Emissions Reduction Potential from Common Energy Efficiency Projects in Small to Medium-Sized Industries

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Preface

About the South-central Partnership for Energy Efficiency as a Resource (SPEER)

SPEER is an Austin, Texas based non-profit organization dedicated to increasing and accelerating the adoption of energy efficient products, technologies, and services. Much of SPEER's work focuses on finding the best market-based approaches to increase energy efficiency and overcoming persistent market barriers. The views expressed in this paper do not necessarily reflect the views of all of SPEER's members, funders, or supporters. For more information about SPEER, please visit: www.eepartnership.org.

About the Energy Systems Laboratory (ESL)

The Energy Systems Laboratory (ESL) is a division of the Texas A&M Engineering Experiment Station and a member of the Texas A&M University System. The ESL is affiliated with the Energy Systems Group in the Department of Mechanical Engineering (five faculty), as well as two faculty from the Department of Architecture in the College of Architecture and celebrated its 25th anniversary two years ago. The Lab focuses on energy-related research, energy efficiency, and emissions reduction. For more information about the ESL please visit: esl.tamu.edu.

About Industrial Assessment Centers

The USDOE Industrial Assessment Centers (IAC) are teams of university-based faculty and student engineers that provide no-cost energy, productivity, and waste assessments to small and medium sized US manufacturers nationwide. After site visits, a comprehensive report is developed providing specific details on all cost-saving opportunities identified during the assessment, including applicable rebates and incentives.

The Texas A&M Industrial Assessment Center has been serving the central and east Texas communities and parts of Louisiana for 30 years completing over 700 assessments and providing annual potential resource savings of $50,000 per client. For more information about the Texas A&M IAC please visit: iac.tamu.edu.

The Oklahoma State University Industrial Assessment Center has served over 850 clients in their three state regions and conducted over 940 audits over the past 35 years. In FY 2015, they performed 30 assessments and identified potential savings of $3.8 million. For more information about the IAC program, please visit: http://iac.okstate.edu.

Executive Summary

Industrial efficiency is not a part of investor owned utilities' (IOU) programs in Texas or Oklahoma; industrial consumers' trade association's secured exemptions or opt-outs when the programs were first established in both states. There is no momentum and little chance that the programs in either state would be expanded in the foreseeable future to include industrial efficiency. Industrial electricity rates are among the lowest in the country: 5.21 cents per kWh in Oklahoma and 6.07 cents per kWh in Texas[1]. With low rates and no subsidies, and a very high penetration of cogeneration (in Texas), there is seemingly little to motivate industrial consumers to actively pursue energy efficiency.

The Clean Air Act requires major emitters in areas of non-compliance with National Ambient Air Quality Standards (NAAQS) to pay penalties. As the standards are strengthened, the threat of greater fines increases for point sources like industrial facilities. Further, the Clean Power Plan final rule may create opportunities to receive credit for industrial energy efficiency provided the efficiencies achieved are measured and verified.

Since 2001, Texas A&M University's Energy Systems Laboratory (ESL) has been calculating the emissions benefits of energy efficiency and EPA has approved energy efficiency as an effective means to reduce emissions. With increasingly stringent air quality standards and proposed new emissions regulations, TCEQ, the Oklahoma Department o f Environmental Quality (ODEQ) and local communities will likely be looking for additional ways to reduce emissions.

We believe that by providing industrial customers an avenue to voluntarily report verified energy efficiency for credit toward reducing emissions as a mechanism to acknowledge activities already underway, as well as provide additional motivations for energy efficiency investment in this sector in the Texas and Oklahoma energy markets.

A voluntary program to encourage implementation and reporting of these recommendations by small to medium-sized industries could reduce NO_X emissions in Texas by 750 metric tons annually, which is comparable to savings from the Texas Emissions Reduction Plan (TERP). Broader implementation of an incentive program to include large industries could potentially save Texas 17,300 metric tons of NO_X and 13.4 million tons of CO_2 annually. Savings will be proportionally similar in Oklahoma demonstrating the potential impact across the South-Central region.

[1] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

1 Introduction

The Texas A&M Industrial Assessment Center (IAC) and the Energy Systems Laboratory (ESL) have completed a preliminary study to quantify potential emissions reductions from common energy efficiency projects implemented by industrial manufacturers. This report uses public data from the national IAC Database [1] as well as confidential client data to identify these projects and calculate their impact.

The Texas A&M IAC is one of 24 centers across the country funded by the U.S. Department of Energy to conduct free energy audits for small to medium-sized industrial facilities. A team of professional staff and trained students conduct assessments to identify potential cost savings from energy efficiency improvements, waste minimization, and productivity enhancements. These teams typically spend a single day at facility learning about the manufacturing process and identifying potential projects. Recommendations are compiled within 3 months of the visit and implementation is self-reported 9-12 months after the audit report is submitted to the client.

Since 1976, IAC centers across the country have conducted over 17,000 facility audits and have made over 60,000 individual energy recommendations. Information on each audit is compiled in the national IAC Database available publicly online. Statistics from this database provide an indication of how common energy efficiency projects can reduce emissions. As of 2013, Texas accounts for 21% of all industrial energy used in the United States [2]. Over the past ten years (2005-2014), a majority of recommendations that reduce CO_2 emissions in Texas have been related to five common plant systems (Figure 1). Recommendations for these systems account for 58% of all recommended and 77% of all implemented proposals. The data also shows that 28% of recommended and 45% of implemented energy efficiency projects reducing CO_2 are related to system 'best practices' (e.g. minimum compressed air set points, maintaining sky lighting, synthetic lubricants, etc.). In total, implementation of IAC energy efficiency projects related to these common systems was calculated

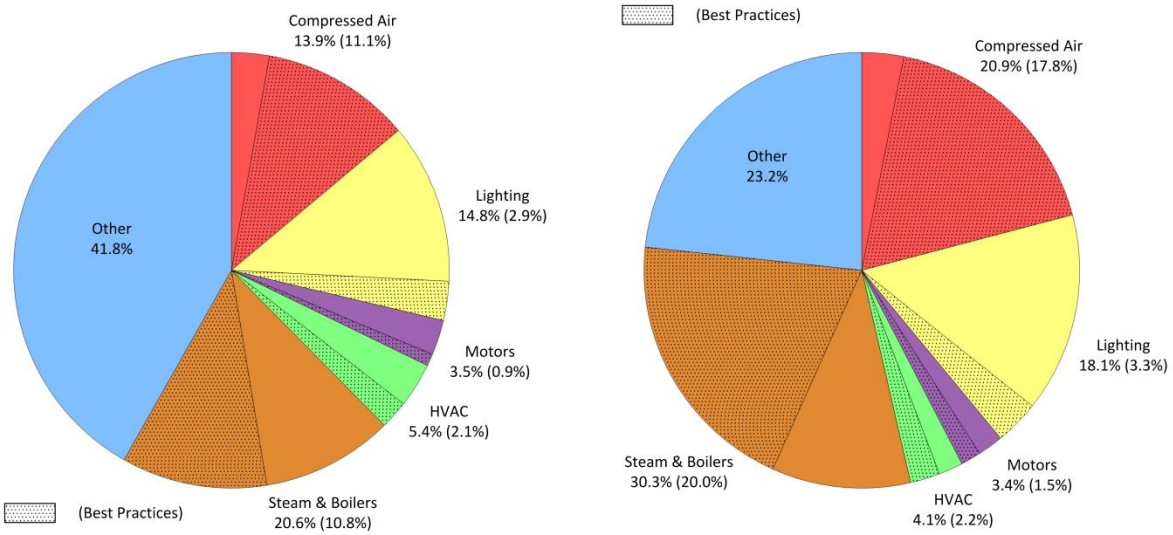

Figure 1: CO_2 reductions from IAC audits conducted in Texas from 2005-2014.

to have reduced CO_2 output in Texas by 6,900 tons annually. These trends are similar to those of neighboring states including Oklahoma.

The statistics from Figure 1 demonstrate that there exists a large opportunity for emissions reductions from common energy efficiency recommendations and best practices. The data highlight that more than half of all IAC proposals are related to common plant systems and that these kinds of recommendations are most likely to be implemented by manufacturers. The purpose of this study was to verify energy savings from common recommendations and to develop methods for accurately estimating resulting emissions reductions. Towards this goal, the following tasks were completed:

Task 1: Analysis of National IAC Data

- The Assessment Recommendation Code (ARC) Manual [3] used by all IACs was evaluated and each recommendation categorized in terms of: 1) equipment installation, 2) operational changes, or 3) behavioral modification. Each of these Assessment Recommendation (AR) types required different verification techniques and had different estimated depreciation rates for avoided energy use.
- The IAC database was analyzed to identify ARs with the greatest potential for emission reductions. This included identifying recommendations with the largest individual savings, largest aggregate savings, and highest implementation rate.
- The potential aggregate emissions reduction due to industrial clients performing self-evaluation and implementing common ARs was estimated. A potential Texas-wide impact was calculated (with a high degree of uncertainty) to be used as motivation for subsequent, more detailed studies. Results for savings in Oklahoma are understood to have the same general trends.
- For the ARs with the most emissions reduction potential, procedures for measurement and verification of savings were developed.

