should not be implemented on buildings that utilize small furnaces to heat/cool the building. DCV will typically reduce energy consumption on an average HVAC system by 10% to 30% with an estimated construction cost of $5,000 to $7,500 depending on existing system, excluding soft costs. The City should create a ranked list of facilities with large mechanical ventilation systems and a varying occupant load, such as office spaces, convention centers, and recreation centers, making special note of HVAC systems that bring in large amounts of outside air in buildings with low average occupancy compared to peak occupancy will hold the most potential for demand control ventilation.

Key Performance Indicator

Total number of buildings evaluated for implementation of DCV control strategy; total number of identified buildings retrofitted with DCV control strategy.

Target

100% of buildings evaluated for use of DCV control strategy by end of FY2012; 25% of buildings identified as good candidates for DCV retrofitted by end of FY2013.

Initiative #18: Convert Constant Volume Rooftop/Air Handling Systems to Variable Volume

Issue

The amount of air required to cool a space typically varies throughout the course of a day and year; however, the air handler peak design supply air volume is typically sized for the peak space sensible cooling load. The peak space sensible cooling load is comprised of the following:

- Solar heat gain from windows and skylights
- Conductance through the building envelope (windows, walls and roof)
- Indoor lighting
- Plug loads such as computers, printers, refrigerators, equipment and process loads

The space sensible load components above vary through the course of a given day and year. Typically the space sensible load is less than 50% of peak 75% of the time. For constant volume systems, a significant amount of energy is wasted during non-peak space sensible cooling load hours due to:

- Additional cooling energy is used to cool a larger volume of air than is required to meet the space sensible load.
- Additional fan energy is used to supply more air than is required.
- Additional reheat used because air to the space needs to be heated to prevent the space from over-cooling.
- Higher first cost for air handler replacement due to necessary over-sizing.

Recommendation

Evaluate City buildings for applicability of variable volume air distribution systems and install in those buildings that are good candidates, especially HVAC systems with varying occupancy. Variable volume air distribution systems reduce supply air volume as well as the demand for cooling and reheating during non-peak cooling conditions; therefore, a significant amount of energy can be saved by converting from a constant volume to a variable volume air distribution system. In a variable air volume system, terminal unit dampers (VAV boxes) modulate the quantity of cooling air delivered to a space in order to maintain space temperature. As demand for air flow increases the terminal unit dampers open to allow more cool air to be delivered to the space and the supply fan increases the amount of air delivered to the building in response. An increase in duct static pressure indicates that terminal unit dampers are starting to modulate closed which indicates that the demand for air flow is decreasing. Conversely, a decrease in duct static pressure indicates that terminal unit dampers are starting to open which indicates that the demand for air flow is increasing.

A sensor installed in the ductwork measures the static pressure of the air inside the ductwork and communicates the changes in demand for cooling airflow to the HVAC control system, which in turn varies the amount of air delivered by the supply air fan to the building in response. The amount of supply air delivered to the building is varied by a variable frequency drive (VFD) installed to control the supply fan speed. The VFD varies the speed of the supply fan motor in order to vary the amount of supply air flow to the space. Variable speed drives reduce the speed of the fan motor as demand for supply air decreases. The change in the amount of energy a motor consumes is related to the cube of the change in speed. As an illustration, a 50% reduction in fan motor speed results in an 87.5% reduction in fan energy. Variable speed drives typically represent the best overall approach

for reducing fan energy while increasing reliability and minimizing first cost and maintenance cost when serving areas with variable loads.

HVAC systems with varying occupancy will hold the most potential for a variable air volume system.

Key Performance Indicator

Simple payback (in years) of the relevant buildings with constant volume air handling units. Create a ranked list of facilities with the large mechanical ventilation systems with constant volume systems and a varying occupant load, such as office spaces, convention centers, and recreation centers.

Target

Implement on all buildings that yield a simple payback of less than 5 years.

Initiative #19: Convert Constant Volume Hydronic Pumps to Variable Volume

Issue

The amount of water required to meet the cooling or heating demands typically varies throughout the course of a day and year; however, a pump is selected based on the maximum amount of flow required.

For chilled water pumps, the amount of flow required is based on the cooling coil load which is comprised of the following:

- Solar heat gain from windows and skylights
- Conductance through the building envelope (windows, walls and roof)
- Indoor lighting
- Plug loads such as computers, printers, refrigerators, equipment and process loads
- Ventilation load (outside air quantity, dry bulb and wet bulb temperature)
- Supply and return fan heat

Typically all of the cooling coil load components above vary through the course of a given day and year. For constant flow systems, a significant amount of energy is wasted during non-peak cooling coil loads hours due to:

- Additional pump energy that is used to supply more water than is required. Reduced chiller efficiency due to low delta T conditions caused by 3-way control valves diverting cold supply water away from the air handler coils to the chilled water return.

Similarly for hot water heating systems, the amount of hot water required varies based on the peak heating load. The peak heating load is comprised of the following:

- Ventilation load (outside air quantity and dry bulb temperature)
- Heat loss from conductance through the building envelope (windows, walls, roof and floors).

Typically all of the heating load components above vary through the course of a given day and year due to:

- Additional pump energy is used to supply more water than is required.
- There is a reduction in heating efficiency on condensing boiler systems due to low delta T conditions caused by three-way control valves diverting hot supply water away from the air handler coils to the hot water return.

Recommendation

A significant amount of energy can be saved by converting the water distribution from constant flow to variable flow. Variable speed drives reduce the speed of the pump motor as demand for flow decreases. The change in the amount of energy a motor consumes is related to the cube of the change in speed; therefore, a 50% reduction in pump motor speed results in an 87.5% reduction in pump energy.

A variable flow retrofit of an existing constant flow system will typically include:

- Installation of new two-way modulating control valves on all loads with direct digital controls (DDC)
- Installation of new or retrofit existing pumps with premium efficient inverter duty motors and variable speed drives
- Installation of new DDC controls to properly modulate pump speed in response to changes in demand
- Sometimes as part of a larger comprehensive project, the cooling and/or heating plants' equipment and controls will be replaced with new high efficiency equipment that is better suited for variable flow applications.

This ECM could be applied to buildings that utilize hot water and chilled water for building heating and cooling, and can also be used on water pumps at the Water and Waste Water Treatment Plants. This ECM is not typically cost effective on retrofits of motors smaller than 7.5HP.

Key Performance Indicator

Total number of constant volume hydronic pumps replaced with variable volume pumps

Target

100% of constant volume hydronic pumps replaced by FY2013.

Initiative #20: Convert Air Handling Units with Inlet Guide Vanes to Variable Frequency Drives

Issue

Inlet guide vanes are an inefficient means of regulating air flow in an air handling system to meet demand. With an inlet guide vane system, the fans and motors run at constant speed while a mechanical device such as an inlet guide vane regulates the airflow. This system wastes energy because rather than directly regulating fan speed to satisfy demand, it regulates the airflow and uses more fan energy than the system actually requires. In addition, many times the linkages or actuators of the inlet guide vanes become damaged and the blades are locked at 100% to ensure adequate airflow, and the system then becomes essentially a constant volume unit.

A couple air handling units in the Tulsa Convention Center utilize Carrier's Modudrive technology. This is an outdated form of volume control in which the tension of the belt between the motor and fan is adjusted to increase/decrease slippage and increase/decrease the fan speed. This system is not the most efficient method to control fan speed and requires more maintenance to ensure proper operation then does a variable speed drive. AHU-17 at the Convention Center does not appear to be functioning properly and as a result is essentially a constant volume unit.

Recommendation

Air handling units that utilize inlet guide vanes and the Modudrive system should be replaced with variable speed drives. The existing motors should be replaced with premium efficient, inverter duty motors designed for use with variable frequency drives.

Key Performance Indicator

Total number Air Handling Units with inlet guide vanes fitted with variable frequency drives

Target

100% of AHUs with inlet guide vanes fitted with variable frequency drives by FY2013.

Initiative #21: Convert Aeration Blowers to Variable Frequency Drive

Issue

Wastewater treatment plants utilize high horsepower motors on aerator blowers that supply air to aerator tanks. Blowers typically use throttling valves to control the volume of air to the tanks. This is an inefficient method of volume control since the motors are run at 100% speed and full power, while throttling valves adjust flow to satisfy demand. The most energy efficient method of volume control is a variable speed drive that slows the motor speed (in RPM) to regulate the amount of air flow needed by the system, which in turn reduces the amount of power consumed by the motor.

Recommendation

Throttling valves could be removed or locked in the 100% open position and the motors for the blowers could be replaced with premium efficiency, inverter-duty motors with variable frequency drives. If the current motors are premium efficient and inverter-duty, VFDs could be installed on the existing motors.

If the blowers share a common header, another option is to incorporate VFD speed control on a few of the blower motors and use the VFD-controlled blowers as the trim control and run the remaining motors at full speed, being staged on and off as needed based on demand.

Key Performance Indicator

Percentage of eligible existing motors retrofitted with VFDs

Target

100% of aeration blowers evaluated for conversion to VFDs and 25% of eligible existing motors converted to VFDs by end of FY2013.

Initiative #22: Use a Heating Hot Water Reset Strategy

Issue

Typical boilers are enabled based on outside air temperature, but adjust the hot water supply temperature according to outside air temperature. This results in the boilers supplying a constant heating hot water temperature at all times when running.

Recommendation

Consider hot water reset for eligible boilers. Hot water reset is an energy-saving automatic control algorithm for hot water boilers that are typically fired with fuel oil or natural gas. A hot water reset control loop measures the outside air temperature which is used to estimate heating load as the outdoor temperature varies. The supply hot water temperature is modulated in an inverse linear ratio to outside air temperature. For example, when the outside air temperature is 0°F, the reset loop will make the boilers supply 180°F heating hot water; however when the temperature is 50°F the reset loop will modulate the boiler supply heating hot water temperature down to 140°F. Boiler reset controls can be implemented on the existing boiler system by installing a hot water reset controller. The City should evaluate the life-cycle costs associated with installing boiler reset controls on its boilers.

Key Performance Indicator

Percentage of eligible boilers retrofitted with hot water reset controllers.

Target

100% of boilers evaluated for installation of hot water reset controllers and 25% of eligible boilers retrofitted by end of FY2013.

Initiative #23: Retrofit Magnetic Bearings on Vehicle Exhaust Boot System in Fire Stations

Issue

Pneumatic air compression systems at Tulsa fire stations may not be operating as efficiently as they could be. Fire station apparatus rooms are typically equipped with an exhaust system that is used when vehicles are turned on indoors. The system typically includes a boot that covers the vehicle exhaust pipe so that exhaust is directed outdoors. This boot is enclosed around the vehicle exhaust pipe through a pneumatic air compression system throughout the fire stations in Tulsa. The pneumatic system typically requires the use of a 5-HP air compressor.

Recommendation

The current pneumatic system can be retrofitted with a magnetic system that will dramatically reduce the use of the air compressor. The Fire Department plans to implement this change out to the magnetic system over time as money is available. Investigate current ONG and PSO incentives.

Key Performance Indicator

Percentage of pneumatic boots changed to the magnetic system.

Target

All of the pneumatic boots changed to magnetic systems over the next five years.

Source: Clean Air Company

Initiative #24: Convert to Infrared (IR) Heating in Large Garage and Storage Spaces

Issue

Large garage and storage spaces are often heated with multiple, gas-fired, forced-air unit heaters. With forced air heating systems, most of the heat escapes when garage doors are opened.

Recommendation

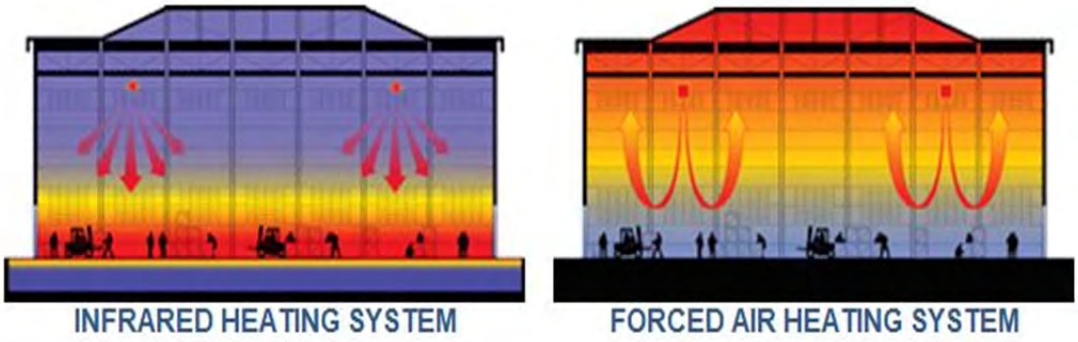
Given the use of large heated garages and storage spaces, infrared (IR) heating is a more efficient system for heating the spaces. With forced hot air heating systems, hot air rises to the ceiling and stratifies, which creates a cold layer where heat is needed and unnecessarily heats the empty space above that layer. Conversely, IR heating systems heat the floor, equipment, and people first and the air second, which allows for the use of all methods of heat transfer including: radiation, conduction, and convection. The resulting heat placements for the two methods of heating are shown in the image below. Typically, an IR heating system is 30% more efficient than the standard forced air heating system.

Key Performance Indicator

Total number of eligible forced hot air heating systems replaced with IR heating systems.

Target

100% of forced hot air heating systems evaluated for installation of hot water reset controllers and 25% of eligible systems replaced with IR heating by end of FY2013.



Initiative #25: Replace Domestic Hot Water Heaters with High Efficiency Models

Issue

First cost is typically considered a priority over energy efficiency when selecting equipment. As a result, high efficiency water heaters are not always used.

Recommendation

As domestic hot water heaters reach the end of their useful lives, units should be replaced with high efficiency models. Electric water heaters that are kept in a consistently warm environment (such as a mechanical room) should be replaced with electric heat pump water heaters. Natural gas water heaters should be replaced with high efficiency condensing water heaters. Tankless water heaters are ideal for energy savings, but are often difficult to install in already existing buildings. When a water heater is nearing the end of its useful life, energy efficiency should be considered when determining the best replacement type. This initiative should be integrated with the City's procurement policies regarding domestic hot water heaters so that life-cycle cost assessments are part of the decision-making process. Investigate ONG and PSO incentives.

Key Performance Indicator

Total number of City-owned domestic hot water heaters scheduled for replacement that are replaced with high-efficiency model.

Target

All newly purchased domestic hot water heaters are high-efficiency type.

Initiative #26: Replace Single-Pane Windows

Issue

Older City buildings often have single-pane windows with little or no shading coefficient. Additionally, older windows are typically thermally broken and may have significant infiltration.

Recommendation

Upgrading single-pane windows to new double-pane windows with a U-value less than 0.35 results in reduced infiltration, energy consumption, and use of electric space heaters, as well as improved occupant comfort and building aesthetics. Although window upgrades can significantly reduce energy consumption, due to its high first cost the simple payback is generally greater than 10 years. When replacing windows that are beyond their useful life, it is typically cost effective to purchase energy efficient windows that may require a higher up-front cost. Buildings with windows that are beyond their useful lives should be ranked based on need and energy savings potential. Window replacements are typically good energy projects to pay for with grant dollars because grant money helps offset the high upfront cost and long payback periods. The ECST may also consider doing infrared scans to find leaks through a program sponsored by PSO.

Key Performance Indicator

Percentage of single-paned windows replaced with double paned windows.

Target

100% of City-owned buildings assessed for presence of single-pane windows. One building targeted for replacement of single pane windows with double-pane windows by the end of FY 2012 and two more buildings in FY2013.

Initiative #27: Maximize Utility Incentive Opportunities

Issue

Currently, not all departments in the City take advantage of the utility rebates offered through the electric utility company. The Model Cities program through AEP offers $0.06/kWh for energy-saving projects based on annual kWh savings. AEP's CoolSaver program offers $75 for an HVAC tune-up completed by registered qualifying contractors who work to improve the HVAC equipment's energy efficiency. AEP also offers a demand response program.

Recommendation

The City should work with AEP on all projects completed in City-owned facilities that result in energy savings that qualify for the utility incentive program. The City should also work with the CoolSaver program to complete tune-ups of HVAC equipment. Tune-ups can be completed by contractors or City maintenance staff who have completed AEP's free training course on energy efficient tune-ups.

Key Performance Indicator

The total dollar value of acquired rebate incentives.

Target

All projects that result in energy savings have applied for a utility incentive.

Initiative #28: Provide Incentives and Resources for Comprehensive Life Cycle Analysis (LCA) Energy Reviews for New City Facilities and Major Renovations

Issue

There is currently no systematic approach to evaluating the life cycle energy costs of new construction or major renovations for new or existing City-owned facilities. Significant life cycle energy and water cost savings can be achieved through including design elements in the initial planning and specification process for new construction or major renovations. However, this approach is strictly voluntary at this time.

Recommendation

Implement a new policy that provides the necessary resources and incentives for every new construction or major renovation project to conduct a comprehensive review of design elements that will increase the facility's energy and water efficiency over its life. Implement a requirement that construction managers present to City management as part of periodic project reviews the efficiency design elements that were considered and the LCA justification for either including them or not including them in the final design.

Several energy efficiency standards and checklists exist that may provide guidance to construction managers when evaluating different efficiency design elements. The City should not necessarily require a specific level of certification under these different programs (such as LEED, Green Globes, etc.), as these certifications can be prohibitively expensive and do not necessarily add value to the project. However these certification programs can be used as guidance in evaluating certain design elements that may be good candidates for inclusion in the projects based on site-specific constraints and attributes.

Initiative #29: Revise City of Tulsa Codes to Encourage Adoption of Electric and Compressed Natural Gas Vehicles

Issue

According to the 2011 State of the Air Report issued by the American Lung Association, Tulsa received a grade of "F" for high ozone days, indicative of very poor air quality that threatens the health of Tulsa's citizens. The City of Tulsa is poised to assume a leadership position with regards to alternative fuel vehicles in the region and in the country. Widespread adoption of alternative fuel vehicles would help alleviate this air quality problem and would also contribute to the growth of alternative fuel vehicle businesses locally which would result in the creation of new jobs.

Recommendation

The City of Tulsa should amend its residential building codes to require all new single-family homes to be designed in such as a way as to facilitate the installation of residential electric vehicle battery charging and compressed natural gas refueling stations. Since it is much less expensive to install this type of infrastructure during initial design and construction, this change to the Code would significantly reduce retrofitting costs for homeowners as EVs and CNG vehicles gain wider adoption.

Electric Vehicle (EV) Charging Stations

Most plug-in EVs can be easily charged overnight via a receptacle supplied by a dedicated 120V 20 Amp circuit, which will provide an average of 5-8 miles of driving range per hour of charging. Some full performance EVs, with larger battery capacity and range, take longer to receive a full charge from the same circuit. Homeowners with these vehicles wanting to increase the recharge capacity and speed can opt for a 240V 40 Amp power supply that allows for a full charge in about 3 hours at a higher upfront cost. Under the amended Code language recommended in this Plan, new single-family residential construction would need to be equipped with the proper receptacles to facilitate EV charging. This can be accomplished by amending Title 52, City of Tulsa Electrical Code. Below is sample language that could be used to amend the Code:

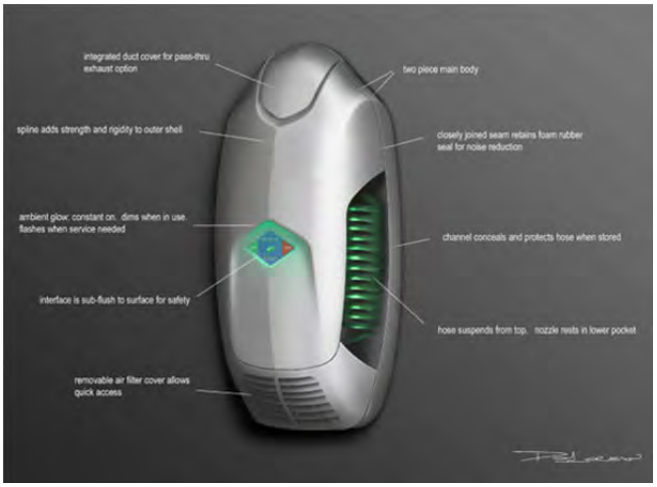
"210.52.5 Receptacles for electric vehicle charging systems-Added. At least one 120V 20 Amp and one 240V 40 Amp receptacle shall be provided for each car space in a garage or carport serving single-family residential occupancies for use with an electric vehicle charging system in accordance with Article 625."

The International Electrical Code contains requirements for the installation of EV charging equipment in Article 625 that is already part of the City of Tulsa's residential building code.

Compressed Natural Gas Vehicle Refueling Infrastructure

A natural gas vehicle (NGV) is a car, truck, van, bus or other vehicle that runs on compressed natural gas (CNG). Natural gas is compressed so that it can be stored in secure aluminum, fiberglass, steel or carbon-fiber cylinders within the vehicle. NGVs work like traditional vehicles, burning a gaseous blend of fuel and air in an engine. However, natural gas vehicles run cleaner, as the more efficient natural gas does not require the conversion of liquid fuel. More information on the benefits of NGVs can be found in Section 4: Sustainable Fleet.

NGVs can be charged overnight in residential homes equipped with natural gas connections and proper CNG refueling infrastructure. Under the amended Code language recommended in this Plan, new single-family residential construction would need to be equipped with the proper natural gas infrastructure to facilitate the installation of CNG refueling infrastructure. This can be accomplished by amending Title 52, City of Tulsa Electrical Code. Below is sample language that could be used to amend the Code:



Home NGV Refueling Station
Source: www.natgascar.com

"404.13.1 Location of outlets for Compressed Natural Gas Vehicle Refueling Infrastructure-Added. At least one natural gas outlet, installed in accordance with the requirements contained in Section 413 of the ICC International Fuel Gas Code, 2006 Edition, shall be provided for each car space in a garage or carport serving single-family residential occupancies for use with a compressed natural gas refueling system."

Key Performance Indicator

Consideration of Code amendments and adoption of new residential building code amendments in the appropriate sections.

Target

Code amendments related to this Initiative considered and adopted by Tulsa City Council by end of FY2012.

Water Management

Protect and Preserve for Future Generations

Water is a fundamental component of our lives, both from a health and a quality of life perspective. The City of Tulsa has enjoyed a natural abundance of water throughout its recent history and has a strong history of maintaining a robust program for managing water resources. The long-term water sustainability goals for the City are to protect and preserve water quality and quantity for future generations and to provide cost-effective water resources to Tulsa's growing population. The water management plan is broken down by function (i.e., drinking water, wastewater, and stormwater), with an additional section for the drinking water portion for conservation, which affects all aspects of water management functions.

Water Management Sustainable Solutions

- **Drinking Water.** Create cost savings by improving energy and water efficiencies of water treatment plants and their distribution systems. Encourage water conservation to delay capital costs of expansion. Continue investigating potential projects that would reduce the phosphorus load below the Beaty Creek and Spavinaw Creek confluence and above Lake Eucha.
- **Wastewater Treatment.** Create cost savings by reducing energy consumption at wastewater treatment plants and their collection systems.

30%

Average percentage of Tulsa's electricity bill spent on drinking water treatment

(FY2010)

- **Stormwater/Low Impact Development.** Establish pilot programs, incentives, and eliminate barriers to mitigate stormwater runoff and improve water quality. Incorporate innovative rain capture and other low impact systems in City developments.
- **Conservation.** Encourage water conservation by restructuring water rates and through public education. Set a City of Tulsa goal for water reduction. Recognize local businesses for water and other sustainability successes.

Existing Water Management Programs

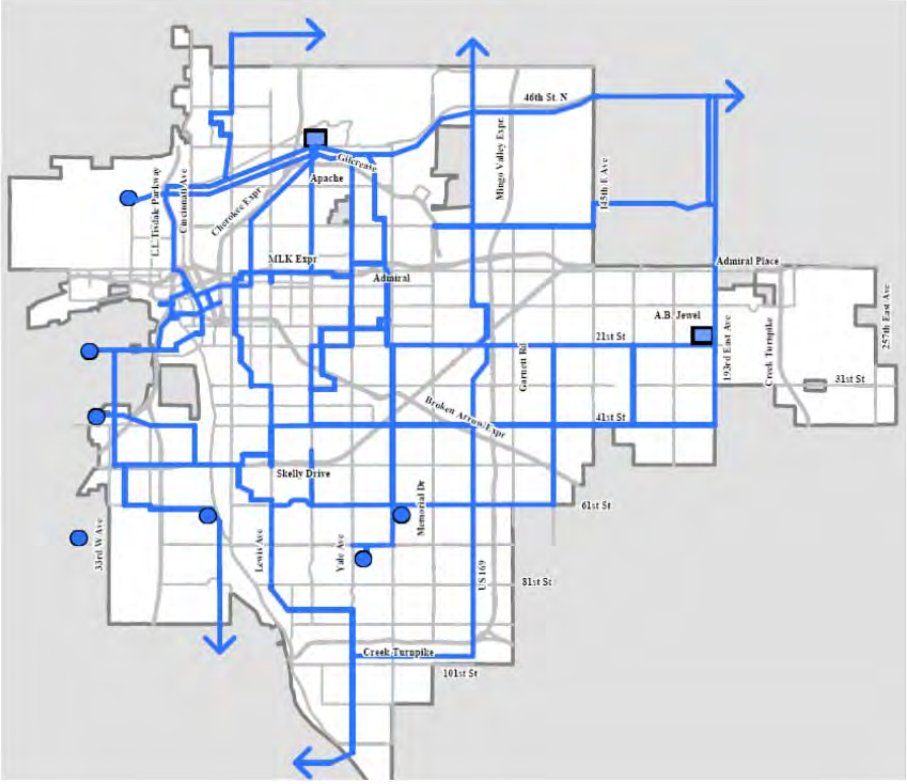
The Tulsa Metropolitan Utility Authority (TMUA) is responsible for managing, constructing, and maintaining Tulsa's water works and sanitary sewer systems, and for setting rates for water and sewer services rendered within its boundaries. In 1990, the City Public Works Department was formed. It was restructured in 2011 to include the following departmental programs: Engineering Department, Water & Sewer Department, and the Streets & Stormwater Department. Although much of the water management services are provided by entities within the City of Tulsa, partnerships exist between the City, U.S. Geological Survey (USGS), the Oklahoma Conservation Commission, the Oklahoma Water Resources Board (OWRB), U.S. Army Corps of Engineers, academia, and other stakeholders with regards to source water quality and availability.

Drinking Water

Existing Drinking Water Programs

The City operates two water treatment plants, the Mohawk Water Treatment Plant and the A. B. Jewell Water Treatment Plant. The total design capacity is 220 million gallons per day (MGD), providing drinking water to more than 145,000 metered accounts in the City and more than 500,000 people in the metropolitan area. The average daily pumpage is 101 MGD. The water distribution system as seen in Exhibit 11 consists of 2,237 miles of underground water lines, thousands of valves, 15,927 hydrants, 12 pump stations, and 12 treated water storage reservoirs in the Tulsa city limits.

Exhibit 11: Tulsa Water Treatment and Distribution System Map



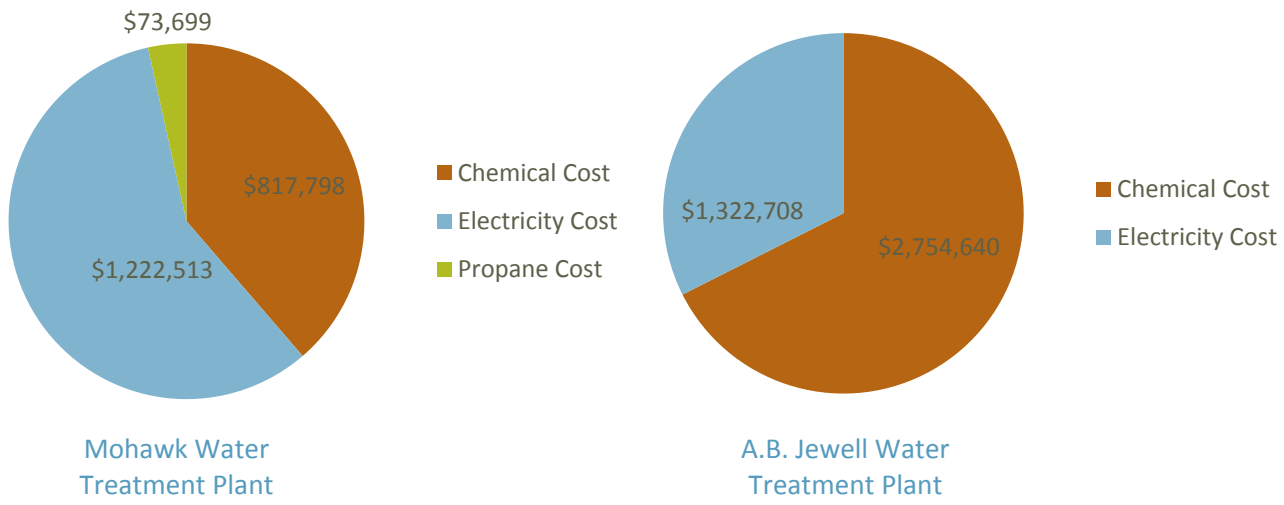
Elements of the City's drinking water programs are outlined in the *2008 City of Tulsa Strategic Plan for the Public Works Department,* the TMUA *Water 2012 Capital Improvement Plan*, the TMUA *Water Capital Improvement Plan – 15 Year,* and the TMUA *Comprehensive Water System Study Report (2001) and the 2005 Comprehensive Water System Study Addendum*. The City's *Watershed Restoration Action Strategy (WRAS) for the Eucha/Spavinaw Watershed* and the OWRB's *2012 Oklahoma Comprehensive Water Plan* provide valuable insight into Tulsa's source water quality and water availability. A TMUA comprehensive assessment of Tulsa's water and wastewater system is underway with the goal of making recommendations that could include improvements to management operations, strengthening of financial position, and a strategic alternative.

Drinking Water Treatment Baseline Data

The first step in designing a comprehensive approach to water management is to gain a full understanding of how much water is being used, who is using it, how it is being used, and how much it costs. This baseline assessment of the City of Tulsa's water use also serves as a basis for comparison against which future water reductions will be measured.

In fiscal year 2010, approximately 30% of the City's electricity bill was allocated to drinking water treatment. In fiscal year 2009, the average combined cost of electricity, chemicals, and propane used to provide 1,000,000 gallons of treated drinking water was $161.20.[4] On average, the expense associated with treating the drinking water was 53% chemical costs and 47% energy costs.[5] The majority of energy use in the drinking water process (see Exhibit 12) is associated with pumping the 39 billion gallons of water through the treatment process and distribution system annually.[6] In general, energy use is affected by water source, water quality, storage, elevation, distance, age, and process.[7]

Exhibit 12: FY 2010 Total Drinking Water Treatment Costs



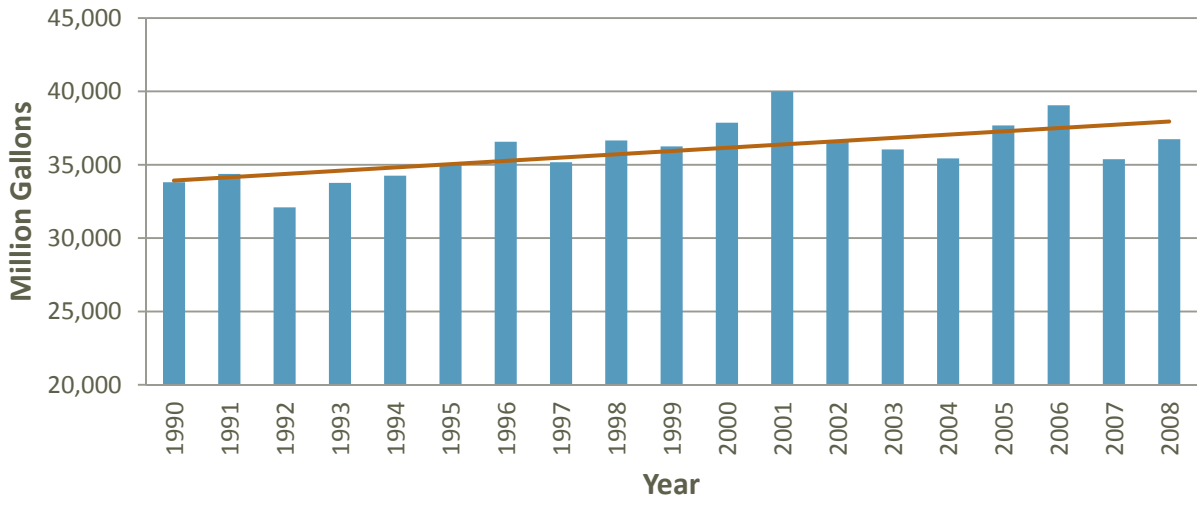
From 1990 to 2008, the annual average volume of delivered water was 36 billion gallons per year as shown on Exhibit 13. On average, the annual delivered volume increased at a rate of 224 million gallons per year. As indicated in the 2001 Tulsa Comprehensive Water Study, the population of the City of Tulsa is expected to increase to 436,000 persons by the year 2020. At current population densities, this number of people would occupy all developable land within the present City limits.

[4] Based on electricity usage, chemical costs, and propane usage. This figure does not include taste and odor costs.
[5] Does not include personnel cost.
[6] 38,966 million gallons of pumpage for FY2010.
[7] U.S. EPA, Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, January 2008. http://www.epa.gov/owm/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf

Population projections were updated in 2005 based on the 2000 census data and current growth rates. Water projections will be updated as part of the comprehensive study currently underway using the 2010 census data.

Growth outside of the city limits, within the Tulsa Metropolitan Statistical Area (MSA), is expected to increase from the present level of 786,000 to approximately 1 million people by 2050. If the area experiences high growth rates similar to those seen from 1950 to 1980, this number could reach as high as 1.5 million persons. Total water needs, including wholesale customers, raw water, and an allowance for unbilled water, are projected to increase from the current usage of approximately 108 MGD (average daily demand) to between 123 MGD and 238 MGD, depending upon the actual level of population growth, service area boundaries, and the demand characteristics of the users.

Exhibit 13: Annual Delivered Water (In Millions of Gallons)



Drinking Water Sustainability Goals

The key strategic priorities for the City's drinking water programs include improving and maintaining existing infrastructure while increasing the capacity for managed expansion and planned growth.

By leveraging existing City strategies and harnessing innovative ideas from City employees and URS national practice leaders, the following list of recommended initiatives was created as part of the Sustainability Workshop held on June 29-30 in the City of Tulsa offices. Of several ideas that were introduced before the Water Management Committee, the initiatives detailed in this section were considered to be the highest priority with the greatest opportunity for cost savings associated with them. This list is not intended to be comprehensive. As new ideas emerge and are cycled through the Energy and Water Management Program described previously, this list should continue to grow. See Appendix 1 for a full list of Sustainability Initiatives associated with all of the Plan's different sections.

As demonstrated in Exhibit 14, the costs associated with the water treatment plants are primarily energy- and chemical-related. Short-term initiatives are associated with identifying incremental energy savings. On a long-term timeline, the leak detect/repair program could be expanded to reduce the amount of uncollected revenue due to unaccounted for water.

Initiative #1: Establish Best Management Practices and Training for Energy Usage at Water Treatment Plants and Distribution System

Issue

City does not have Best Management Practices (BMP) guidance in place for energy or water conservation at water treatment plants.

Recommendation

Establish BMP and training for energy usage at water treatment plants.

A formalized BMP should be developed for the water treatment plants that explores and evaluates operational energy savings practices at the facility. This BMP could be built upon the results of the water facility energy audit conducted by URS and expanded into a training program for maintenance staff.

Key Performance Indicator

Completion of the BMP and training program.

Target

BMP and training program developed within six months of the URS energy audit.

Initiative #2: Evaluate Water Treatment Chemical Pricing and Contracts

Issue

As part of the water treatment process, millions of dollars are spent annually on chemical costs. As shown in Exhibit 16, over the last five years, the average amount of money spent on chemicals such as chlorine, caustic soda, fluoride, aluminum chlorhydrate, and granular activated carbon was $3.38M. These chemicals are required as part of the treatment process, and although the quantity of chemicals purchased cannot easily be decreased, the purchasing process for the chemicals should continually be refined.

As part of the procurement process, any water and wastewater treatment chemical purchase over $25,000 per year undergoes a sealed bid process, and any chemical purchase over $100,000 per year is placed under a formal contract. The chemical bid requests currently provides the bidder the option of basing the annual price increase on either the U.S. Bureau of Labor Statistic's Consumer Price Index for All Urban Consumers (CPI-U)[8] or a fixed percentage provided by the bidder. One issue identified by the Tulsa Purchasing Division is that, due to pricing volatility, chemical suppliers are hesitant to renew contracts and or to even initially bid on the contract. The Purchasing Division has noted that the CPI index is too broad a pricing index for chemical purchasing.

Recommendation

Identify and incorporate a more specific chemical pricing index into City bids for water and wastewater chemicals to encourage more participation in the bid process.

Key Performance Indicator

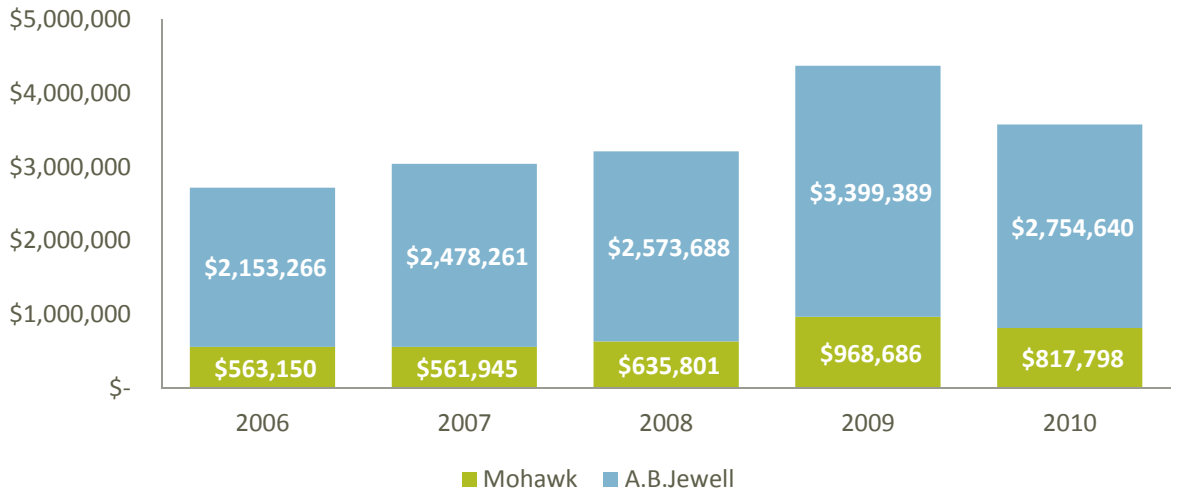
Identification of a relevant pricing index and incorporation into procurement process.

Target

Specific chemical pricing index for water and wastewater chemicals in place by December 2011.

[8] http://www.bls.gov/news.release/cpi.t01.htm

Exhibit 14: Annual Water Treatment Chemical Costs



Initiative #3: Evaluate Granular Activated Carbon Regeneration Options

Issue

Evaluate granular activated carbon regeneration options. Granular activated carbon (GAC) is a component of the filter process at the water treatment plants. Each treatment plant has 12 GAC filters, and the GAC has to be changed out every three years to be regenerated. There is no on-site regeneration capability, so the GAC has to be removed from the filters and shipped to an off-site regenerator for processing. Currently, approximately $500,000 is spent annually to regenerate the GAC at the Tulsa water treatment facilities.

Recommendation

Investigate alternate GAC regeneration providers and pursue contracts through the competitive bid process. An alternate GAC regeneration provider (Calgon) has indicated a 16% savings in the cost of carbon regeneration. If it is demonstrated that the alternate provider can supply the same or better quality GAC as the current provider, place the GAC regeneration out for bid. The current GAC provider's contract expired on 07/19/2011.

Recommendation

Conduct a feasibility study to investigate whether on-site carbon regeneration is a viable option. Many water and wastewater facilities in the US use an on-site activated carbon regeneration system. A technical and cost-associated feasibility study could be conducted to determine if on-site GAC regeneration is a practical option for the City. Another option would be to pool bids for GAC between the different plants to minimize unit costs.

Initiative #4: Evaluate Expansion and Enhancement of Leak Detect/Repair Program

Issue

The City of Tulsa water distribution system experiences an approximate 9-12% annual leak rate.[9] Although this leak rate is within industry standards, it does represent an average of 10-12 MGD of unaccounted-for water. The City defines unaccounted water as the percentage of water produced that cannot be attributed to water sales, fire protection, or known leaks and breaks. In terms of the marginal cost of water production (i.e., costs of chemicals and energy), the average lost revenue for the unaccounted water is $0.16/1,000 gallons; this represents a total of $1,700 per day, or $624,000 per year of uncollected revenue.

Realistically, it is impossible to eliminate all water losses along the water distribution system, as even the best systems have losses. Since 2002, the City of Tulsa has spent over $71,000,000 for water line replacement and relocation. The City of Tulsa currently has a leak detection program that consists of two crews that assist with locating leaks and breaks as well as systematically scanning portions of the city's distribution system to locate non-surfacing leaks. Although it is not possible at this time to quantify the potential water recovered by using the leak detect and repair program, some data is available. During FY 2010,
69 atlas pages representing 34.5 square miles were surveyed; 268 leaks and 117 leaking fire hydrants were located. The City also has 500 acoustic data loggers installed in the distribution system. These data loggers, which are located in the area in and around downtown, identified 189 leaks between July 2010 and December 2010.

Recommendation

Evaluate expanding the data logger program. Data loggers are relatively easy to install on main line valves. The program would target the older areas of the City's distribution system. Loggers could be installed in an area and monitored during nighttime hours. Once leaks in a particular area were identified and corrected, the data loggers would be relocated to a new area. If the water losses could be reduced by 2% on average, Tulsa would be able to recover approximately $118,850 per year in uncollected revenue. Based on a rough estimate of a 2% leak reduction,
2 MGD could be recovered, which is equivalent to the demand from approximately 5,770 single-family housing units per year.

Key Performance Indicator

Results of cost-benefit analysis on leak repair program. The City currently experiences a 9-12% loss along the water lines. Although the City maintains data on the number of leaks detected in the program, it would be beneficial to follow up with the leak repair team to quantify the amount of water recovered by identifying and repairing those leaks. Once the amount of recovered water is quantified, a cost-benefit analysis should be conducted to determine the extent to which leak detect/repair program should be expanded and whether the installation of the additional 500 data loggers is a cost-effective investment.

Target

Completion of program cost-benefit analysis by end of FY 2012.

[9] Average from 2005-2010.

Initiative #5: Set a Goal for Reduction in City Water Use and Track Progress toward Goal

Issue

The City does not currently have a goal for reducing water use for municipal operations, and it does not have a way to track progress toward a water use reduction goal. A key component of protecting Tulsa's water for future generations is conservation. Although the City of Tulsa has advocated water conservation, the Water Management Team of the Sustainability Program has identified opportunities for the City to boost its message of conservation and lead by example. The primary benefit of conservation is to delay or defray costs of water resource expansions (i.e., building a new drinking water or wastewater plant, securing new sources of drinking water, etc.). Other water conservation benefits include:[10,11]

- Lower energy and chemical costs associated with water treatment.
- Fewer sewage system failures caused by water overwhelming the system.
- Natural pollution filters such as downstream wetlands.
- Reduced water contamination caused by polluted runoff from over-irrigating yards and agricultural lands.
- Reduced need to construct additional dams and reservoirs or otherwise regulate the natural flow of streams, thus preserving their free flow and retaining the value of stream and river systems as wildlife habitats and recreational areas.
- Fixed water supplies used more effectively.
- Known, stable water availability that attracts businesses and new residents.

The City of Tulsa developed a Water Conservation Plan in 2008 that focused on balancing future demand with future water supply; managing water usage or demand; providing for sufficient revenue for development, operation, and maintenance of the water system; reducing water loss; enhancing community involvement and participation; and establishing a rate structure that supports water conservation. It is unclear which initiatives have been enacted since that report was released, but using those conservation recommendations as a starting point, the following section describes a process the City can undertake to develop an integrated and comprehensive water management conservation program.

[10] U.S. EPA WaterSense, http://www.epa.gov/watersense/water_efficiency/environmental_benefits.html.
[11] Kohler Company, Green Tulsa! 2009, "Green Living: Water H2O Making the Most of a Precious Resource."

Two primary ways of encouraging water conservation are through behavior modification and more efficient water equipment and water system design (i.e., low flush toilets). Additional details for the following programs are included in Appendix 1:

- Using pilot water conservation incentive programs
- Re-structuring water rates to promote conservation
- Providing more water usage data to consumers.

Recommendation

The City should set a water use reduction goal and develop metrics for tracking progress toward that goal. At various times during the City's recent history, water reduction targets have been set, but results have not been realized. For example, in 2009, the Energy Conservation & Sustainability Team sought to reduce baseline water use by 10% for City-owned/operated facilities and associated equipment in the establishment of its Operational Plan. Without a way to track progress toward the goal and without a formal group tasked with implementing steps toward the goal, the establishment of a 10% target did not generate results. When it comes to water conservation, there is a lack of available City operational data on water consumption and benchmarking. A significant effort must be undertaken to bring water conservation and usage to the level of that enjoyed by the energy management components of the Sustainability Plan. As a WaterSense Partner, the City has access to a wealth of related resources.

Key Performance Indicator

Water use reduction goal based on analysis of City water consumption data.

Target

Goal and progress tracking system in place by end of FY 2012.

Initiative #6: Collect and Organize Water Data

Issue

The City of Tulsa has no central water data management system. The City of Tulsa does not currently have a system in place for conducting detailed analysis of what it spends on water and water treatment. The data is available but is not readily accessible and is not being benchmarked or monitored for identification of potential cost savings opportunities.

Recommendation

Consolidate water data and make it widely available to City departments. Since accurate and reliable water data is a crucial component of a water management program, the City of Tulsa should establish a water data management system that collects and organizes water data in a format that is readily available and easily accessible to the ECST and other City departments. In addition to the recommendations in the Energy Management Section, the following list contains the water data sets that the City of Tulsa should collect:

- Annual chemical purchases – to track trends in chemical purchasing and to evaluate alternative chemicals if needed.
- Water pumpage data (in million gallons) – to track monthly water usage trends.
- Individual pump electrical usage – since the electricity cost is such a large contributor to overall water treatment costs, individual pump electricity usage along with water pumpage data will provide a foundation for identifying potential pump upgrades and replacements.
- Large customer meter accounts – Similar to the energy management portion of the Plan, it would be invaluable to first identify which City owned/operated facilities consume the most water. By having this data available, baseline data would be available to benchmark water consumption and identify facilities that may have higher than normal water losses.
- TMUA maintains cost-of-service rate models for both the water and wastewater systems. Through the rate models, TMUA tracks cost of various components of each system, including water supply, treatment, and distribution for the water system; collection and treatment for wastewater; and debt, return on investment, and depreciation for both. This information will be valuable for ongoing analysis by the ECST.

Key Performance Indicator

Percentage of City's water consumption data readily available for review and analysis.

Target

100% of City's water consumption and water treatment cost data in Hara EEM and/or other readily accessible databases by December 2011.

Initiative #7: Collect City Facility Water Usage Data and Conduct Benchmarking

Issue

No information on water costs and City-owned facility water usage is readily available. The City of Tulsa does not currently have a system in place for conducting a detailed analysis of what it spends on water in City-owned/operated facilities.