Task 2: Verification of Regional IAC Client Reported Savings

- Five former clients of the Texas A&M and Oklahoma State IACs with reported implementation of the candidate ARs were identified. These clients were contacted and asked to voluntarily participate in the verification process.
- Personnel have visited these five former clients from the IAC database to verify energy savings. Verification was conducted on-site using instrumentation owned by the Texas A&M IAC. Coordination with the Oklahoma State IAC allowed for two client visits in Oklahoma. Comparisons between measured savings and self-reported savings were analyzed.

The remainder of this report is organized as follows: first, an explanation of the Assessment Recommendation Code is given; second, a discussion of the IAC database analysis is presented including the methods used to identify top recommendations; finally, results from follow-up site visits to former IAC clients are given.

2 IAC Manual & Database

Industrial Assessment Center (IAC) programs have conducted over 17,000 energy audits in all 50 states. Information from each of these visits is maintained in the national IAC Database. To organize the data in a useful way, the Center for Advanced Energy Systems at Rutgers University has assembled and maintains a coding system for each Assessment Recommendation (AR). This list is contained in the Assessment Recommendation Code (ARC) Manual [3]. Recommendations are grouped together based on the type of system or general strategy for efficiency improvement. The ARC has the following format:

X.YYYY.Z

The first number 'X' is the recommendation type (energy reduction, waste management, or productivity); the second four numbers 'YYYY' identify the specific recommendation; the final number 'Z' gives the *application* of the AR (manufacturing, production support, building/grounds, or administrative). These codes can be used to collect data on specific recommendations from multiple companies spanning several years.

The database consists of two parts: an audit level list and a recommendation level list. The audit level list contains information including which IAC conducted the audit, the products being manufactured, annual electrical/natural gas usage, and the location (state) of the facility. Example audit level entries are given by Table 1.

The recommendation level list gives information on individual recommendations from each audit report. This information includes the specific ARC of a recommendation, a self-reported implementation status, and the type of resource being conserved (e.g. electrical demand/ consumption, natural gas, fuel oil, etc.). Specific resources are listed using the Resource Identification Codes (RICs) from the IAC Database Manual [4]. Example recommendation level entries are given in Table 2. Implementation codes and relevant RICs are given in Table 3.

Table 1: Example Audit Level Database Entries

Audit #	Product(s)	Usage (kWh/yr)	Demand (kW-mo/yr)	State
AM0655	Plastic plates, bowls, etc.	96698750	-	TX
AM0656	Aloe Vera Lotions and Sunscreens	7,064,225	13,365	TX
AM0657	Poultry Products	36,568,800	71,275	TX
AM0658	Threaded Steel Tubing	4,492,725	13,851	TX
AM0659	Vertical Centrifugal Pumps	559,025	4,382	TX

Table 2: Example Recommendation Level Database Entries

Audit #	ARC	Resource	Resource Savings	Implementation Status
AM0480	2.4232	EC	63,600	I
AM0480	2.4236	EC	28,500	I
AM0480	2.7143	EC	2,450	N
AM0480	2.7124	EC	9,700	I
AM0480	2.4231	EC	5,680	I

Table 3: Important IAC Database Codes

Implementation Status		Common Resource Identification Codes	
I	Implemented	EC	Electrical Consumption
P	Pending	ED	Electrical Demand
N	Not Implemented	EF	Electrical Fees
K	Data Excluded/Unavailable	E2	Natural Gas
		E3	Liquefied Petroleum Gas
		E4-E7	Fuel Oil #1,2,4,6
		E8	Coal
		E9	Wood

3 Classification of Recommendations

The first objective of this project was to categorize recommendations in the IAC Database based on the type and difficulty of emissions verification. This was done to separate recommendations whose verification only requires evidence such as proof of purchase from those that must be verified by independent inspection. With this general idea in mind, the ARs in the ARC Manual were classified into three categories:

1) Equipment/Support Changes
   Includes ARs that are related to purchasing, replacement, repair, or modification of machinery used for production (e.g. mills, ovens, CNC welders) or process support (e.g. lighting, HVAC, compressed air). These ARs are easily verifiable through purchase receipts or inspection and are permanent once implemented.
2) Operational Changes
   Includes ARs related to the alteration of a support or manufacturing process. These include recommendations like lowering compressor set point pressures, using motion sensors for

lighting, or rearranging machinery for better process flow. These ARs are most easily verified by inspection and require deliberate human intervention to disable.

3) Behavioral Changes
   Includes ARs that are dependent on changing human behavior. Examples include turning off ventilation hoods when not in use, turning off machinery during breaks, and closing doors and windows on hot or cold days. These recommendations can only be verified by inspection and must be continually monitored to determine savings.

These categories are roughly summarized as: permanent, semi-permanent, and day-to-day. Each recommendation in the ARC Manual was sorted into these categories and the resulting list was used in the next section to identify recommendations with the highest potential for reducing industrial emissions.

4 Identification of Potential Recommendations

The IAC Database contains national audit information, so the data were filtered for audits completed by the Texas A&M IAC which comprises most of the South-Central region. The database was further limited to assessments from the past ten years (2005-2014) to eliminate companies that are out of business or have changed personnel and to remove recommendations that are now out of date. These filters reduced the total number of audits from 16,858 to 478 and the number of individual recommendations from 124,478 to 3,576.

Estimates of emissions reductions for individual recommendations are not included in the IAC Database. To calculate emissions savings, the emissions factors in Table 4 are used to convert resource savings into kilograms (kg) of CO_2 and kg of NO_X. Note that productivity, waste reduction, and resources savings were not considered and only emissions related to electrical and fuel consumption were used. This analysis generated four new values: total CO_2 emissions reductions, total NO_X emissions reductions, total energy savings in kilowatt-hours (kWh), and total demand

Table 4: Emissions Factors for Common Energy Sources [5,6]

Fuel Type	Code	CO_2 Emissions Factors		NO_X Emissions Factors	
Electrical Consumption	EC	0.538	kg/kWh	0.000276	kg/kWh
Natural Gas	E2	53.34	kg/MMBtu	0.043	kg/MMBtu
L.P.G	E3	61.71	kg/MMBtu	0.2	kg/MMBtu
#1 Fuel Oil	E4	73.25	kg/MMBtu	0.2	kg/MMBtu
#2 Fuel Oil	E5	73.96	kg/MMBtu	0.2	kg/MMBtu
#4 Fuel Oil	E6	75.75	kg/MMBtu	0.2	kg/MMBtu
#6 Fuel Oil	E7	75.75	kg/MMBtu	0.2	kg/MMBtu
Coal (coke)	E8	113.67	kg/MMBtu	0.023	kg/MMBtu
Wood	E9	93.8	kg/MMBtu	0.07	kg/MMBtu

Table 5: Example ARC Emissions Data for South-Central Assessments

ARC	Rec. Rate	Imp. Rate	CO_2 per Rec. (kg/yr)	NO_X per Rec. (kg/yr)	kWh per Rec. (kWh/yr)	kW per Rec. (kW/yr)
2.1233	7.30%	65.70%	116,108	94	637,942	0
2.2135	6.10%	82.80%	1,763,831	1,382	7,260,232	0
2.4231	39.50%	51.90%	34,867	18	64,776	70
2.7111	19.50%	48.40%	41,678	21	51,322	104
2.7442	1.20%	66.70%	82,893	43	154,077	0

savings in kilowatts (kW). An example calculation of CO_2 savings for a recommendation from audit AM0582 is given by Equation 1 where 'F' stands for emissions factor and 'Q' for quantity of resource.

$$\begin{aligned} \mathrm{CO_2\ Saved} &= \mathrm{F_{EC}} \cdot \mathrm{Q_{EC}} + \mathrm{F_{E2}} \cdot \mathrm{Q_{E2}} \\ &= 0.538 \frac{\mathrm{kg}}{\mathrm{kWh}} \cdot 1{,}496{,}000\ \mathrm{kWh} + 53.34 \frac{\mathrm{kg}}{\mathrm{MMBtu}} \cdot 4{,}600\ \mathrm{MMBtu} \\ &= 1{,}050{,}212\ \mathrm{kg\ CO_2} \end{aligned} \tag{1}$$

From the previous calculations, an average emissions reduction rate for each AR code was calculated. Partial results are shown in Table 5 which gives the recommendation rate of an ARC, its implementation rate, and average recommended savings for CO_2, NO_X, kWh, and kW. This ARC data was then used to identify the recommendations with the greatest emissions reduction potential from each of the three categories in Section 3. The complete list of identified ARs with the greatest potential to reduce emissions is given in Sections 4.1-4.3 where ARCs were chosen based on their average emissions savings, implementation rate, and total number of times recommended.

The emissions factors used in this analysis are average values of emissions for each resource type. As this report is only identifying common ARs with the largest emissions reduction potential, average values will provide the necessary trends. Future programs or projects that seek to calculate real emission savings will require more detailed data. Projects will need to determine which power plants a facility is receiving power from during production in order to determine the local, regional, or instant emissions factor. This type of information is being compiled and maintained by researchers such as the Energy Systems Laboratory at Texas A&M University [7].

4.1 Category #1: Potential Equipment Changes

Recommendation (ARC)	Rec. Rate	Imp. Rate	CO_2 per Rec. (kg/yr)	NO_X per Rec. (kg/yr)	kWh per Rec. (kWh/yr)	kW per Rec. (kW-mo/yr)
Insulation of Bare Equipment (2.1121, 2.1131, 2.2131, 2.2123, 2.2511)	36%	53%	291,100	110	872,375	35
Energy Efficient Motor (2.4111, 2.4322, 2.4133)	18%	64%	62,900	35	100,600	155
Repair Compressed Air Leaks (2.4236)	78%	82%	98,400	50	182,600	145
Replace Existing Lighting (2.7143, 2.7142)	78%	58%	80,200	40	148,900	215
Replace HVAC Systems (2.7232)	6%	28%	115,300	65	187,500	290

4.2 Category #2: Potential Operational Changes

Recommendation (ARC)	Rec. Rate	Imp. Rate	CO_2 per Rec. (kg/yr)	NO_X per Rec. (kg/yr)	kWh per Rec. (kWh/yr)	kW per Rec. (kW-mo/yr)
Boiler Tune-Up (2.1233)	7%	65%	119,500	95	656,320	0
Variable/Multi-Speed Drives (2.4141 - 2.4145)	14%	24%	246,000	130	514,535	20
Reduce Compressed Air Pressure (2.4231)	39%	51%	35,600	20	66,200	86
Use Photocell Controls (2.7134)	17%	45%	59,500	30	110,600	5
Install Timers/Thermostats (2.7261)	6%	39%	25,700	20	115,550	0

4.3 Category #3: Potential Behavioral Changes

Recommendation (ARC)	Rec. Rate	Imp. Rate	CO_2 per Rec. (kg/yr)	NO_X per Rec. (kg/yr)	kWh per Rec. (kWh/yr)	kW per Rec. (kW-mo/yr)
Turn Off Equipment (2.6212, 2.6218, 2.6231)	14%	57%	117,300	65	290,475	25
Turn Off Lights (2.7111, 2.7121, 2.7124, 2.7135)	69%	54%	34,700	20	64,400	85
Clean & Maintain Cooling Towers (2.2615, 2.7211)	8%	86%	25,500	15	47,400	100
Reduce Space Conditioning (2.6232, 2.7224)	23%	35%	78,500	40	162,305	0
Keep Doors & Windows Shut (2.7442)	1%	67%	82,900	45	154,100	0

4.4 Impact on Emissions from Identified ARs

The recommendations from Sections 4.1-4.3 were identified as having the greatest potential to reduce toxic gas emissions according to the information in the IAC database. To calculate their potential impact, the following analysis aims to determine the resulting emissions reduction should programs be put in place to incentivize industries in Texas to implement and report savings from these recommendations. Texas was chosen for these calculations due to its share of national industrial usage (21%) as well as the readily available expertise of the ESL regarding emissions reduction programs already in place in the state. Results are expected to be qualitatively similar throughout the South-Central region. However, future studies regarding common energy efficiency projects to reduce emissions should be carried out for the most accurate results.

Incentives for small to medium-sized industries (i.e. clientele of the IAC program) to report energy efficiency savings could have a large impact on emissions. According to the latest Texas Manufacturers Registry [8], there are 23,723 industrial companies operating in the state of Texas. Of these, approximately 6,100 fit the criteria for an IAC assessment. Namely these industries have:

- Gross annual sales below $100 million
- Less than 500 employees at the plant site

- Annual utility bills between $100,000 and $2.5 million
- No in-house professional energy assessment staff

The South-Central database used to identify potential recommendations was further filtered to only include audits conducted within the state of Texas. Using the same analysis as before, recommendation and implementation rates for the identified projects were calculated for Texas only. This information was then used to determine emissions savings should incentives be offered to companies causing implementation to approach 100%. An example calculation of CO_2 savings for insulating bare equipment is given by Equation 2 where 'AVG_{CO_2}' is the average CO_2 reduction per recommendation and 'R_{REC}' is the average recommendation rate.

$$\begin{aligned} CO_2 \text{ Savings} &= AVG_{CO_2} \cdot R_{REC} \cdot 6{,}100 \text{ Clients} \cdot \frac{1 \text{ ton}}{1000 \text{ kg}} \\ &= 100{,}300 \frac{\text{kg } CO_2}{\text{Rec.}} \cdot 25.8\% \cdot 6{,}100 \text{ Clients} \cdot \frac{1 \text{ ton}}{1000 \text{ kg}} \\ &= 157{,}900 \text{ ton } CO_2 \end{aligned} \tag{2}$$

A detailed breakdown of potential resource savings by category is given by Table 6. As shown, if all recommendations were to be implemented, the state of Texas would reduce its CO_2 output by 1,363,500 metric tons per year. This is equivalent to 3.2 million barrels of oil or 375 installed wind turbines. These calculations indicate that a national program to incentivize CO_2 could have a significant impact on emissions. Incentive programs are key to realizing these savings as calculations with current implementation rates see an annual CO_2 savings of only 876,000 tons or 65% of the potential savings (Table 7).

To put these numbers in context, a comparison with established emissions reductions plans is helpful. Since 2001 the state of Texas has funded a program called the Texas Emissions Reduction Plan (TERP). This program's primary goal is to reduce NO_X emissions through voluntary incentive programs. Annual savings as of 2014 from TERP programs have reached more than 6,500 tons of NO_X per year [7]. From the analysis above, Texas would save 750 tons of NO_X per year if all mid-sized manufacturers implemented the identified ARs. As shown by Figure 2, these savings, excluding wind power, are in line with current programs in the TERP family.

Implementation by all manufacturers in Texas has a greater potential impact on emissions. Clientele of the IAC program in Texas typically see a 7.1% reduction in CO_2 and NO_X emissions due to the identified recommendations. Given the most recent state-wide emissions data for Texas manufacturers [9, 10], common recommendations can save Texas approximately 13.4 million metric tons of CO_2 and 17,300 metric tons of NO_X per year.

Table 6: Annual Potential Emission & Energy Impact in Texas with Perfect Participation

Category	Description	CO_2 (ton)	NO_X (ton)	MWh	MW
1	Equipment Changes	918,900	497	1,969,700	2,616
2	Operational Changes	234,800	140	716,600	451
3	Behavioral Changes	209,800	109	435,900	394
Total	-	1,363,500	747	3,122,200	3,460

Table 7: Annual Potential Emission & Energy Impact in Texas with Current Implementation Rates

Category	Description	CO_2 (ton)	NO_X (ton)	MWh	MW
1	Equipment Changes	614,700	331	1,300,400	1,782
2	Operational Changes	130,300	81	443,300	227
3	Behavioral Changes	131,000	68	269,200	248
Total	-	876,000	480	2,012,900	2,257

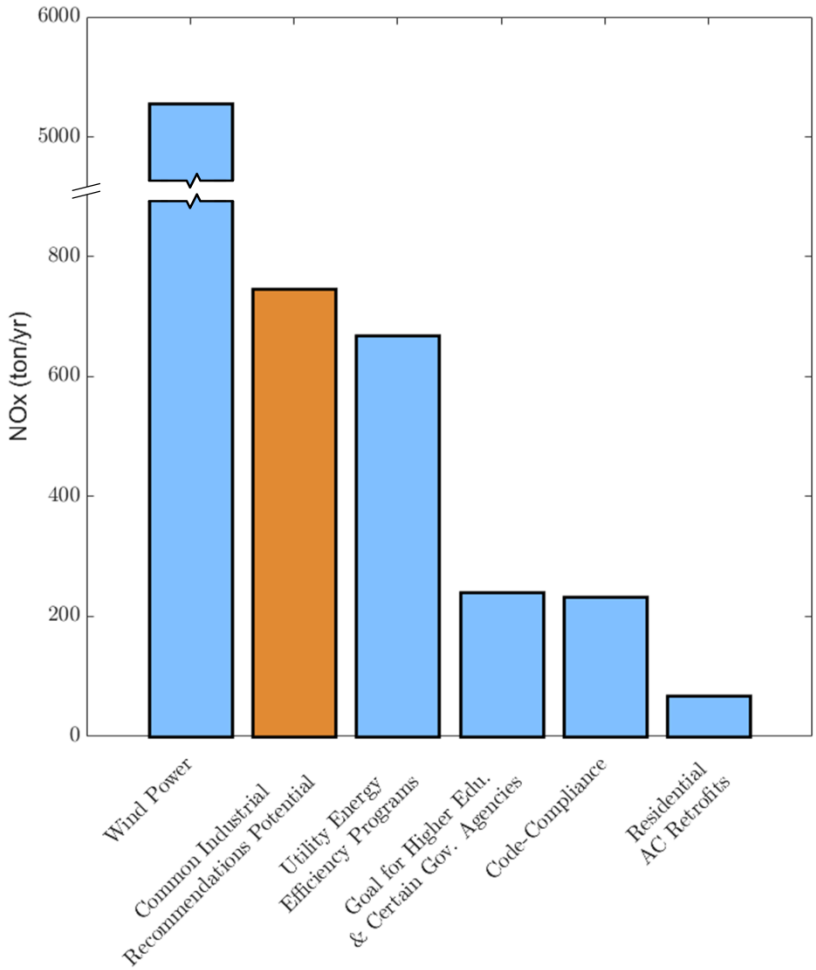

Figure 2: Comparison of NO_X savings from TERP energy efficiency programs and NO_X savings from common recommendations with potential IAC Clientele.