Recommendation

Collect City-owned facility water usage data and conduct benchmarking. In addition to the energy audit discussed in the Energy Management section, water audits should be conducted for key City-owned facilities to benchmark City facilities using intensity metrics. These metrics could include total water usage, water usage per person, water usage per square footage, etc. This comparison will indicate which facilities or processes use the most water relative to similar City-owned facilities. Data should be uploaded into Hara EEM or other suitable database.

Key Performance Indicator

Identification of top 10 biggest consumers of water at City facilities and processes.

Target

Top 10 List compiled using results of benchmarking by December 31, 2011.

Initiative #8: Perform Water Audits of Top 10 Biggest Water Users

Issue

The City does not have a systematic approach to finding water conservation opportunities in its facilities.

Recommendation

Use the results of the benchmarking exercise in Initiative #4 and target the top 10 water consuming facilities/processes for water audits by ECST members. The City should prioritize the replacement of water fixtures and any other recommendations discussed in water conservation audits at City facilities and implement the following recommendations to modify behavior:

- Post water conservation signage in City facilities
- Pilot conservation Incentive Program for City facilities
- Continue participation in local and national committees to better disseminate water conservation messages to City personnel

The City currently partners with the entities shown in Exhibit 15.

Exhibit 15: City of Tulsa Local and National Committee Partners

Water Associations	Outside Agencies	Outside Non-Profits and Others
National Association of Clean Water Agencies - NACWA	Environmental Protection Agency - EPA	Green Building Strategy Team, GBST - loosely affiliated with Sustainable Tulsa
American Public Works Association, APWA - branch, state, and national level	Oklahoma Department of Environmental Quality - ODEQ	American Institute of Architects Committee on the Environment, AIA COTE
Water Environment Federation, WEF	Oklahoma Conservation Commission - OCC	Tulsa Partners (Millennium Center Project & Green Building Resource Library
Oklahoma Water Environment Association, OWEA - state chapter of WEF	Indian Nations Council of Government - INCOG	Sustainable Tulsa
Oklahoma Municipal League, OML	Tulsa County Conservation District - TCCD	Sustainable Green Country
American Water Works Association, AWWA	Metropolitan Environmental Trust - M.e.t.	TCC Green Jobs Team
AWWA Southwest Section	United States Geological Survey Society, USGS	Oklahoma Sustainability Network, OSN
Water Environment Research Federation, WERF	US Army Corps of Engineers, USACE	Environmental Education Committee, EEC
Water Research Foundation, WaterRF	Oklahoma Water Resources Board, OWRB	
Oklahoma Floodplain Managers Association, OFMA		
Green Country Stormwater Alliance, GCSA		
EPA WaterSense Partner		
EPA Energy Star Partner		
EPA WasteWise Partner		
National Association of Lake Managers, NALMS		
Oklahoma State Pretreatment Coordinators		
Oklahoma Clean Lakes & Watersheds Association, OCLWA		
Association of Metropolitan Water Agencies		

Key Performance Indicator **Number of water audits conducted at top 10 water consuming facilities.**

Target **Five water audits conducted by end of FY 2012.**

Initiative #9: Recognize Local Businesses for Water/Energy Conservation Efforts

Issue

Although the City's new Sustainability Plan is focusing on internal processes and looking for ways to conserve resources, thereby saving taxpayer dollars, it is important to promote these same conservation efforts in the community. On average, Tulsans consume 102 gallons of water per day, which is approximately the same level as the national average.

Recommendation

Expand City's PACE (Partners for A Clean Environment) Program to recognize local businesses and civic organizations that are making an impact on energy or water conservation. The purpose of this initiative is to develop a program that provides assistance and/or recognition to area businesses, community groups, and individuals who adopt and implement BMPs to conserve water and energy, and reduce or eliminate environmental problems in Tulsa, with the potential for expansion to include other resource conservation areas and BMP development.

PACE – Partners for A Clean Environment, recognizes businesses that go above and beyond environmental regulations by following voluntary pollution prevention BMPs. The program's goal is to reduce the use of hazardous materials and the amount of waste from business, government, and household activities that pollute Tulsa's water, land, and air. Participating businesses associated with certain traditionally high polluting industries receive recognition for the steps they take in the course of their daily operations that demonstrate a concern for the environment and a willingness to participate in a voluntary BMP program. Recognition under this program provides information that consumers can use when deciding on companies with which they want to do business. PACE provides free pollution prevention training, public outreach, and technical assistance to its participants.

The City's PACE program began in 2002, and was based on the City of Boulder's program. Members of the Environmental Education Committee (EEC) organized PACE as a way to encourage environmental responsibility in citizens, civic groups, and businesses. These entities could sign a pledge promising to maintain an industry-specific standard of environmental stewardship and receive recognition certificates and PR materials. Currently, PACE is used as an incentive/recognition program for businesses who, in lieu of a costly and time consuming wastewater discharge permit, implement pollution prevention BMPs. These businesses are recognized with certificates and are listed on the City of Tulsa's website as program participants. Inspections are conducted every two to three years to make sure participating facilities are still following BMPs. During inspections, BMPs still being implemented are noted and education occurs regarding new or updated BMPs that could be implemented.

A PACE-like program should be expanded to reach citizens, civic groups, and businesses that practice water conservation and pollution prevention/environmental stewardship practices; i.e., solid waste reduction and reduced energy consumption. Many community groups, as well as departments and divisions within the City, could benefit from such a program, and it would provide opportunities for increased environmental education.

The water conservation program outlined in this initiative description should be administered by the existing Environmental Education Committee made up of employees from the City Water, Sewer, Streets, and Stormwater Departments and other environmental/resource conservation oriented

groups. These groups include Indian Nations Council of Governments (INCOG), Tulsa County, Oxley Nature Center, Tulsa Zoo, Tulsa County Conservation District, Tulsa Master Recyclers, OSU-Tulsa, the Metropolitan Environmental Trust and others. The EEC is currently focused on sharing important education and outreach information from their respective groups, collaborating on projects, sharing resources in their education and outreach efforts, and maintaining a community-wide calendar of local environmental and conservation events. The EEC currently meets the second Tuesday of each month.

The expertise and interest exists in the EEC to oversee a PACE-based, community-wide water conservation and water quality program developed under the City's Sustainability Plan. In fact several EEC members have been involved with the existing PACE program since its inception, and have expressed interest in reviving and expanding the program. Therefore, the recommendation is to develop a new community water conservation and water quality recognition and education program based on the existing PACE model. Once this program is established, it can be expanded and/or replicated to include issues addressed in the original PACE program, as well as other environmental and resource issues.

Objectives of the program include:

- Coordinate public outreach programs, using the EPA WaterSense partnership materials to inform local businesses of the need to conserve water and improve urban water quality, the potential for cost savings, positive effects on the environment, and the benefits of being a PACE member including increased patronage from conservation-minded customers.
- Make citizens and businesses more aware of the impacts of water conservation.
- Encourage participants to develop and follow water conservation best management practices.
- Have participants continually refine water conservation BMPs and adoption will expand within the community.
- Recognize entities that adopt and follow water conservation BMPs.
- Develop and enhance partnerships with other government agencies and non-government organizations.
- Connect the various environmental efforts to produce a synergistic effect.
- Expand this model to include other environmental, pollution, and resource topics.

Potential Actions:

- Monthly PACE Public Outreach Committee meetings tied into the existing Environmental Education Committee
- Participant training to develop conservation culture within their company or group
- Participant recognition on the COT website sustainability page and on water bill inserts
- Information on total water saved and associated cost savings updated regularly and distributed though water bill inserts and on the website
- Involvement of TMUA
- Education and training provided on development of BMPs and how/why they should be adopted

- Regular reviews of participant conservation practices conducted to make sure BMPs are still being followed, PACE water conservation goals are being met, and water conservation continues to be a priority
- Benchmarking of participant facilities against industry peers and provide annual special recognition for peak performers
- An annual report defining BMPs and use for annual reporting to WaterSense partner program
- A website or other vehicle for networking of PACE participants so they can share BMPs and experiences, and provide help and support for new participants or those considering participation
- Communication tool for stakeholders
- All forms, guidance, schedules and agendas, etc. for PACE program
- Development and presentation of PACE workshops to potential participants

Key Performance Indicator

Recognition program established and first group of local businesses recognized for their water/energy conservation efforts.

Target

Program established and three local businesses recognized by end of FY 2013.

Source Water

Source Water Background Information

The primary surface sources of drinking water for the City of Tulsa are Lakes Oologah, Spavinaw, and Eucha. Lake Hudson is designated as an emergency water supply for the City. Spavinaw Lake and Lake Eucha are located in the Eucha/Spavinaw Watershed and Lake Oologah is located in the Verdegris River Watershed. Approximately 60% of the water demand for both basins is industrial/municipal, with livestock and thermoelectric power comprising the remainder.

Verdigris River Basin (Oologah Watershed)

Watershed Description: The drainage area above Oologah Dam is elliptical in shape, covers 4,339 square miles and is approximately 100 miles long and 45 miles wide. Of the total drainage area above Oologah Dam, approximately 77 percent (3,354 square miles) occurs in Kansas while the remaining 23 percent (985 square miles) resides in Oklahoma.

Eucha/Spavinaw Watershed

Watershed Description: The 389-square mile Eucha/Spavinaw Watershed straddles Oklahoma and Arkansas in the Ozark Highlands and Central Plains ecoregions of the Ozark Plateau. The watershed drains to Lake Eucha, a reservoir of 2,880 surface acres that lies immediately upstream from Lake Spavinaw (1,638 surface acres). Spavinaw Creek and Beaty Creek are the two primary tributaries to Lake Eucha (Brush Creek, Dry Creek and Rattlesnake Creek are the other tributaries). Spavinaw Creek drains approximately 56 percent of the Lake Eucha watershed basin, while Beaty Creek drains most of the rest. The upstream areas of Spavinaw Creek and Beaty Creek are located in Arkansas.

From 1996 to 2009, Spavinaw Lake experienced a highly significant upward trend (alpha </= 0.05) in total phosphorus concentrations (mg/L).[12] Excess nitrogen and phosphorus lead to significant water quality problems, including eutrophication, harmful algal blooms, hypoxia, and declines in wildlife and its habitat. Increases in total phosphorus can lead to excessive growth of algae, which can increase taste and odor problems in drinking water as well as increased costs for treatment. Both Spavinaw Lake and Lake Eucha are included on Oklahoma's Clean Water Act 303(d) list as impaired by phosphorus, chlorophyll-a, and low dissolved oxygen (2010 draft listing).

Source Water Management Measures

In the 1990s, Tulsa developed a holistic approach to ensuring sustainable source water protection. Since 1992, over 100 intensive studies and programs have been completed to address nutrient-related water quality problems in Tulsa's source watersheds by quantifying nutrient loadings (e.g., State-developed TMDLs, USGS studies, etc.), assessing impacts on water quality and algae production, and developing and implementing nutrient reduction strategies identified in source water protection plans. Also, outcomes of a source water lawsuit, which include (1) appointment of a "Special Master" to implement the settlement agreement; (2) hiring and training four watershed management team members; (3) development of a Phosphorus Index by a major university resulting in adoption by U.S. Department of Agriculture – Natural Resources Conservation Service (USDA –NRCS); (4) creation of a non-profit organization to identify potential assistance and solutions; and (5) limitations and compliance schedule for a municipal wastewater treatment plant; and development of a Nutrient Management Plan resulted in significant phosphorus reduction.

[12] 2012 Update of the Oklahoma Comprehensive Water Plan – Middle Arkansas Watershed Planning Region, Draft Report July 15, 2011.

The City of Tulsa developed and wrote:

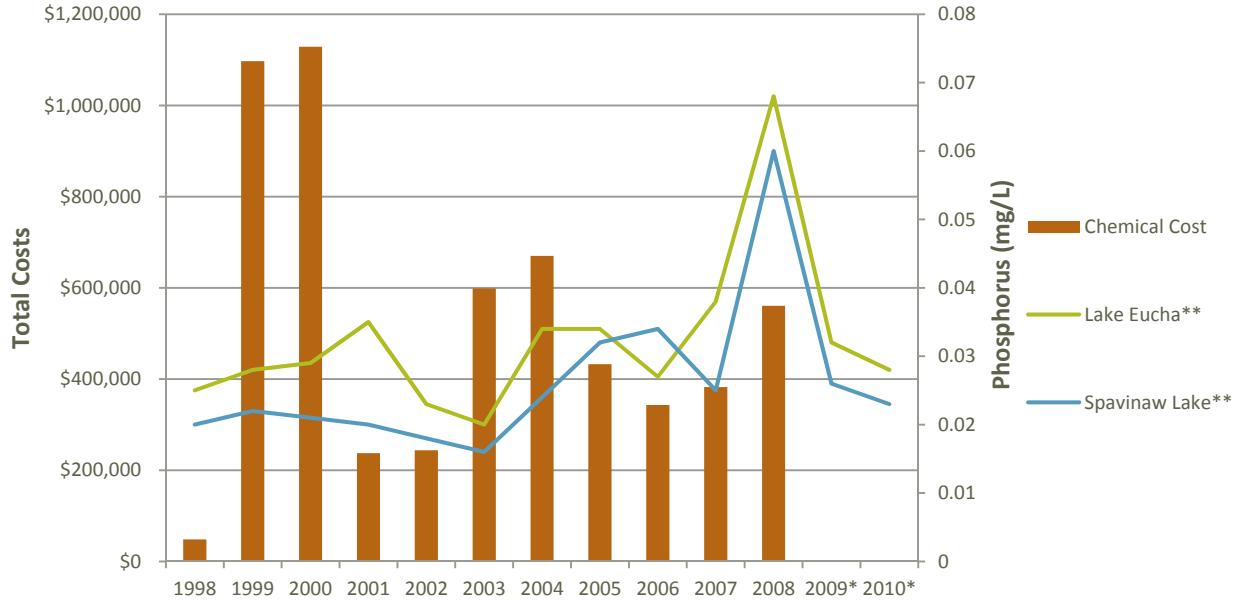
- The State's first Watershed Restoration Action Strategies (WRAS), which became a template for other watershed WRASs in Oklahoma
- The State's first and only lake phosphorus criteria (includes Lake Eucha and Spavinaw Lake),
- Dissolved Oxygen Criteria for Reservoirs and the Associated Use Support Assessment Protocol adopted by the State of Oklahoma on May 31, 2011.

The City of Tulsa and USGS have an ongoing intensive lake and stream monitoring program in the Eucha/Spavinaw watershed (18 monitoring sites), collecting weekly, monthly, and storm-event water quality data and continuous hydrologic data. The USGS continues to measure nutrient loads and yields in the watershed. The Oklahoma Conservation Commission also continues to monitor the effectiveness of the BMP installations. The City of Tulsa is collaborating with universities, agencies, and organizations on phosphorus reduction projects and programs (e.g., wetland projects, conservation easements along lake tributaries, etc.).

Taste and Odor Control

As previously discussed, over 100 studies and programs have been completed to address phosphorus water quality problems. From 1999 to 2008, The City spent approximately $5,700,000 on the chemical treatment of source water specifically for phosphorus-related taste and odor problems. Exhibit 16 illustrates water treatment costs at the Mohawk Water Treatment Plant (not including the costs associated with studies and programs) and the whole-lake phosphorus concentrations of Lake Eucha and Spavinaw Lake. In addition to the existing studies conducted by the City of Tulsa, other State Agencies, academia, and public-interest groups, this Plan identifies two areas of interest which may help to further mitigate the effects of phosphorus in the source water: (1) passive phosphorus reduction projects near the mouth of Lake Eucha, and (2) conservation easements in the riparian areas of Lake Eucha tributaries.

Exhibit 16: Annual Taste and Odor Chemical Expenses at Mohawk Water Treatment Plant



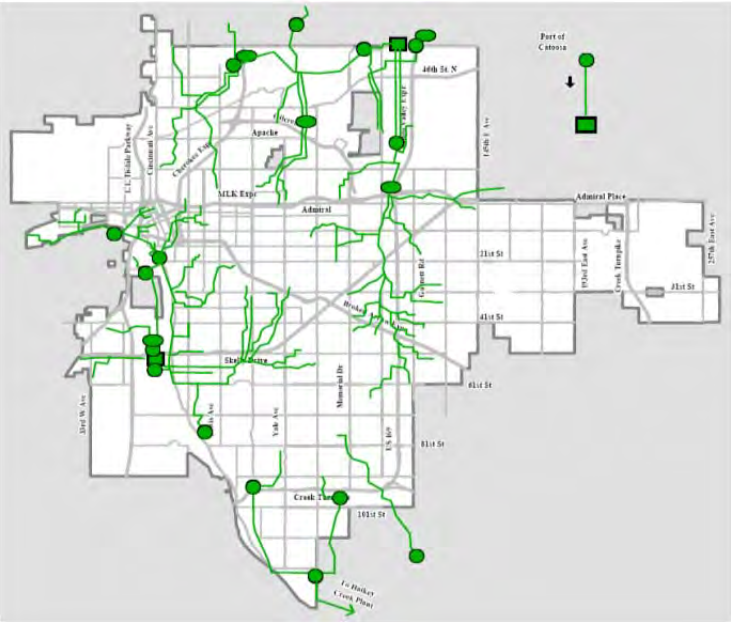
*Chemical cost data unavailable
**Whole lake volume-based area-weighted average total phosphorus concentrations

Wastewater

Existing Wastewater Programs

The City of Tulsa operates four wastewater treatment facilities – Northside, Southside, Lower Bird Creek, and Haikey Creek – with a total rated capacity of 102.6 MGD (currently permitted at 96.8 MGD). In May 2008, the City of Tulsa Water Pollution Control and EMA Inc. entered into a collaborative project to develop a Strategic Asset Management (SAM) plan for equipment assets at the wastewater facilities. The purpose of this program is to manage facility assets and provide documentation to justify replacement of assets, and to assist in long-range budget planning. The SAM was last updated in 2011. The last comprehensive wastewater system study was conducted in 2001, during which a study of collection and treatment systems was conducted to provide recommendations for capital improvements needed to meet the wastewater system needs through the year 2020. A comprehensive TMUA study is underway covering all of Water & Sewer Operations, portions of Engineering Services, and other support groups. A map of the City of Tulsa wastewater system is presented in Exhibit 17.

Exhibit 17: City of Tulsa Wastewater System Map



Wastewater Treatment Baseline Data

Baseline data from 2006 to 2011 was reviewed to identify energy trends from the wastewater treatment facilities. In the 2010 fiscal year, approximately 17% of the City's electricity expenditures and 14% of the City's natural gas expenditures were spent on wastewater treatment operations.[13] In the 2010 calendar year, the average cost to treat 1,000,000 gallons of wastewater was $136.20

[13] Gas usage for Lower Bird Creek facility is not included in this estimate.

(see Exhibit 18). Typically, the majority of energy used in a wastewater treatment plant is in the treatment process (aeration) and pumping. In general, energy use is affected by population, influent loading, effluent quality, process type, size, and age of equipment.[14] Baseline energy data is presented in Exhibits 18-21.

Exhibit 18: City of Tulsa Wastewater Treatment Costs

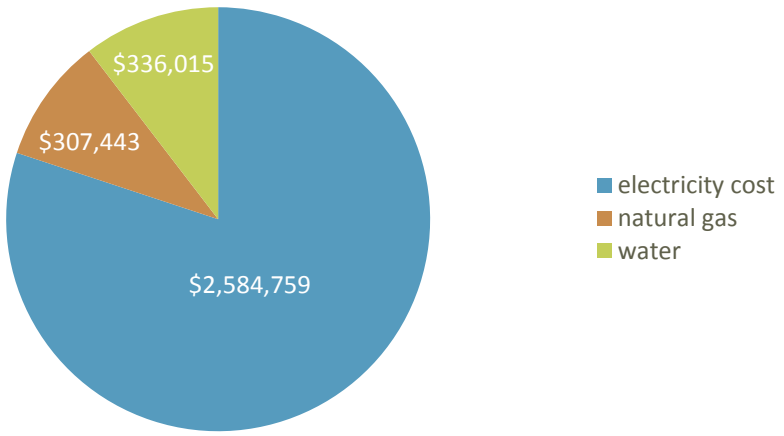
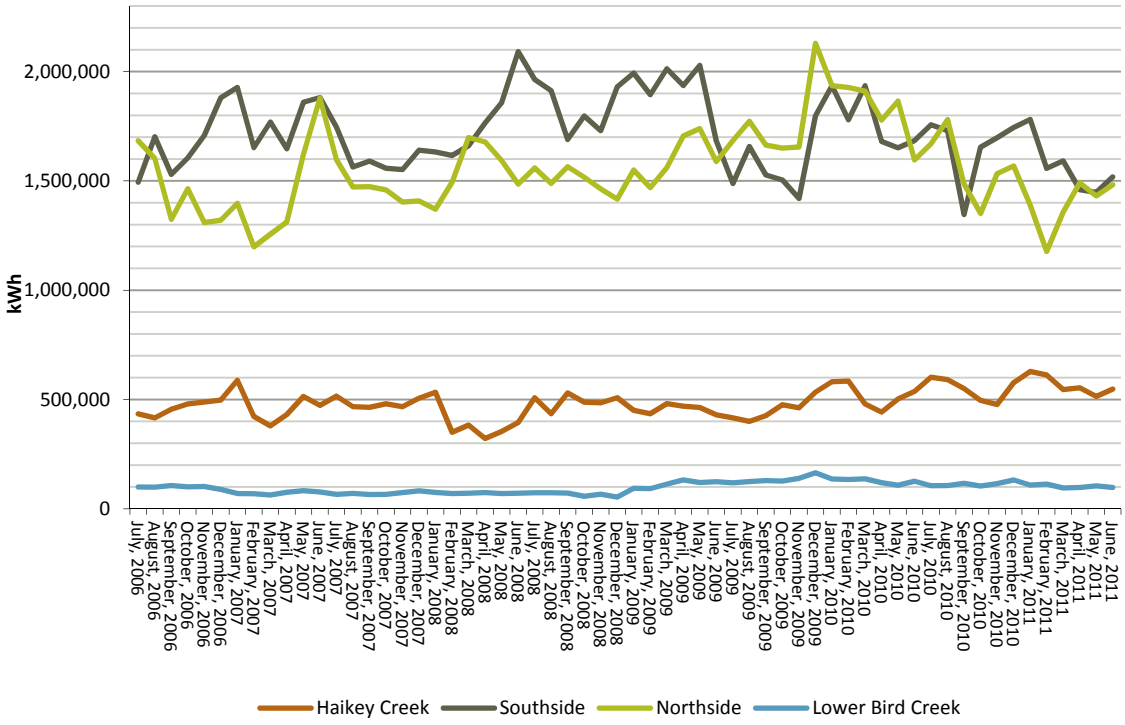


Exhibit 19: Monthly Electricity Usage at COT Wastewater Treatment Facilities



[14] U.S. EPA, Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, January 2008. http://www.epa.gov/owm/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf

Exhibit 20: Normalized Electricity Usage (kWh per Million Gallons Effluent)

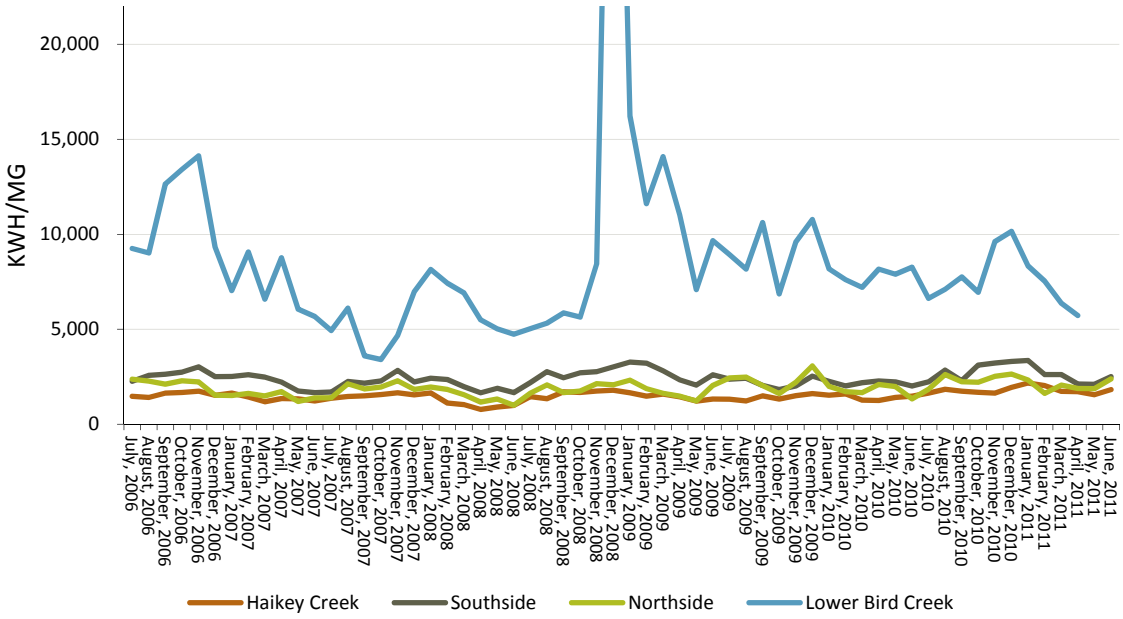
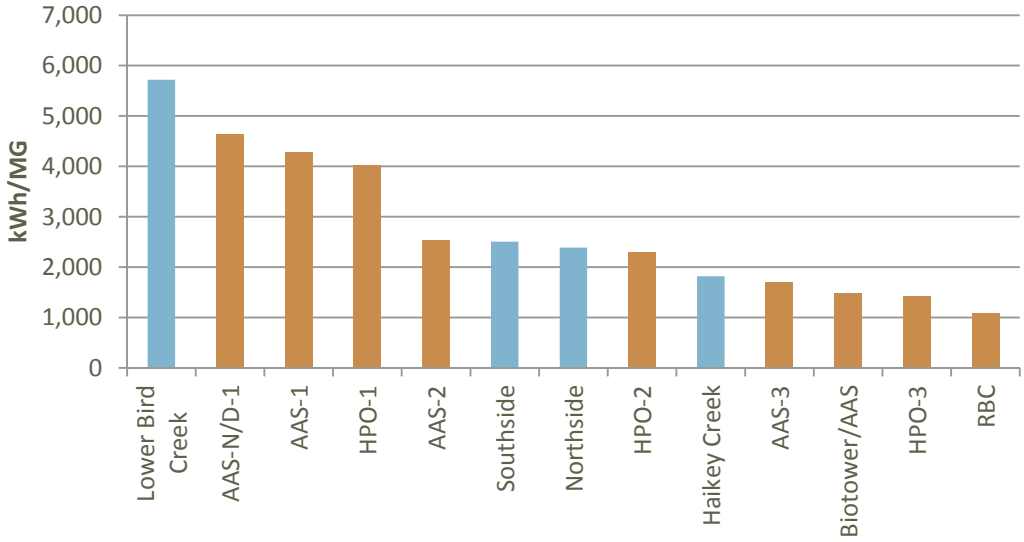


Exhibit 21: Wastewater Treatment Plant Energy Consumption Benchmarking



Lower Bird Creek does not have an activated sludge process but is included for comparison purposes.

COT wastewater treatment plants kWh/MG data (blue) from June 2011.

Benchmarking data (orange) from PG&E "Municipal Wastewater Treatment Plant Energy Baseline Study", June 2003.

AAS: Air Activated Sludge

AAS-N/D: Air Activated Sludge with Nitrification and Denitrification

HPO: High Purity Oxygen Activated Sludge

RBC: Rotating Biological Contactor

Initiative #10: Collect and Organize Water/Energy Data and Consolidate Planning Activities

Issue **The City of Tulsa does not have a sufficient level of detail in its energy/water operational data for wastewater treatment facilities.**

The City knows in general which processes at wastewater treatment facilities use the most energy; however, sufficient real-time energy data does not exist for individual pieces of equipment and individual treatment processes. Exhibit 22 characterizes operational energy use from a National Association of Clean Water Agencies (NACWA) survey of water and wastewater utilities.[15]

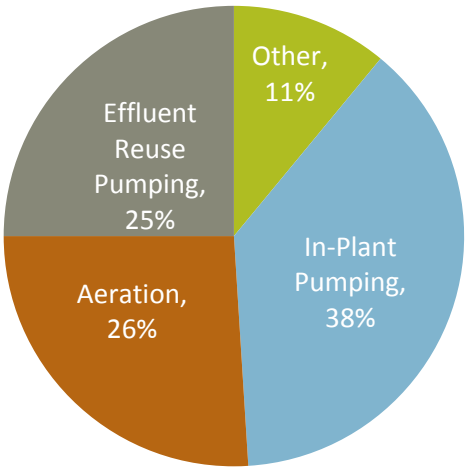
Recommendation **Collect and organize new water/energy data by conducting sub-metering studies at the facilities.**

The wastewater treatment plants currently have one meter going into the facility that is used by PSO for billing purposes; this is beneficial from a billing perspective for the facility. Installing several temporary (non-billing, internal-use only) meters could be an effective way of gathering energy data on the processes in the plant and identifying which systems could be improved from an energy standpoint. One meter should be installed on the main feed to the plant and some on the main sub-lines. This information would need to be analyzed with regard to peak demand consumption curves. In time, the meters could be moved to more specific places to perform monitoring based on the first round of power consumption evaluations. Additionally, there might be some opportunities to perform pumping efficiency monitoring to answer questions such as "Is it more cost effective to operate two pumps at 65% versus one at 90%?", or "Is the pumping efficiency low due to the pumps being worn out?" This project could be funded by the City or jointly conducted by the City and a local university through grants.

Significant and continuous upgrades at the plants will complicate an evaluation. A monitoring program would need to be narrowly focused on individual pieces of equipment not scheduled to be replaced in the immediate future. More information from other treatment plants should be gathered to assess potential benefits. Ongoing projects optimizing aeration and pumpage (soft starts & VFDs); are underway and should be installed first.

[15] T. Jones, "Water-Wastewater Committee: Program Opportunities in the Municipal Sector: Priorities for 2006," presentation to CEE June Program Meeting, June 14, 2006, Boston, MA. Available online at http://www.cee1.org/cee/mtg/6-06_ppt/jones.pdf.

Exhibit 22: National Association of Clean Water Agencies (NACWA) Survey of Energy Use[16]



Initiative #11: Increase Cross-Sectional Collaboration for Strategic Asset Management

Issue

There is not enough cross-sectional collaboration for strategic asset management. The Water and Sewer Department has at least two strategic asset management plans – one for Water Supply and one for Water Pollution Control. Both of these plans use EMA software and support; however, the two plans use different versions of the software and are under two different contracts.

Recommendation

Increase cross-sectional collaboration between Water Supply and Water Pollution Control strategic asset management. The strategic asset management plans provide a long-term strategic decision-making and planning tool to save capital and operational expenses while improving services. There could be further benefits by increasing cross-sectional collaboration and use of common software versions.

Initiative #12: Create Best Management Practices for Auxiliary Water Usage

Issue

As demonstrated in Exhibit 18, $14.56 per 1,000,000 gallons, or nearly 11% of the 2010 calendar year costs associated with treating wastewater were related to water usage itself. According to interviews with facility superintendents, auxiliary water usage can easily be overlooked at wastewater treatment plants because of the belief that the water is "free."

[16] 47 Respondents used 2.1 billion kWh of electricity

Recommendation

Institutionalizing a BMP for auxiliary water usage could help to curb extraneous water usage by making operators more aware of the costs associated with water usage and by identifying and replacing leaky auxiliary equipment (i.e., hoses). The BMP and associated training should be developed and made available to all wastewater operators in the City. If auxiliary water usage were reduced by 25%, the City could realize approximately 2.5% in cost savings annually, or approximately $84,000 per year using calendar year 2010 as a base case. Assuming that a BMP could be developed and a training program established for $84,000, this project would have a one-year payback period.

Initiative #13: Identify Alternate Practices and Technologies to Replace or Enhance Existing Wastewater Treatment Infrastructure or Practices

Issue

Incorporate innovative solutions for wastewater treatment facility operations. The willingness to try emerging technologies and revisit past ideas will lead to the success of the wastewater treatment programs.

Recommendations

The following operational and facility-based initiatives have been identified as innovative solutions to problems commonly experienced at the City of Tulsa's wastewater treatment plants.

Wet Weather Storage Facilities

Consider using wet weather storage facilities during the dry weather flow conditions when peak energy demand is high. If the flow equalization basins are used to collect and store wastewater during peak demand hours, pumping time could be offset to off-peak hours. Although this practice would not reduce total energy used at the facilities, it could potentially reduce peak demand and associated peaking costs. Chemical costs, flow fluctuation to Southside, pumping in and out of basin, aeration of the basin, and a reduction in wet weather storage and increase in maintenance costs–are areas of concern. A positive result in a comparable treatment plant should be evaluated prior to consideration.

Solar Sludge Dewatering

Solids treatment is one of the final phases of the wastewater treatment process. Sludge disposal is one of the major operating expenses of any wastewater treatment process (anaerobic digestion is an energy-intensive process). Recent increasingly restrictive regulations on sludge disposal have contributed to the need for and expense of sludge processing. Many biological and physical-chemical operations, including anaerobic digestion, are used to reduce the volume and

Parkson solar sludge drying facility in Fayetteville, Arkansas.

(photo: City of Fayetteville)

quantity of sludge, as concentrated sludges are more easily controlled at the disposal site.[17] The solids treatment processes at the wastewater plants are detailed in the following table:

Solids Treatment Process	Northside	Southside	Haikey Creek	Lower Bird Creek
Gravity Thickening	N	Y	Y	N
Air Flotation Thickening	Y	N	N	N
Sludge Stabilization (anaerobic digestion)	Y	Y	Y	Y
Sludge Dewatering	N	Y	N	N
Stabilized Sludge Storage	Y	Y	Y	N
Land Application	Y	Y	Y	N

The Southside plant is the only facility that has a dewatering process; this process can reduce the biosolid volume, further reducing handling costs. An innovative sludge dewatering option is solar sludge dewatering. In solar sludge dewatering, a greenhouse-like structure is erected that uses the sun as its main power source to provide 95% of the energy required for drying. Based on information provided by Parkson Company, the capital cost for a solar sludge drying facility for a 5 MGD plant is $1M – $2M. Over a 20-year period, Parkson estimates that the energy savings associated with using solar processing over traditional drying techniques is $6M – $8M. Comparative projects in this geographic region should be considered as part of this analysis as drying may not be cost-effective versus dewatering in this region. Centrifuge installation can also be considered for dewatering at Northside. An improvement at Southside would be to cover the sludge storage beds. This would keep the rain out, reduce odors, and perhaps increase the solids content due to evaporation caused by radiation or wind.

Depending on how much biosolids are available from the City's wastewater treatment operations, the processed and dried biosolids would be considered "Class A" biosolids, and could be used as fertilizer, or as input to a new joint sludge biosolids/yard waste compost program. Additionally, the dried biosolids can be combusted as fuel (approx. heating value of coal). These programs could potentially generate revenue for the City. If the City is interested in expanding its biosolids program, solar sludge dewatering should be considered as a viable and cost-effective alternative to traditional sludge dewatering. Further discussion of a biosolids program is found in the Waste Management section of this Plan.

[17] Droste, Ronald L. Theory and Practice of Water and Wastewater Treatment. New York: John Wiley & Sons, Inc., 1997.

Stormwater/Low Impact Development

Existing Stormwater Management Programs

Stormwater runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment, or other pollutants that could adversely affect water quality if the runoff is discharged untreated.[18] Under National Pollutant Discharge Elimination System (NPDES) Storm Water Permit #OKS000201, the City of Tulsa, along with the Oklahoma Turnpike Authority and the Oklahoma Department of Transportation, are authorized to discharge stormwater from the Tulsa Municipal Separate Storm Sewer System (MS4). The City of Tulsa is also authorized to discharge stormwater from construction sites owned and/or operated by the City of Tulsa to receiving waters in the Arkansas and Verdigris River Basins. Under the NPDES Stormwater Permit, the City is required to meet certain discharge requirements as well as to operate a Stormwater Management Program.

Components of the Stormwater Management Program include:

- Structural controls and stormwater collection system operation
- Areas of New Development and Significant Redevelopment, which includes a comprehensive master planning process (or equivalent) to develop, implement, and enforce controls to minimize the discharge of silt, scrap, trash, and other pollutants from areas of new development and significant re-development after construction is completed
- Maintenance of roadways to minimize discharge of pollutants
- Flood control projects
- Controls to reduce the discharge of Pesticide, Herbicide, and Fertilizer Application
- Prevention of illicit discharges and improper disposal
- Spill prevention and response
- A plan for industrial and high risk runoff
- A program to reduce the discharge of pollutants from construction sites
- Public and employee education
- Monitoring programs

Stormwater Sustainability Goals

The sustainability goals for stormwater focus on the New Development and Significant Re-Development component of the Storm Water Management Plan, specifically with promoting Low Impact Development (LID) and other green design strategies as a BMP to minimize the impact of urban runoff discharges from those areas on the receiving streams.

[18] US EPA, NPDES Stormwater Program Overview http://cfpub1.epa.gov/npdes/home.cfm?program_id=6

Initiative #14: Bring the City's Storm Water Management Plan Up-To-Date

Issue

Significant work is needed to maintain the City's Stormwater Management Plan. Over the past three decades, both the frequency and severity of flooding have been greatly reduced by improved management and land use practices. However, the potential for larger-than-100-year rains will continue, with a perennial risk for catastrophic floods.

The Flood and Stormwater Management Plan 1990–2005 was the first citywide master drainage plan. This plan prioritizes and coordinates the flood protection projects that are detailed in the city's 29 master drainage plans. (The plan was last revised on September 7, 2001.) The City later developed the Flood and Stormwater Management Plan 1999-2014, published on September 10, 1998. It was developed in accordance with planning criteria from the Community Rating System (CRS), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant Program (HMGP). The Flood and Stormwater Management Plan recommended stormwater capital improvement projects.

Recommendation

The Flood and Stormwater Management Plan (1999-2014) was last updated in 2005 and is currently being updated. The purpose of the update is to account for changes in the various drainage basins throughout the City due to private development and completed capital improvement projects.

Initiative #15: Raise awareness of Potential Flood Threats and Re-direct Funding to the Stormwater Management Plan

Issue

The City should implement a public awareness program to remind Tulsans that major flooding is inevitable and requires a coordinated and proactive community-wide approach. Tulsa has not experienced a major flood event since the famous Memorial Day flood of 1984. The flooding Tulsa has experienced over the last several years has been caused by short duration, high intensity storms that cause more localized flooding. It seems the public perception is that the City has solved all the flooding problems of the 1970s and 1980s. Another problem is that only a small percentage of Tulsa's citizens are affected by flooding while everyone drives on the streets and uses the other infrastructure. The City of Tulsa has a Hazard Mitigation Plan that looks at the risk of floods and provides flood mitigation priorities for the city.[19]

Recommendation

Implementation of the Stormwater Management Plan requires that adequate funding be allocated to stormwater projects from bond issues and third-penny sales tax funding packages. In recent years, stormwater projects have not been perceived as a priority by the citizens of Tulsa and therefore funding has been allocated to more pressing issues such as street repairs, and water and sewer infrastructure.

[19] http://www.cityoftulsa.org/media/103341/tulsa2009approvedmultihazardmitigationplan.pdf

Initiative #16: Promote Watershed Conservation and Education Initiatives

Issue

Watershed projection awareness needs to be raised. Working with members of the community to encourage stewardship of Tulsa's water resources will help to increase public awareness and ownership of water initiatives.

Recommendation

Engage in Adopt-Your-Watershed Activities. EPA's Adopt-Your-Watershed program (not to be confused with Adopt-A-Watershed which is a non-profit that promotes educational awareness) has a campaign to encourage stewardship of the nation's water resources. "Adopt" means participating in a citizen-based effort to restore or protect a watershed, river, lake, wetland or estuary. Examples of recommended adoption activities include:

- Volunteering to monitor water quality
- Marking or stenciling storm drains
- Organizing stream cleanups
- Planting trees along eroding stream banks
- Hosting a water festival

This type of program could serve as a supplement to the City's existing Stormwater Management Plan that contains watershed development permit requirements, including stream quality evaluations and impairment assessments along with required Low Impact Development (LID) components.

Initiative #17: Establish Public/Private Low Impact Development (LID) Team

Issue

There is no City working group in place to provide leadership on Low Impact Development initiatives.

Recommendation

Establish Public/Private LID Team. A team is needed to bring various experts to the issue of LID implementation and performance documentation. A Public/Private LID team could be established to formally review current and evolving codes for upcoming energy and water national/international code requirements; LID performance indicators; and new technologies. This effort will include an educational outreach element and possibly interns or college students. This team could identify barriers to LID, seek to eliminate those barriers when possible, and educate and promote LID both internally and throughout the community.

Initiative #18: Coordinate Stormwater Grant Applications

Issue **Large grants are available for a coordinated approach to environmental, job growth, transportation, and housing issues in underserved areas, and there is currently no coordinated effort on the City's part to take advantage of them.**

From the Advance Notice of Requirements for HUD's Fiscal Year 2011: Sustainable Communities Regional Planning Grant Program: [20]

"The Department of Defense and Full-Year Continuing Appropriations Act, 2011 (Public Law 112-10, enacted April 15, 2011) (Appropriations Act), provided a total of $100,000,000 to HUD for a Sustainable Communities Initiative to improve regional planning efforts that integrate housing and transportation decisions, and increase the capacity of communities to modernize land use and zoning plans. Of that total, $70,000,000 is available for the Sustainable Communities Regional Planning Grant Program, and $30,000,000 is available for the Challenge Planning Grant Program.

$1M

Grant money available from HUD/DOT/EPA Sustainable Communities

The Sustainable Communities Regional Planning Grant Program supports metropolitan and multijurisdictional planning efforts that integrate housing, land use, economic and workforce development, transportation, and infrastructure investments in a manner that empowers jurisdictions to consider the interdependent challenges of: (1) economic competitiveness and revitalization; (2) social equity, inclusion, and access to opportunity; (3) energy use and climate change; and (4) public health and environmental impact. Of the $70 million available for the Regional Planning Grants program, $2 million has been reserved for capacity support grants distributed separately. This notice announces the availability of approximately $67 million for Sustainable Community Regional Planning Grants, of which not less than $17.5 million shall be awarded to regions with populations of less than 500,000.

The Sustainable Communities Planning Grant Program is being initiated in close coordination with the U.S. Department of Transportation (DOT) and the U.S. Environmental Protection Agency (EPA), co-leaders with HUD in the Partnership for Sustainable Communities."

Recommendation **Establish a coordinated stormwater grant application as an ongoing action item for the ECST Team.**[21]

[20] Advance Notice of Requirements for HUD's Fiscal Year 2011, Sustainable Communities Regional Planning Grant Program DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, [Docket No. FR-5559-N-01].

[21] At the time of the Sustainability Plan's publication, grant application deadlines have not yet been released.

Initiative #19: Identify LID Barriers/Opportunities in Existing Codes

Issue **No analysis has been done to determine if existing City codes support LID Goals.**

Recommendation As a component of this Sustainability Plan, a thorough review of existing City Codes was conducted to determine if the current codes are adequate in supporting LID initiatives. This exercise is also a component of the City's Stormwater Management Plan (SWMP), and should be cross-referenced as a follow-up action to the BMP task to review Tulsa's development regulations to identify impediments to LID. The following topics were analyzed and are presented in detail in Appendix 1:

- Commercial and residential graywater systems
- Low flush toilets and waterless urinals for commercial and residential use
- Rainwater for irrigation
- Swimming pool water for irrigation
- Curbs on city streets
- Landscaping and irrigation requirements.

Initiative #20: Incorporate LID Initiatives in City Facilities

Issue **The City should take a leadership role in the community by highlighting the benefits of LID in its own facilities.**

Recommendation **As a way to promote innovation and low impact development (and potentially reduce operational construction permitting costs), the City should incorporate LID projects in the design of new construction or major remodels.**

- Incorporate LID design elements in City buildings, including the following (See Appendix 1 for further details):
    - Pervious pavement
    - Rainwater harvesting
    - Rain gardens

Rainwater harvesting is the concept of collecting and storing rainwater for other uses, often for irrigation purposes. There are many types of rainwater harvesting systems, the most common being rain barrels that collect rainwater channeled from a roof. Tulsa has a large physical and ecological footprint and should lead the way regionally in protecting our natural resources. The rainwater harvesting potential (in gallons) of a given location in Tulsa is 21 x collection area (in square feet).The potential benefits of rainwater harvesting are as follows:

- City facilities save money by using captured water for landscaping/irrigation
- Helps reduce peak utilities demands in the summer

- Reduces stormwater runoff and improves water quality
- Reduces erosion in urban environments
- Reduces non-point source pollution

A Go/No Go list could be created to determine if a rainwater harvesting system could be implemented in a new or existing City building. It would be beneficial to determine the return on investment of installing rainwater capture systems as an increased first cost to save on irrigation costs over the life of the building.

- Raingardens/bioswales

  Implementation of rain gardens is a relatively easy way to process surface water runoff, capture and store rain water, and promote groundwater recharge rather than allowing the surface water from impervious surfaces to exacerbate erosion and flooding. In addition, the upcoming draft stormwater permit for the City of Tulsa requires promotion of LIDs as a BMP to reduce such urban runoff. This urban runoff is a source of impairment to various urban streams and is divided into three categories directly related to city operations on the local 303d Listed Streams and priorities list. Those categories include:

  - Discharges from municipal separate stormwater sewer systems (MS4)
  - Municipal (urbanized high density area)
  - Municipal point source discharges

- Green Roofs

  Green Roofs are roofs that are fully or partially covered in vegetation. Green roofs could be integrated into applicable City buildings.

  The benefits of green roofs are as follows:

  - Reduced electric bills through insulating property of green roofing
  - Addition of functional outdoor space that would have previously been unattractive and typically unused
  - Virtually maintenance-free after the first year of established growth
  - Allowed by City of Tulsa code (IBC 2006) with an Oklahoma licensed structural engineer's seal (as required for all commercial projects).
  - Could reduce size of detention pond or fees in lieu of detention costs
  - Lowers urban heat island effect and smog production by reducing the local temperature. Rising temperatures lead to increased cooling requirements that require more energy use and increase emissions.
  - Reduces stormwater runoff and improves water quality.

  Some disadvantages of green roofs are:

  - Cost of the structure – metal truss/concrete roof must be built to support 100 pounds per square foot.
  - Potential additional cost of design if structural engineer is not familiar with system

- Maintenance needed during first year to establish growth and keep trimmed/mowed. Lower maintenance covering (i.e., sedum or cactus) can be used in lieu of a longer grass if maintenance-free situation is desired).

A Go/No Go list could be created to determine if an upcoming green roof project could be implemented in a new or existing City building. Existing buildings must be checked to see if their structural loading capacities are as designed. For new buildings, structural loading capacities can be increased as part of their design. It would be beneficial to determine the return on investment to install a green roof as an increased first cost to save on heating and cooling costs over the life of the building.

Green Roof Case Study - TriArch Architectural Offices, 618 E 3rd Street, Tulsa, OK

Background Information

The building case study is a 7,500 SF building located in downtown Tulsa that is a brick warehouse shell with a combination metal truss/concrete roof built in 1919. The project is LEED certified, and is thought to be the only LEED certified building within the inner dispersal loop (IDL). Roughly half of the building has been finished out and certified to date (3,750 SF).

The following LEED elements were implemented: VAV HVAC systems with local controls, automated dimmable lighting that adjusts to daylighting levels, natural and forced ventilation systems to enhance airflows, low volatile organic compound (VOC) material solutions, green roof substrate and vegetation requirements, recaptured gray water mechanisms for irrigating green roof, recycled cotton denim insulation, tankless hot water heater, shower for commuting, use of recycled windows for building exterior in interior offices, use of recycled doors from the Habitat for Humanity Restore, etc. The cost of commissioning for LEED purposes was around $9,000 and was a one-time cost. This is roughly 2.4$/SF (2.4$ x 3,750 SF = $9,000).