5 Verification of Savings from Identified ARs

For each of the identified recommendations from Section 4, a procedure for verifying implementation and calculating resulting emissions reductions was developed. These procedures have three basic steps: reporting opportunities for savings, verifying implementation, and calculating savings over time. For each step, several options are given to increase the likelihood of reporting.

Identification of savings opportunities falls into two categories: self-reporting and independent audit reports. Reports from an auditor are preferred as they are independent evidence of a facility operating inefficiently. Self-reporting of savings opportunities will require more documentation as a measure to prevent fraud. Sufficient data must be provided to establish that a facility has been operating inefficiently for a specified period of time. This is to prevent companies from simply altering operations briefly to take advantage of incentive programs.

Verifying implementation of an AR can be accomplished through sub-metering/data-logging of equipment, providing documentation of installation and operation, or by an independent inspection report. Each method must provide data to establish energy efficiency improvements after implementation of a recommendation. Documentation in the form of logged data and photographs or an independent report reduces the opportunity for fraud.

Some recommendations will require annual data submission to verify energy savings. Systems like boilers and compressed air require constant maintenance which will greatly affect the amount of energy and emissions saved. ARs that have such time-dependent savings will require that data be provided annually to establish continued emissions reductions.

The following sections discuss two verification procedures in detail to highlight key aspects of the above criteria. A complete list of verification procedures can be found in Appendix A where procedures are organized by the categories used in Sections 4.1-4.3.

5.1 Example: Verification for Insulation of Bare Equipment

This recommendation was identified as an equipment upgrade project. As this recommendation involves only the addition of insulation to existing equipment and will be permanent provided proper maintenance, minimal information will be needed to verify emissions savings. The following procedure is typical of ARs involving equipment changes/upgrades.

- Identification of AR:
  The preferred method for identification of this recommendation is through an independent audit report. Typically these reports will include surface temperature readings as well as an estimate of exposed surface area. This information can be used to calculate wasted energy resources. Should a company choose to self-report exposed equipment, additional documentation is required such as time stamped photographs before installation.
- Implementation of AR:
  Verification of implementation requires receipts showing expenditures on new insulation as well as photographs after installation. Calculation of energy savings can be done using sub-metered data before and after installation, data from insulation contractor, or by providing

new surface temperature data. Given proper maintenance, no annual submission of data will be required for verifying future emissions savings.

5.2 Example: Verification for Turning Off Equipment

This recommendation was identified as a behavioral change project. As this recommendation refers to non-automated equipment, savings will be realized on a day-to-day basis. In general, recommendations of this type will require proof of an active effort to change behavior as well as annual inspections to show continued savings.

- Identification of AR:
  As with the procedure for insulating equipment, identifying opportunities from turning off equipment will require either an independent audit report or internal documentation. Self-reporting will require logging of operating times for identified equipment over a sufficient time period to demonstrate a persistent problem.
- Implementation of AR:
  To verify savings, a facility must demonstrate an active effort to turn off equipment in the form of a documented program to turn off equipment when not in use. In addition, a facility must provide either data showing equipment is only being used when necessary or results from an unscheduled independent inspection.
- Continuation of Savings:
  As this recommendation has savings that are day-to-day, annual submission of documentation is necessary. As with implementation verification, either logged data or an inspection report is required to demonstrate continued savings.

6 Site Visits

To determine accuracy of reported emissions reductions, the Texas A&M IAC conducted five on-site visits to former IAC clients in Texas and Oklahoma. This section details the criteria for identifying former clients and results from completed visits.

6.1 Site Identification

Manufacturing facilities that received an IAC visit within the last five years (2010-2014) were selected as possible site visits. Each of these assessments was filtered for the identified recommendations from Section 4, and information from the IAC Database was used to determine the number of implemented recommendations for each audit. Clients were selected based on a high number of implemented recommendations as well as their proximity to the Texas A&M IAC. This process was repeated for clients located in Oklahoma. Table 8 gives the top candidates for follow-up site visits in both states. Highlighted clients indicate sites selected for follow-up visits.

Table 8: Top Candidates for Follow-up Visits in Texas & Oklahoma

IAC Client #	Manufactured Products	Total ARs	Implemented ARs
AM0669	Beverage Cans	6	5
AM0662	Aerosol Cans	6	5
AM0639	Plastic Drums	4	3
AM0628	Petrochemical Products	6	4
AM0620	Fruit Juices	7	7
OK0839	Clay Bricks	13	7
OK0819	Ferrous Castings	5	3
OK0816	Motors	7	4
OK0813	Oil Country Tubular Goods	7	5
OK0798	Fencing	8	6

6.2 Results

The following sections summarize follow-up visits to former IAC clientele to verify their current energy savings and calculate resulting emissions savings. Of the five total site visits, three were made to facilities in Texas and two to facilities in Oklahoma.

6.2.1 Visit to Texas A&M IAC Client AM0628

	ARC	Description	Implementation	
			Reported	Verified
1	2.1233	Tune Boiler for Proper Air-Fuel Ratio	Yes	Yes
2	2.7142	Replace Metal Halides with T8 Fluorescent Fixtures	No	No
3	2.4236	Repair Leaks in Compressed Air System	Yes	Yes
4	2.4231	Reduce Pressure Setpoint from 120 to 100 psig	No	No
5	2.2123	Insulate Boiler Feed Water Tanks	Yes	**No**
6	2.7121	Turn Off Outdoor Lighting During Daylight Hours	Yes	**Partial**

This facility manufactures, blends, and packages petrochemical products. Annual resource consumption for this facility is 1,254,400 kWh and 6,140 kW of electricity as well as 33,744 MMBtu of natural gas per year. According to the IAC database, this company self-reported

implementing 4 of 6 recommendations from the identified AR list. Details for each recommendation are included below:

1. *Tune Boiler for Proper Air-Fuel Ratio*
   The facility has had an annual boiler tune-up once per year since the initial IAC audit. A boiler tune-up was scheduled for the day of the follow-up site visit. Tuning of the boiler has decreased excess oxygen in the flue gas and improved overall efficiency.
2. *Replace Metal Halide Lighting with T8 Fluorescent Fixtures*
   During the initial IAC audit, students identified 80 metal halide fixtures in the warehouse area. The company feels that there is sufficient sky lighting to turn off lighting during production hours and that resulting savings from replacing fixtures would therefore be minimal. The company is utilizing T8 fluorescent fixtures in a new warehouse being constructed on site.
3. *Repair Leaks in Compressed Air System*
   During the initial IAC audit, two large leaks with diameters of 1/16 and 1/8 inch were identified. One of these leaks was repaired immediately and the other has since been fixed. Savings for these leaks are therefore the same as reported. However, the facility has not implemented a program to regularly inspect for leaks. Savings from such a program has the potential to further reduce energy usage by 36,500 kWh per year or 20 tons of CO_2 and 10 kg of NO_X annually based on a conservative estimate of 20% air loss due to leaks [11].
4. *Reduce Compressed Air System Operating Pressure*
   The facility has a large compressed air system spread throughout the facility. The maintenance manager has discovered that any pressure below 120 psig does not provide enough pressure to operate machinery. This recommendation may be revisited if an air leak program is implemented.
5. *Insulate Boiler Feed-Water Tanks*
   This recommendation was reported to the IAC as implemented. However, the company did not implement this recommendation and feels that the payback is not large enough to invest in insulating the tanks.
6. *Turn Off Outdoor Lighting During Daylight*
   The facility has expanded greatly and has added more exterior lighting since the time of the initial audit. A drive-thru of the facility found no malfunctioning exterior lighting photocells. The initial IAC report did note 3 fixtures of 5 foot fluorescent lighting left on in the machine shop area that were still left on during the follow-up site visit.

Summary:

The follow-up site visit found that only 2 recommendations were completely implemented as reported (ARs 1 & 3). One AR was only partially implemented (AR 6) while one AR was falsely reported as implemented (AR 5). Verified electrical savings for this company are similar to those

self-reported by the company. Natural gas consumption savings are less than reported as the feed-water tanks to the boiler were not insulated.

Table 9: Summary of Savings from Visit to AM0628

Annual Savings	Nat. Gas Usage (MMBtu)	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_x (kg/yr)
Reported	3,038	41,740	136	185	142
Verified	2,887	37,179	115	174	134

6.2.2 Visit to Texas A&M IAC Client AM0669

	ARC	Description	Implementation	
			Reported	Verified
1	2.4231	Reduced Pressure Setpoint from 110 to 100 psig	Yes	**Alternate**
2	2.7124	Install Occupancy Sensors In Maintenance & Warehouse	Yes	**Partial/Alternate**
3	2.4141	Install VFD for Cooling Tower Fan Motors	Yes	**Alternate**
4	2.6231	Install Sensors to Operate Blower Only When Necessary	No	No
5	2.4236	Repair Condensate Valve Leak In Compressed Air System	Yes	Yes
6	2.7111	De-lamp Unnecessary Metal Halide Fixtures	Yes	**Partial**

This facility manufactures aluminum beverage cans and has annual electrical consumption of 44,809,250 kWh/yr and 70,660 kW-mo/yr. According to the database, this company had implemented 5 of 6 recommendations from the identified AR list. Details for each recommendation are included below:

1. *Reduce Compressed Air System Operating Pressure*
   At the time of the initial IAC audit, the facility utilized six compressors with a combined power of 2,350 HP. At the main header where all six systems meet, the pressure was 110 psi. The reading at the plant on the day of follow-up site visit was 111.4 psi. This means that the plant has not reduced its pressure setpoint from 110 psi to 100 psi as reported. The plant did however install two 250 HP, low pressure (50 psi) systems and take 4 high pressure compressors offline. The plant is effectively now using only 1,300 HP for compressed air, a reduction of 45%.
2. *Install Occupancy Sensors In Maintenance and Warehouse*
   The initial IAC audit found 12 fixtures of fluorescent high bay lighting in a maintenance area and 132 fixtures in the storage warehouse left on when no activity was present. The warehouse lighting has since been fully retrofitted with occupancy sensors. The maintenance area lighting

has not been turned off or sensored. However, that area has been converted to high efficiency LED lighting.

3. *Install VFD for Cooling Tower Fan Motors*
   The facility has two cooling towers on site that currently have fixed speed drives. Replacement with VFDs has been approved in the company budget for 2016 and 2017. Although the AR in the original report was specifically for cooling tower motors, the facility has 43 other motors between 5 and 300 HP used in production that are in the process of being converted to VFD control.

4. *Install Sensors to Operate Blowers Only When Necessary*
   During the initial visit, IAC personnel noticed a 15 HP blower system used to reject deformed cans. This blower operated 24/7 despite only being required once or twice per day. The IAC recommended installing a sensor to operate this blower only when rejected cans were detected. This AR has not been implemented and is not part of future company budgets.

5. *Eliminate Leaks in Compressed Air System*
   During the initial IAC visit, one of the compressed air system condenser valves had failed open. Although this valve has been replaced, the system has since been taken out of service. (See AR 1).

6. *Reduce Illumination to Minimum Necessary Levels*
   IAC personnel noted five 400W metal halide lamps left on despite newer fluorescent lighting being installed. All but one fixture has been removed.

Summary:

The follow-up site visit revealed that only one recommendation had been completely implemented as reported (AR 5). Installation of occupancy sensors was partially implemented with sensors added to the warehouse lighting. Lighting in the maintenance areas was converted to LEDs instead of occupancy sensors. VFDs for cooling tower fans have not been installed but are approved in the company budgets for the next two years. Although not recommended, the company has phased in VFDs for production line motors with large estimated savings. The company did not reduce its compressed air pressure in its main line but did reduce its total horsepower. By removing 4 high-pressure compressors and installing two low pressure air compressors, the company is saving an estimated 10% of their total energy usage which is substantially more than the savings recommended by the initial IAC audit.

Table 10: Summary of Savings from Visit AM0669

Annual Savings	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_X (kg/yr)
Savings from Initial IAC Audit				
Reported	805,465	1,027	433	222
Verified	148,311	88	80	41
Additional Savings from IAC Inspired Efficiency Projects				
Compressed Air Alterations (HP Reduction & Low-Pressure System)	4,808,560	9,898	2,587	1,327
Production Line VFD (Est. 5% Savings)	979,215	-	527	270
Total Verified Savings	5,936,085	9,986	3,194	1,638

6.2.3 Visit to Texas A&M IAC Client AM0639

	ARC	Description	Implementation	
			Reported	Verified
1	2.4236	Repair Leaks in Compressed Air System	Yes	Yes
2	2.4231	Reduce Pressure Setpoint from 120 to 105 psig	Yes	Yes
3	2.2615	Repair Chiller Condenser Coil Fins	Yes	Yes
4	2.6231	Install Occupancy Sensors in Maintenance and Warehouse Areas	No	**Partial**

This facility manufactures large plastic drums and has annual electrical consumption of 15,892,000 kWh/yr and 28,870 kW-mo/yr. According to the database, this company had implemented 3 of 4 recommendations from the identified AR list. Details for each recommendation are included below:

1. *Repair Leaks in Compressed Air System*
   The original IAC audit estimated that 10% of the energy used by the compressed air system was lost to leaks. The facility has implemented a leak repair policy and actively monitors the load factor of their compressor to determine when leaks have become substantial. The leak fixing program has facilitated lowering of the compressed air pressure setpoint (see AR 2).

2. *Reduce Compressed Air System Operating Pressure*
   During the original IAC audit, it was observed that the compressed air setpoint pressure was 120 psig. The facility has since lowered the setpoint to 105 psig. During the follow-up site visit, the compressed air pressure was observed to fluctuate between 100 and 105 psig.
3. *Repair Chiller Condenser Coil Fins*
   The facility has four large chiller systems of 80 tons or more. Two of these systems have condenser fins that are exposed to the warehouse isles. Various accidents had caused a large percentage of the fins to become bent and obstruct air flow. On the day of the follow-up site visit, fins on one chiller had been completely repaired and new protective grating has been installed. The second chiller has been almost completely repaired with similar protective plans in place.
4. *Install Occupancy Sensors to Turn Off Lighting When Not Needed*
   The original energy audit found over 100 T8 fluorescent light fixtures running in areas that had minimal occupancy. The company has installed lighting timers in the warehouse area but not in the maintenance area.

Summary:

The follow-up site visit found that the company had at least partially implemented all four recommendations from the identified AR list. The visit found that the facility has lowered their compressed air setpoint and is actively monitoring load factor to identify when air leaks have become substantial enough to effect production. Exposed cooling fins of chillers in warehouse have been fixed and are being protected. The facility also chose to install light timers instead of occupancy sensors in the warehouse area but has not installed timers in the maintenance area.

Table 11: Summary of Savings from Visit to AM0639

Annual Savings	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_X (kg/yr)
Reported	564,990	953	304	156
Verified	554,130	953	298	153

6.2.4 Visit to Oklahoma State IAC Client OK0839

	ARC	Description	Implementation Status	
			Reported	Verified
1	2.4141	Install VFD Drives on Compressed Air System	Yes	**No**
2	2.4231	Reduce Pressure Setpoint from 127 to 90 psig	Yes	**Partial**
3	2.4236	Repair Leaks in Compressed Air System	Yes	Yes
4	2.7142	Replace Probe-Start with Pulse-Start Metal Halide Fixtures	Yes	**Partial**
5	2.7142	Replace 1000 Watt Metal Halide Security Lighting	No	No
6	2.7142	Retrofit T12 Office Lighting with T8 Lighting and Occ. Sensors	No	No
7	2.7232	Replace Current HVAC Units with Higher Efficiency Models	Yes	**Partial**
8	2.6232	Install Setback Timers for Space Conditioning	No	No
9	2.7211	Clean and Maintain HVAC Filters	Yes	Yes
10	2.4131	Install VFDs on Kiln Car Drives	Yes	Yes
11	2.4131	Install VFDs on Circulation Fans	No	No
12	2.2511	Repair Kiln Heat Recovery Insulation	No	**Yes**
13	2.2511	Insulate Kiln Slide Damper Lines	No	No

This facility manufactures clay bricks and has annual electrical consumption of 6,343,132 kWh/yr and 18,300 kW-mo/yr. Annual natural gas consumption is 262,246 MMBtu per year. According to the database, this company had 13 recommendations from the identified AR list of which 7 were implemented. Details for each recommendation are included below:

1. *Install VFDs on Compressed Air System*
   At the time of the initial IAC visit, the facility used a single 50 HP fixed speed air compressor. The facility had installed a second air compressor that has been idled after an internal audit of compressed air leaks. During the visit, the compressor cycled on and off indicating that a true VSD air compressor has not been installed.

2. *Reduce Pressure Setpoint from 127 psi to 90 psig*
   During the original IAC audit, it was observed that the compressed air setpoint pressure was 127 psig. The facility attempted to operate equipment at 90 psig but found that this setpoint caused problems with certain equipment. The facility is therefore using 100 psig as their target pressure setpoint. During the follow-up site-visit, it was observed that the pressure setpoint of the system had returned to 127 psig but this has since been corrected.

3. *Repair Leaks in Compressed Air System*
   The initial IAC energy assessment estimated a total of 60 scfm of compressed air leaks. After an internal audit, the company identified and repaired several large leaks. One of two 50 HP air compressors has been idled since an air leak repair program was implemented. A compressed air

drop-down test was completed after the follow-up site visit. This test calculated a total air leak of 140 scfm. This caused savings from this recommendation to be verified as negative.

4. *Replace Probe-Start with Pulse-Start Metal Halide Fixtures*
   In production areas, the company has 129 probe-start 400 Watt metal halide lighting fixtures. The company is in the process of replacing these fixtures as they fail. Currently 29 fixtures have been replaced.