Green Roof Costs and Specifications

The cost of the green roof was about 2-3$/SF and was installed with employee help. (Many types of green roof systems exist and can be in the range of a 1 to 2 inch thickness to 8 to 12” thickness). Buffalo grass is used and is roughly 3 to 4” thick. Grass is currently mowed with a push lawnmower kept on the roof. The roof has not had any leaks since the green roof was installed 1+ years ago. The nearly flat roof actually had more leaks before the green roof was installed. The roof has a ¼” per foot slope and is covered entirely with a thermoplastic olefin or polyolefin white membrane roof. The green roof covers roughly half of the roof (3,500 SF), adding the layer to the green roof side. Most “flat” roof buildings are required to have a 1/8” per foot slope; ¼” per foot slope is recommended for this green roof system.

Green Roof Realized Benefits

- Required air conditioning reduced from 40 tons to 7 tons.
- Added additional pleasant outdoor space for employees that would have previously been unattractive and typically unused. (Owner's wedding occurred on green roof this spring).

Sustainability and State Revolving Funds. The State Revolving Funds now include a "green reserve" component that can be used for energy efficiency improvements at treatment plants, LID improvements, alternative energy improvements, and similar types of activities. Tulsa is an active user of the Oklahoma Water Resources Board SRF programs.

Solid Waste & Recycling

Reducing waste and finding new ways to recycle

Baseline Information on the Current Program

Today, the City collects waste from a small portion of City residences in the City; however, the City is changing the residential solid waste/recycling system, and will no longer collect waste from residential customers after the changes are implemented in 2012. This Plan focuses on the waste and recycling generated in City facilities, and therefore not the waste generated by the City's residences and businesses. Also, the City of Tulsa does not collect waste and recycling from its own facilities, but contracts out these services.

Currently, approximately 9,400 tons of waste and recyclables are generated each year by the City, or about 9,175 tons of waste sent to the landfill, and 230 tons diverted for recycling. The current cost of waste removal (which is offset by included recycling revenue) is about $175,000 per year. Revenue received for recyclables reduces waste removal costs by about one third. A summary of waste removal costs and revenue received for recyclables is shown in Exhibit 23.

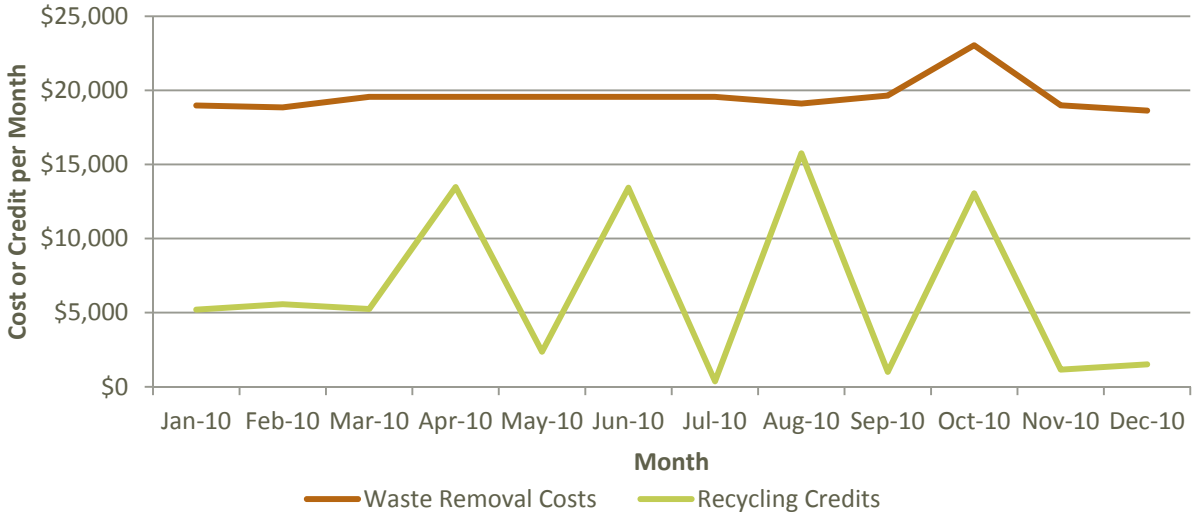
9,175

Tons of waste the City of Tulsa government operations sends to the landfill annually

$175k

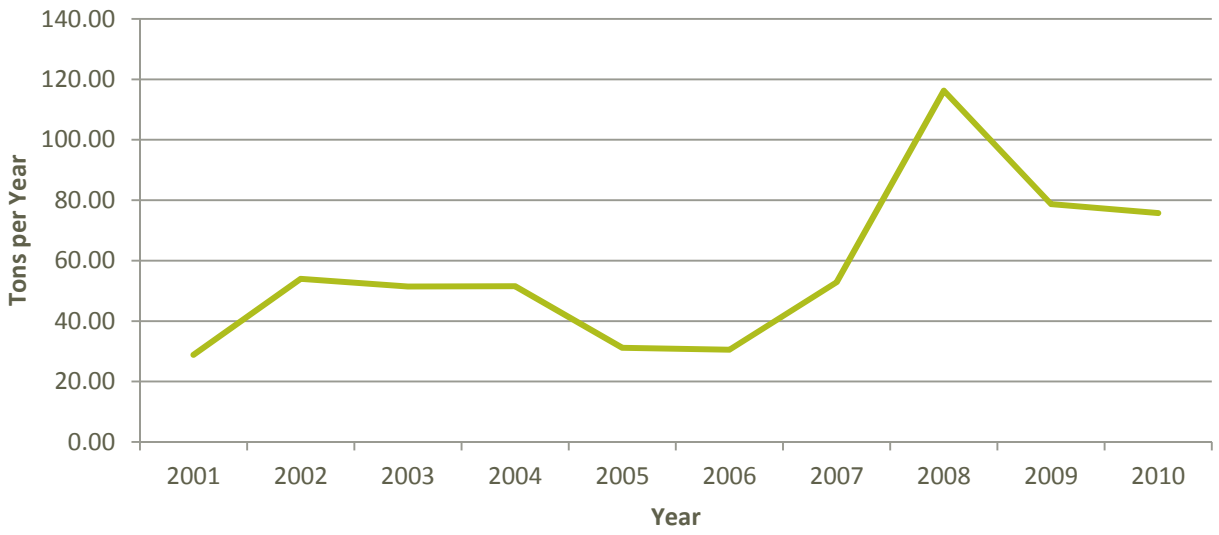
Annual cost to send City's waste to landfill

Exhibit 23: City Government Solid Waste and Recycling – 2010



The City recycles bulk metal, paper, cardboard, and bottles and cans. Since 2001, the City has been recycling paper from 53 locations, including City Hall, police and fire stations, and numerous other facilities. See Exhibit 24 for a summary of the annual amount of paper recycled by the City.

Exhibit 24: Annual Tons of Paper Recycled at City Facilities

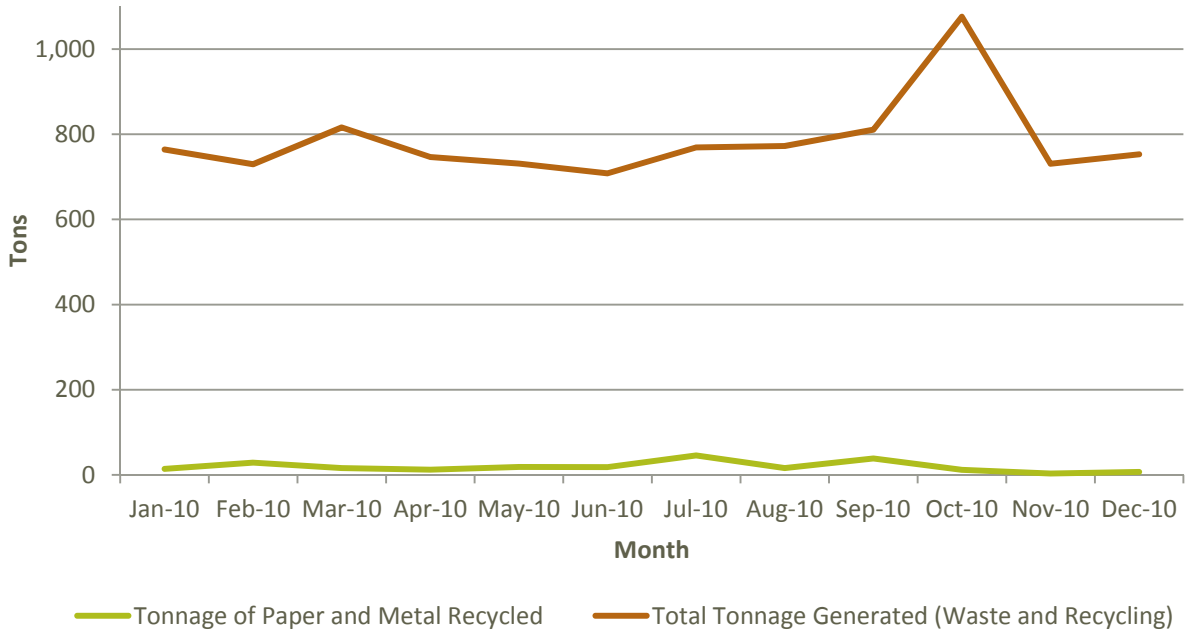


The City recently rolled out a pilot program for collecting bottles and cans made of glass, metal, and plastic; the results from this program will be monitored, and the program will be expanded if the results are successful. Certain locations, such as City Hall, collect cardboard boxes for recycling.

Bulk metal is also collected for recycling, although there is no centralized system currently in place for metal recycling. The City does not generate much construction and demolition (C&D) waste on a regular basis, but does occasionally demolish old City buildings (such as recreation centers) or abandoned residences. In these cases, the C&D waste is hauled by City staff to a local waste disposal facility.

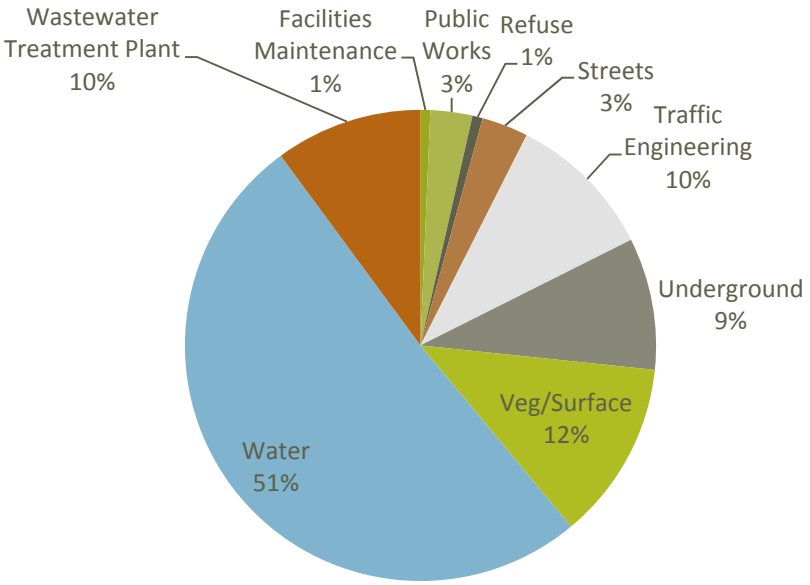
The current diversion rate of the tonnage of waste that is recycled is estimated at 3%, but this only includes paper and bulk metal items and does not include the tonnages of green waste, cardboard, and bottles and cans that are diverted for recycling. Exhibit 25 shows the tonnages of waste and recyclables generated at City facilities in 2010.

Exhibit 25: Tonnage of Waste and Recyclables Generated at City Facilities in 2010



The City recycles bulk metal items as needed when the waste is generated; in 2010, about 210 tons of metal were recycled, and the City received a credit of about $91,000. A breakdown of the origin of the metal sent for recycling, by City department, is shown in Exhibit 26.

Exhibit 26: Quantity of Metal Recycled in the City of Tulsa (by Department)



Additionally, the City owns and operates a small Green Waste facility, in which yard clippings are converted to mulch. Some City waste is sent to this facility, and residents can drop off yard waste for free. Commercial haulers are charged 55 cents per cubic yard to dispose of green waste at this site. The mulch created at the Green Waste site is distributed free to City residents; however, there is a surplus of mulch, so some is also sent to a nearby waste-to-energy facility. The City is exploring the possibility of converting the Green Waste facility to a composting operation that would accept food waste as well as biosolids from the City's wastewater treatment plants.

Finally, the City is deploying an inspector to conduct waste audits at all City facilities. The purpose of the audits will be to review the size and pickup frequencies of the bins at each site, to measure the amount of waste in each bin at the time of removal, and determine if more efficient system (i.e., a larger bin with fewer pickups) could be implemented. The audits will also determine the makeup of the waste stream that is currently picked up as trash, with special note of whether there is a high percentage of recyclable materials in the trash. The materials that are collected for recycling will be audited to determine if contamination in the form of non-recyclable materials is improperly disposed of in the recycling bins. The results from these audits will be used to design and expand recycling programs, as well as to inform future education efforts associated with recycling programs.

The City has developed a system to reuse materials and supplies that are no longer needed by a particular staff member or department. Unwanted or unneeded items are sent to a central location and redistributed as needed.

Recommended Tools and Methods for Improving Recycling Programs

The key objectives related to Solid Waste and Recycling are:

- Set up systems to track total solid waste and recycling tonnages generated at City facilities, and improve recycling and waste reduction programs based on the data that are tracked.
- Save costs by reducing the amount of waste generated, and increasing cost-effective recycling programs.

As with other initiatives in this Plan, financial costs and benefits are key considerations when evaluating new programs to reduce waste or increase recycling. While recycling items such as paper and metal can create revenues, there are often costs associated with renting recycling storage bins, and transportation of the materials to the processing facility. However, avoided costs include waste transport and tipping fees.

A key challenge in adding recycling programs is that most cleaning staff are not currently required to pick up recyclable materials separately from the trash. Thus, adding a recycling program could require changing the contract for the vendors that provide janitorial services, and could even result in additional cleaning fees. Other challenges may include lack of storage space for recycling bins, and the lack of high rebates for some types of recyclable materials. Addressing some of these challenges will require taking a long-term view of the problem, and keeping these issues in mind when cleaning contracts are renewed or renegotiated, and when new facilities are designed or retrofitted.

A simple measure of the recycling program's success is the participation rate, determined by measuring the amount of recyclable material that was properly disposed in the recycling bins vs. the amount that was improperly disposed in the trash bin. If the participation rates are found to be high, the program is considered to be successful. If participation rates are not optimal, then increased educational efforts may be needed to improve recycling programs at City facilities.

Potential Future Initiatives

Cardboard Recycling. Cardboard boxes are generated by numerous City facilities, and are not collected for recycling at all facilities. Currently, the City's recycling vendor does not accept cardboard from all locations. In some cases, the generation of cardboard is erratic, and a particular facility may only generate cardboard after receiving a large, one-time shipment of new equipment. In other cases, there is no space for a separate container to collect cardboard. The City will continue to review options for increasing cardboard recycling.

Construction and Demolition (C&D) Waste Reuse and Recycling. C&D Waste is not always recycled by City staff, although there are local facilities that accept this waste for recycling. Furthermore, deconstruction is a process to collect and reuse building materials taken from a demolished building, instead of hauling all the waste to the landfill. A key challenge for the City in implementing deconstruction is a lack of labor. The City's labor crews have been reduced in recent years, and most staff have extremely high workloads. Although deconstruction has multiple benefits, the process of deconstruction is more time consuming than demolition. Because time is so limited, deconstruction may be difficult to implement at this time, but will be considered for future projects.

Recycling in City Parks. The City has also considered expanding the recycling program to include City park locations, and explored the concept of using small solar-powered trash compactor bins within parks for waste and recycling collection. The solar-powered bins were expected to lead to significant savings in both equipment and labor. However, after performing a cost/ benefit analysis it was found that there would be no cost savings by replacing the current trash system with the solar-powered bins. The analysis of Parks' trash service data shows a payoff on capital investment of 22.78 years; literature provided by the manufacturer claims that the life expectancy of their equipment is only 2 to 4 years. In addition, City staff found that because of the close proximity of the trash receptacles within the parks, there was not a cost savings on labor and equipment.

A portion of the problem may be the capital cost of the initial purchase; at $4,744,383.80, it will take significant time to reach payoff. In addition to the cost/ benefit analysis performed, contact was made with two other cities (San Antonio, Philadelphia) currently utilizing The BigBELLY system. Both San Antonio and Philadelphia claimed that they were able produce a significant savings by targeting a specific area with high volume of pedestrian traffic and using a combination of reducing waste receptacles and adding the BigBelly solar trash compactors. However both cities stressed that this system would not work in all applications. Also Philadelphia stated "that if it were not for federal funding they would not have begun the purchasing of the BigBelly compactors". A possible solution would be to identify parks that have lengthy travel times between receptacles and high volumes of usage. Once identified, the purchase of the solar-powered bins would be limited to those facilities.

Recommended New Initiatives

The following new objectives and initiatives are recommended to increase recycling and reduce waste within City operations.

Initiative #1: Improve Tracking of Recycling and Solid Waste Generation Tonnages and Costs

Issue **Data regarding the total amount of solid waste generated by the City currently is not centralized, in part because different vendors provide services for waste removal, metal recycling, and other recycling programs.** For example, the data presented in this report was collected from the various vendors and assembled to determine the City's total waste generation and the overall recycling diversion rate.

Recommendation **Centralize Data Collection for Recycling and Solid Waste Generation at City facilities.** By centralizing the data into one location and comparing data from month to month and year to year, certain trends may be discovered that could help improve current systems. The City should track the recycling diversion rate using data on solid waste sent to the landfill and the tonnage of materials diverted for recycling. Tracking the recycling diversion rate could also allow the City to benchmark against similar programs in other cities or other organizations, and would provide a useful indicator of the recycling program's success.

Furthermore, the tonnage of waste that is sent to the landfill is estimated based on the total cost of solid waste removal and assumptions to convert the cost to solid waste volumes, and to then convert from volumes to tonnages. In the future, the City could request better tonnage data from the waste removal vendor to improve the accuracy of solid waste tracking.

To achieve this initiative, the City should assign one person or department the responsibility of creating an annual report showing total waste generation and costs, and recycling generation and costs, and the annual recycling diversion rate. Although the staff time that is needed to achieve this initiative could be considered a cost, collecting this baseline information will provide a foundation to inform future recycling efforts.

Key Performance Indicator **Percentage of City's waste stream that is regularly measured and tracked in Hara EEM.**

Target **75% of City waste measured and tracked by end of FY2013.**

Initiative #2: Implement a Quartermaster System

Issue

City employees sometimes discard City-issued items that may be reused or recycled. Reducing waste of City-issued items should reduce solid waste container size or collection frequency at City facilities, which leads to cost savings for the City. Reducing waste could also lead to cost savings by lowering the amount of new items that are unnecessarily purchased.

Recommendation

Develop a new quartermaster system to reduce waste. Many items issued from City of Tulsa warehouses, such as tools, safety equipment, boots, cleaning equipment, batteries, and many other items, could be included in a quartermaster system. The total annual cost of the items that have been identified is approximately $204,000. Exhibit 27 shows a list of all the categories of items that were identified for inclusion in the program, and the annual expenditures in each category.

Exhibit 27: 2010 City Expenditures on Items to be Included in the Quartermaster System

Category of Items	Annual Expenditures
Storage Supplies	$ 16,036
Cutting Tools (Axes, Cutters, Knives, Saws, Etc.)	$ 6,219
Cutting Accessories (Saw Blades, Etc.)	$ 3,799
Digging Tools (Post Hole Diggers, Hoes, Rakes, Etc.)	$ 10,654
Twisting Tools (Pliers, Etc.)	$ 18,472
Flaring	$ 546
Hammers	$ 5,285
Flashlights and Lanterns	$ 3,857
Finishing	$ 338
Measuring and Gauges	$ 2,670
Painting Supplies	$ 8,057
Miscellaneous Tools	$ 27,931
Cleaning Supplies	$ 3,973
Safety Supplies (First Aid Kits, Ear and Eye Protection, Etc.)	$ 13,613
Clothing Supplies (Rain Suits, Boots, Gloves, Etc.)	$ 82,935
TOTAL:	**$ 204,384**

The military uses a 'quartermaster' warehouse system that could be implemented in the City of Tulsa as a means to verify the need for certain replacement items. For example, under this new system, a replacement pair of knee boots would be issued when the damaged pair of knee boots is presented for inspection and exchange.

Staff conservatively estimates a 5% reduction in annual costs or approximately $10,000 in annual savings just by reducing requests for replacement items. By acquiring the damaged item, it reduces

waste if the item can be fixed, reused, or recycled. For example, batteries are accepted for recycling for free at multiple city facilities through a producer responsibility program.

The program could be implemented as soon as education is provided to the warehouse storekeepers and they are given authority to make decisions regarding material approval. The City would also need to provide education to field supervisors and employees who use the warehouse system, and provide collection containers for material. Finally, City staff would need to write and review contracts that provide material take-back or recycling of approved items.

Warehouses have sufficient space to accept and store material made in exchange. Costs will include bins or crates to store material collected at the warehouse. Savings from the program can be applied to the purchase of material containers.

A successful program will be accomplished through an active monitoring program by the warehouse staff and field supervisors. Monthly usage reports per employee and material item should be available to field supervisors, followed by quarterly reports when the employees understand the program.

Key Performance Indicator **Purchasing costs reduced by the quarter master system**

Target **5% reduction in costs of certain types of supplies and tools.**

Initiative #3: Increase Recycling of Bulk Metal Items

Issue

Tulsa does not currently have a central contract in place with a metal recycler, and often City staff transport the metal items to the vendor's facility using City vehicles.

Recommendation

Implement a centralized program for bulk metal recycling. By implementing a centralized program and entering into a single contract with a recycling vendor, costs could be reduced in several ways. First, the vendor would likely provide bins for the storage of the items and then would pick up the items to be recycled at no cost to the City, thus reducing staff time and equipment needed to transport the materials. Also, by creating a centralized system, some additional departments or units might recycle more material than is currently diverted. A centralized system would allow for easier tracking of recycling and recycling credits, and could ensure that the City is receiving the highest possible credit for each type of metal that is recycled. If the 2010 tonnage that was recycled is increased by 5%, then 11 additional tons could be recycled, with the City receiving credits worth approximately $4,780 (based on average credits received in 2010). Finally, creating a centralized system would allow for each department to receive the credits from the recycler; currently, the credits are sent to the City's General Fund, and are not sent back to the department that recycled the items. Distributing the credits back to the department that generated the waste item would add an incentive to each department to recycle all items possible.

Key Performance Indicator

Total tonnage of metal recycled by the City

Target

5% increase in the tonnage recycled.

Sustainable Fleet Management

Energy independence and more miles per dollar

"The FY 12 budget is a 34.5 percent increase over the FY 11 budget as a result of increased fuel costs."

CITY OF TULSA ANNUAL BUDGET, FISCAL YEAR 2011 – 2012

The cost of operating the City of Tulsa vehicles and mobile equipment is expected to increase more than one third in fiscal year 2012 compared to 2011. This more than $3.5 million one-year increase is directly related to the rising cost of fossil fuels needed to keep the City's fleet of more than 4000 vehicles and other equipment moving and providing services to the citizens of Tulsa. An increase in average motor fuel costs from $2.00 to $3.60 a gallon (80%) is projected for the FY 12 budget. The increasing cost of fossil fuels is a major factor driving many cities, including Tulsa, to seek alternative fuels and technologies, and to adopt sustainable fleet practices.

80%

City of Tulsa's projection for per gallon cost increase of motor fuel in 2012

The Equipment Management Department (EMD) will use the $16 million operating budget to run a centralized maintenance program for all City vehicles. EMD provides vehicle repair, both regular preventive maintenance as well as unscheduled repairs, body shop repairs, and vehicle washing. EMD also operates the fuel dispensing and distribution for the City's on-road and off-road vehicles. Half of the budget, $8 million, is planned to pay for the more than 2,000,000 gallons of fuel. Exhibit 28 shows Tulsa's fleet vehicle fuel consumption over the past several years by fuel type.

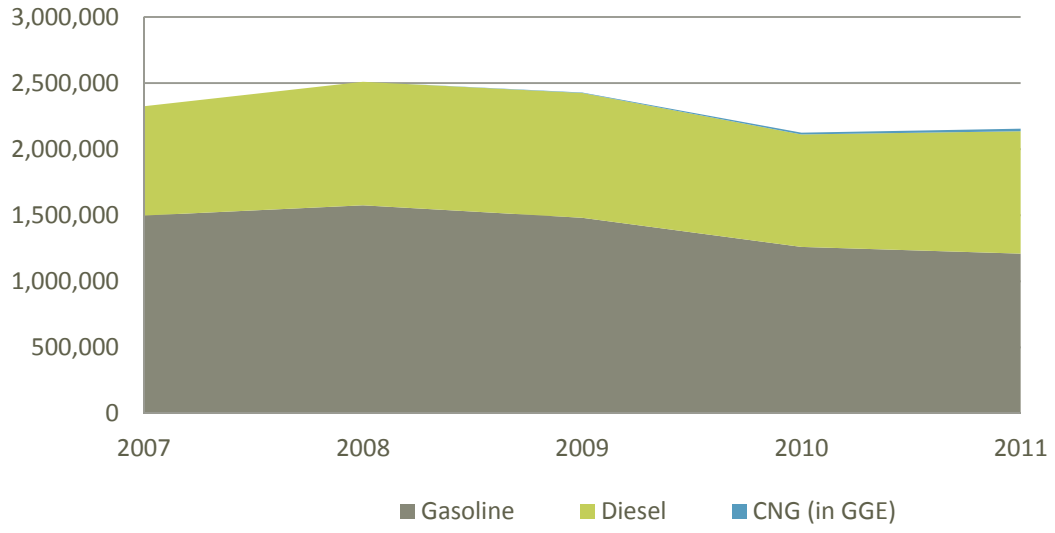
2,245,625

Forecasted gallons of fuel the City of Tulsa fleet will consume in FY2012

EMD does not "own" the majority of city vehicles and equipment; they only maintain and fuel them. The respective City Departments, such as Police, Fire, and Public Works "own" and manage their respective fleets of cars, trucks, and specialized equipment. EMD invoices the other city departments monthly for the fuel and services they provide. In this respect, the EMD is an internal city service with many departments as their customers. This is reflected in the EMD mission statement, which is: "To provide our customers with safe, economical, environmentally efficient and reliable services to ensure maximum utilization of the fleet."

In September 2011, the City's Fleet Management Steering Committee was formed to manage these and other related issues.

Exhibit 28: Tulsa Fleet Motor Fuels Consumption by Type



The City's "rolling stock" fleet of on-road vehicles numbers about 2600. The remaining units are off-road vehicles and equipment such as construction, earthmoving and landscaping, boats, emergency generators, pumps etc. The breakdown between the departments and the relative consumption fuel for Fiscal Year 2011 is shown in Exhibits 29 and 30.

Exhibit 29: Total Fleet Vehicle Ownership by Department

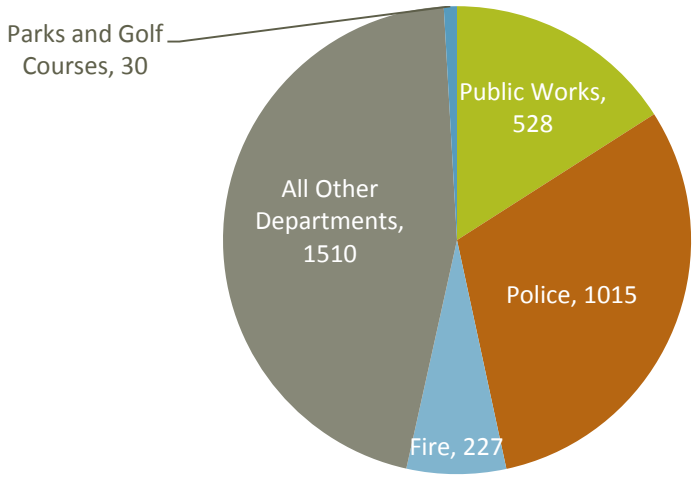
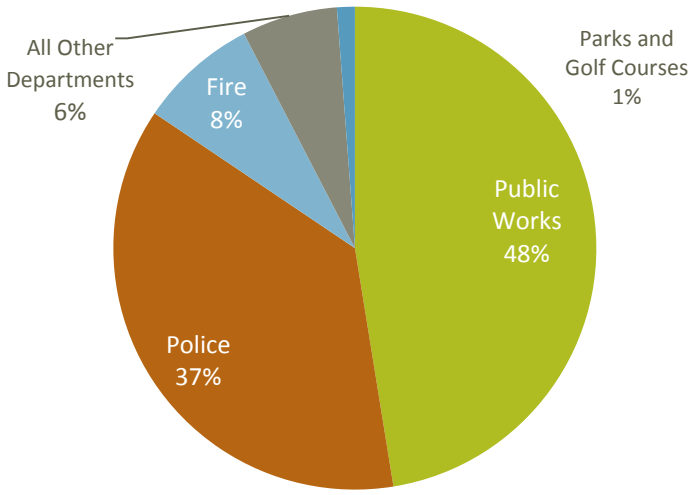


Exhibit 30: Percent of Total Motor Fuels Consumption by Department



The City's current organizational structure allows each major City Department to control and management its fleet in the sense that they determining the vehicle assignments and use of vehicles as well as the number and types of vehicles it operates. Since each department is responsible for gaining approval for its own capital funds, these departments plan their fleet size to meet their needs and procure vehicles that they specify.

This dispersed control of the operation, vehicle mix, and size of the City's fleet presents a challenge to managing the net fuel efficiency and fuel consumption. EMD is in charge of gathering and managing the City-wide fleet operational data, and has been tasked with tracking and managing the City's fuel and maintenance costs, but they do not have control of the type and number of vehicles operated, nor how these vehicles are operated. This makes setting and achieving fuel consumption and efficiency goals challenging for the City and something that requires leadership and cooperation and coordination of many competing departments and interests. This is the challenge of sustainable fleet management—to provide the same level of service with less energy and lower carbon emissions. It will require innovation and a clear focus on improving efficiency and eliminating waste.

The City and the EMD have been actively addressing this challenge and other city-wide fleet cost issues over the last several years. There are good practices and processes that establish a baseline from which to map a path forward. The next section will review some of these past successes and current practices that support and will facilitate the fleet management sustainability initiatives proposed in this plan.

The current policies, practices, and processes of the City of Tula include cost and resource control strategies related to fleet operations. These existing strategies set the baseline for the sustainability initiatives included in this plan. One of the key policies supporting fleet energy efficiency strategies is the Tulsa Code of (and Revised) Ordinances Title 12 Internal Policies; specifically, Chapter 1 Energy Policy which requires the City to actively promote energy conservation and implement cost-efficient energy savings in all of its activities and operations. The ordinances have specific policy objectives regarding City transportation and fleet energy consumption, including:

100+

Number of hybrid and alternative fuel vehicles currently in City of Tulsa Fleet

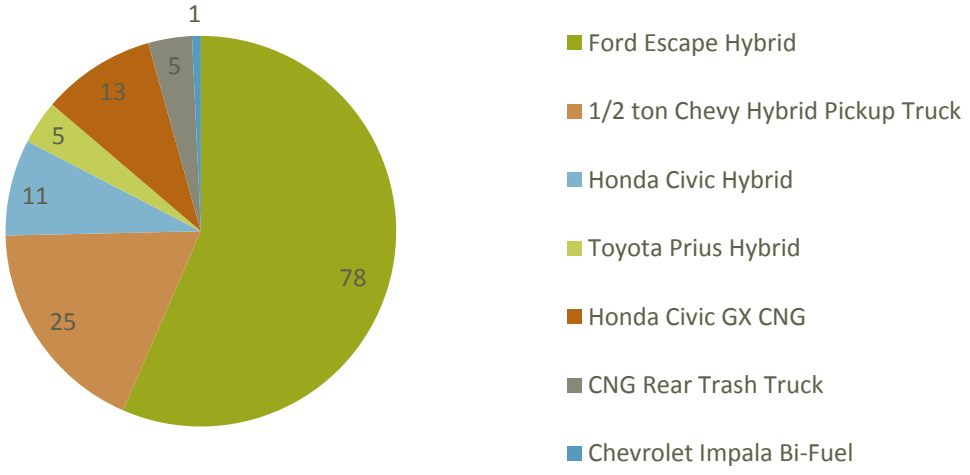
- Evaluating the feasibility of using of hybrid powered or alternative fuel powered vehicles
- Developing annual fuel use reduction objectives for each city administrative department, division, board, commission, authority, or agency.
- Carefully consider the need, use, vehicle size, and fuel efficiency before the acquisition of any new or replacement city vehicle.
- Ensuring that all vehicles have a fuel efficiency rating equal to or better than the vehicle being replaced.

Vehicle Procurement and Control

Despite this policy, the existing vehicle procurement process does not involve a formalized methodology or process for considering fuel efficiency for all new City vehicles. Currently Central Purchasing manages the actual bidding, contracting, and purchasing of the vehicles, but the detailed vehicle specifications are developed by the larger City departments, namely Police, Public Works, and Fire Departments. The vehicle specifications tend to focus on the mission needs of the department instead of fuel efficiency. In many cases, this equipment is so specialized, such as fire trucks and construction equipment, that fuel efficiency or alternative fuels are not considered as important as the intended departmental function.

EMD prepares specifications for vehicles used by the remaining City departments and for less specialized vehicles and equipment. EMD puts a greater focus on operating costs and fuel efficiency in developing their specifications. In fact, the EMD has been a longtime proponent of better fuel economy and use of Compressed Natural Gas (CNG) as an alternative fuel. In this regard, EMD is leading the way in improving the overall fuel efficiency of the City fleet. Through their efforts and leadership, the City of Tulsa has 138 hybrid, CNG or alternative fuel vehicles as of 2011. The City's 78 Ford Escape Hybrids have been particularly useful, cost effective and well accepted (see Exhibit 31).

Exhibit 31: City Fleet Count by Vehicle Make/Model



Fleet Data Management

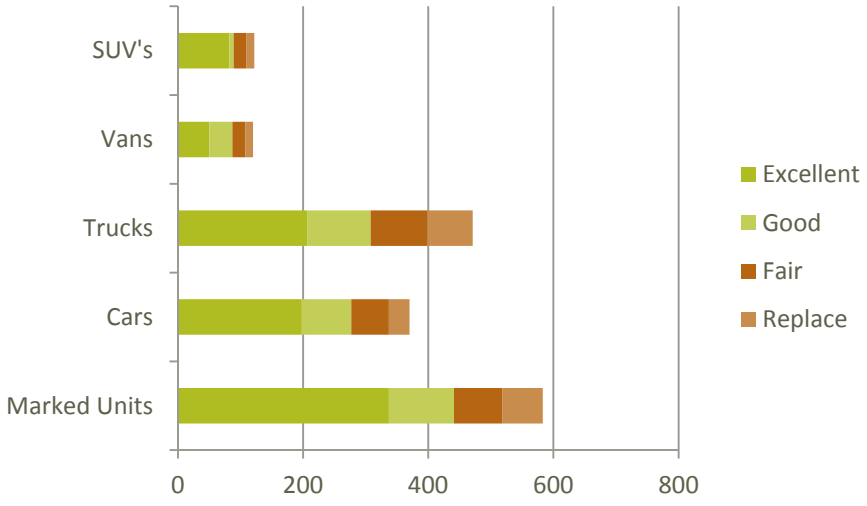
The cost effectiveness and overall operating costs of City-owned vehicles and equipment is tracked by EMD as part of their recordkeeping of maintenance and fuel distribution activities. This is an important function and service they provide, and it is critical to their department's mission. EMD uses automated systems and specialized fleet management computer programs to maintain and manage the data for each vehicle.

One of these core software programs, AssetWorks (the current Version M4, and prior versions), has been in use for almost 20 years. One module of Assetworks, called Fleetfocus, tracks all functions related to the maintenance of vehicles and equipment, including processing repair and preventive maintenance PM work orders and capturing operating expenses (e.g., fuel, oil, and licensing), and offers billing and tracking for vehicle equipment usage. Another module, Fuelfocus, collects and manages data from the City's fueling dispensing facilities.

Using the data from AssetWorks, EMD prepared a Fleet Utilization Scoring System (FUSS) in early 2011 to help set replacement priorities for City of Tulsa vehicles under 1-ton gross vehicle weight (GVW). The FUSS is an extension of a 2008 Equipment Study that was prepared to set replacement priorities for vehicles over 1-ton GVW. The FUSS is based on the American Public Works Association Vehicle Replacement Guide. The FUSS considers factors such as age, mileage, reliability, downtime, maintenance and repair costs, fuel use, and fuel efficiency (MPG).

The results and findings of the FUSS recommend 195 specific vehicles that scored poorly in the criteria for replacement. A summary of the scoring and recommended replacements are shown in Exhibit 32. One of the main benefits of the FUSS approach is that it facilitates rotating less fuel efficient vehicles out of the fleet and thereby raining overall fleet fuel efficiency.

Exhibit 32: FUSS Scoring Results by Vehicle Type



In addition to managing the costs of fleet maintenance and tracking fuel and operating costs, the EMD has implemented sustainable fleet management strategies that benefit the City and support energy innovation and the smart use of resources. Several of the prior initiatives and ongoing

strategies include piloting the use of hybrids and expanding use of hybrids and evaluating alternate fuels and vehicles. One key initiative is the use of CNG-fueled vehicles and the development of CNG fueling infrastructure.

Compressed Natural Gas

The City's initiative to evaluate and transition to CNG vehicles is driven by the many potential benefits that CNG- fueled vehicles can provide, including significantly lower fuel costs, lower air emissions, lower carbon footprint, and less maintenance. Furthermore, CNG is a local Oklahoma-sourced fuel (instead of imported petroleum). The City currently owns and operates 18 CNG-fueled vehicles: five large refuse trucks and 13 Honda Civics. While this is not a large percentage of the fleet, it is a start. Vehicle operating data to date show that the vehicles are very cost effective.

The City has installed fast-fill and time-fill CNG vehicle fuel dispensers at the EMD West Maintenance Yard fueling depot. Plans are proceeding to install additional fueling capacity at this location, including a public fast-fill CNG dispenser. This approximately $1,000,000 of fueling infrastructure will have been paid for with a combination of grants and city funds, with 65% of the money coming from the City of Tulsa and 35% from the U.S. Department of Energy.

Fleet Services Review

During 2011 a Fleet Services Review was conducted by CST Fleet Services, a consultant hired by the City's Management Review Office. This review confirmed that EMD was using many practices and processes that are considered best fleet management practices, some of which are summarized above. The consultant report also acknowledged the challenges posed by decentralized fleet ownership—most of the control over the vehicles resides within the City's departments. Some of the major recommendations made by the consultant that relate to sustainability are:

Fleet Right-sizing - City departments have historically controlled their own vehicle purchases. This has led to significant overbuying and redundancy. When benchmarked with cities like Houston, Indianapolis, and Chicago, the City probably has too many vehicles. It was recommended that the City could probably reduce its fleet size by about 22% (about 550 vehicles) with no loss in employee effectiveness.

Create a Fleet Management Steering Committee - To facilitate the fleet rightsizing and to prevent fleet creep once the the right size fleet is obtained, it was recommended that the City implement a single board with accountability to the Mayor. This board would consist of representatives from all City departments that use vehicles who would authorize and coordinate vehicle purchases.

Consider Shop Consolidation – The City has six EMD maintenance shops. Without reducing maintenance personnel, there may be an opportunity to close two of the six shops. In addition, it is possible to improve customer service while reducing costs. Operating fewer facilities would probably reduce the energy used by the EMD maintenance shops.

Non-Fuel Equipment Management Sustainability Progress

In addition to fuel savings and fleet efficiency, EMD has implemented several other sustainability strategies. For example, EMD has taken the following energy- and resource-effective steps to reduce impacts and save the City money:

- Lighting has been upgraded at several shops and EMD managed facilities.
- Water recycling is being practiced at vehicle washing stations.
- Used motor oil is being used in specially designed used oil heaters to provide heat to shop areas.
- Recycling programs are in place for used motor oil and other maintenance fluids.
- A body shop salvage program has been set up to and reuse vehicle body parts where possible.
- EMD has installed Stage 2 vapor recovery on gasoline dispensers. This is over and above the requirements of local air pollution regulations.

Fleet Sustainability Objectives and Plan Initiatives

Sustainability initiatives for fleet management proposed in this plan are based on four objectives that resonate with the overall vision of Tulsa becoming a leader in sustainability and energy efficiency. Four key fleet management initiatives to support these objectives are presented in the remainder of this chapter. Refer to Appendix 1 for a table of these initiatives and the specific recommendations.

Fleet Management Sustainability Objectives

- Reduce energy use and costs to operate the City fleet
- Reduce carbon footprint of City fleet
- Streamline energy data collection from City fleet operations and make dashboard summaries and details readily available to City departments and City administration
- Lead the region in adopting CNG as a cost-effective, secure, and locally sourced transportation fuel and capture the related economic development opportunities.

Initiative #1: Develop and Implement a Plan to Right-Size the City Fleet

Issue Total fleet costs are directly related to the number of vehicles and pieces of equipment in a fleet. The size of the City of Tulsa fleet has traditionally been established by the City departments with budget approval from City Council; however, this is changing. In a June 30, 2011 memo to City department heads, the Mayor asked the Management Review Office and the Equipment Management Department to develop and implement a plan to “right-size” the City’s fleet and to prevent unintended fleet growth in the future. The intent is to keep vehicle spending in line with true operational needs. The challenge is that this drive to reduce costs by trimming fleet size can result in pressure to eliminate vehicles on one side, and pressures from City departments to retain vehicles on the other. In addition to the number of vehicles, right sizing the fleet also includes optimizing the size and weight of vehicles, which can improve overall fuel efficiency and lower annual fleet operating costs. Some Departments may be expected to explain why they are motivated to resist use of right-size vehicles; however, in many cases a smaller vehicle will fully meet the mission-critical needs.

Averting potential conflicts when rightsizing the fleet will require accurate fleet operating data and rational decisions. It will also require City Departments to increase their overall fleet utilization with a focus on efficient use of their vehicles to complete their operational mission while maintaining the

same or better delivery of City services. Often, to accomplish this involves a deep-dive review into the mission, methods, and staffing, and operating procedures of a department. Getting to the optimum fleet would involve innovative solutions and new paradigms, and may involve elimination of certain vehicle “perks” that may have been considered “rights”, or even part of negotiated employment contracts. Change in these areas may not come quickly but goals and objectives should be set according to this Plan.

The benefits of successfully implementing this initiative would reduce motor fuel consumption and reduce fleet operating costs for the city. Using the right-size vehicles will also improve overall fleet fuel efficiency. Therefore this initiative supports both objectives 1 and 2.

Recommendations

- Use motor pools to decrease the number of vehicles assigned to individuals and expand the pool of "unassigned" vehicles that can be used by multiple users and multiple departments. Use vehicle reservation systems to end sense of “ownership.”
- Set Departmental goals to reduce the number of vehicles per person. Consider Departmental needs by vehicle class and employee assignment. Include consideration of inter-departmental sharing of specialized equipment with low utilization.
- Align the vehicle procurement process for all City departments with the City’s sustainability vision. Fully enforce the Tulsa Code of Ordinances Energy Policy at Title 12, Chapter 1, Sec. 102.D, which among other provisions, requires that the need, use, vehicle size, and efficiency be carefully examined and considered prior to acquisition of any new or replacement city vehicle.
- Develop or establish use of a calculation tool and standard protocols to assess Total Cost of Ownership for any new or replacement city vehicle. The Total Cost of Ownership considers initial capital costs, fuel costs for the expected life of the vehicle, and other ongoing maintenance costs.
- Decrease the number of vehicles assigned to individuals and expand the pool of "unassigned" vehicles that can be used by multiple users. Use vehicle reservation systems to end sense of “ownership.” Establish baselines and set Departmental goals to reduce the number of vehicles per person. Consider Departmental needs by vehicle class and employee assignment.

Efforts to right-size the fleet and right-size vehicles will certainly involve behavior transformation within the City departments. Leadership and adherence to a common vision of a sustainable future for the City of Tulsa will facilitate this transformation.

Key Performance Indicator

The key performance indicator is total fleet size, meaning the number of vehicles. The fleet of “rolling stock” and of road vehicles and equipment should be tracked separately.

Target

Reduce the City’s “rolling stock” fleet of on-road vehicles by 550 within 5 years.

Initiative #2: Increase the net fuel efficiency of the Fleet

Issue

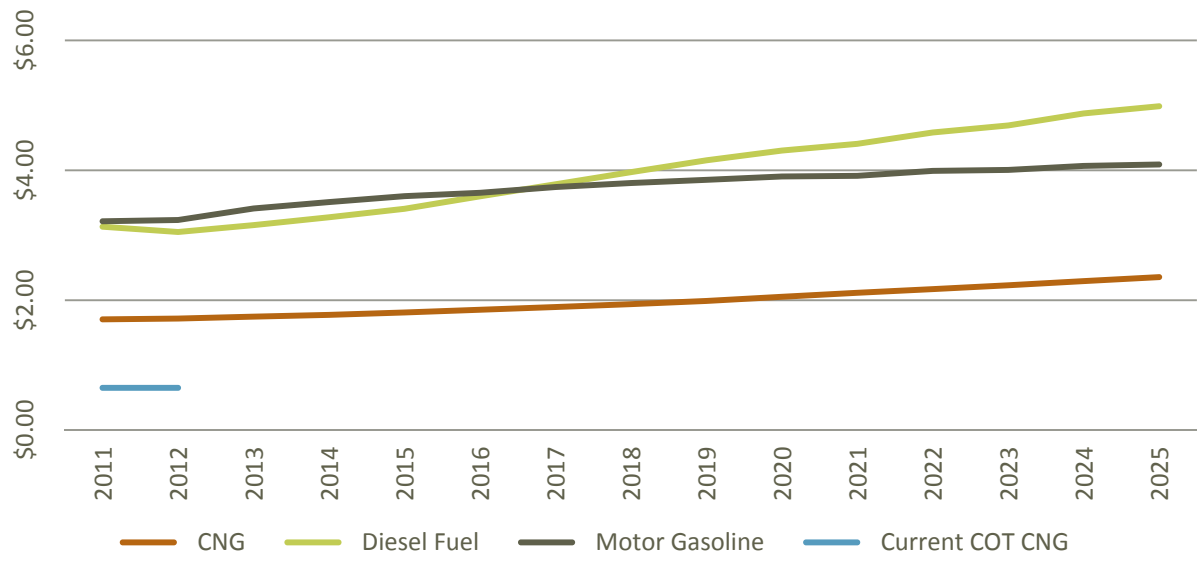
To most people, the need to improve fuel efficiency is an obvious issue in a world of decreasing fossil fuel supply and rising prices. The amount of City funds spent on motor fuel is directly related to fuel consumption and fuel consumption depends both on the fuel efficiency of the vehicles and that make up the City's fleet and fleet utilization. In other words, the cost of motor fuel depends on the total Vehicle Miles Traveled (VMT) and the fleet's average Miles per Gallon (MPG). Exhibit 33 show current cost projections for liquid fuels over the next 15 years.

20,157

Metric tons of carbon dioxide emitted from City's Fleet in FY2011

Another significant factor in the cost equation is the unit cost of motor fuel, and that, with one key exception, is beyond the control of the City. The 80% increase in fuel prices experienced in FY2011 is a prime example. However, the City can affect the mix of fuels needed to operate the fleet when procuring new vehicles. The next initiative addresses the fuel mix of the fleet. Initiative #2 is focused on improving the fuel efficiency of the City's fleet. By applying appropriate technology, policies, management, and procurement, the City can improve the net average fuel efficiency of their current and future fleet.

Exhibit 33: Motor Fuel Price Projections ($ per diesel-gallon equivalent)[22]



The benefits of successfully implementing this initiative will be a reduction in motor fuel consumption and a reduction in fleet operating costs for the city. Therefore this initiative also supports both objectives 1 and 2.

[22] Data from U.S. Energy Information Adminstration, Annual Energy Outlook 2011. Data Set: Energy Prices by Sector and Source, United States, Reference case. Note the current realized price of CNG includes a $0.50 Tax Credit and local discount for bulk purchase agreements and is about $1 less than EIA projection.

Recommendations

The following recommendations are specific actions that the City can take to implement this initiative to increase the net fuel efficiency of their vehicle and motorized equipment fleet.

- Finalize the Draft Idling Policy by amending Tulsa City Ordinances to add this policy to the Energy Policy of Title 12, Section 102, D. Fully implement and enforce the new ordinance and provide training to city employees who use City vehicles and equipment. Conduct a City outreach program to dispel the myths and teach the facts about idling.
- Fully enforce the Tulsa Code of Ordinances Energy Policy at Title 12, Chapter 1, Sec. 101 and 102.D, including requirements to carefully examine the need, use, vehicle size, and fuel efficiency prior to acquisition of any new or replacement city vehicle.
- Develop and require use of a calculation tool and standard protocols to assess Total Cost of Ownership, including life-cycle estimated fuel consumption, and compare alternative fuel and energy efficient technology options for any new or replacement city vehicle or motor fuel-using equipment.
- Continue to replace older less efficient vehicles and equipment with more efficient equipment according to the findings of the 2011 Fleet Utilization Scoring System.

Fuel efficiency is a fundamental characteristic of vehicles and equipment that significantly impacts the total city cost of ownership and operation. Appendix 1 presents additional recommendations and details to implement this fleet management sustainability plan initiative. Metrics to be used to monitor and verify the successful implementation plan, along with the proposed targets and an implementation timeline, are included where applicable. In most cases, specific reduction values will not be specified until a baseline value is established and the involved City departments are consulted.

Initiative #3: Increase the use of CNG in City Fleet

Issue

Petroleum-based vehicle fuels are subject to global market pressures and costs are increasing substantially. However, there is a domestic supply of an alternative vehicle fuel—natural gas, which is produced in Oklahoma. Furthermore, technology exists today to operate a large portion of the City of Tulsa fleet on compressed natural gas, or CNG.

CNG costs on average one-third less than conventional gasoline at the pump. This cost advantage is expected to continue into the future.

Natural gas is also the cleanest burning fuel available for the transportation industry. Natural gas vehicles emit up to 95% less pollution than gasoline or diesel vehicles. Compared to gasoline or diesel, natural gas significantly reduces the emissions of hydrocarbons (HC), nitrogen oxides (NOx) and lowers amounts of carbon dioxide (CO_2) (see Exhibit 34).

The consumption of natural gas reduces our energy dependence on foreign supplies and greatly contributes to our country's energy security. Natural gas is abundant and the United States has a large domestic supply of natural gas with a growing infrastructure to extract, transport, and deliver it. There are over 1,200 CNG vehicle fueling stations currently in use in America and 12 of those stations are within 50 miles of Tulsa.

Maintenance costs of natural gas vehicles can be significantly reduced due to the need for fewer oil changes and less engine wear because there are fewer particulate materials produced during the combustion cycle.

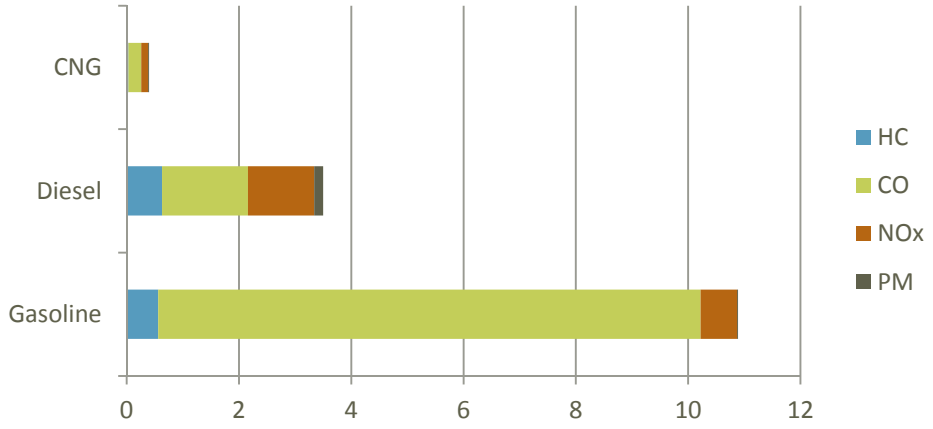
50 billion

Dollars each year that could be saved if just 10% of America's vehicles convert to CNG fuel.

284

Proven wet natural gas reserves in trillion cubic feet in the United States.

Exhibit 34: Air Pollutant Emissions by Fuel Type



Recommendations

The key recommended actions to implement this initiative involve investments in CNG vehicles and fueling infrastructure, and stakeholder education. Four specific recommended actions are:

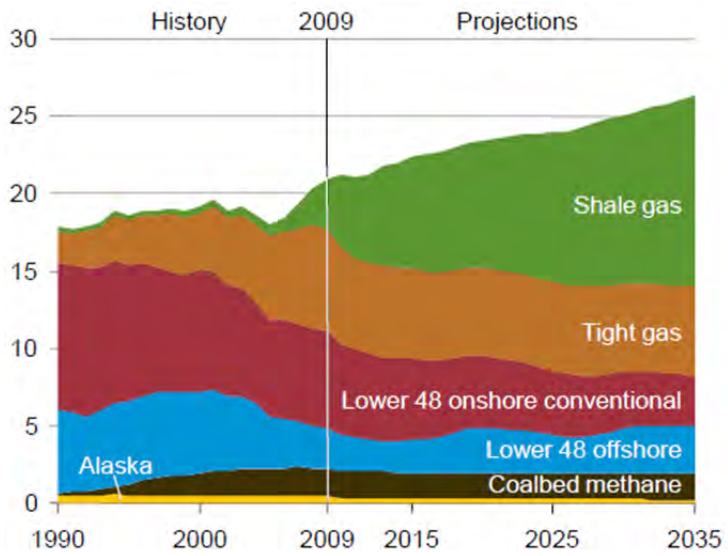
- Invest in (and seek grants for) City fleet CNG fueling sites
- Encourage and support development of private CNG fueling sites within the City of Tulsa.
- Purchase and operate Pilot CNG vehicles for all new or replacement city vehicles if the CNG fueling infrastructure, the Total Cost of Ownership, and the need, use, vehicle size, and efficiency make sense.
- Educate City employees, department heads and fleet stakeholders about the benefits of CNG.

Economic Development Opportunities related to CNG

In addition to being a locally sourced and cost-effective vehicle fuel, the use of CNG as a vehicle fuel could also support the local Tulsa economy and enhance job growth within the region. There are several existing companies and educational institutions within the Tulsa area that are directly involved in natural gas vehicles, fueling infrastructure, and CNG vehicle technology.

- The natural gas distribution company ONG is an obvious commercial stakeholder in CNG technology. Three of the CNG fueling stations in Tulsa are owned by ONG. ONEOK, which owns ONG, is also headquartered in Tulsa.
- Another Tulsa-based corporation in the CNG business is Tulsa Gas Technologies, the largest manufacturer of CNG dispensers in North America.
- Crane Carrier Company is a heavy-duty truck manufacturer and leading producer of Class 6, 7 & 8 alternate-fueled vehicles equipped with CNG or LNG systems. Their division headquarters, manufacturing operations, and primary parts distribution center are based in Tulsa.

Exhibit 35: Natural Gas Production Projections (2011-2035)



Initiative #4: Integrate Fleet Data into Overall City Sustainability and Energy Data Management Program (Hara)

Issue

EMD currently maintains detailed, vehicle by vehicle records of maintenance and fuel consumption using the existing AssetWorks system. Based on these records the City Departments that "own" the vehicles are invoiced for the fuel and services EMD provides. Because of the need to maintain these detailed records and track costs for interdepartmental fund transfers, the data management systems maintained by EDM are robust and proven over time.

EMD also uses the data to produce annual and other periodic or on demand reports to City management and departments. For example, the 2011 Fleet Utilization Scoring System Report is an innovative use of the City's vehicle operation and maintenance data. The approach and data processing provides City management with a way to prioritize vehicles for replacement as well as identify underutilized equipment. Another example is the annual reporting of fleet energy use and fleet fuel efficiencies as required by the City's energy policy.

However, there are several issues with the current recordkeeping program that do not fully support this Sustainability Plan. One issue is that it is a standalone system; the data is not easily or automatically aggregated with other citywide energy consumption data. A second issue is that the EMD program does not calculate greenhouse gas (GHG) emissions for the fleet operations. A third issue is that it does not have a method for setting quantitative sustainability goals and tracking progress toward meeting them.

Recommendations

- Use the new version M5 of AssetWorks, a planned upgrade to be installed in 2011, to track fleet fuel consumption and vehicle use data (miles traveled). The new browser-based M5 version of the program includes dashboards and efficiency reports for informing departments of their performance.
- Run periodic reports (at least annually) in AssetWorks and output these as Microsoft™ Excel files. These files can be scrubbed for data anomalies and insignificant equipment (such as non-motorized trailers) and prepared for importing into the Hara EEM Sustainability platform. The Hara interface will also allow tracking and analysis of the City's progress toward initiatives 1, 2 and 3 in dashboard.
- Install radio frequency identification (RFID) on rolling stock (rate of implementation depends on a Federal Grant that is pending)

These recommendations are detailed in Appendix 1 along with proposed metrics to monitor and verify the successful implementation of this initiative. Implementation milestones are included where applicable.

The key to managing energy as a program versus managing it as a project is to establish program metrics and performance requirements to achieve continuous improvement. Implementing this initiative to integrate fleet data will support establishing achievable program goals and gathering data to measure performance against these goals. Integrating fleet data into a City-wide program would allow best practices to be tracked and evaluated. It would also support implementation of this plan's fleet management initiatives and reporting of program achievements through a variety of communication channels.

Sustainable Procurement

Integrate life-cycle cost analysis into purchasing process

State and municipal governments together spend an estimated $12 billion per year on energy bills and another $50-70 billion per year on energy-related products. [23] The City of Tulsa spends approximately $75 to 100 million per year on goods and services, and an additional $300 million per year on construction projects. What the City buys not only has upfront costs, but also life-cycle costs for operations, maintenance, and disposal.

Sustainable procurements, which conserve resources, save the City money, and/or add jobs and associated skilled labor to the area. These procurements further the realization of the City's overall sustainability vision – to "create high quality places for people to live, work, and play, but with a small footprint on the environment." [24] Obtaining quality goods and services that meet performance requirements, are reasonably priced, and are delivered on time are basic criteria in any procurement. Critical components of any sustainable procurement initiative are specifications and contracting mechanisms that direct bidders to respond with sustainable solutions in addition to basic procurement criteria.

The following summary of the City's current practices and the types of procurements addressed in this plan highlight the challenges and opportunities the City faces when implementing sustainable procurement. Recommended objectives and initiatives, along with example approaches to specifications, are provided to address those challenges and capitalize on those opportunities. Case studies and tools follow. Rejected initiatives are also provided so that if conditions at the City change, these initiatives could be reevaluated for potential future implementation.

$300M

City of Tulsa estimated annual construction costs

Current Practices

Multiple departments, guided by three committees, are responsible for the types of procurements that would be addressed in the City's first sustainable procurement initiative:

- Standards, Specifications, and Awards Committee (SSA) works in conjunction with Centralized Purchasing, which oversees procurement of contractual services, professional services, supplies, and equipment. Centralized Purchasing is responsible for routine maintenance services for a variety of city departments and operations. End users create technical

[23] Dolin, J. and N. Raynolds. 1998. "The ENERGY STAR® Purchasing Initiative." Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings. Asilomar, CA. August. http://enduse.lbl.gov/Info/ACEEE-ESTARProc.pdf

[24] http://www.planitulsa.org/vision/planchapters/sustainability

specifications for needed goods and services, which Centralized Purchasing reviews and then provides to the SSA for approval. While Central Purchasing is also responsible for City vehicle fleet purchases, the Police Department and Fire Department create their own vehicle specifications, and routine fleet repair and maintenance is overseen by the Equipment Management Division (EMD).

- Professional Consulting Services Selection Committee (PCSSC) works in conjunction with the Engineering Department, Water and Wastewater Department, and Streets, Stormwater and Facilities Department (all of which were formerly consolidated under Public Works) to oversee procurement of services for design of public improvement projects related to the drinking water and wastewater treatment plants, new facilities, parks, streets and infrastructure, special projects and other large-scale City improvements. End users either write technical specifications or work with staff in the relevant departments to collaborate on their creation.
- Pre-Qualification Committee works in conjunction with the Engineering Department and the Legal Department to confirm that technical, legal, and other administrative requirements have been met in selected construction bids. The Engineering Department creates construction specifications, or uses those created by outside A&E firms during a project's design phase, when preparing construction bid documents.

Engineers and other technical staff in Central Purchasing, Engineering, Water and Wastewater Department, and Streets, Stormwater and Facilities Department work with City customers, including end users, operations, and maintenance personnel to create technical and/or performance specifications for bid documents. The bid documents are then prepared by procurement professionals in their respective departments and include both unique procurement-specific requirements such as detailed technical and/or performance-based specifications and selection criteria, and more universal requirements such as terms and conditions, affidavits and other standardized documents that provide consistency and result in legally compliant packages.

Clear selection criteria are critical to reduce the risk of contract selection protests. The various aforementioned oversight committees serve some or all of the following roles depending upon the department(s) involved and the nature of the procurement: identify qualified bidders, approve specification and bid packages, approve bid awards, hear protests of bid award recommendations, and approve bidder selection recommendations before they are sent to the Mayor for award.

The City accomplishes the majority of its significant procurement actions through a number of mechanisms, including competitive invitations for sealed bids and requests for proposals, depending upon the nature and cost of the procurement. City ordinance often dictates what mechanism can be applied, and is currently undergoing revision to allow expanded use of performance-based contracting clauses where appropriate.

Capital improvement projects typically run on a five-year cycle from inception to design and construction. Capital improvement projects are broken down into design versus construction services, which are carried out by different firms. Design services are selected based on bidder qualifications, with fees for designs and their associated cost estimates subsequently negotiated. Construction firms then bid on a given project using the design firm's specifications, or using Engineering Department specifications, and are selected based on lowest cost. Construction bids often consist of "base bids" and "add alternates" bids; selection is based on total cost for both, but "add alternate" are optional. More routine purchases, which are typically the responsibility of Central Purchasing, can be executed by the selected bidder within days, weeks, or months depending on the urgency of the need and the cost of the purchase. Central Purchasing selects bidders based on "lowest secure bidder" criteria which can take into account factors other than cost.

The City has recently begun to develop utilization goal programs for women and minority-owned businesses, and a "tie bind" preference for local bidders is included in the current Purchasing Ordinance. This means that, where two or more bidders are equal in cost and quality, the local bidder is awarded to break the tie. Award selection primarily focuses on up-front costs for goods/services once a bidder's qualifications and ability to meet performance requirements/specifications have been determined. Full life-cycle costs, i.e., total cost of ownership, for more sustainable versus traditional goods and service offerings are not routinely requested from bidders, nor are they routinely determined internally by City personnel to aid in bid selection. Some notable recent exceptions include information technology procurements, vehicles, and heavy equipment, which included preventive maintenance, extended warranty, and fuel cost considerations; bids for both hybrid and traditional Ford Escape vehicles for potential fleet purchases; and pricing both CNG and diesel fuel trucks for City solid waste collection.

There are several procurement-related information systems at the City of Tulsa, such as:

- GEAC Financial System
- OnDemand reports
- Supplier Tracker bidder registration and notification system
- Imaging Content Manager document storage system
- BarScan asset tracking system

These systems do not communicate with each other, making tracking, and performance assessment of sustainable procurement decisions challenging and potentially costly. Quality assurance, which is responsible for comparing goods and services to contract documents to ensure compliant procurement, has also been a challenge due to staff limitations, although Central Purchasing has recently added additional staff members from the Inventory Control section of the former Public Works Department to assist with this process. In general, quality assurance usually falls to end user department personnel who then communicate with procurement professionals when a potential non-conformance is identified.

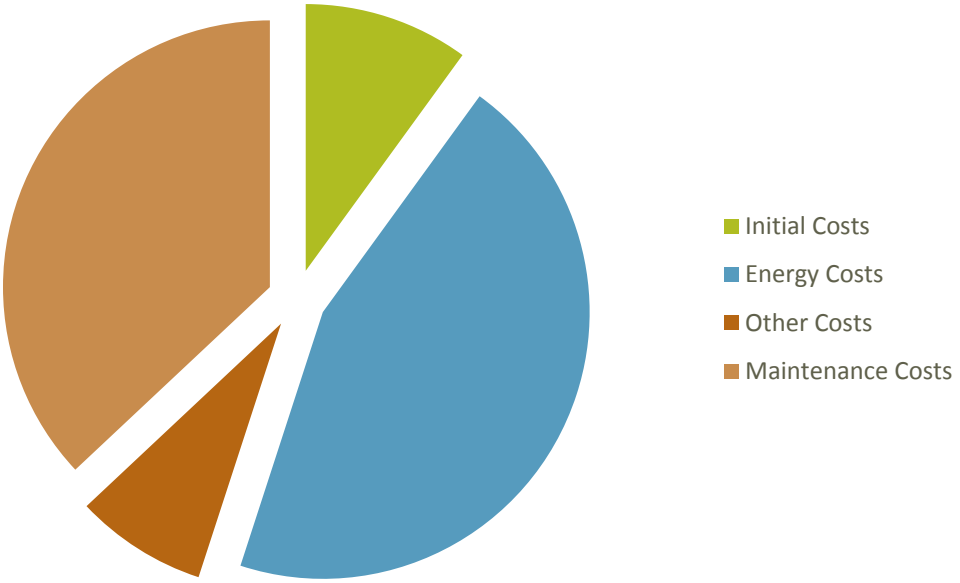
The City of Tulsa is currently undergoing a detailed operations and efficiency review of its fleet purchasing, management, and operations process in order to reduce redundancies and increase efficiencies. Please refer to the Fleet Management section for additional details.

Significant Procurements for Inclusion in the Plan

The City of Tulsa's sustainable procurement efforts would initially focus on significant procurements–capital improvement projects, and other procurements valued at $25,000 or greater–of the following systems and equipment:

- Building mechanical systems (i.e., HVAC, hot water heaters, pumps, and motors)
- Lighting – both outdoors and inside buildings
- Fleet vehicles
- Water treatment chemicals

Exhibit 36: Typical Life Cycle Costs for a Medium-Sized Industrial Pump[25]



These systems and equipment were selected for inclusion in the plan due to the high costs to procure, operate, and maintain them over their expected lifetimes. As the program matures, the City may choose to expand its sustainable procurement efforts to address other areas of consideration such as environmentally preferable materials or product carbon footprints.

Objectives and Examples of Revised Specifications

The objectives of the City of Tulsa's sustainable procurement program are to:

1. Apply a life-cycle analysis approach to cost evaluation in order to select more energy efficient systems/equipment with reduced long-term operating expenses
2. Create specifications that are a blend of detailed technical and performance- based requirements, thereby fostering non-restrictive, competitive bidding
3. Encourage suppliers to become partners in Tulsa's long-term growth and economic development where appropriate.

[25] "Pump Life Cycle Costs: A Guide To LCC Analysis For Pumping Systems", US DOE, January 2001.

Recommended Initiatives

The following initiatives are recommended to achieve the City's sustainable procurement objectives.

Initiative #1: Issue a Sustainable Procurement Executive Order

An Executive Order sets broad operational goals for all departments; individual departmental policy statements and procedures are then revised accordingly. An Executive Order directing staff to incorporate life-cycle costs into city procurement decisions should communicate the City's sustainable procurement objectives without the additional time and coordination challenges that can come with adopting a City ordinance.

Initiative #2: Train City Personnel

A total cost-of-ownership approach to selecting more energy efficient systems/equipment with reduced long-term operating expenses is a new approach to procurement for the City, which is primarily focused on up-front costs once a bidder has satisfied performance and qualification criteria. As total ownership costs include both up-front and longer-term operations and maintenance costs, it is critical that representative end users, procurement staff, and budget analysts be included in the training. Two forms of training are recommended: awareness level and practitioner level. Awareness level training will help make key members of the City's procurement community aware of what this new approach entails and how the City intends to implement it. Practitioner Training will provide more detailed information to contracting personnel and specification writers. Training will therefore target the following personnel:

- SSA Committee Members
- PCSSC Committee Members
- Select user group representatives, including operations and maintenance
- Contract administrators
- Budget analysts

Training will focus on how to incorporate sustainability into specifications and contract language, when to apply performance-based specifications versus more detailed design specifications, and how to evaluate supplier bids and proposals to achieve a more sustainable outcome on a given procurement. Training will emphasize practical applications and incorporate relevant exercises and examples.

In addition to awareness level and practitioner training, the City would evaluate providing additional training and resources to enable select staff to obtain LEED AP, Certified Energy Manager, or similar certifications to enable them to:

1. Create/review specifications that incorporate energy efficiency requirements and critically evaluate bids for the efficacy of proposed solutions.
2. For construction projects, determine where more energy efficient solutions need to be integrated into base bid requirements and when "add alternate" designation is more appropriate.

Initiative #3: Educate Suppliers

Sustainable procurement requires support from suppliers. Web site content, fact sheets to accompany City solicitations, and workshops are ways in which the City can educate current and potential future suppliers on the City's sustainable procurement objectives and expectations.

Case Studies

The following case studies demonstrate the success of sustainable procurement practices and can inspire the City's program as it develops and matures.

- The Department of the Navy was the first federal agency to require that all facility- and infrastructure-related designs incorporate sustainable design principles. The Navy's definition of sustainable design includes selecting construction materials and mechanical systems based on their life-cycle impacts. Using these sustainable design measures, the Navy estimates an annual energy savings of $130,000 for one of its projects at the Washington Naval Shipyard and an annual energy savings of $110,000 for a bachelor enlisted quarters complex in Illinois. [26]
- The state of Wisconsin's decision in 2002 to purchase LED traffic lights using ENERGY STAR® specifications was based on the experience of other states and cities as well as technical advice from the state's Division of Energy. As a further public safety benefit, the low-power LEDs made it possible to install battery backup systems to operate signals during electricity outages. In many smaller communities, the State is also responsible for traffic signals on state highways. The State's use of LED signals thus helped local governments become familiar with the technology, which they were then able to purchase under State contract or from local suppliers.[27]
- Both the public and the private sector are beginning to embrace the concept of Net Zero in their facility designs. In simple terms, Net Zero buildings employ extremely efficient HVAC systems and lighting to reduce energy demand, and incorporate on-site renewable energy generation technology such as wind or solar energy. The building is designed such that its on-site renewable energy supply meets or exceeds its demand, resulting in "net zero" energy use. The nature of Net Zero design is to set a goal--zero net energy use--and allow architects and engineers via performance- based contracts the flexibility to determine how best to reach that goal within specified criteria such as purpose, employee occupancy, and building operating hours. The Aldo Leopold Legacy Center in Wisconsin, an interpretive center and commercial

[26] USEPA, Pollution Prevention and Toxics, 2000. Federal Pioneers, Environmentally Preferable Purchasing Success Stories From the Federal Government. EPA742-F-00-008. September.

[27] Harris, Jeffrey, et.al., 2004. Energy-Efficient Purchasing by State and Local Government: Triggering a Landslide down the Slippery Slope to Market Transformation. http://www.pepsonline.org/publications/Energy%20Efficient%20Purchasing%20By%20State%20and%20Local%20Government.pdf

office facility, was designed to use 70% less energy than a comparable conventional building. Day lighting eliminates the need for electric lighting during most of the day, and a rooftop photovoltaic array produces more than 110% of the project's annual electricity needs. Ground source heat pumps connected to a radiant slab provide heating and cooling. [28]

- The City of Aspen, Colorado, switched its police fleet to Toyota Highlander hybrids in 2008. Pilot testing allowed fine tuning of the vehicles for use in a police application, which included boosting the electrical systems to better power computer, radio, radar and video camera equipment. Driven under regular patrol use, the department achieved 21.73 miles per gallon (mpg) as compared to 12.9 mpg for the traditional fueled police fleet. The city projected a $7,000 annual savings in fuel costs per vehicle. Officers using the vehicles found the acceleration to be good and handling an improvement over their traditional fueled predecessor, and noted that the quiet nature of a running hybrid vehicle was a benefit while on patrol. In 2008, the City of Aspen's bulk purchase price for gasoline was $3.565 per gallon. [29] Because hybrid vehicles are typically more expensive to purchase than their gasoline counterparts, life-cycle costing is key to determine overall savings against up-front expense.

Relevant Tools

City procurement staff may find the following tools to be of assistance when developing sustainable procurement specifications:

- The U.S. Department of Energy's Federal Energy Management Program and the U.S. EPA's Energy Star® Program provide energy efficient performance specifications, energy cost calculators, and sample contract language for lighting and commercial and industrial equipment (heating and cooling systems, boilers, motors, and pumps). These specifications can readily be incorporated into bid packages by reference, and suppliers and procurement staff can use the calculators to estimate cost savings for particular projects. [30]
- Motor Decisions Matter, a national campaign sponsored by manufacturers, electric utilities, and nonprofit organizations to encourage the use of sound motor management and planning to cut energy costs and increase productivity, developed the 1*2*3 Approach to Motor Management. By reviewing a representative sample of motors and preparing a comparative financial analysis for future decisions based on life-cycle costing methods, 1*2*3 allows the user to make the most appropriate repair/replace decision for a particular motor. 1*2*3 also provides best practice motor management strategies. [31]
- The BEES (Building for Environmental and Economic Sustainability) software, developed by the National Institute of Standards and Technology Engineering Laboratory, is a web enabled tool for selecting cost-effective, environmentally-preferable building products based on consensus standards. BEES Online, aimed at designers, builders, and product manufacturers, includes actual environmental and economic performance data for 230 building products and is designed to be practical, flexible, and transparent. [32]

---

[28] US Department of Energy's Energy Efficiency and Renewable Energy Building Technologies Program, Zero Energy Buildings, http://zeb.buildinggreen.com/overview.cfm?projectid=946
[29] http://www.aspentimes.com/article/20080530/NEWS/363789003; http://www.aspenpitkin.com/Departments/Police/About-Us/Vehicles/Toyota-Highlander-Hybrid/
[30] http://www1.eere.energy.gov/femp/technologies/eep_purchasingspecs.html
[31] http://www.motorsmatter.org/tools/123approach.html
[32] http://www.nist.gov/el/economics/BEESSoftware.cfm

- US EPA has a SmartWay vehicle certification program. Each vehicle listed in its Green Vehicle Guide receives an Air Pollution Score and a Greenhouse Gas Score, on a scale of 1-10. For the SmartWay designation, a vehicle must receive a combined score of at least 12, with a minimum air pollution score of 5. EPA deems vehicles that receive the SmartWay designation to be very good environmental performers relative to other vehicles. SmartWay Elite is given to those vehicles that receive a combined score of at least 17, with a minimum air pollution score of 8. EPA provides an online searchable database of vehicles by type (cars, pickups, SUVs, and special purpose vehicles), state of purchase, and year of manufacture with SmartWay scoring. [33]

[33] http://www.epa.gov/smartwaylogistics/vehicles/smartway-certified.htm

Renewable Energy Feasibility Study

Harness abundant renewable energy sources

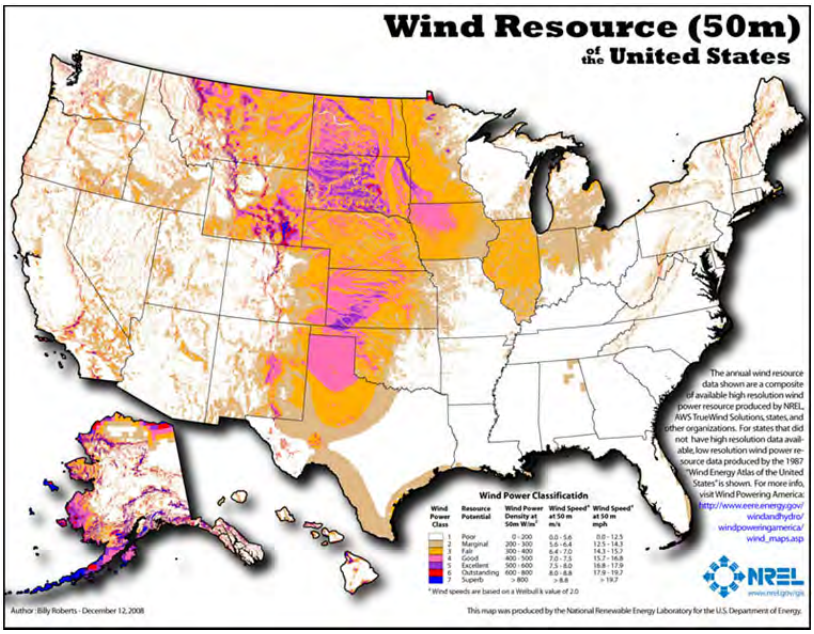


Over the last decade, renewable energy has undergone dramatic technology advancements and product cost reductions. Although renewable energy still relies on incentives and public policy to achieve financial viability, renewable energy generation serves an ever increasing role in meeting the environmental and energy challenges of the future. The Renewable Energy Feasibility Study section of the Sustainability Plan provides specific examples of renewable energy policies and measures that the City can implement to increase its supply of clean, renewable energy. The study investigates alternative energy options for both technical and economic feasibility. The economic feasibility of alternative energy options is measured against retail electricity and natural gas rates, which can be volatile and unpredictable. Alternative energy solutions can provide predictable long-term energy pricing which can provide certainty for budgetary planning. In addition to providing economic benefits, alternative energy can help meet environmental goals of reducing pollution and reducing dependence on fossil fuels. Renewable energy investment can also be used to foster local economic development and “green job” creation. To assist the City in developing a framework for renewable energy development, this section of the Plan contains a feasibility assessment of City properties and buildings, provides examples of codes and ordinances that promote the adoption of alternative energy, and evaluates potential opportunities for public outreach and education.

Renewable Energy Resources

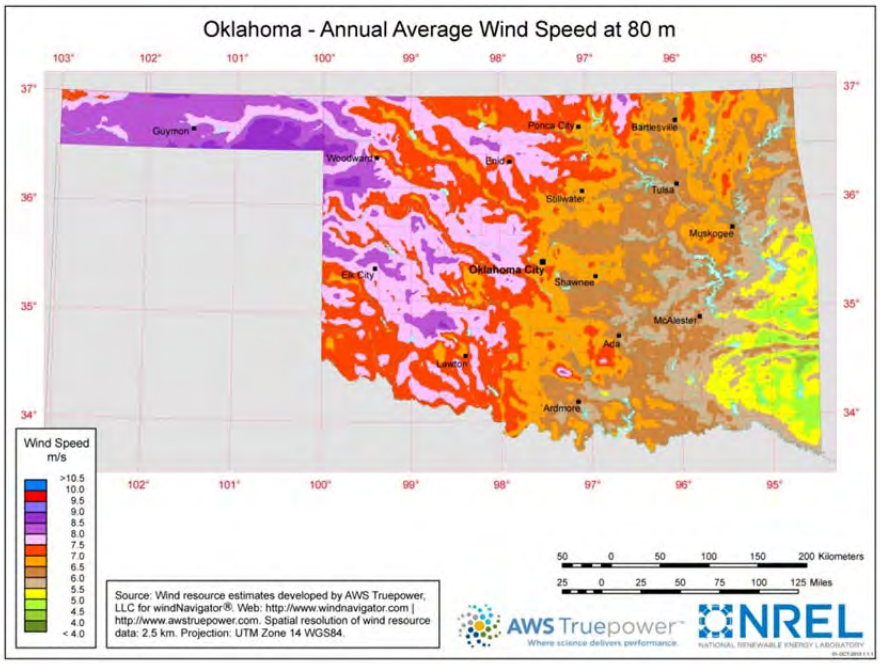
Exhibits 37 and 38 show renewable energy resource potential for wind and solar energy generation.

Exhibit 37. United States 50m Wind Resource Map



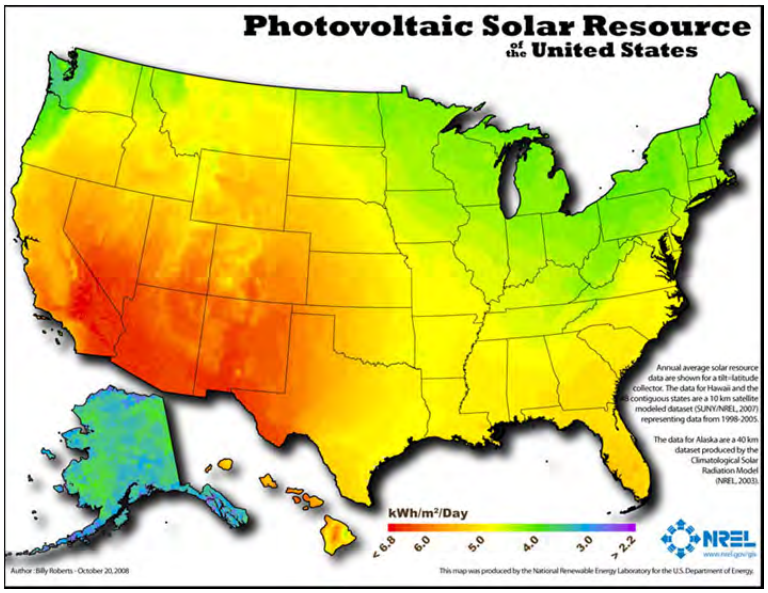
Source: NREL 2008

Exhibit 38. Oklahoma 80m Wind Resource Map



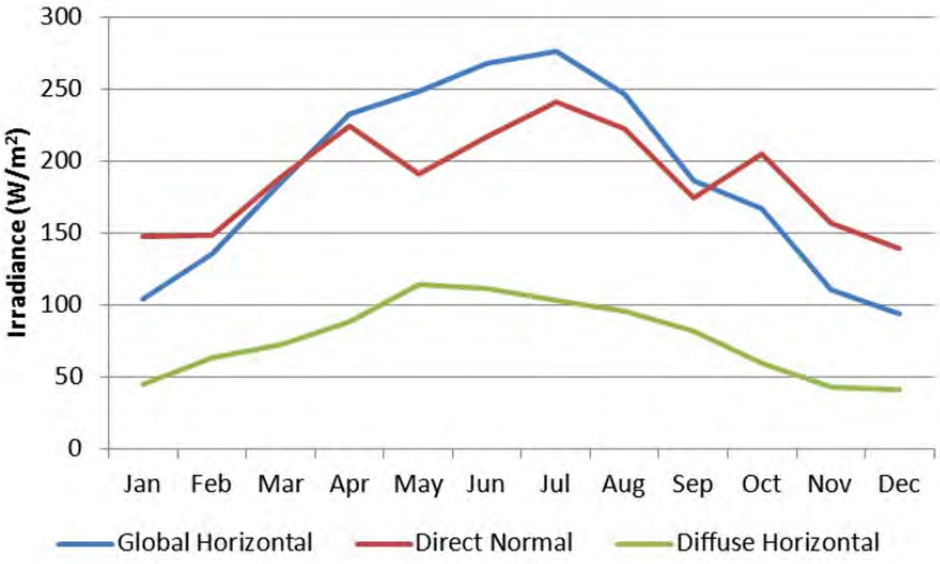
Source: NREL 2008

Exhibit 39. United States Solar Resource Map



Source: NREL 2008

Exhibit 40. Solar Resources in Tulsa, Oklahoma



The resource maps show moderate solar insolation levels and marginal wind speeds for the City of Tulsa and surrounding area. As evidenced by the statewide distribution of operational utility scale wind farms, the wind energy resources of western Oklahoma are better suited for development. The lack of adequate wind speed resources and presence of buildings and other obstructions in and around the City of Tulsa inhibits the viability of wind energy generation in an urban setting.

Renewable Energy Site Assessment

Before implementing a commercial or utility scale wind energy generation system at a City building or property, URS recommends that a comprehensive micro-siting study be conducted at potential host sites to verify and account for site wind speeds, wind shear, topology, and obstructions. The Page Belcher Golf Course, Hicks Park Community Center, and Central Recreation Center are high visibility candidate sites for wind energy generation. The high facility energy consumption and availability of unobstructed land at the AB Jewell, Haikey Creek, and Lower Bird Creek water treatment plants also make them potentially viable candidates. Conversely, the close proximity of the Mohawk, Southside, and Northside water treatment plants to the Tulsa International Airport and Richard Lloyd Jones Jr. airports is likely to create Federal Aviation Administration permitting issues and render those sites unsuitable for wind energy generation.

The initial phase of the renewable energy feasibility assessment was conducted as a site-by-site analysis of nearly 100 City buildings and properties. During the initial site assessment phase, URS reviewed facility site conditions such as facility energy consumption, renewable resources, available space, roof type, slope, surface orientation, accessibility, shading, and presence of obstructions (e.g., buildings, HVAC units, vegetation, etc.).

Conceptual solar PV array layouts for AB Jewell Water Treatment Plant, Mohawk Water Treatment Plant, Air Force Plant #3, Maxwell Convention Center, Central Recreation Center, Emergency 911 Facility, Fire Station #24, and Tulsa City-County Central Library are attached in Appendix 3.

Renewable Energy Financial Incentives

Investment Tax Credit

The federal business energy investment tax credit (ITC) available under 26 USC § 48 was expanded significantly by the Energy Improvement and Extension Act of 2008 (H.R. 1424), enacted in October 2008. This law extended the duration of the existing credits by eight years for solar energy; established new credits for small wind energy systems; allowed utilities to use the credits; and allowed taxpayers to take the credit against the alternative minimum tax (AMT), subject to certain limitations. The credit was further expanded by The American Recovery and Reinvestment Act of 2009, enacted in February 2009.

In general, the credits are available for eligible solar and wind energy systems placed in service on or before December 31, 2016. The solar energy credit is equal to 30 percent of expenditures, with no maximum credit. Eligible solar energy property includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. Hybrid solar lighting systems, which use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight, are eligible. Passive solar systems and solar pool-heating systems are not eligible.

The credit for wind energy systems is equal to 30 percent of expenditures, with no cap for small wind turbines placed in service after December 31, 2008. Eligible small wind property includes wind turbines up to 100 kW in capacity. Under the American Recovery and Reinvestment Act of 2009,

wind-energy systems of all sizes now qualify for the 30% ITC through the in-service deadline of December 31, 2012.

Production Tax Credit

The federal renewable electricity production tax credit (PTC) is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources including large wind energy and sold by the taxpayer to an unrelated person during the taxable year. Originally enacted in 1992, the PTC has been renewed and expanded numerous times, most recently by H.R. 1424 (Div. B, Sec. 101 & 102) in October 2008 and again by H.R. 1 (Div. B, Section 1101 & 1102) in February 2009. The February 2009 legislation revised the credit by allowing facilities that qualify for the PTC to opt instead to take the federal business energy investment credit (ITC). For wind energy, the tax credit amount is $0.022/kWh for systems installed before December 31, 2012. The duration of the credit for wind energy systems is 10 years after the date the facility is placed in service.

Accelerated Depreciation

Under the federal Modified Accelerated Cost-Recovery System (MACRS), businesses may recover investments in certain property through depreciation deductions. The MACRS establishes a set of class lives for various types of property, ranging from three to 50 years, over which the property may be depreciated. A number of renewable energy technologies including solar and wind energy are classified as five-year property (26 USC § 168(e)(3)(B)(vi)) under the MACRS.

Renewable Energy Asset Ownership

Because the City is not a taxable entity, tax-based incentives such as the federal business energy investment tax credit (ITC), the production tax credit (PTC), or federal Modified Accelerated Cost-Recovery System (MACRS) will not be accessible if the City owns the renewable energy generating system(s). However, public entities are able to take advantage of some financing options that are not available to private entities, including special incentives, tax-exempt leases, and government subsidy bonds. Done correctly, modest funding combined with low-interest debt can be sufficient to finance public renewable energy projects. Bonds and grants such as American Recovery and Reinvestment Act (ARRA) subsidies, Energy Efficiency and Conservation Block Grants (EECBG), and Clean Renewable Energy Bonds (CREB) allow public entities to reduce the cost of a new renewable energy measures. Public financing offers the ability to take advantage of Tax Exempt Municipal Leases (TEML), which allow public entities to finance projects by entering into lease agreements with traditional lenders. Offering full ownership and access to lower costs of debt, TEMLs can make renewable energy installations affordable for public entities

Equipment Lease

This option would allow the City to benefit from renewable energy in exchange for a monthly lease payment for the use of the system hardware. Typical renewable energy lease agreements are for a 20-year term at which point the lease can be renewed or the City can choose to purchase the system or have the system removed. For organizations like the City that cannot fully capitalize on available tax incentives and want to avoid upfront capital investment, a lease option may facilitate renewable energy development.

Power Purchase Agreement

Power Purchase Agreements (PPAs) are allowed in at least 21 states and Puerto Rico; however, according to the Database of State Incentives for Renewables and Efficiency, it is unclear or unknown at this time whether or not PPAs are allowed in Oklahoma.

PPAs are a form of third-party ownership which provide several benefits to municipal governments. PPAs would allow the City indirect access to tax-based incentives and would relieve the City from the burden of securing upfront project funding. Furthermore, the third-party system owner would be responsible for operations and maintenance (O&M) of the system rather than the City.

The PPA mechanism is a popular offering for solar energy providers. A solar PPA is a financing arrangement that allows the City to purchase solar electricity with no upfront capital cost. To achieve this, the City hosts a solar installation on City-owned unused rooftop, land, parking lot space, or other City-owned property. A third-party PPA provider pays for the cost of the solar installation and assumes all responsibility for ownership, operation, and maintenance after the solar project is complete. As the host organization, the City enters into an agreement to purchase the solar electricity produced by the system owned by the PPA provider at a predetermined rate per kilowatt-hour.

A well-structured PPA allows the City to reduce electricity costs immediately and realize increased savings over time as grid electricity prices rise. Once the PPA contract period expires (typically after 20 years), the City can purchase the system at a reduced price, initiate another PPA, or have the solar installation removed.

The PPA option offers several benefits. No initial capital investment is required on the part of the City. The City only pays for the solar electricity that is produced. Electricity is purchased at fixed rates that are locked in over the term of the contract. The City has no responsibility for owning, operating, or maintaining the equipment. The PPA financier is able to monetize available tax incentives and pass these savings to the City in the form of a lower PPA rate.

PSO WindChoice

PSO offers its customers the option to purchase 100% wind energy from wind farms located in Oklahoma for an additional $0.0172/kWh. The program is called WindChoice and Oklahoma wind power is sold in blocks of 100 kWh for $1.72 per block added to customers' regular PSO bill. PSO's WindChoice Program is the first Oklahoma utility renewable energy program that is Green-e Energy® Certified by the Center for Resource Solutions. If WindChoice was used to procure 100% wind energy for the electric energy needs of the AB Jewell Water Treatment Plant, the annual additional cost would be roughly $480,000. Similarly, to supply the Mohawk Water Treatment Plant with 100% wind energy using WindChoice, the annual additional cost would be roughly $275,000. For the Maxwell Convention Center, an additional annual cost of roughly $74,000 would supply 100% of the facility's electricity needs with wind power.

Case Studies

The following case studies outline successful renewable energy initiatives carried out other municipalities.

City of Houston, TX

The City of Houston's comprehensive renewable energy plan calls for the purchase of fixed-price renewable power to hedge against the rising cost of conventional energy and diversify its power portfolio. As part of this plan, the city purchases wind power totaling more than 350 million kilowatt-hours, earning it a spot in EPA's Green Power Leadership Club. Houston Mayor Bill White comments, "Purchasing green power helps our city become more sustainable and cost-effective, while also sending a message that supporting clean sources of electricity is both a sound business decision and an important choice in reducing harmful emissions."

City of Dallas, TX

As a member of the Green Power Leadership Club, the City of Dallas purchases more than 302 million kilowatt-hours of wind power annual to meet a significant portion of its annual electricity use. Dallas, says Mayor Tom Leppert, "is committed to being the Greenest City in America." He adds that "[t]he City of Dallas understands that each of us - every individual, every business, every government must act to protect our environment. And this city knows it must lead by example." The city's green power is equivalent to avoiding the carbon dioxide emissions of nearly 40,000 passenger vehicles per year, or is the equivalent amount of electricity needed to power nearly 27,000 average American homes annually.

City of Austin, TX

Austin is the capital of Texas, the 16th largest city in the U.S. and fourth largest in Texas. Recent national surveys rank Austin as one of the best places to live, work and play and as one of the safest, cleanest and 10th healthiest large city in the country. The City of Austin has taken a leadership role in the promotion of a clean, sustainable environment. The City of Austin's goal is to have 100 percent of all City accounts powered by renewable energy sources by 2012. The City's commitment is a reinforcement of that leadership effort that has helped motivate Austin citizens and businesses to participate in clean initiatives. "The success of Austin's green energy program and other clean initiatives has helped focus national attention on our community and the quality of life which our city provides. This has helped promote Austin as a destination for both businesses and a progressive population." said Mayor Will Wynn.