5. *Retrofit T12 Office Lighting with T8 Lighting and Occ. Sensors*
   The initial IAC visit identified 50 fixtures of old style T12 fluorescent lighting. This AR has not been considered and is not budgeted.

6. *Replace 1000 Watt Metal Halide Security Lighting*
   This AR has not been considered and is not budgeted.

7. *Replace Current HVAC Units with Higher Efficiency Models*
   The facility has 7 HVAC units with a total of 35 tons cooling capacity. The facility has replaced three of these units totaling 13 tons and increasing individual unit EER values from 8.5 to 12.

8. *Install Setback Timers for Space Conditioning*
   Certain areas of the plant must be kept at a certain temperature for equipment to operate properly. This AR has not been considered and is not budgeted.

9. *Clean and Maintain HVAC Filters*
   The facility has a large dust output during the the brick making process. IAC personnel found that HVAC filters were clogged leading to increased power consumption. The facility has contracted with a local company to have their air filters replaced twice a month during the summer and once a month during the winter.

10. *Install VFDs on Kiln Drive Cars*
    In the kiln area, the facility used fixed speed motors to move brick batches through the furnace. Installation of VFD drives allowed for more precise control of heat treatment as well as energy savings from reduced motor usage.

11. *Install VFDs on Ventilation Fans*
    This AR has not been considered and is not budgeted.

12. *Insulate Kiln Heat Recovery Ductwork*
    Several surfaces along the kiln recovery ductwork were found to have damaged insulation or exposed surfaces. These areas have since been repaired reducing heat loss from those lines.

13. *Insulate Kiln Slide Damper Lines*

    Several lines extending from the furnace have slide dampers. These lines are uninsulated and are at high temperature. The facility has looked into insulating these surfaces but has not budgeted for installation.

Summary:

The follow-up site found two recommendations that had been reported incorrectly. Three implemented recommendations were found to only be partially completed but with company personnel working towards completion. The company had installed a second air compressor from a sister plant but found it unnecessary once an internal air leak audit was conducted. A compressed air leak test scheduled after the follow-up visit found larger air leaks than estimated in the original report. Verified savings are lower than reported as an air leak check found substantial leaks in the compressed air system. Overall, reported savings are similar to savings calculated during the follow-up site visit.

Table 12: Summary of Savings from Visit to OK0839

Annual Savings	Nat. Gas Usage (MMBtu)	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_x (kg/yr)
Reported	0	1,086,893	635	585	300
Verified	647	687,897	56	405	218

6.2.5 Visit to Oklahoma State IAC Client OK0813

	ARC	Description	Implementation Status	
			Reported	Verified
1	2.4141	Install VFD Drives on Quenching Line Motors	Yes	**No**
2	2.4141	Install VFD Drives on Cooling Tower Motors	No	No
3	2.7142	Replace Metal Halide Lighting with T5 Fluorescents	No	No
4	2.7142	Retrofit T12 Office Lighting with T8 Lighting and Occ. Sensors	Yes	**Partial**
5	2.7142	Replace Probe-Start with Pulse-Start Metal Halide Fixtures	Yes	**Partial**
6	2.4236	Implement Regular Air Leak Maintenance Program	Yes	Yes
7	2.2511	Insulate Hot Spots on Furnaces	Yes	Yes

This facility manufactures metal tubular goods for the oil industry and has annual electrical consumption of 9,881,400 kWh/yr and 30,990 kW-mo/yr. Natural gas consumption is 206,716 MMBtu per year. According to the database, this company had implemented 5 of 7 recommendations from the identified AR list. Details for each recommendation are included below:

1. *Install VFD Drives on Quenching Line Motors*
   The original IAC report identified six motors totaling 925 HP that operated at fixed speed. Although this AR was reported as implemented, the company has not retrofitted the identified motors and has not budgeted for replacement.
2. *Install VFD Drives on Cooling Tower Motors*
   The facility has a large reservoir used to provide cold water in a quenching process. This water is sent through a cooling tower to maintain its temperature. The tower has four motors with a total power of 80 HP operating at fixed speed. The company has not looked into implementing this AR.
3. Replace Metal Halide Lighting with T5 Fluorescents
   Facility has a large area lit by 400 Watt metal halide fixtures. Some of these lights had previously been replaced with two-lamp, T5 fluorescent fixtures. The OK State IAC recommended finishing replacement of the metal halide fixtures. The company has not pursued this AR as the T5 lighting does not meet their requirements.
4. *Retrofit T12 Office Lighting with T8 Fluorescents & Occupancy Sensors*
   During the original visit, the IAC found 87 fixtures with obsolete T12 fluorescent bulbs. The company has replaced all T12 fixtures but opted not to install occupancy sensors.
5. *Replace Probe-Start with Pulse-Start Metal Halide Fixtures*
   The original energy audit identified 253 probe-start, 400 Watt metal halide fixtures in production areas. Approximately 65% of the identified lighting has been replaced.
6. *Implement Regular Air Leak Maintenance Program*
   The facility does monitor leaks in their compressed air system by performing weekly drop-down tests. The most recent leak rate was found to be 300 scfm mostly from an underground leak that has not yet been fixed. This leakage rate is greater than that assumed in the report leading to an over-estimate of reported energy savings.
7. *Insulate Hot Spots on Furnaces*
   The facility uses two furnaces with internal temperatures between 1200°F and 1600°F. The original audit noted several exposed areas with surface temperatures greater than 200°F. These surfaces have been insulated and current surface temperature readings are in line with estimates from the original report.

Summary:

The follow-up site visit revealed that the company had fully implemented only 2 of 5 reported recommendations. Two more recommendations were only partially implemented with one additional recommendation falsely reported. Current savings for this company are skewed due to the presence of a large underground compressed air leak. This leak was identified by an air leak maintenance program suggested by the IAC during their initial visit.

Table 13: Summary of Savings from Visit to OK0813

Annual Savings	Nat. Gas Usage (MMBtu)	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_x (kg/yr)
Reported	212	1,140,429	365	625	324
Verified	212	28,448	(22)	27	17

6.3 Follow-Up Visit Summary

The five follow-up visits conducted for this report attempted to verify savings from 36 common energy efficiency recommendations ranging from reducing compressed air setpoints to insulating hot spots on furnaces. Of the 36 recommendations, approximately 60% were self-reported correctly by the companies (e.g. implemented or not implemented). Another 3% of the recommendations were misreported due to partial implementation. This includes projects reported as unimplemented or completed at the time of the IAC implementation report 9-12 months after the initial audit. The remaining 10% of recommendations were misreported with the majority being recommendations not implemented as claimed. Some recommendations, although not implemented, inspired companies to seek deeper retrofits for their systems. These retrofits had significantly more savings than the initial IAC recommendation. Overall these results show that there are significant problems with self-reporting of energy and emission savings. However these errors tend towards over reporting of savings due to partial implementation. Therefore, future projects that seek to verify emissions reductions from common energy efficiency recommendations must include either independent verification or stringent documentation from companies and be able to capture savings from incomplete recommendations. A summary of verified energy and estimated emissions savings is included in Table 14.

Table 14: Summary of All Follow-Up Visits

Annual Savings	Nat. Gas Usage (MMBtu)	Elec. Usage (kWh/yr)	Elec. Demand (kW-mo/yr)	CO_2 (ton/yr)	NO_X (kg/yr)
Reported	3,250	3,639,500	3,120	2,130	1,140
Verified	3,750	1,455,970	1,190	980	560
Deeper Retrofits	-	5,936,085	9,990	3,190	1,640
Total Verified Savings	3,750	7,392,050	11,180	4,170	2,200

6.4 Lessons Learned

The completed follow-up site visits discovered several key lessons for future studies or programs seeking to verify energy and emissions savings:

Timeliness: When verifying energy and emissions savings, time is an important factor. Small to medium sized manufacturers visited outside a two year window may have closed or have changed management. This makes verification of continued savings difficult as staff present during the initial audit may no longer be working at the facility. Time is also important in terms of enthusiasm in that the likelihood of implementation and willingness to correspond decreases with time. However, additional time before verifying savings may allow for companies to budget for larger, more expensive efficiency projects that may otherwise be unfeasible.

Challenges of Self-Reporting: Follow-up visits found that there appears to be a large problem with companies self-reporting implementation of energy efficiency projects. During site visits, several projects marked as implemented were never started. Either on purpose or by honest mistake, misreporting underscores the need for independent verification of implementation. The reverse case was also found to be true; some projects reported as unimplemented were completely finished at the time of the follow-up visit. This is mostly due to companies having time to budget large-scale projects outside of the traditional IAC implementation window.

Alternative Implementation: On several occasions, companies chose to use IAC recommendations as motivation to implement radical changes in operation. One company significantly altered their compressed air system after an initial IAC visit with resulting savings being much larger than recommended. That company also took a Variable Speed Drive recommendation for cooling tower motors and instead installed VSDs on production line motors. This behavior strongly indicates that simple yes-or-no implementation reports are not sufficient in capturing how companies implement energy saving projects.