During the initial solar feasibility assessment, each site was evaluated and ranked according to its viability for development. Estimated benefit was calculated assuming that the system degradation rate is offset by the electricity price escalation rate. First year electricity rate was assumed to be $0.085/kWh. URS selected the following City-owned properties and buildings for a more detailed assessment:

- **AB Jewell Water Treatment Plant**

  Ground Mount Solar PV Array
  System Size: 750 kW (dc)
  Estimated Construction Cost: $3,300,000
  Estimated Year 1 Energy Output: 1,049,909 kWh
  2010 Electricity Consumption: 27,789,528 kWh
  Consumption Offset Potential for Solar: 3.8%
  Estimated Annual Benefit: $89,242
  Simple Payback: 37 years

- **Mohawk Water Treatment Plant**

  Ground Mount Solar PV Array
  System Size: 500 kW (dc)
  Estimated Construction Cost: $2,242,000
  Estimated Year 1 Energy Output: 699,940 kWh
  2010 Electricity Consumption: 15,995,556 kWh
  Consumption Offset Potential for Solar: 4.4%
  Estimated Annual Benefit: $59,495
  Simple Payback: 38 years

- **Air Force Plant #3**

  Roof Mount Solar PV Array (Adhered)
  System Size: 3,128 kW (dc)
  Estimated Construction Cost: $13,231,000
  Estimated Year 1 Energy Output: 3,768,463 kWh
  Estimated Annual Benefit: $320,319
  Simple Payback: 41 years

- **Maxwell Convention Center**

  Roof Mount Solar PV Array (Adhered)
  System Size: 750 kW (dc)
  Estimated Construction Cost: $3,400,000
  Estimated Year 1 Energy Output: 913,704 kWh
  2010 Electricity Consumption: 4,291,642 kWh
  Consumption Offset Potential for Solar: 21.3%
  Estimated Annual Benefit: $77,665
  Simple Payback: 43 years

- **Central Recreation Center**

  Roof Mount Solar PV Array
  System Size: 12.5 kW (dc)
  Estimated Construction Cost: $70,500
  Estimated Year 1 Energy Output: 15,827 kWh
  Estimated Annual Benefit: $1,345
  Simple Payback: 52 years

- **Emergency 911 Facility**

  Roof Mount Solar PV Array
  System Size: 49 kW (dc)
  Estimated Construction Cost: $260,000
  Estimated Year 1 Energy Output: 62,581 kWh
  Estimated Annual Benefit: $5,319
  Simple Payback: 49 years

- **Fire Station #24**

  Roof Mount Solar PV Array
  System Size: 20 kW (dc)
  Estimated Construction Cost: $111,500
  Estimated Year 1 Energy Output: 25,552 kWh
  Estimated Annual Benefit: $2,172
  Simple Payback: 51 years

- **Tulsa City-County Central Library**

  Roof Mount Solar PV Array
  System Size: 150 kW (dc)
  Estimated Construction Cost: $728,500
  Estimated Year 1 Energy Output: 191,690 kWh
  Estimated Annual Benefit: $16,294
  Simple Payback: 45 years

For the purposes of the solar PV feasibility study, a technology evaluation was performed to select the most suitable solar PV and mounting technologies for each host site. For example, URS evaluated solar PV roof-mount applications that can be designed to meet minimum wind load ratings, be installed without roof penetrations, and comply with restrictive roof loading requirements. URS then used PVSyst version 5.42 to estimate the energy production for each solar PV site conceptual layout and design. PVSyst is an industry leading solar energy system performance and design software package. The software generates hourly and monthly energy production estimates based on solar resource data, module choice, inverter technology, array design configuration, array shading, and system loss assumptions. URS used the typical meteorological year version 3 (TMY3) data gathered from the Tulsa International Airport in the National Renewable Energy Solar Radiation Database as the solar resource data input. The solar PV energy production outputs for each of the facilities assessed in the detailed study are included as Appendix 4.

Initiative #2: Reduce Natural Gas Consumption

Issue Solar hot water systems are a cost-effective and highly visible way to reduce energy costs, but the City of Tulsa has never conducted a pilot project to determine the feasibility of this technology.

Recommendation Install a solar hot water with gas auxiliary system at Fire Station #24 as a pilot project to be evaluated for possible replication at other City facilities. Fire Station #24 is a good candidate because its roof is not shaded by adjacent trees or structures; it consumes a significant volume of hot water; and it is close to a school, which would allow the City to use the solar hot water system as a hands-on learning experience.

Estimated Costs for Solar Hot Water System:

- 10 square feet per person collector area for 10 people = 100 sf total collector area
- Six collectors, two 100-gallon tanks, control equipment and piping
- $3,500/collector total installed cost
- **$21,000** total installed cost
- Estimated solar energy factor (SEF) = 2.5
- Estimated annual operating costs (with gas auxiliary system) = 365 × 0.4105/2.5(SEF) × $0.50 (per therm fuel cost) = **$29.97**

Estimated Benefits for Solar Hot Water System:

- Operating costs for conventional natural gas water heater with storage:

  365 x 0.4105/0.6 (Energy Factor) x $0.50 (fuel cost per therm) x 4.66 (adjustment for estimated water consumption of 300 gallons/day, 300/64.3) = **$582**

Simple Payback Calculation (without incentives):

- $21,000/(582-29.97) = 38 Years

The simple payback for replacing an existing natural gas water heater is not good due to the high upfront cost of the solar water heating system and the low price of natural gas. However, the project's main purpose would be to serve as a pilot project to provide real pricing, cost savings, and performance data about a renewable alternative to conventional water heating systems when other City facilities need to purchase or replace water heaters.

Exhibit 41: Solar Water Heating System Installed on Fire Station in Charlotte, NC

Photo courtesy of SolarHot (Morrisville, NC)

Key Performance Indicator **Total annual savings associated with avoided natural gas costs for conventional hot water heating.**

Target **$500/year annual savings**

Renewable Energy Public Policy Review

The promotion of renewable energy can be achieved through policy measures that encourage renewable energy adoption and/or remove undue burdens on development activities. URS reviewed a variety of renewable energy policy initiatives and best practices enacted by State and local governments. These policy initiatives include topics such as solar easements, land use and zoning, restrictive covenants, and permitting.

Renewables Portfolio Standard

In May 2010, House Bill 3028 established a renewable energy goal for electric utilities operating in Oklahoma. The goal calls for 15% of the total installed generation capacity in Oklahoma to be derived from renewable sources by 2015. Eligible renewable energy resources include wind, solar, hydropower, hydrogen, geothermal, biomass, and other renewable energy resources approved by the Oklahoma Corporation Commission (OCC). Energy efficiency may be used to meet up to 25% of the goal.

Unlike the renewables portfolio standards adopted by other states, which require utilities to retire renewable energy credits (REC) to demonstrate compliance, Oklahoma's law does not require utilities to purchase and retire RECs. Instead, each utility in Oklahoma that owns or operates

electricity generation facilities must file a report with the OCC each year by March 1. The report must document the total installed capacity of all generation facilities, the number of kilowatt-hours (kWh) generated by each facility and the energy source for each facility. The law also requires utilities to file a report with the OCC each year by March 1 detailing and quantifying the energy efficiency programs they have administered.

Net-Metered Energy

Net metering has been available in Oklahoma since 1988 under Oklahoma Corporation Commission (OCC) Order 326195. The OCC's rules require investor-owned utilities and electric cooperatives under the commission's jurisdiction to file net-metering tariffs for customer-owned renewable energy systems and combined heat and power (CHP) facilities up to 100 kilowatts (kW) in capacity. Net metering is available to all customer classes. There is no limit on the amount of aggregate net-metered capacity.

Utilities are not allowed to impose extra charges for customers signed up for net metering, nor are they allowed to require new liability insurance as a condition for interconnection. Utilities are also not required to purchase net excess generation (NEG) from customers. However, a customer may request that the utility purchase NEG. If the utility agrees, then NEG will be purchased at the utility's avoided-cost rate.

Systems must be installed and maintained in compliance with the National Electric Code (NEC). An external disconnect switch is required.

Zero-Emission Facilities Production Tax Credit

68 O.S. § 2357.32A (OSCN 2011) provides a credit against state income taxes for taxpayer's production and sale to an unrelated person of electricity generated by zero-emission facilities located in Oklahoma. The credit applies to electricity that is exclusively produced by any facility located in Oklahoma with a rated production capacity of one megawatt (1 MW) or greater which utilizes eligible renewable resources as its fuel source. The construction and operation of such facilities shall result in no pollution or emissions that are or may be harmful to the environment, pursuant to a determination by the Department of Environmental Quality. For electricity generated on or after January 1, 2007, but prior to January 1, 2012, the amount of the credit shall be twenty-five one hundredths of one cent ($0.0025) per kilowatt-hour of electricity generated by zero-emission facilities. For facilities placed in operation on or after January 1, 2007, and before January 1, 2016, for the electricity generated by these facilities the amount of the credit shall be fifty one hundredths of one cent ($0.0050) for each kilowatt-hour of electricity generated by zero-emission facilities.

Renewable Energy Education and Outreach

In addition to promoting the adoption of renewable energy through public policy, many state and local governments foster community support for sustainability initiatives through partnerships with the educational system. Partnerships with educational institutions help communicate the City's sustainability goals and objectives while providing valuable learning opportunities to tomorrow's workforce. URS has participated in successful renewable energy educational outreach initiatives with students enrolled in public higher education and secondary school Science, Technology, Engineering, and Mathematics (STEM) programs. Many public higher education institutions, such as Tulsa Community College, have existing alternative energy training programs. The creation of partnerships with these training programs can afford mutually beneficial exchanges of ideas and information.

Economic Development

Turn New Energy into New Jobs

Part one: Clean Technology and Tulsa

Tulsa has a significant opportunity to build a strong "clean technology" (Clean Tech) industry cluster, which can be one initiative that is a part of a broader Sustainable Economic Development Strategy. To take advantage of this opportunity, it is important to begin with an understanding of the economic conditions that are leading to the emergence of the Clean Tech industries across the U.S. and around the world.

The Great Economic Transformation

There is an economic transformation taking place today—a transformation from an old economy that is high pollution, high carbon, waste intensive, and ecologically disruptive, to a new economy that is low pollution, energy/resource efficient, low or zero carbon, and ecologically supportive. Businesses, cities, and regions that lead this economic transformation will prosper because the new economy will outperform and eventually replace the old one in the long run. Businesses, cities, and regions that lag are in danger of being left behind.

Our time is somewhat analogous to 100 years ago when the oil and automobile industries emerged together and everything changed – the way cities and regions grew; the way transportation took place, which industries succeeded and which failed. In the 1920s, Detroit became a world headquarters of the automobile industry and a rapidly growing, highly prosperous city and region, while, at the same time, Tulsa became known as the "Oil Capital of the World."

Today's economic transformation is also analogous to the information technology (IT) revolution 20 years ago when a complex of related technologies—the personal computer, the cell phone, and the internet – emerged and everything changed again, with San Jose/Silicon Valley becoming one of the leading economic regions in the world.

Clean Enterprise

This time it is the Clean Tech industries—energy conservation, resource efficiency, renewable-energy generation, pollution prevention, and waste minimization and recycling—that are the engines of transformation.

A new way of doing business is emerging from this transformation—clean enterprise—and the way all businesses operate is significantly changing. As clean enterprises grow and interact with each other as suppliers and customers, and as they all become greener, a clean economy is developing. The new Clean Tech industries are at the heart of this economic transformation. While some businesses are specializing in producing and distributing clean technologies, all businesses are coming to use them.

Many of the leading corporations in the U.S. are embracing the perspective that clean green business is good business. Recognizing the economic opportunities inherent in going clean and green, many well-known corporations are taking very significant actions. For example:

According to its 2010 Sustainability Progress Report, Walmart—the largest corporation in the world for the last two years, according to Fortune—has committed to an environmental responsibility program, targeting 100% renewable energy, zero waste, and the sale of sustainable products. Walmart has invested $500 million in sustainability, increased building and fleet efficiency by 15%, built a set of experimental green stores, and is requiring its suppliers to go green through its Sustainable Value Networks.

In its 2010 report, GE indicated that its Ecomagination initiative now has 60 products generating $85 billion in revenue, with overall corporate GHGs reduced by 20% from 2004 levels.

DuPont reports on its social and environmental progress using the Global Reporting Initiative reporting format and is independently monitored by Environmental Resource Management. DuPont has saved $3 billion while reducing GHGs by 72% over a decade. DuPont is aggressively developing sustainable products for buildings and construction, transportation, agriculture and nutrition, and communication.

In its 2010 Sustainability Report, Interface, Inc., the world's largest manufacturer of commercial and residential modular carpet and broadloom, shows that it has grown $200 million (to over $1 billion) without increasing resource consumption, and the company has avoided $250 million in waste management bills.

Other major U.S. corporations with comprehensive clean and green programs include: Dell, Johnson Controls, Hewlett Packard, Johnson and Johnson, Coca Cola, H.J. Heinz, Google, Random House, Nike, Starbucks, TimeWarner, UPS, Whole Foods, Xerox, Target, Walgreens, and many others.

Clean Tech Regions

A number of regions have embraced the clean economy by, among other things, developing powerful Clean Tech industry clusters. The metro regions centered in San Jose/Silicon Valley, Boston, Austin, and San Francisco are generally seen as being among the leading Clean Tech regions in the nation and the world.

San Jose/Silicon Valley is a particularly interesting example for Tulsa. San Jose leveraged its premier position in the IT revolution to become a Clean Tech leader. San Jose's leadership in entrepreneurship, skilled workforce, venture investment, and venture business services combined with its strong position in relation to semi-conductor, computer, optics, and nano technologies have allowed it to emerge as a Clean Tech leader, particularly in relation to solar and other renewable energy applications.

Tulsa and Clean Tech

Tulsa has the opportunity to leverage its historic position as a leading region for production, manufacturing, and services in relation to the oil and gas industry cluster to become a leading region in relation to clean energy and many of the other industries that compose the Clean Tech industry cluster. Tulsa already has some momentum in this direction.

8th

Tulsa's national ranking for annual rate of green jobs growth (8.3%)

In July 2011, the Brookings Institution in association with Battelle Technology Partnership, released *Sizing the Clean Economy: A National and Regional Green Jobs Assessment*. This project has developed and analyzed a detailed database of employment statistics on Clean Economy industries in the U.S. and its metro regions. According to *Sizing the Clean Economy*, the Tulsa metropolitan region ranks 68th out of 100 metro regions for green jobs, with 7,130 green jobs that constitute 1.7% of all jobs in the region. This aspect of the Tulsa economy is growing at the rate of 8.3% annually, which ranks as the 8th fastest green job growth rate in the country.

Tulsa has a number of strategic advantages that it can draw upon in pursuing a Clean Tech strategy, including:

- Companies with highly relevant engineering and business expertise.
- A workforce with the skills required for Clean Tech industries and a strong workforce training infrastructure.
- A large number of successful entrepreneurs embedded in a very strong culture of entrepreneurship, with a complete network of business incubation and acceleration organizations and institutions.
- High quality business services (e.g., lawyers, bankers, accountants, marketing professionals, etc.) with experience working with the oil and gas business cluster and with entrepreneurial ventures.
- At least one strong Clean Tech sub-cluster – Compressed Natural Gas (CNG).
- Universities generating some relevant research and development (R&D) and intellectual property (IP).
- Some seed, angel, venture, and private equity investors.
- A municipal commitment to develop the Clean Tech cluster in Tulsa.

However, Tulsa also has some distinct challenges to overcome, including:

- The absence of other strong Clean Tech sub-clusters.
- A relative lack of venture investors and relative invisibility to national Clean Tech investors.
- Lack of a coherent integrated strategy for developing the Clean Tech Cluster in Tulsa.

To build on these strengths and address these challenges, it is useful to look at Clean Tech strategies, best practices and examples of success, and then draw on some of the potential lessons for Tulsa.

Business Clusters

A Clean Tech Cluster Strategy uses the approach of business cluster development to encourage the emergence of and/or the strengthening of a Clean Tech business cluster in a city/region.

According to Harvard Professor Michael Porter, one of the leading developers of the concept of business clusters, business clusters are “geographic concentrations of interconnected companies, specialized suppliers, service providers, and associated institutions in a particular field that are present in a region.” Clusters arise because they:

- Increase the productivity of the companies in the cluster.
- Drive innovation in the field.
- Stimulate new businesses in the field.

The process for defining, describing, and encouraging business clusters is not standardized, and different economic development practitioners have developed their own methodologies. However, most cluster analysis uses evaluation of regional employment patterns, usually based on the North American Industrial Classification System (NAICS).

Economic development best practice suggests that regions should identify a few clusters and develop a comprehensive approach to encouraging the clusters to thrive in the region. It is important to select clusters in industries that are likely to grow nationally and globally, and that already have a base of activities and support in the region.

Silicon Valley

Silicon Valley in California is the best-known example of a business cluster. In the mid- 1990s, a number of successful computer-related companies emerged in Silicon Valley, This led entrepreneurs interested in starting up new high-tech companies to do so in Silicon Valley. This led to many venture capital firms relocating to or expanding their offices in Silicon Valley, thereby encouraging more entrepreneurs to locate their startups there.

The cluster effect in the business and capital markets also led to a cluster effect in the labor market because programmers, engineers, and other technologists realized that they would find greater job opportunities by moving to Silicon Valley. At the same time, Stanford University business and technology graduates tended to stay in Silicon Valley, finding work or starting a business, often utilizing the technology transfer of intellectual property developed at Stanford.

High-tech companies and startups around the country knew they could find capital and a workforce with the proper skill sets in Silicon Valley, which provided incentives for them to move there, in turn leading to more high-tech workers locating there. At the same time, business (legal, accounting, marketing, PR, etc.) and financial services firms have been attracted to Silicon Valley by the markets created by high-tech businesses located there.

The Clean Tech Cluster

The term “Clean Technology” or “Clean Tech,” has emerged as an umbrella term encompassing a diverse business cluster with a range of environmental products, services, and processes, all intended to:

- Provide superior performance at lower costs
- Greatly reduce or eliminate negative ecological impacts
- Improve the productive and responsible use of natural resources.

The emergence of Clean Tech is a response to the challenges of environmental disruption that resulted from the way older industrial technologies operated. However, in a very large and growing number of cases the new clean technologies are turning out to be highly cost effective with a positive return on investment (ROI) coming within relatively short time periods.

Categories of Clean Tech Businesses

There are many different ways of categorizing Clean Tech businesses. A short summary of the primary categories is included in the table below.

Category	Description	Segments
Clean Energy Sources	The production, storage and distribution of renewable or low carbon energy sources.	• Clean energy generation • Energy storage • Energy infrastructure
Energy Efficiency	Technologies and services that reduce the amount of energy consumed by different sectors of the economy.	• Building energy efficiency • Appliances and controls • Energy management
Green Production Practices	Enterprises that produce products and services or use production practices that reduce the consumption of natural resources.	• Transportation and logistics • Manufacturing and industrial • Materials and nano-technologies • Green construction • Agriculture
Pollution Mitigation, Conservation, and Restoration	Enterprises and technologies focused on reducing pollution or conserving and restoring natural ecologies.	• Water and wastewater • Air and environment • Materials recovery and recycling
Support Services	Consulting and other services that help enterprises develop and implement green and clean technologies.	• Advocacy and policy • Green business consulting • Green finance • Research and development • Education

Key Elements in a Clean Tech Cluster

The key elements involved in a Clean Tech Cluster in a city or region include:

- Entrepreneurs and managers that are starting up and growing businesses in the Clean Tech sector
- Sources of equity and debt finance prepared to make investments in Clean Tech businesses.
- Workforce with the appropriate skill sets to meet the employment needs of Clean Tech businesses
- Business services (legal, accounting, marketing, strategy, management assistance etc.) with domain expertise at the level of operations to which Clean Tech businesses aspire
- Suppliers and customers for the businesses in the Clean Tech Cluster
- Universities and educational and research institutions that are educating entrepreneurs and managers who want to start up businesses and/or work in the Clean Tech businesses, as well as whose research activities are developing new intellectual property that can be the focus of new Clean Tech business development through technology transfer.
- Networks that link the various aspects of the Clean Tech Cluster.

Clean Tech Cluster Development Best Practices

Clean Tech business cluster development typically involves the following steps:

- Mapping of the firms and related support infrastructure in the Clean Tech Cluster and relevant sub-clusters – including the networks of relationships between them
- Benchmarking potential Clean Tech Clusters/sub-clusters against leading clusters /sub-clusters elsewhere and identifying areas of differentiation
- Building networks of Clean Tech Cluster/sub-cluster leaders
- Encouraging knowledge and idea exchange and cross-fertilization
- Supporting collaborative R&D
- Building business relationships
- Understanding the need for specialized support and inputs
- Investing in specialized R&D assets that support Clean Tech Cluster/sub-cluster innovation and connecting clusters to existing R&D assets
- Organizing access to specialized capital resources for Clean Tech Cluster/sub-cluster investment
- Recruiting companies that fill Clean Tech cluster/sub-cluster gaps
- Supporting firm spin-offs and entrepreneurial start-ups.
- Supporting demand for Clean Tech Cluster/sub-cluster products and services through:
    - Local and state policies and incentives
    - Local investments, including infrastructure
    - Development of common industry standards (e.g., product certifications)
    - Consumer mobilization and behavior change

- Organization of Clean Tech Cluster/sub-cluster suppliers
- Organization of Clean Tech Cluster talent providers
- Marketing and branding of regional Clean Tech Cluster differentiation.

Examples of Successful Clean Tech Cluster Development

San Jose, California. Fifteen years ago, the City of San Jose launched the Environmental Business Cluster as a non-profit clean energy and environmental technology commercialization center in San Jose, California. The goal of this center is to assist emerging clean energy and environmental technology companies in reaching the market. The Environmental Business Cluster provides business assistance programs and aids in the formation of technology partnerships and industry networks. During its 15 years of experience, the Environmental Business Cluster has helped more than 150 businesses commercialize and market their products. (See Part Three for a discussion of other aspects of San Jose/Silicon Valley's comprehensive Sustainable Economic Development Strategy.)

Boston, Massachusetts. Boston has instituted some of the most supportive policies in the United States for energy efficiency and renewable energy. After California, the Boston area is second in Clean Tech venture capital investments. With an environment that is supportive of Clean Tech startups, numerous companies are moving their business to Boston. The MIT Clean Energy Prize is a venture and innovation creation competition that encourages clean energy innovation. Its objective is to provide educational opportunities and supply incentives to ventures demonstrating clean energy affordability. The development of MIT's Clean Tech incubator will provide Boston with more access to Clean Tech deal flow.

Austin, Texas. Austin has long been Texas' hub for solar, wind, geothermal, and biomass power, as well as fuel cell technologies. Its commitment to the environment and sustainability has made it a national Clean Tech player. Austin is home to some of the largest Clean Tech companies on a global level, including HelioVolt, Xtreme Power, and Green Mountain Energy. The University of Texas at Austin has created several research initiatives to promote research in energy efficiency and renewable energy. This includes a project by the College of Natural Sciences to create biofuel from blue-green algae and hybrid-electric automobile programs developed by The Center for Electromechanics. The Clean Energy Incubator provides facilities and resources to turn renewable energy ideas into working projects.

San Francisco, California. San Francisco has adopted a plan to become the first city in the world to be completely run by renewable energy by the year 2020. The Sunset Reservoir Solar Project is the largest municipal solar facility in California. San Francisco is also home to a number of Clean Tech investment firms that invest in new and growing Clean Tech businesses, including DBL Investors, California Clean Energy Fund (CalCEF), CalCEF Clean Energy Angel Fund, and CleanPath Ventures. The Energy Foundation partners with other donors to assist in solving energy problems around the globe. Funding is provided to businesses that advance renewable energy and energy efficiency technologies. The Cleantech Group, providing market intelligence on Clean Tech investment and the companies innovating across the Clean Tech spectrum, also is headquartered in San Francisco.

Initiative #1: Clean Tech Tulsa

Based on the best practices and examples discussed above, it is possible to formulate Initiative#1: Clean Tech Tulsa that could either be a stand-alone initiative or the first initiative in a Tulsa Sustainable Economic Development Strategy. A Clean Tech Study, a Clean Tech Inventory, and a Tulsa Clean Tech Network are relatively inexpensive and highly cost-effective actions that could be included as aspects of Clean Tech Tulsa.

Any Clean Tech Initiative should begin with an understanding of what exists in a region and the potential for development.

Clean Tech Cluster Study. A Clean Tech Cluster Study is typically the first step in launching a Clean Tech Cluster Initiative. A Clean Tech Cluster Study identifies:

- The Clean Tech businesses already located in the city/region, categorizing them according to the Clean Tech sub-cluster their product or service belongs to, their number of employees, geographic location in the region, stage of development, and investment received.
- The entrepreneurial (particularly serial entrepreneurs) specialized talent pool, and workforce on which the Clean Tech Cluster can draw.
- Level of activity in related business clusters, i.e., oil and gas, aerospace, and health care.
- The city/region's support mechanisms, including incubators, accelerators, chambers of commerce, related trade associations, and specialized business services providers.
- University and research institution technology transfer and intellectual property commercialization infrastructure in general and specific current and potential engagement with Clean Tech.
- Seed, angel, venture, private equity, and debt financial infrastructure and current levels of investment.
- Local, state, and federal policy, regulatory, and incentive environment.
- Natural advantages (days of sun, presence of natural gas, etc.) and disadvantages.
- General assessment of the local/regional economic trends, challenges, and opportunities.

The CNG Clean Tech Sub-Cluster. It's already clear that a Clean Tech Cluster Study will demonstrate that Tulsa does have one strong Clean Tech sub-cluster – compressed natural gas (CNG).

According to EPA, CNG reduces: carbon monoxide emissions by 90 to 97%; carbon dioxide emissions by 25%; nitrogen oxide emissions by 35 to 60% and particulate matter by 80%. CNG is domestically produced and cheaper than gasoline, and therefore its use would reduce dependence on more expensive foreign oil.

The markets for natural gas in general, and CNG in particular, are expanding rapidly and Tulsa companies are substantial players in this market. For example, Tulsa Gas Technologies is a CNG service company that is the largest manufacturer of CNG dispensers in North America. Tulsa Gas Technologies has also penetrated the international market with a presence in 10 other countries around the world. Tulsa Gas Technologies operates its own CNG station and Oklahoma Natural Gas (ONG) sells CNG at five stations in the Tulsa area.

In 2011, the City of Tulsa opened a high-speed CNG fueling station in the City's west maintenance yard, part of a project that will include construction of six CNG fueling points for refuse trucks, a publically accessible retail CNG fueling station, and replacement of a growing number of the City's

2,600 vehicles with ones that run on CNG. Half of the buses in the Tulsa Public Schools fleet run on CNG, which is selling for $0.75 per gasoline gallon equivalents (GGE). Local companies are building all of these CNG stations.

Clean Tech Inventory. One of the results of a Clean Tech Cluster Study will be a Clean Tech Inventory. The Clean Tech Inventory should be maintained on line and updated as new Clean Tech companies start up or move to Tulsa. The Inventory can be used to stay in touch with and support the companies in the Clean Tech Cluster and its sub-clusters.

Clean Tech Network. Tulsa should consider creating and staffing a Tulsa Clean Tech Network as an aspect of Initiative: Clean Tech Tulsa. The purpose of the Network would be to grow the Clean Tech economy in the Tulsa region.

The mission statement for a Tulsa Clean Tech Network could be to facilitate the startup and expansion of Clean Tech companies in Tulsa to capitalize on the rapid expansion of the Clean Tech market in research and development, manufacturing, distribution, sales, services, and maintenance. Coordination of a Clean Tech Network can either be provided by an existing organization or public agency, or a new organization can be formed to provide coordination.

The members of the Network could be drawn from:

- CEOs, entrepreneurs, management, and workforce of Clean Tech companies
- Investors, including seed, angel, venture, private equity, and bank investors, as well as finance intermediaries
- Business services providers serving the Clean Tech sector, including: legal firms, accountants, management and business strategy consulting firms, public relations and marketing firms, and others
- Chambers of Commerce
- Academic institutions, including research institutes, green MBA programs, and tech transfer programs
- Energy and water utilities
- Government agencies interested in encouraging Clean Tech businesses in their jurisdictions, including economic development, business development, and workforce development agencies

The activities of the Network could include:

- Establishment of a website with Clean Tech Cluster resources, a Clean Tech interactive forum, an electronic newsletter. The Clean Tech Inventory could also function as a directory of Clean Tech businesses in the Tulsa region.
- Organization of networking events and public forums with regional and national thought leaders.
- Creation of a robust inventory of public and private sources of potential intellectual property commercialization.
- Under the umbrella of the Tulsa Clean Tech Network, organization of a sub-cluster network of firms and support organizations focused on CNG.
- Establishment of relationships with the national Clean Tech Network, the American Council on Renewable Energy, and the various national sub-cluster networks.
- Presentation of an annual conference connecting national Clean Tech thought leaders, regional Clean Tech companies, and other members of the Clean Tech Network to share knowledge and best practices in relation to Clean Tech; identify ways to advance the Clean Tech Cluster in Tulsa; encourage joint ventures and other forms of collaboration among Tulsa Clean Tech companies; and gain wider national recognition for Tulsa as a Clean Tech leader.
- Generation of recommendations on how the Tulsa city government, Tulsa educational institutions, and other institutions and organizations can support the growth of the Clean Tech Cluster in Tulsa.

Another set of actions that can be aspects of “Initiative: Clean Tech Tulsa” will be discussed at the conclusion of the discussion of the Tulsa investment capital system that follows.

Part Two: The Tulsa Investment Capital System

A city or region's investment capital system is an essential foundation for a successful Clean Tech Initiative. Some aspects of Tulsa's investment capital system are very strong (the entrepreneurship ecosystem), while others are much weaker (venture investment).

Before addressing Tulsa's investment strengths, weaknesses, and possible actions, it is useful to look at Clean Tech investment, investment capital best practices, and some examples where these best practices have succeeded.

Clean Tech Investment

According to the State of Green Business 2011 (based on figures from Ernst and Young and Dow Jones), venture capital investment in Clean Tech in 2010 rose to slightly more than $4 billion, up 7.6% from 2009, but down from the $7.6 billion invested in 2008. The deal total increased by 7% from 2009 to 278 deals in 2010.

The leading Clean Tech sub-sectors were:

- Solar – thin-film, solar thermal, and solar services – $1.158 billion
- Power and Efficiency Management – $365 million
- Bio-fuels – $305 million
- Energy efficiency – $249 million
- Batteries – $136 million
- Solar energy – $107 million
- Water treatment – $97 million
- Industrial products – $73 million
- Natural gas – $38 million
- Fuel cells – $34 million
- Recycling – $32 million
- Wind – $32 million.

Clean Tech venture investment is largely concentrated on the West Coast and the Northeast. California, the Pacific Northwest, and the Mountain Region collectively completed 154 deals equaling $2.76 billion in 2010. The Northeast, Mid-Atlantic, and Southeast regions of the US jointly secured 74 deals, which amounted to $625.79 million.

Investment Capital System Best Practices

The typical elements of a successful investment capital system, including a Clean Tech investment capital system include:

- Entrepreneurship development that helps entrepreneurs develop skills needed at different stages of business development
- A business acceleration support system to assist companies at different stages with:
    - Market analysis and business planning
    - Capital raising and offering memoranda
    - Management team recruiting
    - Acquisition of high quality business services
    - Board development
    - Physical space and back office support infrastructure.
- A well-integrated capital pipeline that supports businesses as they move from one stage of development to another. This would include:
    - Seed and angel capital networks and funds
    - Venture capital networks and funds
    - Working capital and growth capital
    - Venture debt, mezzanine debt, and commercial debt
    - Private equity investment
    - An intellectual property (IP) commercialization infrastructure that links entrepreneurs and investors to potential sources of IP at universities, federal labs, private labs, and other sources of invention and discovery.
    - A strong business attraction, retention, and expansion program that works with existing companies to help them grow in the region, and targets the appropriate companies for location in the City or region.
    - Peer networks that connect business entrepreneurs with each other in ways that maximize generative relationship building.
    - A business development infrastructure that integrates all these pieces at the regional level with appropriate state and federal resources.

The Tulsa Entrepreneurial Ecosystem

The Tulsa metro economy has survived the recession well. According to a February 2011 article in the *Tulsa Business Journal*, Tulsa was recently recognized by Forbes Magazine as the No. 2 midsized city for jobs and by *Business Week* as the No. 7 strongest U.S. metro economy.

However, Tulsa has not rested on these economic laurels. Rather, Tulsa has aggressively and successfully pursued the creation of an entrepreneurial ecosystem, making Tulsa, in many respects,

a national entrepreneurship leader. The Kauffman Foundation recently ranked Oklahoma the leading state in the nation for entrepreneurship.

As indicated above, fostering entrepreneurship is one essential aspect of a successful investment capital system. Entrepreneurship is the foundation of a strong investment capital infrastructure. Without deals, there can be no investment and no entrepreneurs building the companies that generate the deals. Examples include the following.

StartUp Tulsa is a publicly and privately funded entrepreneurial economy-building project of the Tulsa Economic Development Commission. StartUp Tulsa publishes an annual report that outlines progress in Tulsa's entrepreneurial ecosystem. According to that report, Tulsa's entrepreneurial ecosystem has birthed 64 operating companies and 269 jobs, adding $12.4 million to the city's payroll. Drawing on StartUp Tulsa's annual report and other key elements in the Tulsa entrepreneurial infrastructure includes:

- i2E, Inc. (Innovation to Enterprise) is a nonprofit organization created to help expand the technology-based entrepreneurial economy of Oklahoma. i2E manages Seed Step Angels and also provides venture advisory and entrepreneurship development services.
- Oklahoma Innovation Institute formed The Economic Development Task Force of Step Up Tulsa! – co-chaired by the Managing Partner of Davis, Tuttle Venture Partners and the President, i2E – in a process initiated and funded by the Tulsa Community Foundation the largest community foundation in the United States. The Oklahoma Innovation Institute includes the Tulsa Research Partners to encourage technology transfer, the Entrepreneurship Center, the Entrepreneur Best Practices Service, and the Investor Best Practices Service.
- The Collaboratorium "operates a non-profit entrepreneurial resource center designed to provide hands-on business coaching, education, discounted space, networking, and access to the specific resources that grow startups and businesses."
- Tulsa Global Entrepreneurship Week is a week of large-scale and smaller activities throughout Tulsa focused on expanding Tulsa's emerging entrepreneurial ecosystem through a bottom up approach.
- Tulsa Startup Weekend is a 54-hour event in which startup enthusiasts from a wide range of backgrounds come together to share ideas, form teams, build products and create startups.
- Entrepreneurial Spirit Award is a seven-month business model competition, with more than $400,000 in cash and prizes awarded to date, "designed to inspire the quality and quantity of entrepreneurial endeavors in Tulsa."
- The Tulseys is an online award program in which Tulsa citizens nominate and vote on entrepreneurs in 10 categories.
- Tulsa Community College Launch is a 16-week experiential business-building program designed to accelerate the startup process.

Taken together, these elements of Tulsa's entrepreneurial ecosystem contribute to one of the strongest cultures of entrepreneurship in the nation and can be the foundation for a robust investment capital system to make Clean Tech investments.

Tulsa's Investment Capital System

However, there is still significant work to be done in creating the venture fund aspect of an investment capital system in Tulsa that matches its strength in entrepreneurship.

For example, according to a May 2009 article in *Tulsa World*, Mark Heesen, President of the National Venture Capital Association, observed, "Oklahoma received a small fraction of one per cent of the nation's venture capital funding…to attract investors, Oklahoma needs to focus on a niche…emerging areas like Clean Tech, which includes solar and wind power and battery technology…could be (an) opportunity to make a mark."

While its system is not nearly as robust as that on the two coasts, Tulsa does have the beginnings of an investment capital system with Seed Step Angels, Davis Tuttle Venture Partners, Enterprise Oklahoma Venture Partners, TSF Capital, Trailblazer Capital, and Oklahoma Equity Partners.

Examples of Successful Investment Capital Systems

San Jose/Silicon Valley and the Boston metropolitan area (both areas are discussed above and San Jose/Silicon Valley is discussed again below) are the two most successful examples of successful investment capital systems both in general and specifically in relation to Clean Tech.

The Clean Tech investment in both places grew out of highly successful venture capital infrastructures with very successful histories investing in high tech and biotech. Both areas are home to very successful research universities with well-developed technology transfer programs. In both cases, the investment capital system grew up in interaction with the other aspects of a robust entrepreneurship ecosystem.

There are not many examples of successful investment capital systems, let alone Clean Tech investment capital systems, that have been consciously designed and built through either public or private or public/private initiatives.

JumpStart. JumpStart is a successful example of an initiative to design and build an investment capital system embedded in an entrepreneurship ecosystem. However, Jumpstart does not have a Clean Tech orientation. In response to the desperate need for job and wealth creation in Northeast Ohio, the region's civic, community, and philanthropic leaders came together in 2004 to create a unique partnership between public and private entities. This entrepreneurial ecosystem was charged with creating economic transformation in Northeast Ohio.

Seven years later, JumpStart's vision is to increase the economic impact and sustainability of Northeast Ohio's entrepreneurial ecosystem, while leveraging its experience and expertise to catalyze entrepreneurship nationally.

JumpStart's primary resource is intensive entrepreneurial assistance delivered by former successful entrepreneurs. JumpStart also selectively invests in the highest potential companies through one of its programs. JumpStart has invested $19.3 million in 53 companies and has leveraged an additional $143 million in investments and produced 889 jobs. JumpStart also works to develop other ecosystem elements the companies need to grow, such as advocating for additional capital and service resources beyond what JumpStart provides.

In 2011, JumpStart launched a new initiative, JumpStart America, to build robust public, private, and philanthropic partnerships in all 50 states with the goal of aggregating more than $2 billion to accelerate innovation and entrepreneurship programs across the United States.

The JumpStart investment portfolio focuses on the Clean Tech, health care, information technology, and business and consumer products and services industry clusters. JumpStart has 15 Clean Tech businesses in its investment portfolio. Clean Tech companies are the fastest growing segment of companies receiving venture capital or angel investment in the Cleveland region. They received 20% of the dollars in 2009, with a total of 33 Clean Tech companies receiving venture or angel investment in the last five years.

DB Investors. DBL Investors is a venture capital firm created from the spinout of the Bay Area Equity Fund I from JPMorgan in January 2008. The "Double Bottom Line" investment strategy invests in companies that can deliver top-tier venture capital returns while, at the same time, generating social, environmental and economic improvement in the regions in which they operate.

Bay Area Equity Fund I (a $75 million fund), is successfully implementing this double bottom line investment model in the San Francisco Bay Area. The second fund, DBL Equity Fund – BAEF II (a $140 million fund) has the same investing approach with an expanded geographic focus of the Western U.S. DBL Investors focuses on Clean Tech as well as investments in health care, information technology, and sustainability-oriented products and services. Ten companies of DBL Investors 20 company portfolio are Clean Tech companies.

The Bay Area Equity Fund I was created by a partnership of the Bay Area Council (the business civic organization of the largest employers in the San Francisco Bay Area) and the Alliance for Community Development, a nonprofit economic development organization in the Bay Area with the mission of increasing access to capital for businesses with diverse leadership to generate economic, social and environmental benefits.

The Alliance for Community Development also produces Bay Area Capital Connections events, which bring together entrepreneurs, sources of capital, and business services providers, including pitch events for entrepreneurs to present their companies to investors.

To create the Bay Area Equity Fund I (and the other double bottom line funds in the Bay Area Family of Funds), the Bay Area Council and the Alliance for Community hired a fund-building and initiative-building team to identify the investment manager, raise the capital for the fund, and embed the fund in a comprehensive double bottom line initiative.

There are a number of ways that Tulsa could strengthen its investment capital system as an aspect of an "Initiative: Clean Tech Tulsa."

- Focusing the Tulsa Entrepreneurial Ecosystem on Clean Tech: It warrants repeating that there are no seed, angel, and venture investment deals without seed, angel, and venture fundable deals. The Tulsa entrepreneurial ecosystem has produced some Clean Tech companies and investment deals, but it does not appear that Tulsa's entrepreneurial ecosystem has made Clean Tech a primary focus. Making Clean Tech a primary focus of the Tulsa entrepreneurial ecosystem would be one of the most important actions that could be taken as an aspect of the Clean Tech Tulsa Initiative. This would be somewhat analogous to the way that San Jose/Silicon Valley evolved their entrepreneurial ecosystem to address Clean Tech.
- Establishing a Tulsa Clean Tech Business Incubator: Focusing the Tulsa entrepreneurial ecosystem on Clean Tech could possibly lead to the establishment of a Clean Tech Business Incubator, analogous to San Jose's Environmental Business Cluster. The Environmental Business

Cluster is highly collaborative and a strategic alliance might be established between a Tulsa Clean Tech Business Incubator and the Environmental Business Cluster.

- Form a Strategic Alliance between Start-up Tulsa and JumpStart: Start-up Tulsa and Cleveland's JumpStart programs have many similarities and some similar strengths. JumpStart is beginning to expand to a national focus. Start-up Tulsa could pursue a strategic alliance with JumpStart for mutual support and to undertake various joint projects. One project could be to host a National Entrepreneurship and Investment Conference with a focus on Clean Tech. Funding from the Tulsa Community Foundation could be a major impetus for such a strategic alliance.

Clean Tech or Multi Tech Fund. One of the surest ways for Tulsa to get on the national Clean Tech venture capital map would be to launch a Clean Tech or a Multi- Tech Venture Fund headquartered in Tulsa. Relatively few new Clean Tech or Multi- Tech Funds are currently being built due to economic conditions but when economic conditions improve, Tulsa could consider this route. Such a fund could be managed or advised by a locally based venture fund. The fund/initiative building team that built Bay Area Equity Fund I and the Bay Area Family of Funds (Sustainable Systems, Economic Innovation International, and Strategic Development Solutions) could be contacted for advice on such a project. San Antonio's proposed Multi-Tech Venture Fund (see below) has been on hold due to market conditions, but a strategic alliance might be possible with San Antonio as market conditions evolve.

Part Three: A Tulsa Sustainable Economic Development Strategy

A Clean Tech Cluster Initiative in Tulsa will have significantly greater impact if it is embedded in a comprehensive Sustainable Economic Development Strategy.

Sustainable Economic Development

Within the last four years, "sustainable economic development" has emerged as a strategic perspective that combines two seemingly disparate ideas into a powerful new concept by asserting that the imperative to address the environmental crisis offers the greatest economic opportunity of the 21st century. The power of this concept is leading to the convergence of the fields of sustainability and economic development. Increasingly, sustainability professionals are coming to understand that it is essential to address the economic, business development, job creation, and place- making impacts of sustainability initiatives. At the same time, economic development professionals are recognizing the importance of Clean Tech businesses, energy and resource efficiency for all businesses, eco-smart real estate development, and green jobs. Likewise, elected officials and city, county, and state administrations are discovering the wisdom of integrating Sustainability and Economic Development so that places "become richer by becoming greener. As this convergence proceeds, a new field—sustainable economic development—has taken shape, integrating the best practices from both sustainability and economic development.

From this strategic perspective, there are three basic forms of sustainability.

Sustainability 1.0 focuses on environmental protection to reduce pollution and waste, while encouraging preservation of nature and open space. Sustainability 1.0 is typically implemented by governmental regulation. For businesses, these regulations usually became a cost of doing business that gets passed on to consumers.

Sustainability 2.0 focuses on climate action through climate action plans that begin with the comparison of a place's current carbon footprint with its desired carbon footprint and then move on to formulate a set of actions that are designed to take that place from the current footprint to its desired footprint. These actions are typically a combination of regulations that are imposed on the market and subsidy incentives that supplement the market. Taken together they seek to require/encourage businesses to become low carbon.

Sustainability 3.0 focuses on sustainable economic development that recognizes that a green market is emerging. Sustainable economic development policies and programs are specifically

designed to stimulate the green market in general and individual Clean Tech businesses, sustainable real estate developments, and green investments in particular. The market becomes an ally producing economic prosperity and environmental quality.

All three forms of sustainability are important in their own right. However, in addition, Sustainability 1.0 and 2.0 provide a foundation for Sustainability 3.0, whereby places don't just become greener; rather they can become richer by becoming greener and become greener by becoming richer.

Based on this understanding, cities, counties, and states as diverse as San Jose/Silicon Valley California, San Antonio Texas, Portland Oregon, the State of Delaware, and Sarasota County in Florida have developed and are implementing sustainable economic development strategies.

Market Observations

A set of seven market observations can assist cities and regions in understanding sustainable economic development and formulating sustainable economic development strategies to embrace the economic opportunities offered by building a sustainable economy.

Observation 1: The goals of improved environmental performance and energy independence (resource/energy efficiency; and alternative energy development) are driving the development of new products, services, companies, and markets that will outperform their non-green counterparts over the long run.

Observation 2: Many of the specific sustainable economic development strategies (such as Clean Tech industry development, clean renewable distributed energy, and large-scale building retrofits) have natural economic development potential for stimulating new businesses and jobs.

Observation 3: Environmental gains must generate tangible economic benefits to be successful. Sustainability solutions that combine improved environmental performance and economic benefits are the key to successful sustainability strategies.

Observation 4: Leadership on addressing environmental disruption and regional/global economic competitiveness can reinforce each other rather than cancel each other out. Environmental performance can drive economic prosperity that can be equitable for different groups and places.

Observation 5: As energy and natural resource efficiency become increasingly important competitive advantages in regional and global economies, urban sustainability strategies can be integrated with economic development and community development strategies that leverage the competitive advantage of urban density.

Observation 6: Economic benefits can be realized in two basic ways. (1) Increased participation in the emerging sustainable economy can generate new Clean Tech enterprises, new jobs, and new wealth. (2) The hidden advantages of "urban form" can create significant reductions in the cost of living and the cost of doing business through the integration of community design, energy efficient buildings, and mobility systems.

Observation 7: A "Sustainable Economic Development Strategy" can use many of the same best practices as other kinds of economic development strategies—it is just focused on different kinds of technologies, products, processes, companies, markets, and career pathways.

These seven market observations can be summarized in one proposition: For cities and regions to prosper and be successful in the 21st century, their economic development strategies need to engage with the economic opportunities offered by the rapid emergence of the sustainable economy.

Sustainable Economic Development Best Practices

A sustainable economic development strategy integrates sustainability with economic development best practices. The best practices for economic development in a city or region include:

- Identifying the business clusters in the city or region that are already strong and the nascent business clusters for which there are the preconditions for becoming strong, particularly those business clusters that are effective job producers and wealth producers.
- Assisting existing businesses, particularly those in the identified business clusters, to thrive, while growing new businesses in those clusters.
- Strengthening businesses that produce products and services for export out of the city, community, or region to a national and global market, in balance with city or region serving businesses.
- Attracting businesses, particularly those in the identified clusters, to move to the city, community, or region.
- Encouraging real estate development that locates housing that is affordable near where the businesses are located.

- Promoting the revitalization of low- and moderate-income neighborhoods and communities.
- Fostering robust economic, social, and environmental infrastructures in the city or region that provide the financial, workforce development, educational, and resource systems that businesses need.
- Branding and marketing the city or region, highlighting its business clusters and its economic, social, cultural, physical, and natural advantages to attract businesses to locate and grow in the region.

A sustainable economic development strategy uses all of these best practices in a modified fashion to encourage:

- Businesses that specialize in environmental products and services (the Clean Tech Industry Cluster) to start up, locate, and grow in the city, community, or region.
- All businesses in the city or region to become more energy and resource efficient and, at the same time, more profitable and economically productive.
- Sustainable real estate development to take place – development that is mixed use, energy and resource efficient, low-impact, walkable, and transit oriented.
- The regional financial, workforce, and educational infrastructure to understand sustainable enterprises, in order to encourage investment in the sustainable economy and to prepare people to participate effectively as workers, entrepreneurs, managers, consumers, and investors.
- The regional physical infrastructure to provide energy, water, materials, buildings, and mobility in a way that is both ecologically and economically efficient.

- The city or region to be recognized as a place that is at the forefront of the sustainability revolution, becoming an economically, socially, and environmentally better place to live, work, and locate a business.
- Separately, each of these best practices can make a significant contribution to the emergence of sustainable economic development in a city or region. However, by integrating them into a sustainable economic development strategy, they can lead to building a sustainable economy that provides strategic economic advantage in the global economy.

Examples of Sustainable Economic Development Strategies

Three places – San Jose California, San Antonio Texas, and the State of Delaware – stand out as leaders in the growing number of cities and regions to embrace Sustainability 3.0 and undertake sustainable economic development strategies. They were all featured at the first international conference addressing sustainable economic development, planning for sustainable economic development across the Americas, co-sponsored by the U.S. State Department, the Brazilian government, the American Planning Association, and Global Urban Development. (PowerPoints describing each of these strategies can be found at www.globalurban.org/publications.htm.)

San Jose / Silicon Valley

The City of San Jose and the Silicon Valley region in the San Francisco Bay Area have been a leading force in two economic revolutions—the information and communications technology revolution and the biotechnology revolution. Now they seek to be a global leader in a third economic revolution—the Green and Clean Tech revolution.

Building on San Jose's and Silicon Valley's history of innovation and San Jose's Green Vision 15-year plan and framework for building a green economy, Joint Venture: Silicon Valley Network worked with business, government, academia, labor, and the community to has develop a Climate Prosperity Strategy. In addition, they established a Climate Prosperity Council to encourage the growth of clean and green industries and, simultaneously, to reduce GHG emissions.

Climate Prosperity Strategy. The Silicon Valley Climate Prosperity Strategy, launched in February 2009, is designed to stimulate regional demand for clean and green technology and, at the same time, supply those new products and services to the global marketplace. Based on the recognition that protecting the environment can be an economic driver for the region, the Silicon Valley Climate Prosperity Strategy focuses on four areas on the demand side of green markets:

- Renewable energy
- Building efficiency
- Clean, convenient transportation
- Green infrastructure

On the supply side of green markets, the Silicon Valley Climate Prosperity Strategy seeks to coordinate the regional base of clean and green industries by addressing:

- Innovation production
- Regulatory climate
- Investment

- Land and facilities
- Workforce
- Promotion

Climate Prosperity Council. To guide the implementation of the Climate Prosperity Strategy, Joint Venture: Silicon Valley Network created the Climate Prosperity Council made up of industry, public sector, academic, and community leaders and co-chaired by the Mayor of San Jose and the California Managing Director of Accenture.

The Climate Prosperity Council has adopted five goals:

- Enhance regional competitiveness
- Reduce the environmental footprint of Silicon Valley
- Pursue new investment and industries
- Demonstrate that economic growth and environmental sustainability are interconnected
- Provide a range of career opportunities

Climate Prosperity Benefits. Through the Climate Prosperity Strategy, San Jose and Silicon Valley are pursuing a number of important benefits, including:

- Making homes and vehicles more energy efficient, which will mean less money spent on energy and more disposable income that is likely to stay in the community.
- Adding solar and other renewable energy sources on residential, commercial, and industrial buildings to accomplish important energy saving goals, expand a newly emerging business sector, and stimulate the regional economy.
- Retrofitting homes and offices to be more energy efficient to create new jobs for construction workers, energy auditors, efficiency monitoring tools, network installers, and manufacturers of products ranging from temperature sensors to building components made from sustainable materials.
- Pursuing transportation alternatives to reduce the use of fossil fuels, clean the air, and produce important lifestyle and health benefits.
- Encouraging livable, walkable, and sustainable communities that are more appealing to the rising generation of green talent needed to live and work in Silicon Valley.
- Making progress on all these fronts to help California achieve its goal of reducing GHG emissions by 80% from 1990 levels by 2050.

San Antonio, Texas

In January 2009, the City of San Antonio Texas launched Mission Verde, a sustainability plan that is focused on the economic opportunities inherent in the transition away from a carbon-intensive economy to a sustainable economy.

The Mission Verde Strategy. “Mission Verde…is more than an environmental policy; it is an economic one. This economic approach runs deep. It is driving new technologies, new opportunities, and new jobs. It is expressed in the writings of the best-selling author and columnist Thomas Friedman and the noted economist Jeremy Rifkin, who both see this change as nothing less than the

beginning of the Third Industrial Revolution and the future of the U.S. economy. It will be one of the most dramatic economic changes in world history."

San Antonio is already a national leader in water conservation and open space preservation. Led by the San Antonio Water System, San Antonio uses the same amount of water it did 20 years ago and saves $550 million, even though the city's population has increased 50%. San Antonio has also extended the famous River Walk to be a 13-mile linear park and is building a 311-acre park in a heavily developed part of the City.

Building on these accomplishments, Mission Verde asserts that, "we must invest in green technology, energy conservation, renewable energy, efficient transportation, and smarter buildings. We must build a new energy infrastructure that transforms our city from reliance on centralized power to distributed power. We must create a multi-modal transportation system that is integrated and efficient. We must bring venture capital to invest in new green businesses and technology. With Mission Verde, San Antonio has a plan to do this…to compete successfully in a 21st Century global economy."

10 Initiatives. Mission Verde is pursuing the creation of a sustainable economy in San Antonio through 10 initiatives:

- A 21st century energy infrastructure—generating energy from renewable energy sources such as solar, wind, biomass, and geothermal, originated from buildings and homes, stored until needed, and connected with a multi-directional grid.
- A Multi-Tech Venture Capital Fund—building a regional fund headquartered in San Antonio, capitalized at $100 million, and managed by Brooke Private Equity Advisors.
- A Green Jobs Program—collaborating with employers and educators to match training for existing and emerging green and Clean Tech jobs with employer needs.
- A Sustainable Economic Development Strategy—using tax abatements, cluster development strategies, and business attraction and retention programs focused on clean and green technology companies.
- A Green High-Performance Building Code—moving in phases toward a building code for new residential and commercial construction that produces net zero carbon by 2030.
- A Green Retrofit Program—expanding free weatherization combined with a retrofit program paid for with a surcharge on utility bills.
- An Integrated Multi-Modal Transportation System—pursuing and funding light rail, high capacity rail, and multiple transportation options.
- Sustainable Real Estate Development—utilizing real estate investment funds to advance mixed-use, mixed-income, walkable, transit-oriented in-fill neighborhoods.
- A Green One-Stop Sustainability Center—coordinating sustainability efforts, centralizing the location of sustainability groups and helping to facilitate their activities, demonstrating sustainability best practices, and providing comprehensive information services to residents and businesses.
- Leading by Example—addressing energy conservation, resource efficiency, waste reduction, vehicular emission improvements across all City Departments, coordinated by the City of San Antonio's Office of Environmental Policy and the Sustainability Task Force.

Implementation. San Antonio is well on its way in the implementation of Mission Verde:

- CPS Energy, the municipal utility, has built Texas' largest photovoltaic solar energy plant, which will produce 14 MW of electric power. Also, the utility has committed $96 million to reduce peak demand by 115 MW by 2011 through energy efficiency.
- Established a Green Jobs Leadership Council.
- Opened the Mission Verde Sustainability Center as a Green One-Stop Center and training facility, on the site of a previously closed school in a low and moderate-income neighborhood.
- Adopted a green high-performance building code.
- Expanded free weatherization programs and provided resource efficiency retrofits in City buildings and throughout the City.
- Completed a feasibility study and market assessment for the Multi-Tech Venture Fund.
- Developed a plan to build a multi-modal transportation system.

Delaware

In November 2008, then State Treasurer Jack Markell was elected Governor of the State of Delaware on a sustainable economic development platform.

In a major campaign speech delivered in August 2008, Governor Markell stated: "Green is both a symbol for money and a symbol for the environment. I want to help Delaware businesses see their potential opportunities in the global green economy, because it will help get our economy moving again and it is good for our air, soil, and water. (It) will not only grow our economy and create good-paying jobs, but it will also help Delawareans save money on their energy bills and help our environment by reducing pollution. Everyone wins when we create jobs and help the environment."

Delaware has embraced a Clean Energy Economic Strategy that is based on a "Framework for Prosperity and Sustainability" guided by four principles:

- Green Savings: increasing prosperity by reducing operating costs through reducing energy use and waste
- Green Opportunities: creating jobs in new markets, spurred by new investment in new industries – particularly off shore wind, alternative fuel vehicles, and sustainable chemistry – with new career opportunities
- Green Talent: preparing a world class workforce, trained to participate in these emerging sectors
- Green Places: creating places that protect and enhance the natural and built environment and that attract jobs.

Delaware has initiated the following:

- Executive Order 18 to pursue cleaner, greener government operations
- Energize Delaware to encourage and assist businesses undertaking large-scale retrofits
- Green for Green Program offering rebates for homes built to national third party green building standards
- Small Business Energy and Facilities Revolving Loan Fund to assist businesses to finance energy and resource efficiency

- Offshore Wind Initiative to build the nation's largest offshore wind farm (450 MW), with an associated graduate program in offshore wind at the University of Delaware
- The Delaware Sustainable Chemistry Alliance pursuing safe processes and materials, finding design and process inspiration from nature
- The Applied Energy Education Center at Delaware Tech offering certifications in renewable energy, energy management, energy assessment and cost analysis, green building design and construction, and hybrid and electric transportation
- Cleaner Energy Generation Initiative to shut down a coal-fired power plant and shift fuel from coal to natural gas.

A Tulsa Sustainable Economic Development Strategy

Formulating and implementing a long-term Sustainable Economic Development Strategy is a complex undertaking. It requires strong and consistent leadership, bold vision, and the appropriate level of resources.

Each place is unique. A Sustainable Economic Development Strategy cannot be mechanically imposed. Rather it must grow out of the special conditions and the dynamic trajectory of each place. According to this approach, the strategy needs to be guided by a local/regional leadership structure, often in association with a consultation team.

Following a process that has worked in other cities and regions, Tulsa can develop and implement a Sustainable Economic Development Strategy by following a process that involves five phases of work.

- An Initial Consultation to establish the goals and objectives and the work plan for the strategy creation process.
- A Strategic Assessment and Opportunity Analysis of the area-wide economy, to identify its current direction, its strengths and weaknesses, and the opportunities and challenges for sustainable economic development.
- Design of a Sustainable Economic Development Strategy that builds on the momentum that already exists and weaves together a set of initiatives to create a clear, coherent, easily understood, dynamic strategy, with a strong business model.
- Formulation of an Implementation Plan – including a system for monitoring progress – that addresses who is responsible for each initiative, the timeline and milestones, the costs, the sources of potential revenues, and the processes for mid-course corrections.
- Initiation and, subsequently, full implementation of the Strategy and Implementation Plan.

One way to undertake a Sustainable Economic Development Strategy would be to bring in an experienced consulting team to collaborate with a Tulsa leadership team to complete the five phases of work involved in Sustainable Economic Development Strategy creation.

The first two sections of this report have formulated Initiative: Clean Tech Tulsa, which could be strong as a stand-alone initiative, but would be much stronger as one initiative in a set of initiatives composing a Sustainable Economic Development Strategy. The subsequent sections of this report address other initiatives that might be incorporated in a Tulsa Sustainable Economic Development Strategy in addition to Initiative: Clean Tech Tulsa.

Part Four: Distributed Energy Infrastructure And Energy Efficiency

The Economic Opportunity

A new distributed energy infrastructure is coming to cities in the 21st century. This infrastructure will include power generated through clean energy, such as solar, wind, biomass, and natural gas (e.g., through fuel cells), originated from thousands of sources such as buildings and homes, stored until needed, and connected with a smart, multi-dimensional grid. The foundation of this new distributed energy infrastructure will be energy efficiency, both for new buildings (residential and commercial) and for retrofitting of existing buildings. This new infrastructure will begin to replace our current energy infrastructure, which is based on large, often coal-fired plants that transmit power to consumers on a one-way grid.

The global economic implications of this new energy infrastructure, combined with the use of utility-scale power sources such as hydropower, natural gas, wind, and solar will be dramatic. Billions will be invested in new technologies and infrastructure. Millions of new jobs will be created, along with the transformation of existing jobs. New flows of capital will appear, based not only on the new technologies and infrastructure, but also on the fact that millions of existing and new businesses and homeowners will become energy players - producers of power for themselves and, when in excess, for the grid itself.

This change will touch all cities. Tulsa will not be an exception. But Tulsa is well positioned in this new century of energy. Tulsa understands energy, has a well-established energy industrial base, supports innovation and entrepreneurship, and has the infrastructure to train workers in new opportunities. Tulsa also has the political and business leadership that understands the changes that are coming in the world of energy.

Cities have relied on various strategies to capture the economic opportunities offered by this new energy infrastructure. What follows are initiatives that could be explored by the City of Tulsa to help generate the economic activity and job creation inherent in this new energy infrastructure, along with examples of best practices from other cities around the country.

Initiative #2: City Ownership of Utility

A core strategy for moving forward distributed energy and energy efficiency programs is leadership and cooperation from a local electric utility. Without this leadership and cooperation, the creation and buildout of a 21st century energy infrastructure, with its accompanying economic development opportunities, will either not happen or be significantly delayed. Cities that have been most successful have been those that own their local electric utilities. These include cities such as Los Angeles, San Antonio, Austin, Seattle, and Sacramento. Some of the most aggressive and innovative programs in this area are found in municipally owned utilities, as seen by the following examples.

San Antonio. San Antonio is home to the largest integrated (gas and electric) municipally owned utility in the country, CPS Energy. CPS Energy is vertically integrated. It owns over 6,000 MW of generating capacity, based on nuclear, coal, natural gas, wind, solar, and landfill gas. CPS Energy has also become a leader in renewable energy, energy efficiency, and leveraging the utility for economic development in San Antonio.

CPS has under contract more than 800 MW of wind capacity, representing the largest wind portfolio of any municipally owned utility in the country. In 2009, in coordination with the City's Mission Verde

sustainable economic development plan, CPS introduced Save for Tomorrow Energy Plan (STEP), a program to save 771 MW through energy efficiency programs by 2020 through an investment of more than $800 million. The plan is funded through the fuel adjustment fee, which was approved by the San Antonio City Council in 2009. The results have been stunning. In 2008, CPS saved about 10 MW through its energy efficiency programs. In the first two years of STEP, CPS has saved 244 MW, including 126 MW of peak demand reduction. Ratepayers save in several ways: 1) CPS will not have to pay for and build as much generating capacity in the future, 2) ratepayers (residential and commercial) will save money from the STEP programs themselves, and 3) hundreds of jobs in energy efficiency and retrofitting are being, and will be, created.

Recently CPS Energy, along with San Antonio Mayor Julian Castro (who sits on the CPS Energy board), announced the creation of over 200 clean energy jobs in San Antonio by leveraging CPS assets and market presence. Several companies are either relocating to San Antonio or opening offices in San Antonio because of the opportunity to work with CPS, including areas such as LED lighting, demand response management, clean coal, and electric transportation.

Finally, CPS put out an offer to the global solar industry to build out 400 MW of solar through 2015 conditioned on competitive pricing, establishing solar manufacturing capacity and jobs in San Antonio, and investment in research and education in San Antonio. This is in addition to the 14 MW of solar already in place and another 30 MW of solar under contract.

Because it is municipally-owned, CPS Energy has been able to align its policies with the City's, think long-term, and leverage its market presence for economic development and job creation in San Antonio, all in a period of a few years. At the same time, CPS has the lowest utility rates among any large Texas city and provides up to 14% of its gross revenues back to the City of San Antonio, representing about 25% of the revenues for the City's General Fund.

Sacramento. The Sacramento Municipal Utility District (SMUD), the sixth largest municipally owned utility in the country, is a long-time recognized leader in innovation in energy efficiency and renewable energy. SMUD has been a pioneer in these areas. They first started energy efficiency programs in 1973, the first utility-scale solar facility in the country in 1984, an electric transportation program in 1992, community and residential solar programs in 2008, smart grid build-out in 2009, and by 2020 plans to have 33% of its power from renewable sources such as wind, solar, and hydropower. Currently, SMUD has many cutting-edge programs in energy efficiency and renewable energy, including the following:

- Greenergy: Allows ratepayers to offset 100% of their power needs through renewable energy for $6/mo
- SMUD Solar Smart Home: Combines energy efficiency and solar for 60% savings off utility bill
- SMUD Solar Shares: For a fixed monthly price, based on usage, a ratepayer gets a credit every month for solar power produced on a solar farm
- SMUD Home of the Future: Home that produces 80% savings, including net zero electric use
- Smart Grid: Smart meters deployed through entire service area by end of 2011
- Grow Sacramento Fund: Loan program for businesses in the Sacramento service area to create or retain jobs and help energy-related businesses
- SMUD Commercial Loan Program: Loan program for commercial and multi-family ratepayers for energy efficient buildings and equipment

While this is only a sampling of the programs provided by SMUD, the utility is able to provide these services while having utility rates that are over 20% less than neighboring investor-owned utilities. As with CPS Energy, this is how a municipally owned utility leverages its policies and assets to help its community and become a national leader in energy efficiency and renewable energy.

Austin. Austin, Texas, is the home of the ninth largest municipally owned utility in the country, Austin Energy. Like SMUD, Austin Energy has been a pioneer and leader in energy efficiency, renewable energy, and the smart grid. It developed the first green building program in the country, has aggressively supported renewable energy, and has a comprehensive residential and commercial energy efficiency program. Austin Energy is a key reason why the city of Austin is considered a leader in renewable energy and energy efficiency, leadership that recently lead to the announcement by SunPower, a leading US panel manufacturer, that it will locate up to 450 engineering and technical jobs in Austin.

Austin Energy provides an interesting contrast in governance to CPS Energy and SMUD. CPS Energy is a separate entity in which the Mayor sits ex officio on a five-member board and in which the City acts as both regulator and owner, with management and operations left to CPS Energy. SMUD is also a separate entity from the city and has an elected board of directors through single-member districts. Austin Energy is a city department of the City of Austin. The Austin City Council is essentially the board of Austin Energy. While this directly aligns the interests of the utility with the city government, it also directly aligns the two politically. But regardless of the governance, all three utilities are examples of how city ownership allows a utility to provide low rates to customers, financial support to the city and taxpayers, and innovation and economic development for the community.

While the above examples show the benefits of having a municipally owned utility, it is worth noting that these are examples of long-standing municipal electric franchises. Relatively few cities have recently made the decision to purchase their local electric franchise. Most have been very small cities. (One exception is the Long Island Power Authority, with over a million customers, which was bought by the government entity in 1998.)

In looking at this issue for Tulsa, the threshold issue is whether Tulsa has the power to purchase its local electric franchise. The answer is yes. Tulsa's electricity is provided under a franchise granted by the City of Tulsa to Public Service Company of Oklahoma (PSO), a unit of American Electric Power Co. The franchise is governed by city ordinance, Title 15, Chapter 4, Tulsa Code of Ordinances. Under this chapter, the City of Tulsa has the power to purchase the assets of PSO that serve Tulsa after 15 years from the date that PSO accepted the franchise (which was July 7, 1997). See Title 15, Chapter 4, Sec. 413(a). The ordinance also prescribes a procedure to determine the value of the franchise (determined by a majority of three appraisers), and requires a vote of the people of Tulsa to allow the purchase. Sec. 413(b)(c). Under this ordinance, Tulsa has the right to buy back the electric franchise from PSO any time after July 2012.

The broader question is whether Tulsa should buy its local electric utility franchise. The answer, for the reasons noted below, is beyond the scope of this plan. The reason is that the decision whether to do so is a basic and fundamental one that involves many considerations, including lengthy and in-depth legal and financial analysis, and is one that ultimately must be decided by the community. What can be noted are the general advantages and disadvantages for a city seeking to buy an electric franchise today.

Advantages. The advantages of having a municipally-owned utility can general be grouped into four categories:

- Local control
- Potentially lower electricity rates
- Diversifying city revenues
- Equal or greater reliability and service.

Local control. This is one of the main advantages of ownership. With local control, a city can determine how to provide electricity in a way that incorporates the priorities of the city. This manifests itself in the programs pursued by the utility (such as energy efficiency or distributed energy programs), leveraging the utility for local economic development opportunities, deciding on supply options, having a local workforce, and generally aligning local resources with local needs. With local control, a city controls its own fate regarding the issues surrounding electricity.

Lower electricity rates. Generally, municipally owned utilities have lower electricity rates than investor owned utilities. One reason is the profit motive built into the investor owned model, which is an additional cost, compared to the municipally owned model, which puts an emphasis on reasonable rates for the community. Municipally owned utilities also don't pay taxes and have lower borrowing costs because they are tax-exempt. Another reason for the lower rates is the element of local control. For example, Tulsa may have the option of looking to other supply choices, such as hydropower, that could be less expensive than the current generation mix relied upon by PSO.

Whatever the reason, if lower electricity rates are achieved, the benefits to the community are many, including local economic development.

Diversifying city revenues. A municipally owned utility can be a significant source of revenue for a city. For example, CPS Energy in San Antonio provides up to 14% of its gross revenues to the General Fund of the City of San Antonio, which amounts to over $200 million every year, representing about 25 % of the City's General Fund. This could be particularly important for a city like Tulsa, which gets almost 90% of its revenue from one source - sales taxes.

Equal or greater reliability and service. Municipally owned utilities often have fewer outages and greater customer satisfaction than investor owned utilities. This goes back to the concept of local control and the emphasis on longer-term investment in infrastructure as opposed to a shorter-term need to produce profits. But whether this is true in a particular location is dependent on the reliability and service of the investor owned utility and the potential for improvement through a municipally owned one.

Disadvantages. The disadvantages of creating a new municipally owned utility are:

- Cost
- The process
- The responsibility of ownership

Cost. The single biggest obstacle to buying an investor owned electric system is cost. The largest cost is the cost of buying the local distribution system and all of its equipment. But there are other costs as well:

- Preliminary acquisition costs - Feasibility studies, legal fees, valuation analysis, costs of election
- Start-up costs - As with any new business, they are start-up costs, including office expense, additional equipment, new personnel, and new billing system
- Severance - This is the cost associated with severing the investor owned utility's system from the city-owned system
- Stranded costs - There may be "stranded" costs associated with prior costs incurred by the utility in serving the area now served by the city owned utility
- Lost tax revenue - While the new city-owned utility may provide significant revenues to the city, there will be some lost tax revenue and franchise fees from the investor owned utility
- Interest on debt - The new city-owned utility will have to borrow money to buy the franchise, which will create interest payments on that debt
- Power costs - The new city-owned utility will have to buy power to provide to its ratepayers.

These costs are the main obstacle in the "municipalization" of an electric franchise. Whether these costs are prohibitive for the City of Tulsa can only be known after financial analysis. A pre-feasibility study can be done to get an initial idea of whether this makes financial sense for Tulsa, but only a full valuation analysis of all costs can completely answer the question.

The Process. The process of buying an investor-owned utility can take years, be quite costly depending on the opposition from the utility, and can divide a community. The City of Las Cruces battled El Paso Electric for more than 10 years before settling the case and deciding not to proceed with the purchase. A city that is currently involved in the process is Boulder, Colorado. After lengthy studies and negotiations, the Boulder City Council voted on July 19, 2011, to seek a citywide

referendum on buying the city's electric franchise from the current utility, Xcel Energy, because of the city's desire to have a more diverse renewable energy portfolio. The referendum will be held in November 2011, and is being opposed by Xcel Energy. Boulder's experience will be instructive to watch.

The Responsibility of Ownership. Finally, if a city takes on ownership of a utility, it must take on the responsibility of ownership. This includes ensuring that the utility is soundly managed, that it is fiscally sound, and that it becomes an asset to the community, and not a financial burden. Risk is inherent in any business, including the utility business. While there are ways to mitigate this risk, it cannot be eliminated.

Next steps

Whether Tulsa should own its own electric utility is not answered here. That question requires in-depth financial, technical, and legal analysis that is beyond the scope of this plan, and it requires the requisite political and community will in Tulsa. What is clear, though, is that aligning the interests of the city with that of a city-owned utility provide the opportunity for unique economic development and job creation in ways that an investor-owned utility cannot bring. For these reasons and those cited above, it may make sense for Tulsa to explore the possibility of owning its own electric utility.

Initiative #3: Innovative Financing Models for Distributed Energy and Retrofitting

Energy efficiency retrofitting and distributed energy create economic activity in several ways. They create savings to the users and opportunities for businesses to provide products and services in these areas, and they create jobs. This is particularly true for energy efficiency retrofitting. Energy efficiency retrofitting has the potential to create jobs in designing, engineering, and performing the retrofits or new construction, operating and servicing the buildings, and designing and manufacturing the installed equipment and materials.

The key barrier to energy efficiency retrofitting and deployment of distributive energy is cost. The high, upfront capital cost of energy efficiency improvements and distributive energy systems is often difficult for companies, institutions, and homeowners to justify, even though the improvements bring lower life-cycle costs. Because of this, innovative financing models have begun to emerge to overcome this cost barrier. What follows is a review of some of these models. Some of these have direct application to Tulsa today; others maybe in the future. But all have the potential to help create cost savings, business opportunities, and job creation.

Property Assessed Clean Energy (PACE) Financing

PACE (not to be confused with Partners for A Clean Environment, as discussed in the Water Management Section of the Plan) financing allows property owners to borrow money from a local government entity to pay for renewable energy or energy efficiency improvements, thereby overcoming the high, upfront costs of such systems or improvements. The amount borrowed is usually paid back through a special assessment on the owners' property taxes. Only property owners who opt into the PACE program are subject to the assessment. The assessment runs with the property. If a property owner in a PACE program sells the property, the assessment (the obligation to repay) transfers to the new property owner. There are several advantages of a PACE program:

- It provides long-term, fixed-cost, attractive financing.
- Loans are tied to the tax capacity of the property, not the owner's credit standing.
- The repayment obligation transfers with the sale of the property.
- There is the ability to deduct the repayment obligation from federal taxable income.

PACE financing generally requires state legislative authorization. Twenty-seven states, including Oklahoma (in 2009), have passed PACE legislation. However, in July 2010, the Federal Housing Finance Agency ordered Fannie Mae, Freddie Mac, and the Federal Home Loan Banks (which represent about 95% of residential mortgage lending in the U.S.) to stop underwriting mortgages with PACE assessments. This essentially shut down residential PACE programs, leaving only a few commercial PACE programs in operation around the country.

Two recent legislative events may change this for the country, and Tulsa. The first is a bill introduced in the U.S. House of Representatives on July 20, 2011, called the "PACE Assessment Protection Act of 2011." (H.R. 2599). The bill, which has bipartisan sponsorship, is intended to undo the decision made by the Federal Housing Finance Agency in 2010 and legally protect PACE programs from adverse federal housing mortgage policies. It would set certain requirements for PACE programs, such as limits on project size and home equity thresholds. Its goal is to spur local job creation and economic development. The bill authors project that if 1% of U.S. homes participated in PACE, the projects would generate 226,000 jobs, $42 billion in economic output, and $4.2 billion in combined federal, state and local tax revenue.

If this bill passes Congress, Tulsa will be in position to move forward with PACE financing. In 2011, the Oklahoma Legislature passed the Oklahoma Municipal Energy Independence Act, which becomes effective November 1, 2011. This Act allows a city to create a municipal energy district authority, led by the mayor, which can issue bonds or secure funding from any public or private source for the installation of distributed renewable energy sources or to make energy efficiency improvements. The Act specifically allows the creation of a lien on the property that is the subject of the loan, and this loan is enforceable through foreclosure on the property. In essence, this Act creates a mechanism by which an Oklahoma city, such as Tulsa, can institute a PACE program.

If Congress passes the PACE Assessment Protection Act, Tulsa will be able to establish a broad-based residential PACE program for the community. The question then becomes how to pay for the program. One answer may be Qualified Energy Conservation Bonds.

Qualified Energy Conservation Bonds (QECB)

Qualified Energy Conservation Bonds (QECB) are debt instruments that allow state and local governments to fund qualified renewable energy and energy efficiency programs and projects. QECBs are among the lowest-cost public financing tools because the U.S. Department of Treasury subsidizes the issuer's borrowing costs. Basically, a state or local government can borrow the money from the federal government and receive either a federal tax credit for the interest payments or a cash rebate from the Treasury to subsidize the interest payments.

QECBs were created under the Energy Improvement and Extension Act of 2008. The issuance capacity was extended to $3.2 billion in the American Recovery and Reinvestment Act of 2009. The total allocation is divided among the state and local issuers according to population. Overall only about 10 to 15% of the issuance capacity has been used nationally. Oklahoma has an issuance capacity of almost $38 million, and of this amount, Tulsa has a capacity of about $4 million. It does not appear that Oklahoma (or Tulsa) has used any of its capacity yet.

Most QECBs have been used for public building retrofits but QECBs can be used to fund "green community programs." These programs can finance retrofits of existing private buildings through loans or grants to individual homeowners or businesses, which could include a PACE program. The Oklahoma Municipal Energy Independence Act anticipated this because the Act states that a

municipal energy district authority can make loans to "implement green community programs and qualified energy-conservation programs."

As of June 2011, 46 projects in 15 states have been funded with QECBs. One of these is a PACE program. (On November 5, 2010, the City of Boulder issued $1.575 million in QECBs to fund a commercial PACE program.) So while there has not been widespread use of QECBs for PACE programs, it is clearly contemplated under U.S. and Oklahoma law, and could be a good use of the funds for Tulsa.

Revolving Loan Funds

QECBs could potentially also be used to fund a revolving loan program. Revolving loan funds are funds of capital used to provide loans for energy efficiency and renewable energy. The loan repayments recapitalize the fund to allow additional lending.

These kinds of funds are common--over 30 states have established loan programs for energy efficiency and renewable energy improvements. The advantages of these loan programs are:

- They are simple to set up
- The funds revolve indefinitely, creating funding for the long term
- They can be molded for many different markets and programs.

The disadvantages are:

- If the government is the administrator, this will require staff time and expertise to set up and oversee
- It does not leverage private capital
- Rigorous credit analysis must be done on the borrower's ability to pay
- Costly collateral or security may be needed from the borrower.

A couple of examples of city-based revolving loan funds show application on a large-scale and a small one. The large-scale example is the Philadelphia Greenworks Loan Fund. This fund is intended 1) to finance energy efficiency in commercial buildings (including institutional), 2) to achieve 25% reduction in energy use, and 3) to provide a new model for financing energy efficiency based on traditional real estate lending. The fund is capitalized at $39 million with funding from federal stimulus and private sources. It was started by three separate City agencies, and is administered on the financial side by a nonprofit dedicated to city economic development, partnered with a community development financial institution, and evaluated by an independent technical project evaluator.

The small-scale example is the City of San Antonio City Lights program. City Lights is a hybrid revolving loan/direct rebate program for lighting upgrades to small businesses. Lighting was chosen as the energy efficiency improvement because lighting represents a significant portion of a small business's electric bill, lighting upgrades have quick paybacks, and the upgrades are affordable and relatively simple. The way it works is that participants in the program get a free lighting audit. Then participants have the option of taking out a zero-interest, 36-month loan for up to $3,000, or get a direct rebate of $400. These incentives are in addition to the local city-owned utility's incentives, which cover 50% of the cost.

The Office of Environmental Policy of the City of San Antonio initiated, designed, and funded City Lights. CPS Energy, the local municipally owned utility, identified potential participants and led the marketing and outreach. Enerpath, an energy efficiency implementation company, administers the program, conducts the audits, and manages the subcontractors. ACCION Texas, the nation's leading microlender, provides the loans.

City Lights was funded with $500,000 from EECBG grant funding. In the first six months of the program, 142 small businesses had enrolled, and 500 more were in the assessment stage. This represents investments of over $100,000, with more than $500,000 in potential investment. It is estimated that City Lights will save 3,500 MWh of energy and create or retain 11 jobs.

Given Tulsa's situation, the approach that makes the most sense is a simple, small-scale program like the City Lights program in San Antonio. First, Tulsa would need to identify initial funding for the revolving loan program. The most likely source is the QECB. Although QECBs have not been used for a revolving loan program, they have been used for a $10 million home loan program in St. Louis. QECBs can be used for "green community programs," which can finance retrofits of existing private buildings through loans or grants to individual homeowners or businesses. While this covers PACE programs, it is broad enough also to include revolving loan programs. This would also be covered under the Oklahoma Municipal Energy Independence Act (a municipal energy district authority can make loans to "implement green community programs and qualified energy-conservation programs.")

A small-scale program also makes sense for Tulsa because Tulsa does not have an existing revolving loan fund upon which to build. Tulsa will have to create this program, so it makes sense to start small and then build upon it when there is more funding, experience, and resources.

On-bill Financing

On-bill financing systems are utility programs designed to help customers pay for energy efficiency upgrades. The money is loaned for the costs of the improvements, with the energy savings of the improvements used to repay the loan through a charge on the customer's monthly utility bill. It is similar to PACE financing, except the lender is the utility, not the government entity. This form of financing can be an effective means to overcome the upfront costs of retrofitting. The challenge for local utilities is that 1) these financing systems are often not simple to design, 2) they require an expensive overhaul of old billing systems, and 3) they put the utility in the role of the lender.

On-bill financing programs are not prevalent yet. There are about 10 significant programs around the country. These programs range from to those with $1 million budgets to those with over $10 million budgets, with programs focused on residential and small businesses to larger customers, including government entities. The first statewide bill authorizing on-bill financing was passed in New York in June 2011. Hawaii became the second in July 2011. It is estimated that a broad-based on-bill financing system has the potential to create thousands of jobs.

A particularly successful on-bill financing program is one at Southern California Edison. SoCal's program is open to businesses and government institutions, with loans ranging from $5,000 to $100,000 for businesses, and $5,000 to $250,000 for government entities, with an aggregate cap of $1 million for government entities. SoCal Edison funded the program at $16 million, but was forced to halt the program in April 2011, because of oversubscription. It now has a waiting list of more than $6 million in new applications.

On-bill financing is an example where cooperation with the local utility is essential. But it might be worth exploring for the City of Tulsa to look into an on-bill financing pilot project with the local

utility, PSO. The City is the largest customer of PSO, and maybe with the City's larger facilities, the retrofitting can be paid for through an on-bill financing system unique to the City. If successful, this model can then be applied to other City facilities, other large institutional customers in town, and maybe other large commercial customers.

Initiative #4: Municipal Green Building Policies

Green building is a potent job creator. In a study for the U.S. Green Building Council in 2009, a study found that from 2000-08, the national green construction market generated $173 billion in gross domestic product (GDP), supported over 2.4 million jobs, and provided $123 billion in labor earnings. It also estimated that the next five years would see more growth in the economic impact of green building.

2.4 M

Number of jobs created nationally in green construction market from 2000-2008

Cities can adopt various policies to encourage green building. They range from green building codes to expedited development review to internal policies that lead by example.

Green Building Codes. Many cities have adopted green building codes. Most codes only apply to new construction, often both residential and commercial, and adopt or reference third party standards, such as LEED or Energy Star®. The advantage of these kinds of codes is that they have a broad reach, affecting all construction governed by the codes. They therefore have the most economic impact. The major disadvantage of broad-based building codes is that there is often political opposition from the building industry to mandatory codes. However, as the demand for green buildings rises from homeowners and businesses, and green building practices become more commonplace, opposition to mandatory codes is lessening.

An example of this is San Antonio. San Antonio adopted its first green building code for new residential and commercial construction in 2009. The process for adoption was lengthy. In the summer of 2008, the Mayor of San Antonio, Phil Hardberger, appointed a task force of community stakeholders, from the US Green Building Council, to the builders' association, to recommend a green building code. The building industry initially opposed any kind of mandatory code. But as the task force progressed in its work, it found that new homes and buildings in the city were already meeting higher efficiency standards and that money could actually be saved with green building. Another factor was the desire to build flexibility into the plan. This last point was crucial. The final recommendations called for a 15% reduction in energy use from prior code levels, but gave builders various different means to achieve it. So the plan only mandated the goal, not the means to get there. In March 2009, the plan unanimously passed the San Antonio City Council without community or stakeholder opposition.

Targeted Provisions. An alternative to a green building code is a code with targeted provisions for specific green building practices. For example, in San Antonio all the stakeholders agreed that cool roofs for commercial buildings should be mandated because of the quick and certain payback. As a result, a cool roof provision was added, one of the few specifically mandated practices in San Antonio's green building code. Another example is an ordinance to ensure the installation of electric vehicle (EV) charging stations in homes and businesses. Auburn Hills, Michigan, passed an EV charging ordinance in July 2011, the first city in Michigan to do so. Among other things, it encourages the inclusion of electric vehicle readiness in new home construction. A similar ordinance could be passed for CNG vehicle readiness.

Development Process Incentives. Cities have also provided incentives for green buildings by giving preference to green building projects in the development process. The most common way is to provide expedited review of permits for green buildings. Another is to waive certain development fees. A city that has pioneered this is Chicago. Chicago has an expedited review process for any building that is certified under the LEED standard or the city's residential green building program. Chicago also waives some fees for buildings that achieve higher levels of efficiency. Chicago is also known for its expert green building staff that helps guide green builders through the permitting process.

Internal Green Building Policy. Another popular way for cities to encourage green building is to lead by example. Hundreds of cities have adopted green building standards such as LEED for the construction of new city buildings. This forces local private contractors to learn and use green building practices and train their workers in such practices. At the same time, it saves taxpayers money over the life of the building through green practices, as well as provides a better working environment for city employees. Tulsa's City Hall is a great example of a city leading by example., and internal green building initiatives are highlighted in the Stormwater/LID section of this Plan.

Part Five: Land Use and Transportation

Land use and transportation are key elements of sustainable economic development. The hallmarks of sustainable urban land use and transportation in the 21st century are efficient use of infrastructure, more closely integrated neighborhoods with a sense of community, and the preservation of natural systems. These principles also manifest in higher density, transit-oriented, in-fill development, mixed-use, walkable neighborhoods, and multi-modal transportation systems. The results are conserved resources, higher quality of life, healthier and more vibrant communities, and affordable standards of living. These benefits are important if cities like Tulsa are going to attract and retain the workforce of the 21st century's global economy.

Tulsa is already well positioned to embody these principles. Tulsa has the second shortest commute in the nation, the 15th highest high school graduation rate, and routinely is ranked one of the most livable and affordable cities in the country. Tulsa is also incorporating these principles in its future planning. The PLANiTULSA Vision for Tulsa is a comprehensive and detailed vision for land use, transportation, economic development, housing, and parks. The principles of sustainability and efficiency are found throughout this plan, which presents our vision of a multi-modal transportation system, mixed-use, pedestrian-friendly neighborhoods, and preservation of natural systems.

Appendix 1: Sustainability Initiatives

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Establish a City-Wide Comprehensive Approach to Energy Management					
1.	Re-Establish Energy Conservation and Sustainability Team (ECST)	The City currently has no organized group tasked specifically with energy and water management. In 2008, an inter-departmental group of City employees released the "Energy Conservation and Sustainability Strategic Plan" containing recommendations covering topics ranging from energy efficiency to recycling. After 2008, the ECST ceased to function and there has not been a coordinated inter-departmental effort toward energy management since.	Re-establish ECST with necessary personnel, resources, authority, and budget to lead a coordinated interdepartmental energy management program.	Total percentage of City's energy spend saved due to ECST activities	1% of total City energy spend saved in FY 2012, increasing to 5% by 2015.
2.	Implement a Systematic Approach to Energy and Water Management	The City does not currently have an integrated approach to Energy and Water Management	Use guidance from ISO 50001 Standard for Energy Management Programs to define the process that the ECST will use to identify, evaluate, prioritize and measure energy and water conservation initiatives	Certifiability of City Energy and Water Management Program under ISO 50001	Certifiable (but not necessarily certified) Energy Management Program by end of FY2013
3.	Establish Streamlined Energy Data Management System	Energy data is scattered, inconsistently organized, and not readily available.	Organize and consolidate energy data in a consistent format and make widely available to City departments.	Percentage of total energy spend represented by readily available energy data.	90% of total energy spend accounted for in Hara EEM and/or other readily accessible databases

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
4.	**Prioritized Replacement List for Motors Larger than 10 HP**	The City does not have a systematic approach to identifying and replacing inefficient motors in its water and wastewater treatment and distribution systems. Motors account for 90% of the electric energy consumed in a typical water and wastewater plant.	Organize and consolidate energy data in a consistent format and make widely available to City departments.	Simple payback (in years) for the replacement of inefficient motors.	Year 1: < 2 Years Year 2: < 2.5 Years Year 3: < 3 Years Year 4: < 4 Years Year 5: < 5 Years
5.	**Consider "Soft-Starter" Systems on Motors Larger than 25 HP**	Many of the City's largest motors are constant speed drive motors that cycle on and off regularly. This frequent starting and stopping of large motors tends to add to "peak" energy demand with large spikes in electricity consumption as the motor starts up. It can also reduce the expected life of the motor and increase associated maintenance costs.	Work in conjunction with parallel efforts through Asset Management Planning to compile an inventory of all City-owned and operated motors larger than 10 Horsepower (10 HP) and prioritize motor replacements based on life-cycle costs.	% reduction of total consumed electricity in kWh for motors equipped with soft starter systems.	10% average reduction of total estimated annual electricity consumption in kWh for motors equipped with soft starter systems.
6.	**Institute Large Motor Performance Testing & Efficiency Commissioning (O&M Procedure)**	Large motors, specifically those at the water and wastewater treatment plants, are very high energy users. If large motors are not properly operated and maintained, it can result in significant excess energy use.	Large motors should be tested and commissioned often to ensure that they are working at maximum allowable efficiency.	Motor efficiency should be tested on all motors larger than 50 HP.	Test motors larger than 50 HP, maintain rated efficiency, and ensure that the efficiency of the motor is within +/- 2% of the labeled efficiency.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
7.	Use an Inventory and Replacement Prioritization of Lighting and HVAC Systems	No systematic approach to replacing inefficient lighting or HVAC equipment. 50% of the electricity consumed in a typical commercial office building is for cooling and lighting. New, high-efficiency HVAC and lighting equipment can provide the same or better functionality as existing systems while using a fraction of the electricity.	Implement a systematic approach to identifying and replacing old and inefficient lighting and HVAC equipment.	Simple payback (in years) for the replacement of inefficient lighting and HVAC equipment.	Two year simple payback for lighting retrofits and five year simple payback for HVAC replacements.
8.	Replace Existing Highway Lighting with High-Efficiency LEDs	The City pays the electric bills for highway lighting but these lights are not the most efficient option currently available.	Work with ODOT to move away from replacement with like type fixtures/ballasts to a more energy efficient and similar light output fixture.	Total percentage of existing highway lights replaced with high-efficiency LED highway lights.	25% by end of FY 2013, 100% by end of FY 2016.
9.	Upgrade Interior Lighting, Occupancy Sensors, and Exit Signs	The City of Tulsa still uses inefficient luminaires with T12 lamps and magnetic ballasts.	A lighting upgrade program should be implemented that consists of an assessment of all of the City of Tulsa's facilities beginning with the largest facilities.	Percentage of T12 luminaires replaced by high efficiency alternatives	100% of T12 luminaires replaced by end of FY2013.
10.	Re-Commission Lighting Control at One Technology Center	One Technology Center (OTC) has a lighting control system that may not be optimized to provide only the minimum amount of lighting required for occupant egress.	The lighting control system for OTC should be re-commissioned to ensure that only the minimum amount of light required for safe egress during emergencies is turned on during the nights and weekends.	Total electricity costs for OTC	15% reduction of total electricity costs in FY2013

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
11.	Replace Building Exterior Lighting with High-Efficiency Alternatives	Exterior lighting is typically provided by high-intensity discharge lamps, which are often high wattage.	Replacing HID wall packs and flood lights with LED typically reduces energy consumption by over 70%, reduces re-lamping cost, and limits night light pollution.	Number of HID exterior lighting fixtures replaced with high efficiency alternatives.	Three buildings with HID exterior lighting by end of FY 2013
12.	Implement Retro-Commissioning Program for Existing City Buildings	Many City buildings, particularly those that have never gone through any type of commissioning or quality assurance process, are typically performing well below their potential.	Retro-commissioning is a process that involves a thorough analysis of a facility and its goal is to improve building processes so that they perform, not only the way they were designed to, but in a way that meets current operating needs.	Number of City buildings retro-commissioned and percentage reduction of energy use in those buildings.	Three of the City facilities with the highest energy/sf ratios retro-commissioned with 3-5% reduction in energy consumption by FY2013.
13.	Enforce City Policies Regarding HVAC Controls, Setbacks and Set Points	Many HVAC systems throughout City-owned facilities are controlled by facility occupants and are not controlled in compliance with existing City policy. When occupants are given control of a building's HVAC system, set points and schedules often exceed the range of temperatures and occupied hours ideal for energy efficiency and as a result, systems likely operate more hours than needed. Some buildings throughout the City do not have the ability to automatically adjust temperature set points according to a schedule, but instead are controlled manually.	For buildings with no building automation system or zone-level programmable control, programmable thermostats could provide an effective, economical, and easy way to save energy.	The percentage of buildings utilizing programmable control. The percentage of buildings properly utilizing programmable control.	All buildings with non-24/7 occupancy should have programmable control ability.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
14.	**Reset Domestic Hot Water Temperatures**	Domestic hot water heaters are often set to higher temperatures than needed to adequately meet the demand of the hot water system.	Although some manufacturers set water heater thermostats to 140˚F, many domestic hot water systems only require a set point of 120˚F.	The percentage of domestic water heaters that are set to the optimal temperature that satisfies hot water needs while limiting energy waste.	All of the city facility domestic water heaters are set to the optimal temperature that will satisfy the domestic hot water needs while limiting energy waste within one year.
15.	**Enforce Existing Policy on Computer Power Controls / Laptop Conversion**	A standard desktop computer consumes about 100 watts on average when it is in use, while standard aptops consume about 30 watts. Out-dated cathode ray tube (CRT) monitors consume as much as 70 watts when in use, while liquid crystal display (LCD) monitors that are LED backlit consume about 15 watts. Additionally, a significant amount of energy is wasted when computers are put in screen-saver mode rather than hibernate or shut down when not in use.	All City-owned desktop computers should be set to go into hibernate mode when not in use for 15-30 minutes and to shut down overnight.	The percentage of City-owned desktops on the NightWatchman® system.	All City-owned desktops without a valid exemption are on the NightWatchman® system.
16.	**Install Vending Machine Setback Controls**	Refrigerated and snack vending machines can consume large amounts of wasted energy due to their 24 hour/7 days per week operation, regardless of area occupancy or vending machine use.	Install vending and snack misers on beverage and snack vending machines.	Percentage of vending machines with installed occupancy controls.	100% of vending machines have occupancy controls installed over the next three years.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
17.	Use Demand Control Ventilation	Many City buildings are conditioning more outside air than is necessary, contributing to higher electricity bills. Buildings are designed to promote the health and comfort of their occupants. Part of this design strategy is to provide outdoor air or "fresh air." Often this fresh air is delivered as if the building were at full occupancy regardless of whether or not it is occupied at all. More often than not, this fresh air has to be conditioned to meet indoor temperature set points. The cost to condition this air is a significant portion of the total energy cost for most building HVAC systems.	Implement a Demand Control Ventilation control strategy.	Total number of buildings evaluated for implementation of DCV control strategy; total number of identified buildings retrofitted with DCV control strategy.	100% of buildings evaluated for use of DCV control strategy by end of FY2012; 25% of buildings identified as good candidates for DCV retrofitted by end of FY2013.
18.	Convert Constant Volume Rooftop/Air Handling Systems to Variable Volume	The amount of air required to cool a space typically varies throughout the course of a day and year; however, the air handler peak design supply air volume is typically sized for the peak space sensible cooling load.	Evaluate City buildings for applicability of variable volume air distribution systems and install in those buildings that are good candidates, especially HVAC systems with varying occupancy.	Simple payback (in years) of the relevant buildings with constant volume air handling units.	Implement on all buildings that yield a simple payback of less than 5 years.
19.	Convert Constant Volume Hydronic Pumps to Variable Volume	The amount of water required to meet the cooling or heating demands typically varies throughout the ourse of a day and year; however, a pump is selected based on the maximum amount of flow required.	A significant amount of energy can be saved by converting the water distribution from constant flow to variable flow.	Total number of constant volume hydronic pumps replaced with variable volume pumps.	100% of constant volume hydronic pumps replaced by FY2013.
20.	Convert Air Handling Units with Inlet Guide Vanes to Variable Frequency Drives	Inlet guide vanes are an inefficient means of regulating air flow in an air handling system to meet demand.	Air handling units that utilize inlet guide vanes and the Modudrive system should be replaced with variable speed drives.	Total number Air Handling Units with inlet guide vanes fitted with variable frequency drives	100% of AHUs with inlet guide vanes fitted with variable frequency drives by FY2013.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
21.	Convert Aeration Blowers to Variable Frequency Drive	Wastewater treatment plants utilize high horsepower motors on aerator blowers that supply air to aerator tanks. Blowers typically use throttling valves to control the volume of air to the tanks. This is an inefficient method of volume control since the motors are run at 100% speed and full power, while throttling valves adjust flow to satisfy demand. The most energy efficient method of volume control is a variable speed drive that slows the motor speed (in RPM) to regulate the amount of air flow needed by the system, which in turn reduces the amount of power consumed by the motor.	Throttling valves could be removed or locked in the 100% open position and the motors for the blowers could be replaced with premium efficiency, inverter-duty motors with variable frequency drives.	Percentage of eligible existing motors retrofitted with VFDs	100% of aeration blowers evaluated for conversion to VFDs and 25% of eligible existing motors converted to VFDs by end of FY2013.
22.	Use a Heating Hot Water Reset Strategy	Typical boilers are enabled based on outside air temperature, but adjust the hot water supply temperature according to outside air temperature. This results in the boilers supplying a constant heating hot water temperature at all times when running.	Consider hot water reset for eligible boilers. Hot water reset is an energy-saving automatic control algorithm for hot water boilers that are typically fired with fuel oil or natural gas.	Percentage of eligible boilers retrofitted with hot water reset controllers.	100% of boilers evaluated for installation of hot water reset controllers and 25% of eligible boilers retrofitted by end of FY2013.
23.	Retrofit Magnetic Bearings on Vehicle Exhaust Boot System in Fire Stations	Pneumatic air compression systems at Tulsa fire stations may not be operating as efficiently as they could be.	The current pneumatic system can be retrofitted with a magnetic system that will dramatically reduce the use of the air compressor.	Percentage of pneumatic boots changed to the magnetic system.	All of the pneumatic boots changed to magnetic systems over the next five years.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
24.	**Convert to Infrared (IR) Heating in Large Garage and Storage Spaces**	Large garage and storage spaces are often heated with multiple, gas-fired, forced-air unit heaters. With forced air heating systems, most of the heat escapes when garage doors are opened.	Given the use of large heated garages and storage spaces, infrared (IR) heating is a more efficient system for heating the spaces.	Total number of eligible forced hot air heating systems replaced with IR heating systems.	100% of forced hot air heating systems evaluated for installation of hot water reset controllers and 25% of eligible systems replaced with IR heating by end of FY2013.
25.	**Replace Domestic Hot Water Heaters with High Efficiency Models**	First cost is typically considered a priority over energy efficiency when selecting equipment. As a result, high efficiency water heaters are not always used.	As domestic hot water heaters reach the end of their useful lives, units should be replaced with high efficiency models.	Total number of City-owned domestic hot water heaters scheduled for replacement that are replaced with high-efficiency model.	All newly purchased domestic hot water heaters are high-efficiency type.
26.	**Replace Single-Pane Windows**	Older City buildings often have single-pane windows with little or no shading coefficient. Additionally, older windows are typically thermally broken and may have significant infiltration.	Upgrading single-pane windows to new double-pane windows with a U-value less than 0.35 results in reduced infiltration, energy consumption, and use of electric space heaters, as well as improved occupant comfort and building aesthetics.	Percentage of single-paned windows replaced with double paned windows.	100% of City-owned buildings assessed for presence of single-pane windows. One building targeted for replacement of single pane windows with double-pane windows by the end of FY 2012 and two more buildings in FY2013.