Partial Implementation: Other projects verified during site visits were found to have implementation that was partially complete or continuing. For example, one of the company visited is replacing lighting as fixtures fail. Although only 20% of fixtures had been replaced, this recommendation was reported as implemented in the IAC database. That same company received credit for lowering their compressed air setpoint to 90 psig even though the minimum setpoint they could achieve was 100 psig. The current implementation designations used by the IAC do not distinguish between recommendations that are completely finished, partially completed, or budgeted for future implementation. These differences are extremely important when verifying current energy savings and a verification program must distinguish between them.

Non-Energy Benefits: Verification of efficiency savings also has non-energy related components. For example, one company visited was found to have more compressed air leaks than during the initial IAC visit. However, this company had implemented a compressed air leak maintenance

program and knew about the leaks before the follow-up site visit. While these leaks had not yet been fixed, there was a clear change in energy efficiency behavior. Persistence of energy efficiency projects will depend greatly on behavior which can be difficult to quantify.

7 Conclusion

The Texas A&M IAC and the Energy Systems Laboratory have completed an initial study quantifying potential emissions reductions resulting from common energy efficiency projects. This report analyzed data from the national IAC database to generate regionally representative data for the South-Central region. Analysis of this data showed that almost 60% of all energy recommendations that reduce emissions are related to five common plant systems and that half of these recommendations are energy efficiency best practices. These recommendations account for more than 75% of all implemented projects indicating that large emissions reductions can be realized by focusing on common energy efficiency recommendations especially those related to typical plant systems (e.g. lighting, boilers, etc.).

This report identified common recommendations with the greatest potential for emissions reductions. These recommendations were chosen based on largest individual savings, largest aggregate savings, and highest implementation rate. Recommendations were also separated into three categories based on difficulty of verification and persistence of savings. An incentive program to encourage implementation and reporting of these recommendations by small to medium-sized industries could reduce NO_X emissions in Texas by 750 metric tons annually. These type of savings were shown to be similar to savings from the Texas Emissions Reduction Plan (TERP). Broader implementation of an incentive program to include large industries could potentially save Texas 17,300 metric tons of NO_X and 13.4 million tons of CO_2 annually. Savings will be proportionally similar in Oklahoma demonstrating broad impact across the South-Central region.

Procedures to verify energy and emissions savings due to the identified recommendations were developed and tested on five follow-up site visits to former IAC clientele. Visits highlighted several issues involved with self-reporting of energy savings by industries. Results show that any program that seeks to quantify energy and emissions savings must include independent verification or submission of stringent documentation by companies. Verification programs must also be able to quantify partially completed energy efficiency projects or more expansive retrofits than recommended. Visits also showed that verification of savings from common efficiency projects can be carried out quickly and effectively with the developed procedures.

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APPENDIX A: Emissions Verification Procedures

The following Appendix contains emissions verification procedures the identified assessment recommendations. Recommendations are presented in the same order as Sections 4.1-4.3.

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code: 2.2511 Insulate Bare Equipment

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing identification of bare equipment. Should include surface temperature data and calculation of exposed surface area.
☐ Internal Documentation	Internal documentation showing identification of bare equipment. Should include pictures (with timestamp) of bare equipment, surface temperature data, and estimate of heat losses.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on new insulation
- Pictures (with timestamp) or other supporting documentation proving successful installation
- Equipment Schedule

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for boilers, chillers, etc. before and after addition of insulation. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Surface Temperature Data	Surface temperature measurements, surface area covered, and R-value data for installed insulation.
☐ Contractor Information*	Surface temperature measurements, surface area covered R-value data for installed insulation and detailed explanation of equations used by contractor to estimate emissions savings.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.4111, 2.4133, 2.4322: Use Energy Efficient Motors

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing identification of energy inefficient motors. Should include nameplate data as well as location and end use information.
☐ Internal Documentation	Internal documentation showing identification of energy inefficient motors. Should include nameplate data, pictures (with timestamp) showing motors in use before replacement, as well as location and end use information.

Implementation of AR

Required for All Implementation Verification Options:

- Receipts and nameplate data showing expenditures on energy efficient motors
- Pictures (with timestamp) or other supporting documentation showing successful installation
- Equipment & Production Schedules
- Duty Factor Information

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for systems with upgraded motors before and after installation. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Data from control panel of identified motors. Should include duty factor, load factor, and power information.
☐ No Additional Data	No additional data is required for an estimate of energy savings. However, estimates will be conservative meaning that any calculated emissions reductions will underestimate savings by a generous safety factor.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.4236: Eliminate Leaks in Inert Gas & Compressed Air Lines/Valves

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing discovery of leaks in inert gas and/or compressed air lines. Should include results of a 5-10 psi dropdown test on affected systems and estimates of total system volume (pipes and tanks).
☐ Internal Documentation	Internal documentation indicating discovery of leaks. Should include timestamped video of a 5-10 psi dropdown test on affected systems and estimates of total system volume.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on repair of identified systems
- Production schedule OR duty factor data from control panels

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected systems before and after repair of leaks. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage (load factor, duty factor, etc.) from inert gas and compressor air systems control panels before and after lead repair. Sufficient data should be provided to clearly show efficiency improvement.
☐ Independent Auditor	Documentation from a third party auditor showing results of a 5-10 psi dropdown test on affected systems after repair.
☐ Internal Documentation	Documentation of results (including video with timestamp) of a 5-10 psi dropdown test on affected systems after repair.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of repairs.

Required for All Implementation Verification Options:

- Current production schedule OR duty factor data from system controls panel

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for repaired systems. Sufficient data should be provided to clearly show continued efficiency improvements. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage (load factor, duty factor, etc.) from repaired inert gas and compressor air systems control panels. Sufficient data should be provided to clearly show continued efficiency improvements.
☐ Independent Auditor	Documentation from a third party auditor showing results of a 5-10 psi dropdown test on repaired systems.
☐ Internal Documentation	Documentation of results (including video with timestamp) of a 5-10 psi dropdown test on repaired systems.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7142, 2.7143: Replace Existing Lighting with Most Efficient Option

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing discovery of old/inefficient lighting. Data must include lighting type and wattage as well as a fixture and bulb count.
☐ Internal Documentation	Internal documentation showing discovery of old/inefficient lighting. Data must include lighting type and wattage, a fixture and bulb count, as well as pictures (with timestamp) showing identified lighting in operation.

Implementation of AR

Required for All Implementation Verification Options:

- Receipts showing expenditures on new installation
- Utility bills for the 12 months prior and up to 12 months after installation
- Specification for new lighting systems

Emissions Verification Options:

☐ Sub-metering	Up to 1 month of sub-metered electrical demand data for lighting systems after installation. Sufficient data should be provided to show efficiency improvement over a typical production schedule. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Data Logging*	Installation of low cost light sensors in production areas with replaced lighting. Sufficient data must be collected to establish a typical lighting schedule.
☐ No Additional Data	No additional data is required for an initial estimate of energy and emissions savings. However, estimates will be conservative meaning that any calculated reductions will underestimate savings by a generous safety factor.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7232: Replace HVAC Units with High Efficiency Models

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing discovery of old/inefficient HVAC units. Must include system type, capacity, and efficiency rating (EER or SEER).
☐ Internal Documentation	Internal documentation indicating discovery of old/inefficient HVAC units. Must include system type, capacity, and efficiency data (EER or SEER) as well as pictures (with timestamp) of identified units in operation.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on new installation
- Utility bills for the 12 months prior and up to 12 months after installation
- New system specifications

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical demand data for replaced systems after installation for up to 1 year. Sufficient data should be provided to clearly show efficiency improvement over a typical year. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Data Logging*	Installation of a current clamp data logger attached to the HVAC system compressor. Sufficient data should be collected to clearly show efficiency improvement over a typical year.
☐ No Additional Data	No additional data is required for an initial estimate of energy and emissions savings. However, estimates will be <u>conservative</u> meaning that any calculated reductions will underestimate savings by a generous safety factor.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.1233: Analyze Flue Gas for Proper Air-Fuel Ratio

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing analysis of the current flue gas air-fuel ratio. Documents should include standard information such as capacity, burner types, and serial numbers.
☐ Internal Documentation	Internal documentation with dates showing analysis of the current flue gas air-fuel ratio. Documents should include standard information such as capacity, burner types, and serial numbers.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on flue gas analysis
- Equipment schedule and operating hours

Emissions Verification Options:

☐ Internal Documentation	Internal documentation with dates showing improvement in the flue gas air-fuel ratio.
☐ Independent Contractor*	Documentation with dates from independent company managing the operation of boilers at facility.
☐ Independent Auditor	Documentation with dates showing results of flue gas analysis from third party auditor.

Continuing Verification of AR

Due to the nature of this Assessment Recommendation, continuing verification of emissions reductions is required. Annual submission of flue gas composition will show the persistence of savings.