Energy Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Specific Energy Conservation/Efficiency Opportunities					
27.	**Maximize Utility Incentive Opportunities**	Currently, not all departments in the City take advantage of the utility rebates offered through the electric utility company. The Model Cities program through AEP offers $0.06/kWh for energy-saving projects based on annual kWh savings. AEP's CoolSaver program offers $75 for an HVAC tune-up completed by registered qualifying contractors who work to improve the HVAC equipment's energy efficiency.	The City should work with AEP on all projects completed in City-owned facilities that result in energy savings that qualify for the utility incentive program.	The total dollar value of acquired rebate incentives.	All projects that result in energy savings have applied for a utility incentive.
28.	**Provide Incentives and Resources for Comprehensive Life Cycle Analysis (LCA) Energy Reviews for New City Facilities and Major Renovations**	There is currently no systematic approach to evaluating the life cycle energy costs of new construction or major renovations for new or existing City-owned facilities. Significant life cycle energy and water cost savings can be achieved through including design elements in the initial planning and specification process for new construction or major renovations. However, this approach is strictly voluntary at this time.	Implement a new policy that provides the necessary resources and incentives for every new construction or major renovation project to conduct a comprehensive review of design elements that will increase the facility's energy and water efficiency over its life.		
29.	**Revise City of Tulsa Codes to Encourage Adoption of Electric and Compressed Natural Gas Vehicles**	According to the 2011 State of the Air Report issued by the American Lung Association, Tulsa received a grade of "F" for high ozone days, indicative of very poor air quality that threatens the health of Tulsa's citizens.	The City of Tulsa should amend its residential building codes to require all new single-family homes to be designed in such as a way as to facilitate the installation of residential electric vehicle battery charging and compressed natural gas refueling stations.	Consideration of Code amendments and adoption of new residential building code amendments in the appropriate sections.	Code amendments related to this Initiative considered and adopted by Tulsa City Council by end of FY2012.

Energy Management

Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Additional Objectives				
Develop mandatory maintenance staff energy efficiency training program	Maintenance staff does not receive specific training on how to optimize the energy performance of major energy-consuming equipment.	Obtain outside technical instructors to train maintenance staff on techniques and procedures to use in routine equipment maintenance that preserves the efficiency and projected useful life of equipment. Implement best management practices for maintenance of all energy consuming equipment. Conduct audit of motor repair shops to ensure they follow Electrical Apparatus Service Association (EASA) standards.	Number of maintenance staff who receive training/ certification	Maintenance staff supervisors receive training by end of FY 2012 100% of maintenance staff by end of FY2013
Move interval data meter from old Adult Detention Center (1708 Charles Page Blvd.) to e-911 Facility	The City currently has only 16 interval data meters from PSO and one of them is located at the Adult Detention Center which is currently closed.	Request from PSO that the interval meter at the Adult Detention Center (PSO Acct. #9505641130) to the Emergency 911 Facility at 801 E. Oklahoma (Acct. #9595330740)	Interval meter moved to Account #9595330740	By end of FY2012
Request separate electricity meters for OTC and Performing Arts Center	Currently there is 15-minute interval data available for Account #9591229520 which is the combined electricity use for both OTC and the Performing Arts Center. This makes it difficult to analyze the load profile of the data because it is impossible to distinguish which facility is using electricity at any given time.	Request that PSO install a separate meter for the Performing Arts Center and keep the interval meter active for the OTC account.	Installation of new meter for Performing Arts Center.	By end of FY2012

Energy Management

Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Additional Objectives				
Identify underused utility meters	Many utility meters appear to be unutilized or underutilized.	Perform usage audit on all underperforming meters and recommend removal or consolidation.	Percentage of underperforming utility meters audited. Number of underperforming utility meters removed or consolidated.	100% of underperforming utility meters accounted for and usage identified. 100% of recommended meters have been removed or consolidated.
Develop lighting and HVAC maintenance standards for optimizing performance, life expectancy, and energy efficiency				
Implement Standardized Lighting Citywide	Currently every department can purchase whatever type of lighting system they want so there are dozens of different lighting system configurations, ballast/bulb types, and sizes. This makes routine maintenance more labor intensive and expensive.	Produce a select list of several standard lighting system types that departments can choose from for any new lighting or major retrofitting projects. This will reduce maintenance costs over the long term and allow the City to negotiate favorable pricing with bulk orders of replacement parts.	Approval of official standardized lighting policy by Mayor's Office, Office of Sustainability, and Procurement Committee	Development and implementation of new policy by the end of FY 2013

Water Management - Water Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Reduce Operating Costs of Water Treatment Plants					
1.	Establish Best Management Practices and Training for Energy Usage at Water Treatment Plants and Distribution System	City does not have Best Management Practices (BMP) guidance in place for energy or water conservation at water treatment plants .	A formalized Best Management Practice (BMP) should be developed for the water treatment plants which explores and evaluates operational energy-savings practices at the facility. This BMP could be built upon the results of the water facility energy audit conducted by URS and expanded into a training program for maintenance staff.	The BMP and training program should be developed within six months of the results of the URS energy audit.	The BMP and training program should be developed within six months of the results of the URS energy audit.
2.	Evaluate Water Treatment Chemical Pricing and Contracts	As part of the water treatment process, millions of dollars are spent annually on chemical costs. Due to pricing volatility, chemical suppliers are hesitant to renew contracts and or to even initially bid on the contract. The Purchasing Division has noted that the CPI index is too broad a pricing index for chemical purchasing.	Identify and incorporate a more specific chemical pricing index into City bids for water and wastewater chemicals to encourage more participation in the bid process.	Identification of a relevant pricing index and incorporation into procurement process.	Specific chemical pricing index for water and wastewater chemicals in place by December 2011.
3.	Evaluate Granular Activated Carbon Regeneration Options	There is no on-site regeneration capability, so the GAC has to be removed from the filters and shipped to an off-site regenerator for processing.	There is no on-site regeneration capability, so the GAC has to be removed from the filters and shipped to an off-site regenerator for processing.		
			Conduct a feasibility study to investigate whether on-site carbon regeneration is a viable option.		

Water Management - Water Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
	Objective: Reduce Operating Costs of Water Treatment Plants				
4.	Expand and Enhance Leak Detect/Repair Program	The City of Tulsa water distribution system experiences an approximate 9-12% annual leak rate.	Expand and Enhance Leak Detect/Repair Program if cost-effective	Quantify the amount of water currently recovered in the leak detect/repair program. Once the amount of recovered water is quantified, a cost-benefit analysis should be conducted to determine the extent to which leak detect/ repair program should be expanded and whether the installation of the additional 500 data loggers is a cost-effective investment.	The BMP and training program should be developed within six months of the results of the URS energy audit.
	Objective: Promote Water Conservation among COT Facilities and Employees				
5.	Set a Goal for Reduction in City Water Use and Track Progress toward Goal	The City does not currently have a goal for reducing water use for municipal operations, and it does not have a way to track progress toward a water use reduction goal.	The City should set a water use reduction goal and develop metrics for tracking progress toward that goal.	Water use reduction goal based on analysis of City water consumption data.	Goal and progress tracking system in place by end of FY 2012.
6.	Collect and Organize Water Data.	No central water data management system. The City of Tulsa does not currently have a system in place for conducting detailed analysis of what it spends on water and water treatment. The data is available but is not readily accessible and is not being benchmarked or monitored for identification of potential cost savings opportunities.	Consolidate water data and make it widely available to City departments.	Percentage of City's water consumption data readily available for review and analysis.	100% of City's water consumption and water treatment cost data in Hara EEM and/or other readily accessible databases by December 2011.
7.	Collect City-Facility Water Usage Data and Conduct Benchmarking	No information on water costs and City-owned facility water usage is readily available. The City of Tulsa does not currently have a system in place for conducting detailed analysis of what it spends on water in City-owned/operated facilities.	Collect City-owned facility water usage data and conduct benchmarking. In addition to the energy audit discussed in the Energy Management section, water audits should be conducted for key City-owned facilities to benchmark City facilities using intensity metrics. These metrics could include total water usage, water usage per person, water usage per square footage, etc. This comparison will indicate which facilities or processes use the most water relative to similar City-owned facilities. Data should be uploaded into Hara EEM or other suitable database.	Identification of Top Ten Biggest Consumers of Water at City facilities and processes.	Top Ten List compiled using results of benchmarking by December 31, 2011.

Water Management - Water Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Promote Water Conservation among COT Facilities and Employees					
8.	Perform Water Audits of Top Ten Biggest Water Wasters	The City does not have a systematic approach to finding water conservation opportunities in its facilities.	Use the results of the benchmarking exercise in Initiative #4 and target the top 10 water consuming facilities/processes for water audits by ECST members.	Number of water audits conducted at top 10 water consuming facilities.	Five water audits conducted by end of FY 2012.
	Post water conservation signage in COT facilities	The City of Tulsa should lead by example by reducing its facility water consumption.	Post water conservation signage in COT facilities. Work with the ESCT to identify high priority buildings/locations for the signs. After the signs have been in place for a period of a few months, compare water use for that facility before and after sign installation to measure success. This can be tracked via water bills or water meter data.	Install the signs.	
	Pilot incentive programs	The City of Tulsa should lead by example by reducing its facility water consumption.	Create an incentive program among City employees to identify water conservation initiatives among City facilities. Issue a monthly prize to the top specific water savings recommendation.		

Water Management - Water Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Reduce Operating Costs of Water Treatment Plants					
	Continue Participation in Local and National Committees to better disseminate water conservation messages to City personnel	The City of Tulsa should lead by example by being involved in committees and organizations supporting water conservation.	Continue to participate in local and national committees, and publish/report committee participation on COT website or other avenue.		
Objective: Promote Water Conservation Externally					
9.	Recognize Local Businesses for Water/ Energy Conservation Efforts	Although the City's new Sustainability Plan is focusing on internal processes and looking for ways to conserve resources, thereby saving taxpayer dollars, it is important to promote these same conservation efforts in the community.	Expand City's PACE – Partners for A Clean Environment Program to recognize local businesses and civic organizations that are making an impact on energy or water conservation. The purpose of this Initiative is to develop a program that provides assistance to and/or recognition to area businesses, community groups and individuals who adopt and implement best management practices to conserve water and energy and reduce or eliminate environmental problems in Tulsa, with the potential for expansion to include other resource c onservation areas and Best Management Practice development.	Recognition program established and first group of local businesses recognized for their water/energy conservation efforts	Program established and three local businesses recognized by end of FY 2013

Water Management - Water Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Promote Water Conservation among COT Facilities and Employees					
	Continue Participation in Local and National Committees to better disseminate water conservation messages to City personnel	The City of Tulsa should lead by example by being involved in committees and organizations supporting water conservation.	Continue to participate in local and national committees, and publish/report committee participation on COT website or other avenue.		
Objective: Promote Water Conservation Externally					
9.	Recognize Local Businesses for Water/ Energy Conservation Efforts	Although the City's new Sustainability Plan is focusing on internal processes and looking for ways to conserve resources, thereby saving taxpayer dollars, it is important to promote these same conservation efforts in the community.	Expand City's PACE – Partners for A Clean Environment Program to recognize local businesses and civic organizations that are making an impact on energy or water conservation. The purpose of this Initiative is to develop a program that provides assistance to and/or recognition to area businesses, community groups and individuals who adopt and implement best management practices to conserve water and energy and reduce or eliminate environmental problems in Tulsa, with the potential for expansion to include other resource c onservation areas and Best Management Practice development.	Recognition program established and first group of local businesses recognized for their water/energy conservation efforts	Program established and three local businesses recognized by end of FY 2013

Water Management - Water Treatment

Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Promote Water Conservation Externally				
Pilot water conservation incentive programs	Physical replacement of inefficient water fixtures has been shown to be a successful method of promoting water conservation.	Several cities across the country have successfully funded incentive programs designed to encourage the installation of more efficient plumbing fixtures, such as low-flow toilet replacements, water efficient washing machines, free showerhead and faucet aerators, pressure regulating valves for users who receive water at high pressure. It is recommended that the City of Tulsa conduct a pilot program offering free or discounted water fixtures to the general public.	Success of pilot program could be measured by asking participants to track monthly water usage and report reductions to the ECST.	
Re-structure water rates to promote conservation	Encourage conservation through pricing structure.	Revise water cost structure to promote conservation. Examples include: water budget-based rates (average winter consumption), tiered inclining block rates, indoor use vs. outdoor use	Conduct a study to revise water rates and implement new structure.	By Dec 2012
Provide more usage data to consumers		Design water bills to provide clear water use information. The addition of a graphical representation of usage could further convey usage information.	Incorporate into bill.	By Dec 2011

Water Management - Wastewater Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Reduce Operating Costs of Water Treatment Plants					
10.	Collect and Organize Water/Energy Data and Consolidate Planning Activities	The City of Tulsa does not have a sufficient level of detail of energy/water operational data for wastewater treatment facilities.	Collect and Organize new water/energy data by conducting Sub-metering studies at the facilities. This project could be funded by the City or jointly conducted by the City and a local university through grants.	Conduct the study	Study conducted by Dec 2013
11.	Increase Cross-Sectional Collaboration for Strategic Asset Management	Not enough cross-sectional collaboration for strategic asset management. The Water & Sewer Department has at least two strategic asset management plans – one for, those being for Water Supply and for Water Pollution Control. Both of these plans use EMA software and support; however. However, the two plans use different versions of the software and are under two different contracts.	Increase cross-sectional collaboration among Water Supply and Water Pollution Control strategic asset management.		
12.	Create Best Management Practices for Auxiliary Water Usage	According to interviews with facility superintendents, auxiliary water usage can easily be overlooked at waste water treatment plants because of the thought that the water is "free."	Institutionalizing a Best Management Practice (BMP) for auxiliary water usage could help to curb extraneous water usage by making operators more aware of the costs associated with water usage and by identifying and replacing leaky auxiliary equipment (i.e., hoses). The BMP and associated training be developed and made available to all waste water operators in the City. If auxiliary water usage were to be reduced by 25%, the City could realize approximately 2.5% cost savings annually, or approximately $84,000 per year using calendar year 2010 as a base case. Assuming that a BMP could be developed and a training program established for $84,000, this project would have a one-year payback period.	Development and implementation of program.	Develop and implement training program by Dec 2012

Water Management - Wastewater Treatment

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Identify alternate practices and technologies that could replace or enhance existing waste water treatment infrastructure or practices					
13.	Wet Weather Storage Facilities	Identify alternate practices and technologies that could replace or enhance existing waste water treatment infrastructure or practices.	Consider using wet weather storage facilities during the dry weather flow conditions when peak energy demand is high. If the flow equalization basins are used to collect and store the wastewater during peak demand hours, pumping time could be offset to off-peak hours. Although this practice would not reduce total energy used at the facilities, it could potentially reduce peak demand and associated peaking costs. There is no new capital required to implement this initiative.	Conduct study to see if wet weather storage facilities can be used during off-hours. Implement practice if practical.	
13.	Solar Sludge Dewatering	Identify alternate practices and technologies that could replace or enhance existing waste water treatment infrastructure or practices.	In solar sludge dewatering, a greenhouse-like structure is erected that uses the sun as its main power source, where 95% of the energy required for drying is provided by solar energy. Based on information provided by Parkson Company, the capital cost for a solar sludge drying facility for a 5 MGD plant is $1M – $2M. Over a 20 year period, Parkson estimates that the energy savings in using solar processing over traditional drying techniques is $6M – $8M.	If the City is interested in expanded its biosolids program, solar sludge dewatering should be considered as a viable and cost-effective alternative to sludge dewatering. Consider implementing solar sludge instead of installing other drying equipment.	
13.	Expand the Grease Trap Program	Identify alternate practices and technologies that could replace or enhance existing waste water treatment infrastructure or practices.			

Water Management - Stormwater

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Bring Attention to Stormwater Management Plan					
14.	Bring the City's Storm Water Management Plan Up-To-Date	Significant work is needed to maintain the City's Storm Water Management Plan.	The Plan was last updated in 2005 and is presently in the process of another update. The purpose of the update is to account for changes in the various drainage basins throughout the City due to private development and completed capital improvement projects.	Update the Storm Water Management Plan	By Dec 2012
15.	Raise Awareness of Potential Flood Threats and Re-direct Funding to the Stormwater Management Plan	Implement a public awareness program to remind Tulsans that major flooding is inevitable and requires a coordinated and proactive community-wide approach.	Implementation of the Stormwater Management Plan requires adequate funding be allocated to stormwater projects from bond issues and 3rd penny sales tax funding packages. In recent years stormwater projects have not been perceived as a priority by the citizens of Tulsa and therefore funding has been allocated to more pressing issues such as street repairs, and water and sewer infrastructure.	Re-evaluate strategic priorities of Storm Water Management within COT to address funding	By Dec 2012

Water Management - Stormwater

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
	Objective: Raise Awareness of Watershed Protection				
16.	Promote Watershed Conservation and Education Initiatives	Raise awareness of watershed protection. Working with members of the community to encourage stewardship of Tulsa's water resources will help to increase public awareness and ownership of water initiatives.	Engage in Adopt-Your-Watershed Activities. EPA's Adopt-Your-Watershed program (not to be confused with Adopt-A-Watershed which is a non-profit that promotes educational awareness) has a campaign to encourage stewardship of the nation's water resources. "Adopt" means participating in a citizen-based effort—to restore or protect a watershed, river, lake, wetland or estuary.	Engage in watershed adoption activities	One per year
	Objective: Support Low Impact Development				
17.	Establish Public/Private LID Team	There is no City working group in place to provide leadership on Low Impact Development initiatives.	Establish a Public/Private LID Team. A team is needed to bring various experts to the issue of LID implementation and performance documentation. A Public/Private LID team could be established to formally review current and evolving codes for upcoming energy and water national/international code requirements; LID performance indicators; and new technologies.	Establishment of Team	By Dec 2011
18.	Coordinated Stormwater Grant Applications	Large grants are available for a coordinated approach to environmental, job growth, transportation, and housing issues in underserved areas, and there is currently no coordinated effort on the City's part to take advantage of them.	Establish a coordinated stormwater grant application as an ongoing action item for the ECST Team	Apply for grant	by grant deadline

Water Management - Stormwater

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
	Objective: Raise Awareness of Watershed Protection				
19.	Identify LID Barriers/ Opportunities In Existing Codes	No analysis has been done to determine if existing City codes support Low Impact Development Goals.	As part of this Plan, a thorough review of existing City Codes was conducted to determine if the current codes are adequate in supporting LID initiatives.	Analysis conducted	Completed as part of this Plan
	Objective: Lead by Example - Identify and Implement Innovative Green Solutions				
20.	Incorporate LID Initiatives in City Facilities	The City can take a leadership role in the community by highlighting the benefits of LID in its own facilities.	As a way to promote innovation and low impact development (and potentially reduce operational construction permitting costs), the City should incorporate LID projects in the design of new construction or major remodels		
	Rainbarrels	Incorporate LID design elements in City buildings	Incorporate rainwater harvesting into COT buildings. Rainwater harvesting is the concept of collecting and storing rainwater for other uses, often for irrigation purposes. There are many types of designs of rainwater harvesting systems, the most common being rain barrels that collect rainwater channeled from a roof.	A Go / no go list could be created to determine if a rainwater harvesting could be implemented in a new or existing City building. Determine the return on investment to install rainwater capture systems as an increased first cost to save on irrigation costs over the life of the building.	
	Raingarden/bioswale	Incorporate LID design elements in City buildings	Incorporate rainwater harvesting into COT buildings. Rainwater harvesting is the concept of collecting and storing rainwater for other uses, often for irrigation purposes. There are many types of designs of rainwater harvesting systems, the most common being rain barrels that collect rainwater channeled from a roof.	A Go / no go list could be created to determine if raingardens could be implemented in a new or existing City building. Determine the return on investment to install rainwater capture systems as an increased first cost to save on irrigation costs over the life of the building.	

Water Management - Stormwater

Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Lead by Example - Identify and Implement Innovative Green Solutions				
Green Roof	Incorporate LID design elements in City buildings	Green Roofs are roofs that literally fully or partially covered in vegetation. Green roofs could be integrated into applicable City buildings.		
Pervious Pavement	Incorporate LID design elements in City buildings	Pervious pavement is uncommonly used in the Tulsa area and is an important part of the LID toolkit. Pavement can include pavers, engineered grass covered areas, along with pervious concrete and asphalt. These t echniques need further vetting and demonstrations to confirm performance and then promote its use.		
Landscaping	Incorporate LID design elements in City buildings	Propose using locally tolerant landscaping that requires less or no water to be used as an equivalency to the standard landscape with irrigation requirement.		
Irrigation	Incorporate LID design elements in City buildings	Irrigate landscaping at City facilities in the early morning and late evening. Ensure that water is properly sprayed onto the landscaping instead of into the street.		
Low Flush Toilets / Waterless Urinals	Incorporate LID design elements in City buildings	Measure baseline water use at five City facilities, then implement low flush toilets and waterless urinals, and re-measure water use (could be part of energy / water audit).		

Solid Waste and Recycling

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective: Set up systems to track total solid waste and recycling tonnages generated at City facilities, and improve recycling and waste reduction programs based on the data that are tracked.					
1.	**Improve Tracking of Recycling and Solid Waste Generation Tonnages and Costs**	Currently, data regarding the total amount of solid waste generated by the City is not centralized, in part because different vendors provide services for waste removal, metal recycling, and other recycling programs.	Centralize Data Collection for Recycling and Solid Waste Generation at City facilities.	Percentage of City's waste stream that is regularly measured and tracked in Hara EEM	75% of City waste measured and tracked by end of FY2013.
2.	**Implement a Quartermaster System**	City employees sometimes discard City-issued items that may be reused or recycled.	Develop a new quartermaster system to reduce waste.	Purchasing costs reduced by the quarter master system	5% reduction in costs of certain types of supplies and tools.
3.	**Increase Recycling of Bulk Metal Items**	Tulsa does not currently have a central contract in place with a metal recycler, and often City staff will transport the metal items to the vendor's facility using City vehicles.	Implement a centralized program for bulk metal recycling	Total tonnage of metal recycled by the City	5% increase in the tonnage recycled.

Sustainable Fleet Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective:					
1.	Develop and Implement a Plan to Right-Size the City Fleet	Total fleet costs are directly related to the number of vehicles and pieces of equipment in a fleet.	Implement a plan to "right-size" the City's fleet and to prevent unintended fleet growth in the future.	Total fleet size, meaning the number of vehicles. The fleet of "rolling stock" and of road vehicles and equipment should be tracked separately.	Reduce the City's "rolling stock" fleet of on-road vehicles by 550 within 5 years.

Sustainable Fleet Management

Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective:				
2. Increase the Net Fuel Efficiency of the Fleet	The amount of City funds spent on motor fuel is directly related to fuel consumption and fuel consumption depends both on the fuel efficiency of the vehicles and that make up the City's fleet and fleet utilization.	Finalize the Draft Idling Policy by amending Tulsa City Ordinances to add this policy to the Energy Policy of Title 12, Section 102, D. Fully implement and enforce the new ordinance and provide training to city employees who use City vehicles and equipment. Conduct a City outreach program to dispel the myths and teach the facts about idling.		
		Fully enforce the Tulsa Code of Ordinances Energy Policy at Title 12, Chapter 1, Sec. 101 and 102.D, including requirements to carefully examine the need, use, vehicle size, and fuel efficiency prior to acquisition of any new or replacement city vehicle.		
		Develop and require use of a calculation tool and standard protocols to assess Total Cost of Ownership, including life-cycle estimated fuel consumption, and compare alternative fuel and energy efficient technology options for any new or replacement city vehicle or motor fuel-using equipment.		
		Continue to replace older less efficient vehicles and equipment with more efficient equipment according to the findings of the 2011 Fleet Utilization Scoring System.		

Sustainable Fleet Management

	Initiative	Issue	Recommendation	Key Performance Indicator(s)	Target(s)
Objective:					
3.	Increase the Use of CNG in City Fleet	Petroleum-based vehicle fuels are subject to global market pressures and costs are increasing substantially. However, there is a domestic supply of an alternative vehicle fuel—natural gas, which is produced in Oklahoma. Furthermore, technology exists today to operate a large portion of the City of Tulsa fleet on compressed natural gas, or CNG.	1. Invest in (and seek grants for) City fleet CNG fueling sites 2. Encourage and support development of private CNG fueling sites within the City of Tulsa. 3. Purchase and operate Pilot CNG vehicles for all new or replacement city vehicles if the CNG fueling infrastructure, the Total Cost of Ownership, and the need, use, vehicle size, and efficiency make sense. 4. Educate City employees, department heads and fleet stakeholders about the benefits of CNG.		
4.	Increase the Use of CNG in City Fleet	EMD currently maintains detailed, vehicle by vehicle records of maintenance and fuel consumption using the existing AssetWorks system.	1. Use the new version M5 of AssetWorks, a planned upgrade to be installed in 2011, to track fleet fuel consumption and vehicle use data (miles traveled). The new browser-based M5 version of the program includes dashboards and efficiency reports for informing departments of their performance. 2. Run periodic reports (at least annually) in AssetWorks and output these as Microsoft™ Excel files. These files can be scrubbed for data anomalies and insignificant equipment (such as non-motorized trailers) and prepared for importing into the Hara EEM Sustainability platform. The Hara interface will also allow tracking and analysis of the City's progress toward initiatives 1, 2 and 3 in dashboard. 3. Install radio frequency identification (RFID) on rolling stock (rate of implementation depends on a Federal Grant that is pending)		

Appendix 2: Review of Existing Codes Supporting Low Impact Development

Graywater Systems

Gray water for commercial and residential is currently allowed. City of Tulsa requires 2009 IPC (International Plumbing Code). 2009 IPC adopted July 2011; 2006 IPC previously.

Gray Water Recycling System Codes

General

- Bathtubs, showers, lavatories, clothes washers and laundry trays do NOT have to discharge to the sanitary drainage system where these fixtures discharge to an approved gray water system.

Flushing toilets and urinals (Per 2009 IPC Appendix C Section C102)

- The holding capacity of the reservoir must be a minimum of twice the required volume of water and no less than 50 gallons.
- Gray water must be used within 72 hours.
- Required to be disinfected by an approved method (chlorine, iodine, or ozone) – these disinfectants need pumps to make them work.
- Required to have potable water must be supplied as a backup and protected with a backflow preventer.
- Must be dyed blue or green with a food grade vegetable dye.
- The piping of gray water must conform to one of the standards (table 605.3).
- The gray water piping and reservoirs must be identified as such.

Subsurface Landscape Irrigation Systems (Per 2009 IPC Appendix C Section C103)

- Reservoir sized to use within 24 hours and be identified as containing nonpotable water.
- Check valve and a full-open valve required to be located on the discharge side.
- Potable water is NOT required as a backup, but can be provided.
- Disinfectant is NOT required.
- Dying of the gray water is NOT required.
- Must be sized based on the amount of occupants and type of fixtures connected to system.

- Permeability of soil to be tested by perc test.
- Surface grade of all soil absorption systems must be located at a point lower than the surface grade of any water well or reservoir on the property.
- Design to include absorption areas, seepage trenches, bed excavations, aggregate, and backfill as specified by code.
- Distribution piping to be polyethylene (PE) or polyvinyl chloride (PVC).

Plumbing Codes

Low flush toilets and waterless urinals for commercial and residential are allowed. City of Tulsa requires 2009 IPC (International Plumbing Code)

- Waterless urinals must be maintained correctly to eliminate odor – a chemical that is lighter than water floats on the top. This chemical must be replaced routinely, and care must be taken so that during cleaning the chemical is not washed away; will require education to janitorial staff.
- Suggest measuring baseline of water use at five or so City facilities, then implementing low flush toilets and waterless urinals, and re-measuring water use (could be part of energy/water audit).

Irrigation/Landscaping Codes

Rainwater for Irrigation

- Allowed by code.
- Tulsa receives approximately 36" of rain annually. By rough calculations of rainfall paired with existing paving, rainwater could be used to fully irrigate all landscaping.
- More flexible than gray water for irrigation – does not have a time limit of use as gray water has and does not require disinfecting. Sand filter may be needed.
- Underground cisterns could be used to collect rainwater.
- Need to consider space requirements on site if underground or surface cisterns or rain barrels.
- Water from parking lots could possibly be used for landscaping, but would need to allow for oil from cars and its effect on landscaping.
- Local architect Jeremy Perkins has used rainwater collections for some of his projects in the Tulsa area and might be a possible resource for further information.

Swimming Pool Water for Irrigation

- Swimming pool backwash – not desirable to be drained into sanitary sewer, and may be able to be used for irrigation but would need to determine if it is too much chlorination for landscaping. Swimming pool backwash may be able to be used for toilet flushing with the proper gray water code compliance.

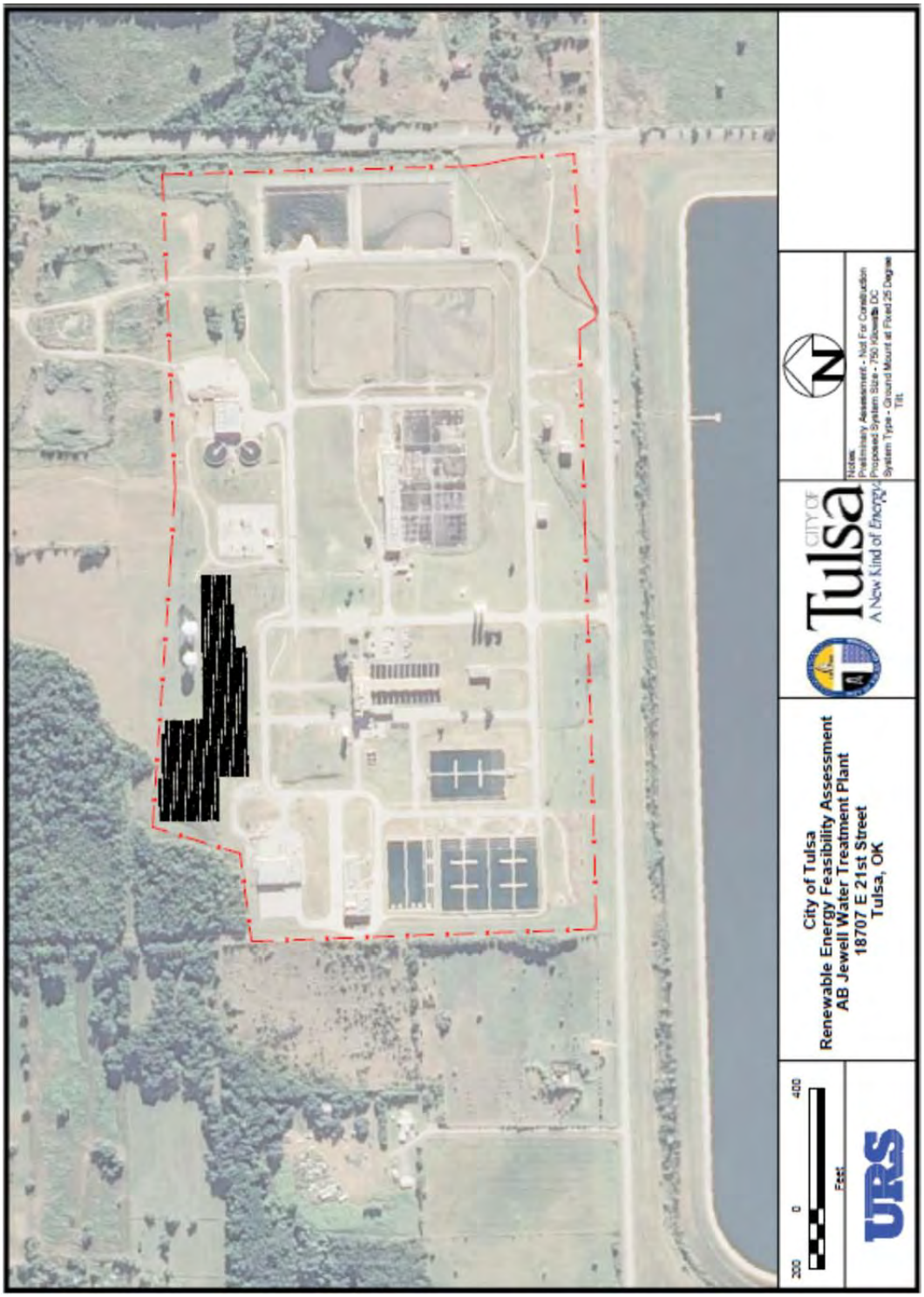
Curbs on City Streets

- Streets and curbs currently assist in drainage.
- If all or partial curb elimination is desired to help with landscape irrigation, must work with streets engineering department ordinances.
- Infrastructure Advisory Board could help with ordinance changes.

Landscaping and Irrigation Requirements

- Currently landscaping and irrigation is required as governed by INCOG – Indian Nations Council of Governments (see attached landscape requirements, chapter 10).
- Propose using locally tolerant landscaping that requires less or no water to be used as an equivalency to the standard landscape with irrigation requirement.

Appendix 3: Solar PV Conceptual Layouts



200 0 400

Feet

URS

City of Tulsa
Renewable Energy Feasibility Assessment
Mohawk Water Treatment Plant
18707 E 21st Street
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Proposed System Size - 500 Kilowatts DC
System Type - Ground Mount at Fixed 25 Degree Tilt

60 0 120

Feet

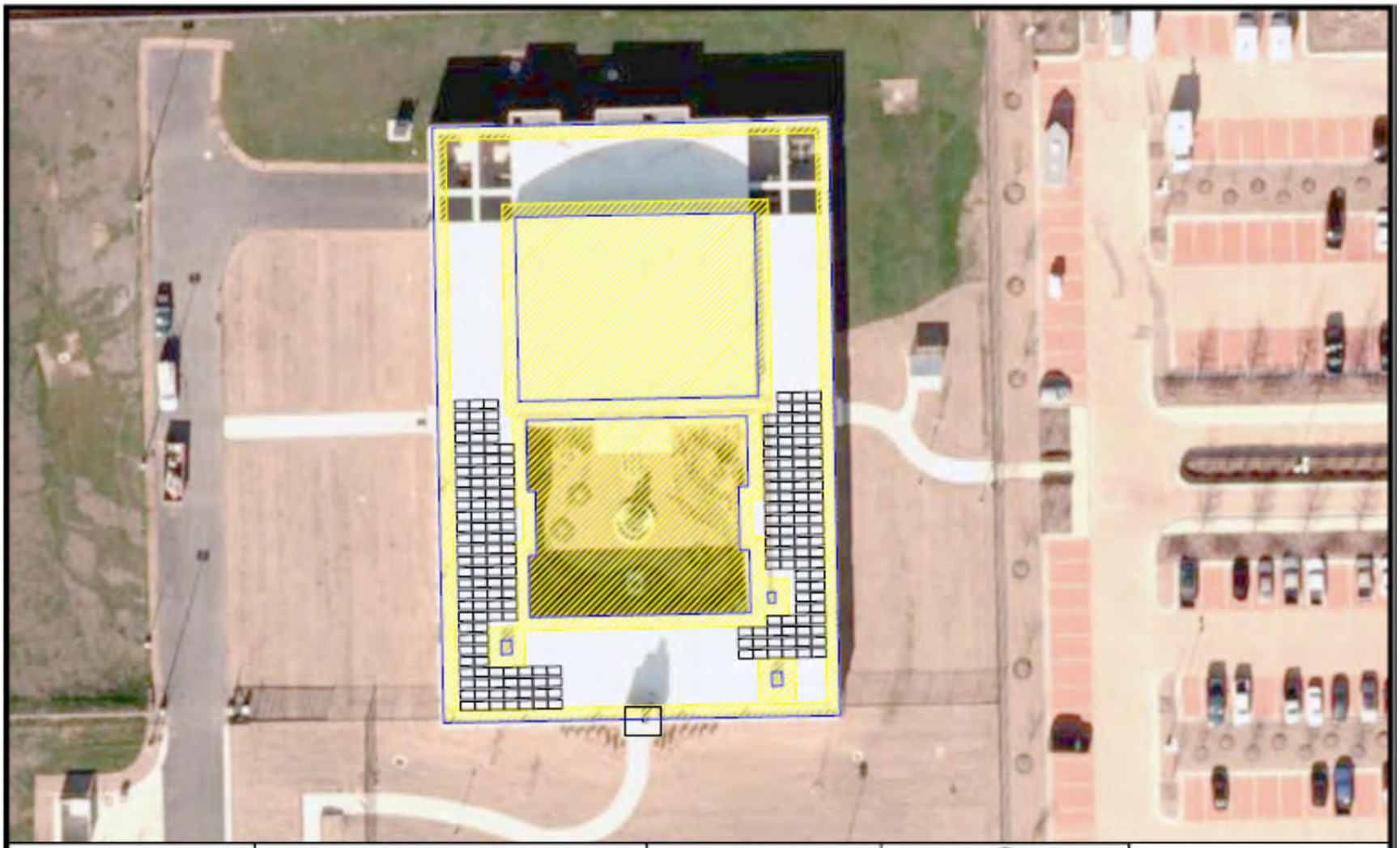
URS

City of Tulsa
Renewable Energy Feasibility Assessment
Maxwell Convention Center
100 Civic Center Plaza
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required.
Proposed System Size - 750 Kilowatts DC
System Type - Roof Mount at 0 Degree Tilt



25 0 50

Feet

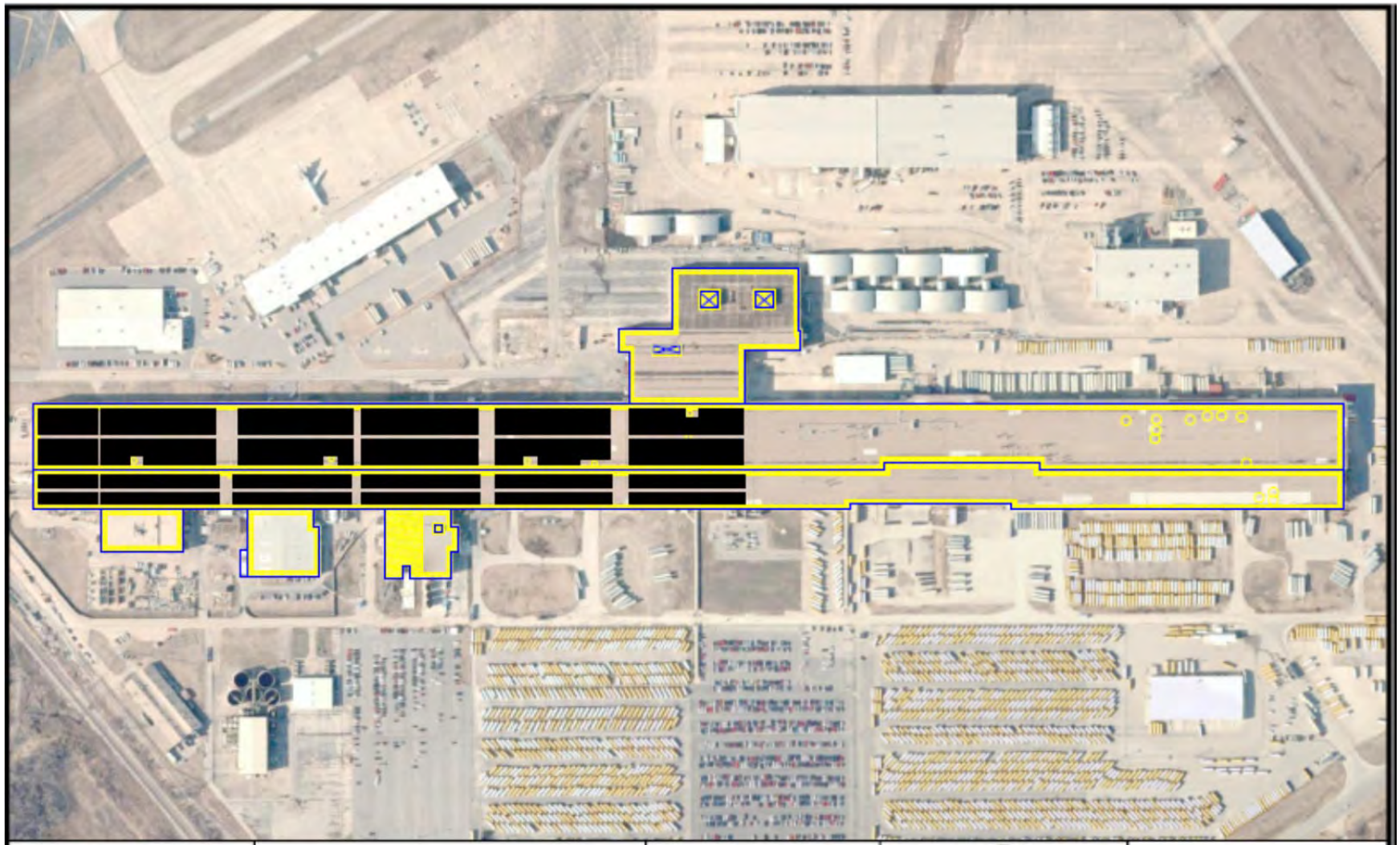
URS

City of Tulsa
Renewable Energy Feasibility Assessment
Emergency 911 Facility
801 E. Oklahoma
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required.
Proposed System Size - 49 Kilowatts DC
System Type - Roof Mount at 5 Degree Tilt.



200 0 400

Feet

URS

City of Tulsa
Renewable Energy Feasibility Assessment
Air Force Plant #3

Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required
Proposed System Size - 3,126 Kilowatts DC
System Type - Roof Mount at 0 Degree Tilt

20 0 40

Feet

URS

City of Tulsa
Renewable Energy Feasibility Assessment
Central Recreation Center
1028 E. 6th
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required.
Proposed System Size - 12.5 Kilowatts DC
System Type - Roof Mount at 5 Degree Tilt

25 0 50

Feet

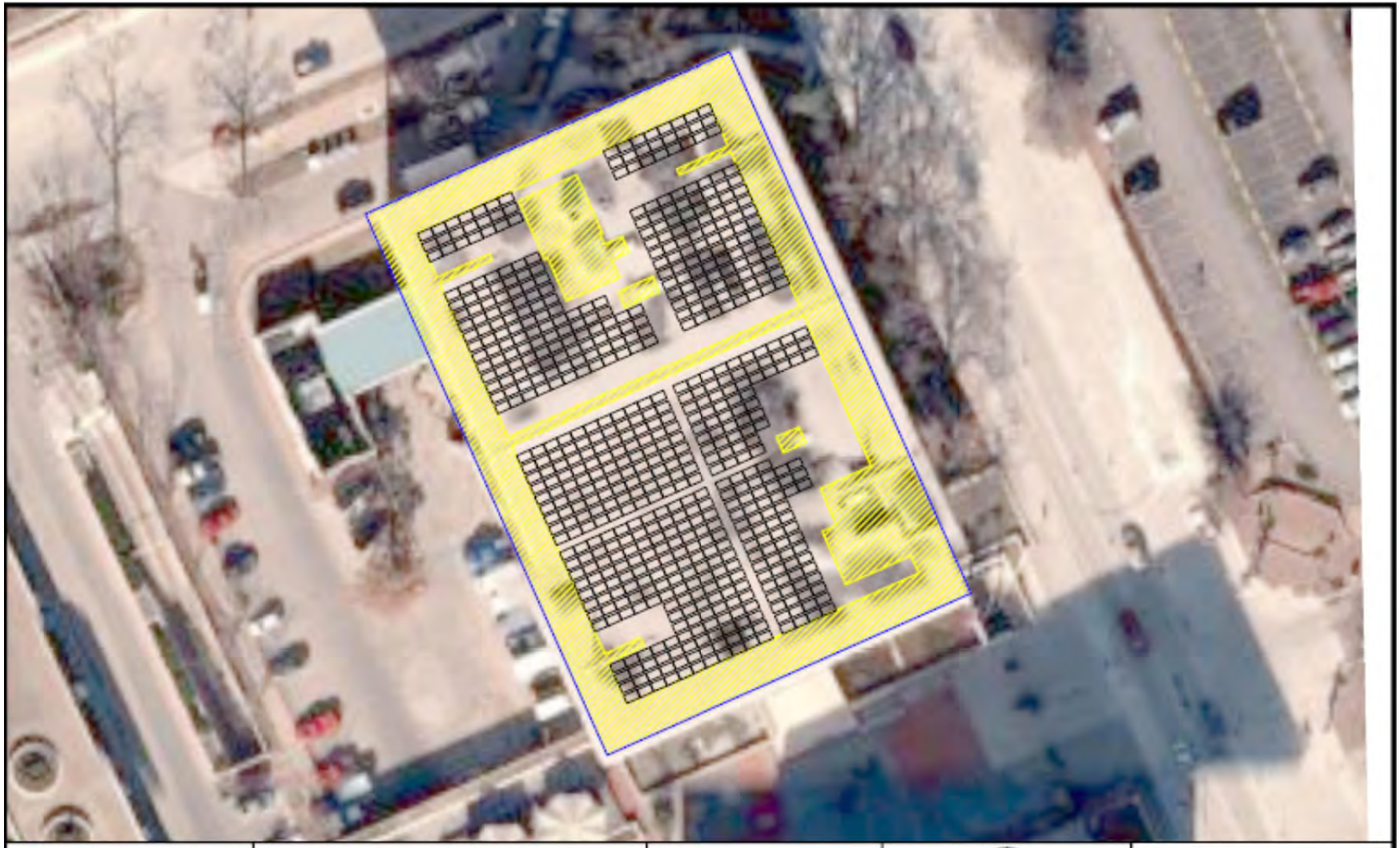
URS

City of Tulsa
Renewable Energy Feasibility Assessment
Fire Station #24
3520 North Peoria
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required.
Proposed System Size - 20 Kilowatts DC
System Type - Roof Mount at 5 Degree Tilt.



25 0 50

Feet

URS

City of Tulsa
Renewable Energy Feasibility Assessment
Tulsa City-County Library
400 Civic Center
Tulsa, OK

CITY OF Tulsa
A New Kind of Energy

N

Notes:
Preliminary Assessment - Not For Construction
Building Structural Assessment Required
Proposed System Size - 150 Kilowatts DC
System Type - Roof Mount at 5 Degree Tilt

Appendix 4: PVSyst Model Results

PVSYST V5.42		29/08/11	Page 1/3

Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: AB Jewell WTP - 750kW c-Si 25 Degree Tilt**	
	Simulation date	29/08/11 03h52

Simulation parameters

Collector Plane Orientation	Tilt	25°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Number of PV modules		In series	13 modules	In parallel	240 strings
Total number of PV modules		Nb. modules	3120	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**749 kWp**	At operating cond.	726 kWp (34°C)
Array operating characteristics (50°C)		U mpp	394 V	I mpp	1845 A
Total area		Module area	**5231 m²**		

Inverter	Model	**PowerGate Plus PVS-250-480**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	320-600 V	Unit Nom. Power	250 kW AC
Inverter pack	Number of Inverter	3 units	Total Power	750 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.) NOCT				56 °C
Wiring Ohmic Loss	Global array res.	3.3 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

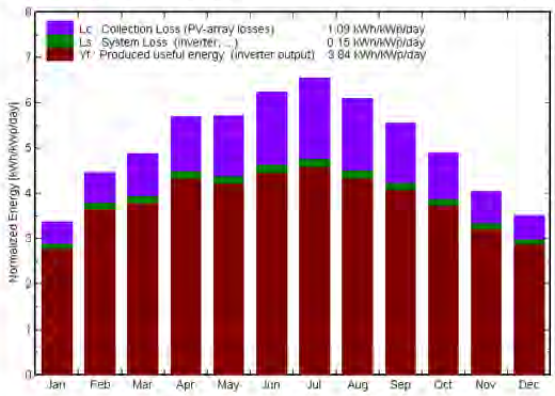
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: AB Jewell WTP - 750kW c-Si 25 Degree Tilt**

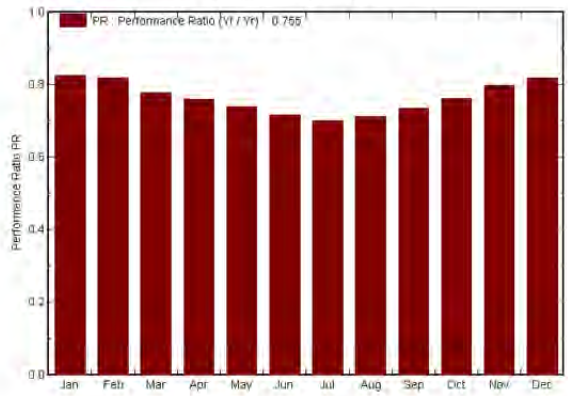
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	3120	Pnom total	**749 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**750 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**1050 MWh/year**	Specific prod.	1402 kWh/kWp/year
	Performance Ratio PR	75.5 %		

Normalized productions (per installed kWp): Nominal power 749 kWp



Performance Ratio PR



City of Tulsa: AB Jewell WTP - 750kW c-Si 25 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	104.6	101.5	67317	64637	12.30	11.81
February	96.2	3.09	125.1	121.6	79769	76731	12.19	11.73
March	129.4	11.57	151.5	147.3	91668	88159	11.57	11.12
April	163.2	15.97	171.2	166.1	101205	97352	11.30	10.87
May	181.9	20.92	177.1	171.5	101803	97942	10.99	10.57
June	197.8	26.63	187.1	181.0	104439	100417	10.67	10.26
July	212.4	29.01	203.2	196.6	110810	106522	10.43	10.02
August	184.1	27.36	189.1	183.6	104663	100723	10.58	10.18
September	145.9	21.46	166.7	162.1	95325	91693	10.93	10.52
October	118.7	16.54	151.5	147.4	89858	86532	11.33	10.91
November	85.2	8.55	121.1	117.4	75180	72357	11.87	11.43
December	72.2	3.89	109.1	105.6	69523	66845	12.18	11.71
Year	1658.1	15.61	1857.1	1801.7	1091559	1049909	11.24	10.81

Legends:			
GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

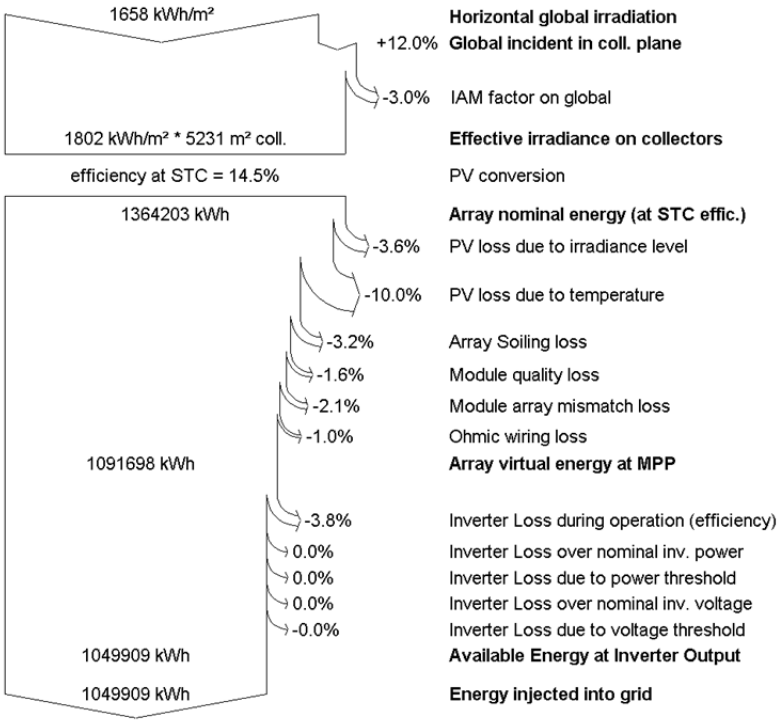
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: AB Jewell WTP - 750kW c-Si 25 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	3120	Pnom total	**749 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**750 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Mohawk WTP - 500kW c-Si 25 Degree Tilt**	
	Simulation date	29/08/11 03h49

Simulation parameters

Collector Plane Orientation	Tilt	25°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Number of PV modules		In series	13 modules	In parallel	160 strings
Total number of PV modules		Nb. modules	2080	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**499 kWp**	At operating cond.	484 kWp (34°C)
Array operating characteristics (50°C)		U mpp	394 V	I mpp	1230 A
Total area		Module area	**3487 m²**		

Inverter	Model	**PowerGate Plus PVS-250-480**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	320-600 V	Unit Nom. Power	250 kW AC
Inverter pack	Number of Inverter	2 units	Total Power	500 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	5.0 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

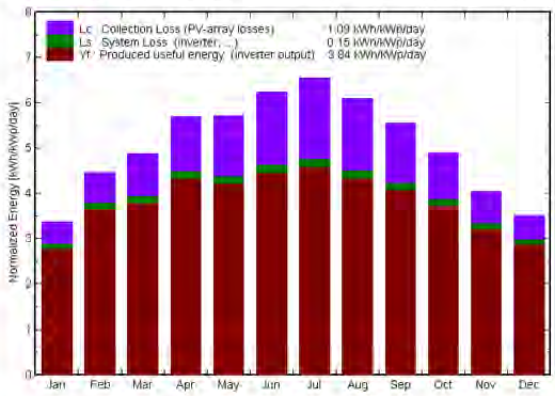
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Mohawk WTP - 500kW c-Si 25 Degree Tilt**

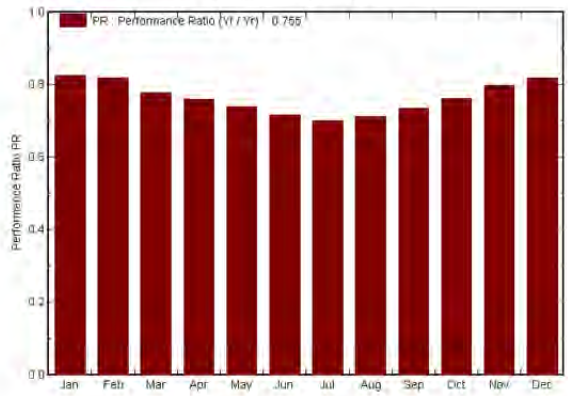
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	2080	Pnom total	**499 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**500 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**700 MWh/year**	Specific prod.	1402 kWh/kWp/year
	Performance Ratio PR	75.5 %		

Normalized productions (per installed kWp): Nominal power 499 kWp



Performance Ratio PR



City of Tulsa: Mohawk WTP - 500kW c-Si 25 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	104.6	101.5	44878	43091	12.30	11.81
February	96.2	3.09	125.1	121.6	53179	51154	12.19	11.73
March	129.4	11.57	151.5	147.3	61112	58773	11.57	11.12
April	163.2	15.97	171.2	166.1	67470	64901	11.30	10.87
May	181.9	20.92	177.1	171.5	67869	65295	10.99	10.57
June	197.8	26.63	187.1	181.0	69626	66945	10.67	10.26
July	212.4	29.01	203.2	196.6	73873	71015	10.43	10.02
August	184.1	27.36	189.1	183.6	69775	67148	10.58	10.18
September	145.9	21.46	166.7	162.1	63550	61128	10.93	10.52
October	118.7	16.54	151.5	147.4	59905	57688	11.33	10.91
November	85.2	8.55	121.1	117.4	50120	48238	11.87	11.43
December	72.2	3.89	109.1	105.6	46349	44563	12.18	11.71
Year	1658.1	15.61	1857.1	1801.7	727706	699940	11.24	10.81

Legends:

GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

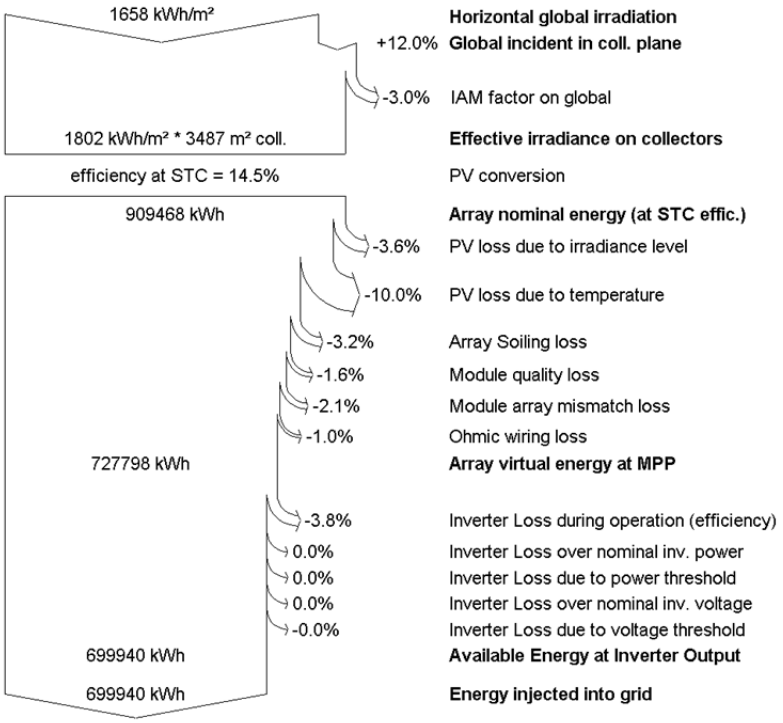
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Mohawk WTP - 500kW c-Si 25 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	2080	Pnom total	**499 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**500 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Convention Center - 750kW c-Si 0 Degree Tilt**			
	Simulation date	29/08/11 03h31		

Simulation parameters

Collector Plane Orientation	Tilt	0°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**Powerply 400**		
		Manufacturer	Lumeta		
Number of PV modules		In series	5 modules	In parallel	375 strings
Total number of PV modules		Nb. modules	1875	Unit Nom. Power	400 Wp
Array global power		Nominal (STC)	**750 kWp**	At operating cond.	720 kWp (34°C)
Array operating characteristics (50°C)		U mpp	391 V	I mpp	1841 A
Total area		Module area	**5443 m²**	Cell area	4568 m²

Inverter	Model	**PowerGate Plus PVS-250-480**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	320-600 V	Unit Nom. Power	250 kW AC
Inverter pack	Number of Inverter	3 units	Total Power	750 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	21.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	54 °C
Wiring Ohmic Loss	Global array res.	3.3 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	2.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

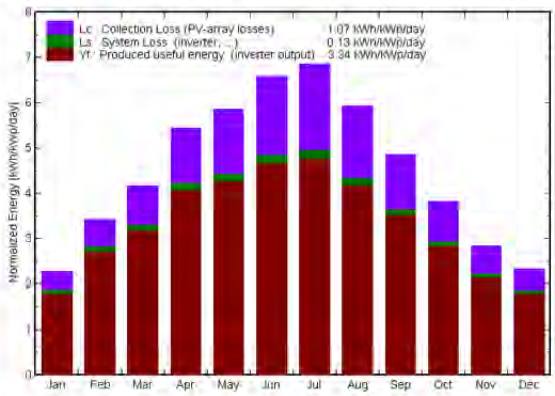
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Convention Center - 750kW c-Si 0 Degree Tilt**

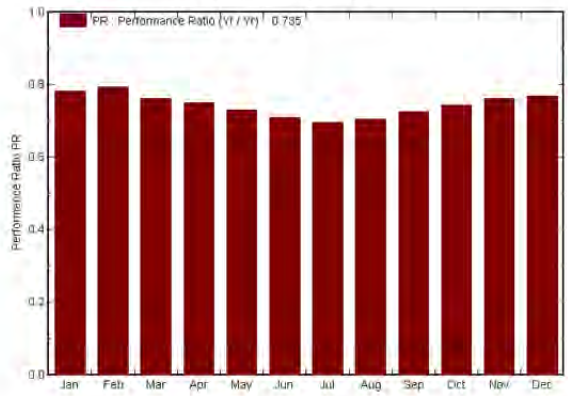
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	Powerply 400	Pnom	400 Wp
PV Array	Nb. of modules	1875	Pnom total	**750 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**750 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**914 MWh/year**	Specific prod.	1218 kWh/kWp/year
	Performance Ratio PR	73.5 %		

Normalized productions (per installed kWp): Nominal power 750 kWp



Performance Ratio PR



City of Tulsa: Convention Center - 750kW c-Si 0 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	70.9	66.4	43558	41679	11.28	10.80
February	96.2	3.09	96.2	91.2	59603	57237	11.39	10.93
March	129.4	11.57	129.4	124.1	76976	73978	10.93	10.50
April	163.2	15.97	163.2	157.4	95375	91761	10.74	10.33
May	181.9	20.92	181.9	175.8	103449	99582	10.45	10.06
June	197.8	26.63	197.8	191.5	109388	105244	10.16	9.78
July	212.4	29.01	212.4	205.9	115349	110971	9.98	9.60
August	184.1	27.36	184.1	178.0	101193	97401	10.10	9.72
September	145.9	21.46	145.9	140.4	82555	79363	10.39	9.99
October	118.7	16.54	118.7	113.2	68873	66239	10.66	10.25
November	85.2	8.55	85.2	79.8	50690	48613	10.94	10.49
December	72.2	3.89	72.2	67.0	43529	41638	11.07	10.59
Year	1658.1	15.61	1658.1	1590.7	950538	913704	10.53	10.12

Legends:			
GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

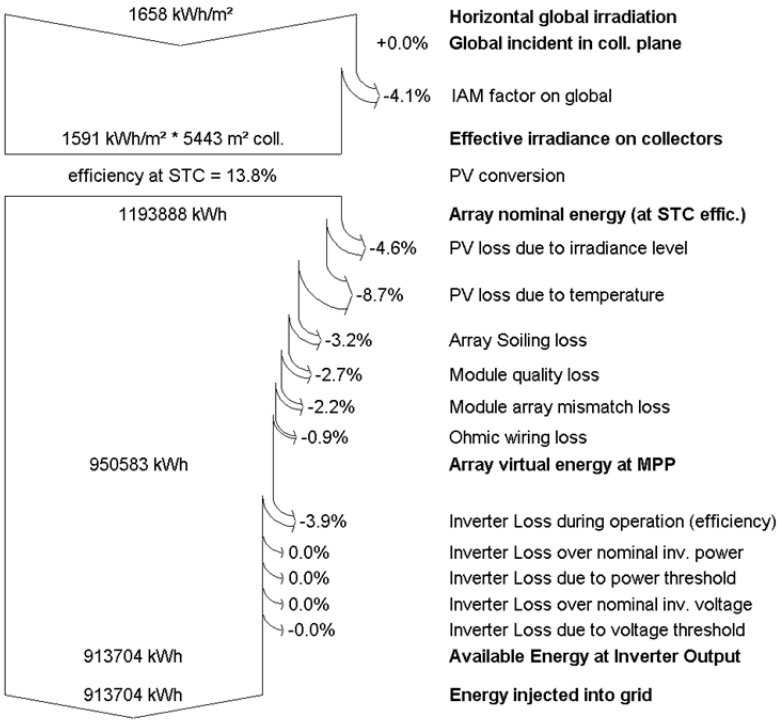
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Convention Center - 750kW c-Si 0 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	Powerply 400	Pnom	400 Wp
PV Array	Nb. of modules	1875	Pnom total	**750 kWp**
Inverter	Model	PowerGate Plus PVS-250-480	Pnom	250 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**750 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Emergency 911 Facility - 48.96kW c-Si 5 Degree Tilt**	
Simulation date	28/07/11 12h18	

Simulation parameters

Collector Plane Orientation	Tilt	5°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Number of PV modules		In series	12 modules	In parallel	17 strings
Total number of PV modules		Nb. modules	204	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**49 kWp**	At operating cond.	47 kWp (34°C)
Array operating characteristics (50°C)		U mpp	363 V	I mpp	131 A
Total area		Module area	**342 m²**		

Inverter	Model	**PowerGate Plus PVS-50-480**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	305-600 V	Unit Nom. Power	50 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	43 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

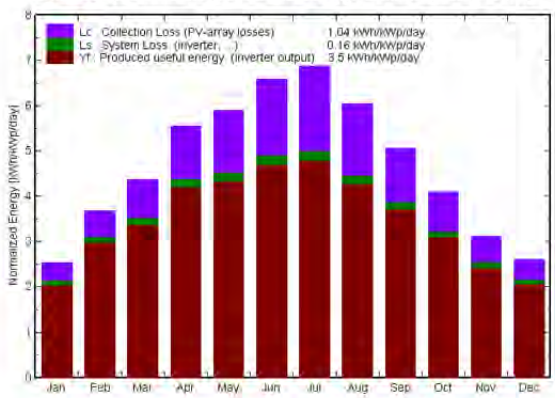
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Emergency 911 Facility - 48.96kW c-Si 5 Degree Tilt**

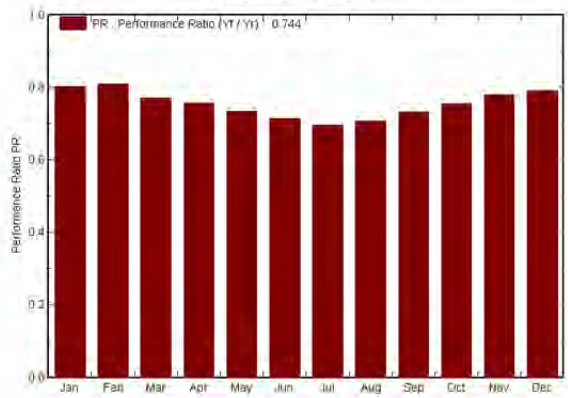
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	204	Pnom total	**49 kWp**
Inverter	Model	PowerGate Plus PVS-50-480	Pnom	50 kW ac
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**62.6 MWh/year**	Specific prod.	1278 kWh/kWp/year
	Performance Ratio PR	74.4 %		

Normalized productions (per installed kWp): Nominal power 49 kWp



Performance Ratio PR



City of Tulsa: Emergency 911 Facility - 48.96kW c-Si 5 Degree Tilt

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	70.9	1.42	78.7	74.5	3263	3096	12.12	11.50
February	96.2	3.09	103.2	98.7	4285	4090	12.13	11.58
March	129.4	11.57	135.5	130.4	5363	5122	11.57	11.05
April	163.2	15.97	166.7	161.1	6456	6179	11.32	10.84
May	181.9	20.92	183.0	177.0	6882	6587	10.99	10.52
June	197.8	26.63	197.9	191.7	7224	6913	10.68	10.22
July	212.4	29.01	213.0	206.7	7592	7266	10.42	9.97
August	184.1	27.36	187.3	181.4	6782	6493	10.59	10.14
September	145.9	21.46	152.0	146.7	5700	5448	10.96	10.48
October	118.7	16.54	126.9	121.7	4909	4691	11.31	10.80
November	85.2	8.55	93.5	88.5	3750	3571	11.73	11.17
December	72.2	3.89	80.6	75.8	3292	3125	11.94	11.34
Year	1658.1	15.61	1718.4	1654.2	65499	62581	11.14	10.65

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

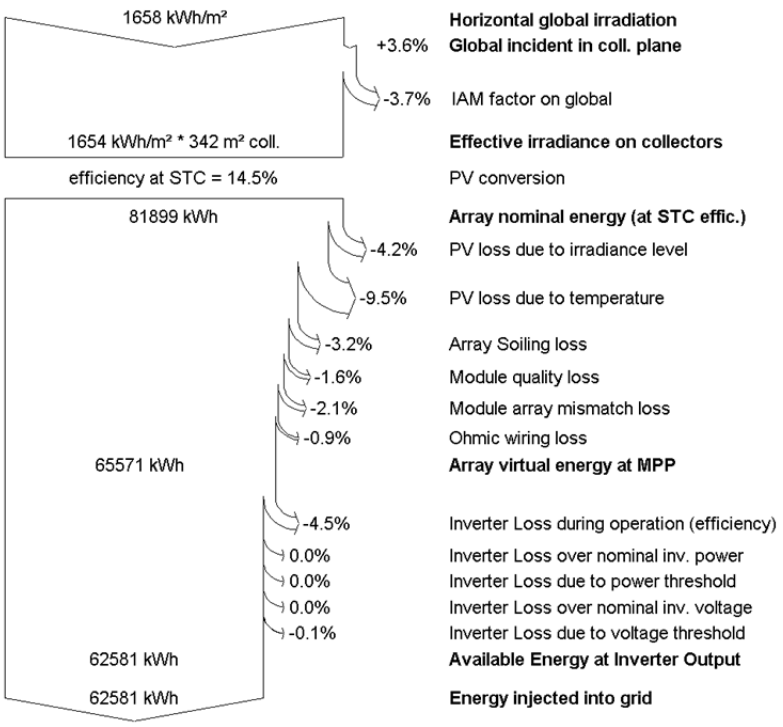
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Emergency 911 Facility - 48.96kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	204	Pnom total	**49 kWp**
Inverter	Model	PowerGate Plus PVS-50-480	Pnom	50 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Air Force Plant #3 - 3128kW c-Si 0 Degree Tilt**	
	Simulation date	27/07/11 15h30

Simulation parameters

Collector Plane Orientation	Tilt	0°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**LPP400A**		
		Manufacturer	Lumeta Solar		
Number of PV modules		In series	5 modules	In parallel	1564 strings
Total number of PV modules		Nb. modules	7820	Unit Nom. Power	400 Wp
Array global power		Nominal (STC)	**3128 kWp**	At operating cond.	2994 kWp (34°C)
Array operating characteristics (50°C)		U mpp	390 V	I mpp	7666 A
Total area		Module area	**22700 m²**	Cell area	18518 m²

Inverter	Model	**PowerGate Plus PVS-500-480**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	320-600 V	Unit Nom. Power	500 kW AC
Inverter pack	Number of Inverter	6 units	Total Power	3000 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	0.79 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

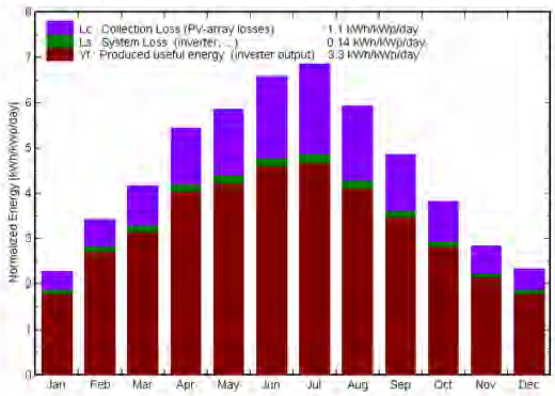
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Air Force Plant #3 - 3128kW c-Si 0 Degree Tilt**

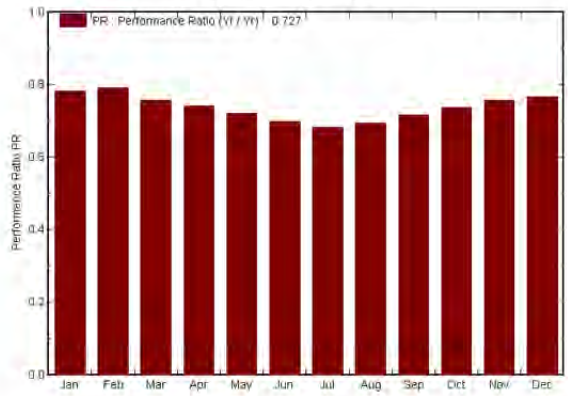
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	LPP400A	Pnom	400 Wp
PV Array	Nb. of modules	7820	Pnom total	**3128 kWp**
Inverter	Model	PowerGate Plus PVS-500-480	Pnom	500 kW ac
Inverter pack	Nb. of units	6.0	Pnom total	**3000 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**3768 MWh/year**	Specific prod.	1205 kWh/kWp/year
	Performance Ratio PR	72.7 %		

Normalized productions (per installed kWp): Nominal power 3128 kWp



Performance Ratio PR



City of Tulsa: Air Force Plant #3 - 3128kW c-Si 0 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	70.9	66.4	181971	173385	11.30	10.77
February	96.2	3.09	96.2	91.2	248649	238093	11.39	10.91
March	129.4	11.57	129.4	124.1	319621	306286	10.88	10.42
April	163.2	15.97	163.2	157.4	394912	379022	10.66	10.23
May	181.9	20.92	181.9	175.8	427023	409994	10.34	9.93
June	197.8	26.63	197.8	191.5	450172	432090	10.03	9.62
July	212.4	29.01	212.4	205.9	473201	454183	9.81	9.42
August	184.1	27.36	184.1	178.0	416230	399657	9.96	9.56
September	145.9	21.46	145.9	140.4	340997	326930	10.29	9.87
October	118.7	16.54	118.7	113.2	285589	273838	10.60	10.16
November	85.2	8.55	85.2	79.8	211186	201823	10.93	10.44
December	72.2	3.89	72.2	67.0	181743	173162	11.08	10.56
Year	1658.1	15.61	1658.1	1590.7	3931295	3768463	10.45	10.01

Legends:			
GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

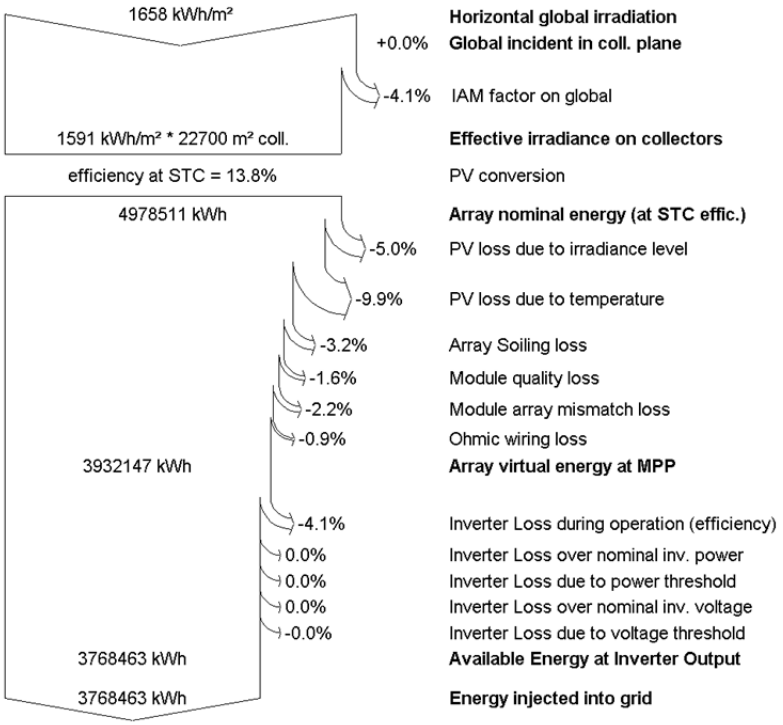
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Air Force Plant #3 - 3128kW c-Si 0 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	0°	azimuth	0°
PV modules	Model	LPP400A	Pnom	400 Wp
PV Array	Nb. of modules	7820	Pnom total	**3128 kWp**
Inverter	Model	PowerGate Plus PVS-500-480	Pnom	500 kW ac
Inverter pack	Nb. of units	6.0	Pnom total	**3000 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Central Recreation Center - 12.5kW c-Si 5 Degree Tilt**	
	Simulation date	29/08/11 03h14

Simulation parameters

Collector Plane Orientation	Tilt	5°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Number of PV modules		In series	13 modules	In parallel	4 strings
Total number of PV modules		Nb. modules	52	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**12 kWp**	At operating cond.	12 kWp (34°C)
Array operating characteristics (50°C)		U mpp	394 V	I mpp	31 A
Total area		Module area	**87.2 m²**		

Inverter	Model	**IG Plus 12**		
	Manufacturer	Fronius		
Characteristics	Operating Voltage	230-500 V	Unit Nom. Power	12.0 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	200 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

Project : **City of Tulsa: Solar Feasibility Assessment**

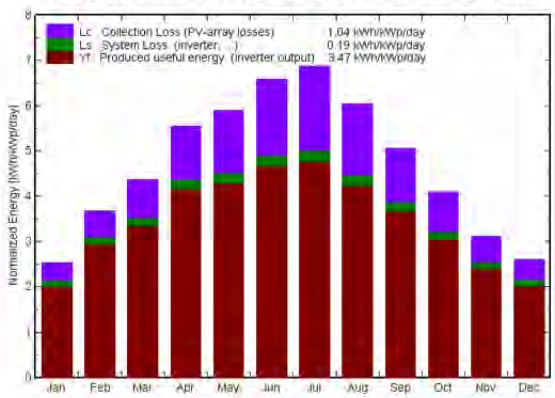
Simulation variant : **City of Tulsa: Central Recreation Center - 12.5kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	52	Pnom total	**12 kWp**
Inverter	Model	IG Plus 12	Pnom	12 kW ac
User's needs	Unlimited load (grid)			

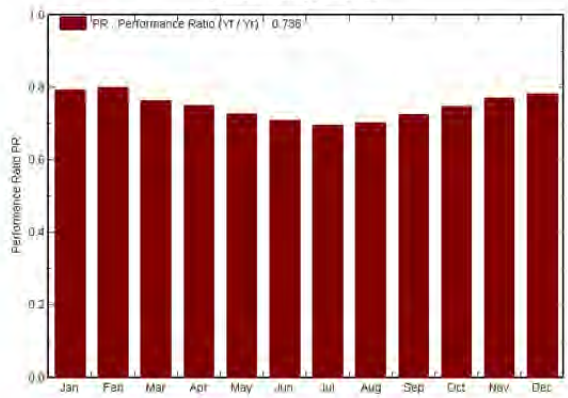
Main simulation results

System Production	**Produced Energy**	**15.83 MWh/year**	Specific prod.	1268 kWh/kWp/year
	Performance Ratio PR	73.8 %		

Normalized productions (per installed kWp): Nominal power 12 kWp



Performance Ratio PR



City of Tulsa: Central Recreation Center - 12.5kW c-Si 5 Degree Tilt

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	70.9	1.42	78.7	74.5	832	781	12.12	11.38
February	96.2	3.09	103.2	98.7	1092	1032	12.13	11.47
March	129.4	11.57	135.5	130.4	1367	1294	11.57	10.95
April	163.2	15.97	166.7	161.1	1646	1560	11.32	10.73
May	181.9	20.92	183.0	177.0	1755	1665	11.00	10.43
June	197.8	26.63	197.9	191.7	1844	1750	10.69	10.15
July	212.4	29.01	213.0	206.7	1946	1848	10.48	9.95
August	184.1	27.36	187.3	181.4	1733	1645	10.62	10.07
September	145.9	21.46	152.0	146.7	1453	1377	10.96	10.39
October	118.7	16.54	126.9	121.7	1251	1186	11.31	10.72
November	85.2	8.55	93.5	88.5	956	901	11.73	11.05
December	72.2	3.89	80.6	75.8	839	787	11.94	11.21
Year	1658.1	15.61	1718.4	1654.2	16714	15827	11.16	10.56

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

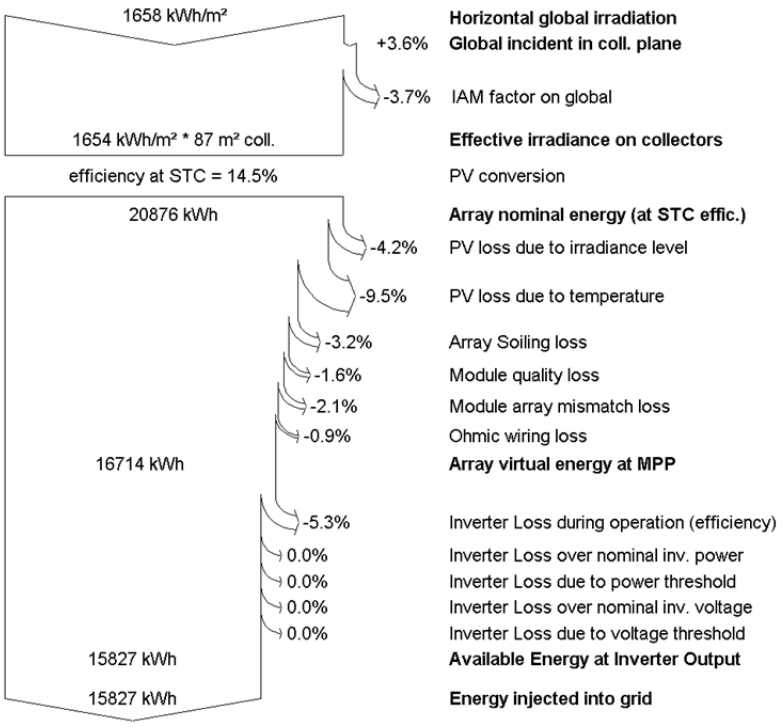
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Central Recreation Center - 12.5kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	52	Pnom total	**12 kWp**
Inverter	Model	IG Plus 12	Pnom	12 kW ac
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Fire Station #24 - 20kW c-Si 5 Degree Tilt**	
	Simulation date	29/08/11 03h08

Simulation parameters

Collector Plane Orientation	Tilt	5°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Arrays Characteristics (2 kinds of array defined)

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Array#1: Number of PV modules		In series	12 modules	In parallel	4 strings
Total number of PV modules		Nb. modules	48	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**12 kWp**	At operating cond.	11 kWp (34°C)
Array operating characteristics (50°C)		U mpp	363 V	I mpp	31 A
Array#2: Number of PV modules		In series	12 modules	In parallel	3 strings
Total number of PV modules		Nb. modules	36	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**8.6 kWp**	At operating cond.	8.4 kWp (34°C)
Array operating characteristics (50°C)		U mpp	363 V	I mpp	23 A
Total Arrays global power		Nominal (STC)	**20 kWp**	Total	84 modules
		Module area	**141 m²**		
Array#1 : Inverter		Model	**IG Plus 12**		
		Manufacturer	Fronius		
Characteristics		Operating Voltage	230-500 V	Unit Nom. Power	12 kW AC
Array#2 : Inverter		Model	**IG Plus 8**		
		Manufacturer	Fronius		
Characteristics		Operating Voltage	230-500 V	Unit Nom. Power	8 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Array#1	185 mOhm	Loss Fraction	1.5 % at STC
	Array#2	246 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

Grid-Connected System: Main results

Project : **City of Tulsa: Solar Feasibility Assessment**

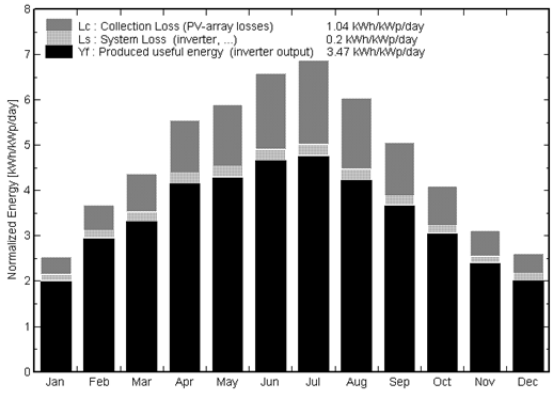
Simulation variant : **City of Tulsa: Fire Station #24 - 20kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	84	Pnom total	**20 kWp**
Inverter	Model	IG Plus 12	Pnom	12 kW ac
Inverter	Model	IG Plus 8	Pnom	8.0 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**20 kW ac**
User's needs	Unlimited load (grid)			

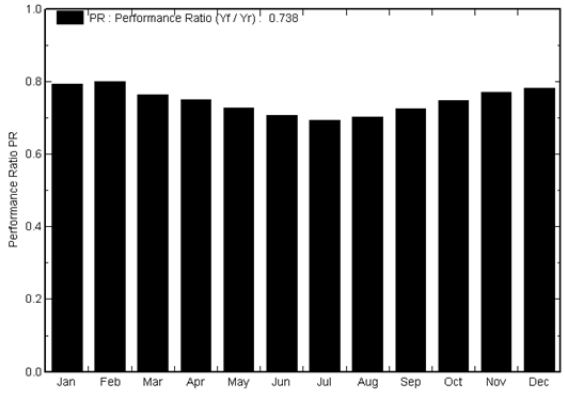
Main simulation results

System Production	**Produced Energy**	**25.55 MWh/year**	Specific prod.	1267 kWh/kWp/year
	Performance Ratio PR	73.8 %		

Normalized productions (per installed kWp): Nominal power 20 kWp



Performance Ratio PR



City of Tulsa: Fire Station #24 - 20kW c-Si 5 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	78.7	74.5	1344	1259	12.12	11.36
February	96.2	3.09	103.2	98.7	1764	1666	12.13	11.46
March	129.4	11.57	135.5	130.4	2208	2089	11.57	10.94
April	163.2	15.97	166.7	161.1	2659	2520	11.32	10.73
May	181.9	20.92	183.0	177.0	2835	2689	11.00	10.43
June	197.8	26.63	197.9	191.7	2978	2826	10.69	10.14
July	212.4	29.01	213.0	206.7	3143	2984	10.48	9.95
August	184.1	27.36	187.3	181.4	2800	2657	10.62	10.07
September	145.9	21.46	152.0	146.7	2347	2223	10.96	10.39
October	118.7	16.54	126.9	121.7	2021	1915	11.31	10.71
November	85.2	8.55	93.5	88.5	1544	1453	11.73	11.04
December	72.2	3.89	80.6	75.8	1356	1270	11.94	11.19
Year	1658.1	15.61	1718.4	1654.2	27000	25552	11.16	10.56

Legends:			
GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

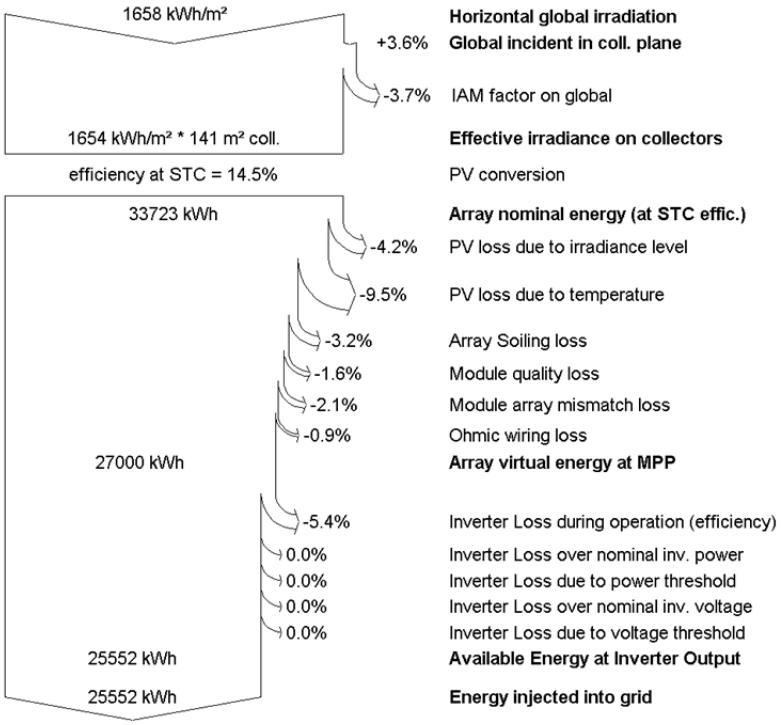
Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Fire Station #24 - 20kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	84	Pnom total	**20 kWp**
Inverter	Model	IG Plus 12	Pnom	12 kW ac
Inverter	Model	IG Plus 8	Pnom	8.0 kW ac
Inverter pack	Nb. of units	2.0	Pnom total	**20 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



Grid-Connected System: Simulation parameters

Project :	**City of Tulsa: Solar Feasibility Assessment**			
Geographical Site	**Tulsa International Airport**		**Country**	**USA**
Situation	Latitude	36.2°N	Longitude	95.9°W
Time defined as	Legal Time	Time zone UT-6	Altitude	198 m
	Albedo	0.20		
Meteo data :	Tulsa International Airport, NREL TMY3			

Simulation variant :	**City of Tulsa: Central Central Library - 150kW c-Si 5 Degree Tilt**	
	Simulation date	29/08/11 03h20

Simulation parameters

Collector Plane Orientation	Tilt	5°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module	Si-mono	Model	**SW 240 Mono**		
		Manufacturer	SolarWorld		
Number of PV modules		In series	13 modules	In parallel	48 strings
Total number of PV modules		Nb. modules	624	Unit Nom. Power	240 Wp
Array global power		Nominal (STC)	**150 kWp**	At operating cond.	145 kWp (34°C)
Array operating characteristics (50°C)		U mpp	394 V	I mpp	369 A
Total area		Module area	**1046 m²**		

Inverter	Model	**PowerGate Plus PVS-50-240**		
	Manufacturer	Satcon		
Characteristics	Operating Voltage	305-600 V	Unit Nom. Power	50 kW AC
Inverter pack	Number of Inverter	3 units	Total Power	150 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	17 mOhm	Loss Fraction	1.5 % at STC
Array Soiling Losses			Loss Fraction	3.0 %
Module Quality Loss			Loss Fraction	1.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

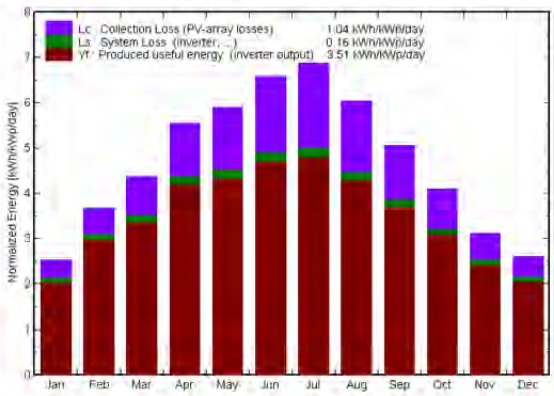
Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Central Central Library - 150kW c-Si 5 Degree Tilt**

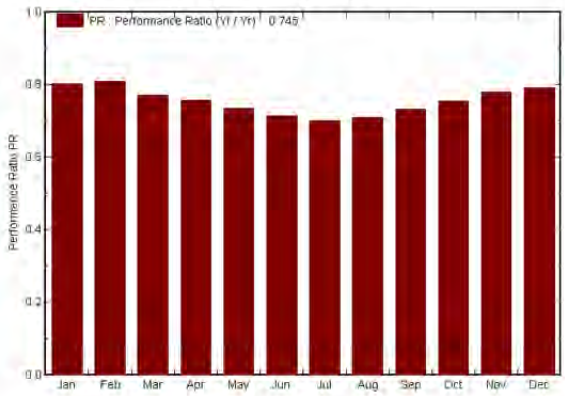
Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	624	Pnom total	**150 kWp**
Inverter	Model	PowerGate Plus PVS-50-240	Pnom	50 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**150 kW ac**
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**192 MWh/year**	Specific prod.	1280 kWh/kWp/year
	Performance Ratio PR	74.5 %		

Normalized productions (per installed kWp): Nominal power 150 kWp



Performance Ratio PR



City of Tulsa: Central Central Library - 150kW c-Si 5 Degree Tilt

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	70.9	1.42	78.7	74.5	9982	9475	12.12	11.51
February	96.2	3.09	103.2	98.7	13107	12515	12.13	11.59
March	129.4	11.57	135.5	130.4	16404	15673	11.57	11.05
April	163.2	15.97	166.7	161.1	19749	18906	11.32	10.84
May	181.9	20.92	183.0	177.0	21060	20162	11.00	10.53
June	197.8	26.63	197.9	191.7	22123	21174	10.69	10.23
July	212.4	29.01	213.0	206.7	23350	22351	10.48	10.03
August	184.1	27.36	187.3	181.4	20801	19919	10.62	10.17
September	145.9	21.46	152.0	146.7	17436	16669	10.96	10.48
October	118.7	16.54	126.9	121.7	15016	14354	11.31	10.81
November	85.2	8.55	93.5	88.5	11471	10928	11.73	11.17
December	72.2	3.89	80.6	75.8	10070	9564	11.94	11.34
Year	1658.1	15.61	1718.4	1654.2	200569	191690	11.16	10.66

Legends:				
	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	E_Grid	Energy injected into grid
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

Grid-Connected System: Loss diagram

Project : **City of Tulsa: Solar Feasibility Assessment**

Simulation variant : **City of Tulsa: Central Central Library - 150kW c-Si 5 Degree Tilt**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	5°	azimuth	0°
PV modules	Model	SW 240 Mono	Pnom	240 Wp
PV Array	Nb. of modules	624	Pnom total	**150 kWp**
Inverter	Model	PowerGate Plus PVS-50-240	Pnom	50 kW ac
Inverter pack	Nb. of units	3.0	Pnom total	**150 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year