Required for All Implementation Verification Options:

- Current Production schedule
- Establishment/Documentation of a boiler maintenance program
- Log books or equivalent documentation showing control of flue gas ratio over time

Continuing Verification Options:

☐ Internal Measurements	Internal documentation with dates showing improvement in the flue gas air-fuel ratio.
☐ Independent Contractor*	Documentation with dates from independent company managing the operation of boilers at facility.
☐ Independent Auditor	Documentation with dates showing results of flue gas analysis from third party auditor.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.4141-2.4145 – Use Multiple Speed Motors or Variable Speed Drives

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing identification of fixed speed motors. Must include nameplate information as well as current control type (i.e. on/off or continuous).
☐ Internal Documentation	Internal documentation showing identification of fixed speed motors. Must include nameplate information, timestamped photographs/video of motor in operation, and current control type.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on new controls and motors
- Pictures or other supporting documentation showing successful installation
- Nameplate information for any new motors
- Specifications for new motor control

Emissions Verification Options:

☐ Data-Logging	Current clamp data for the modified motor drive. Sufficient data must be provided to establish a typical duty factor (i.e. 2 to 4 weeks)
☐ Control Panel Data*	Documented electrical usage from modified systems control panels. Must include duty factor information.

Continuing Verification of AR

Due to the nature of this Assessment Recommendation, continuing verification of emissions reductions is required. Annual submission of motor control data will show the persistence of savings.

Continuing Verification Options:

☐ Data-Logging	Recent current clamp data for the modified motor drive. Sufficient data must be provided to establish a typical duty factor (i.e. 2 – 4 weeks)
☐ Control Panel Data*	Recent documented electrical usage from modified systems control panels. Must include duty factor information.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.4231: Reduce Compressed Air System Pressure to Minimum Required

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing discovery of compressed air systems with excessive pressure setpoints. Information should include nameplate information and current pressure setpoint.

Implementation of AR

Required for All Implementation Verification Options:

- Production schedule OR duty factor data from system control panel

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected systems before and after reduction in pressure setpoint. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage from compressed air system control panel before and after setpoint reduction. Sufficient data should be provided to clearly show efficiency improvement. Should also include pictures or screenshot showing reduced setpoint.
☐ Independent Auditor	Documentation from third party auditor that pressure setpoint has been reduced.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Required for All Implementation Verification Options:

- Current production schedule OR duty factor data from system controls panel

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected systems before and after reduction in pressure setpoint. Sufficient data should be provided to clearly show continued efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage from compressor air systems control panels. Sufficient data should be provided to clearly show continued efficiency improvement. Should also include pictures or screenshot showing reduced setpoint.
☐ Independent Auditor	Documentation from third party auditor that pressure setpoint remains at minimum required level.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7134: Use Photocell Controls for Exterior Lighting

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor showing discovery of lighting that is on during daylight hours either because no photocell controls are used OR because photo cells need to be cleaned.
☐ Internal Documentation	Photographs with timestamps showing that lighting is consistently lit during daylight hours. Information should also include if identified lighting already utilizes photocell control.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on installation or cleaning of photocells

Emissions Verification Options:

☐ Sub-metering	Sub-metered demand data for affected lighting systems before and after installation/cleaning of photocells. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Independent Auditor*	Documentation from a third party auditor that install/cleaning of photocells turns off lighting during daylight hours.
☐ Internal Documentation	Documentation of lighting system operation after install/cleaning of photocells. Should include time-lapse photographs with timestamps showing daily cycling of lighting.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Continuing Verification Options:

☐ Sub-metering	Sub-metered demand data for affected lighting systems. Sufficient data should be provided to clearly show continued efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Independent Auditor*	Documentation from a third party auditor that install/cleaning of photocells turns off lighting during daylight hours.
☐ Internal Documentation	Documentation of lighting system operation. Should include time-lapse photographs with timestamps showing daily cycling of lighting.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7261: Install Timers and/or Thermostats for HVAC Control

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying temperature setback opportunities. Information should include size of affected HVAC systems as well as area of affected space.
☐ Internal Documentation	Internal documentation showing identification of temperature setback opportunities. Should include timestamped data showing that areas are being conditioned when not in use.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing installation of timers and/or thermostats
- Operating hours and production schedule
- 12 months of electrical bills preceding installation of timers or thermostats

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected HVAC systems before and after installation of timers or thermostats. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Thermostat Data	Data logged by the thermostat system showing changing of temperature setpoints according to operating hours or production schedule.
☐ Independent Auditor*	Documentation from a third party auditor showing that setback programs are in operation.
☐ Data Logging	Low-cost temperature and humidity sensors are available. Sufficient data should be provided to demonstrate the implemented setback schedule.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual data submission will show the persistence of savings.

Required for All Implementation Verification Options:

- Current operating hours and production schedule
- 12 months of electrical bills preceding time of continuing verification

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected HVAC systems. Sufficient data should be provided to clearly show continued efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Thermostat Data	Data logged by the thermostat system showing changing of temperature setpoints according to operating hours or production schedule.
☐ Independent Auditor*	Documentation from a third party auditor showing that setback programs are still in operation.
☐ Data Logging	Low-cost temperature and humidity sensors are available. Sufficient data should be provided to demonstrate continued use of a setback schedule.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.6218, 2.6212: Turn Off Equipment When Not In Use

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying equipment is being left on. Information should specify which equipment and time/duration that equipment is left running.
☐ Internal Documentation	Equipment logs with timestamps for each piece of equipment being left on. Enough data should be provided to demonstrate a persistent problem.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Equipment schedule and operating hours
- Documentation of a program to turn off equipment when not in use

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for identified systems after implementation of program to turn off equipment. Sufficient data should be provided to clearly demonstrate new practices. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage from identified systems control panels before and after implementation of program to turn off equipment. Sufficient data should be provided to clearly demonstrate new practices.
☐ Independent Auditor	Documentation from a third party auditor confirming that equipment is being turned off and a program to turn off equipment has been implemented.
☐ Data Logging	Low cost current logging sensors are now available. Enough data should be provided to clearly demonstrate new practices.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of emissions savings.

Required for All Implementation Verification Options:

- Current production schedule and operating hours
- If amended, documentation of most recent program to turn off equipment

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for identified systems. Sufficient data should be provided to clearly demonstrate persistence of new practices. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Control Panel Data*	Documentation of electrical usage from identified systems control panels. Sufficient data should be provided to clearly demonstrate persistence of new practices.
☐ Independent Auditor	Documentation from a third party auditor confirming that equipment is being turned off and a program to turn off equipment continuous to be implemented.
☐ Data Logging	Low cost current logging sensors are now available. Enough data should be provided to clearly demonstrate persistence of new practices.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7124, 2.7121: Make a Practice of Turning Off Lights When Not Needed

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying lighting being left on when not needed. Should include the number and type of lights as well as the time of day (e.g. lights on overnight, lights on in unoccupied rooms, adequate daylight).
☐ Internal Documentation	Internal documentation identifying lighting that is being left on. Should include pictures or logged data showing lighting of areas when not required as well as appropriate measurement of lighting levels.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Operating hours
- Documentation of a plan to turn off unnecessary lighting

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected lighting systems before and after implementation of a program to turn off lights. Sufficient data should be provided to clearly show new practices. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Independent Auditor*	Documentation from a third party auditor indicating that a plan to turn off lights has been implemented and that identified lighting is turned off at appropriate times.
☐ Data Logging	Low cost light level and/or light-and-occupancy sensors are now available. These sensors can be used to document lighting use. Enough data should be provided to demonstrate new practices.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Required for All Implementation Verification Options:

- Current operating hours
- If amended, documentation of program to turn off unnecessary lighting

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected lighting systems. Sufficient data should be provided to show persistence of new practices. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Independent Auditor*	Documentation from a third party auditor indicating that a plan to turn off lights continuous to be implemented and that identified lighting is turned off at appropriate times.
☐ Data Logging	Low cost light level and/or light-and-occupancy sensors are now available. Enough data should be provided to demonstrate persistence of new practices.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7211: Clean and Maintain Refrigerant Condensers and Towers

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying condenser and tower maintenance issues. Should include estimation of fouling and description of other issues. Relevant temperature measurements should also be included.
☐ Internal Documentation	Internal documentation showing condenser and tower maintenance issues. Should include timestamped pictures of issues as well as relevant temperature measurements.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Receipts showing expenditures on repair of condenser and tower issues
- Duty factor information for pumps and fans
- Pictures of condensers and towers after repair

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected systems before and after repair. Sufficient data should be provided to clearly show efficiency improvement. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Data Logging*	Extensive data logging of relevant temperatures, pumps, and fans. Enough data should be collected to establish performance before and after repair.
☐ No Additional Data	Although no additional data is required to estimate energy and emissions savings, these calculations will be <u>conservative</u>. Any calculated savings will include a generous safety factor and underestimate potential savings.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Required for All Implementation Verification Options:

- Current pictures of condensers and towers
- Relevant temperature measurements

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected systems. Sufficient data should be provided to clearly show continued efficiency. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Data Logging*	Extensive data logging of relevant temperatures, pumps, and fans. Enough data should be collected to establish current performance.
☐ No Additional Data	Although no additional data is required to estimate current energy efficiency, these calculations will be conservative. Any calculated savings will include a generous safety factor and underestimate potential savings.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7224: Reduce Space Conditioning During Non-Working Hours

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying space conditioning during non-working hours. Must include temperature measurements.
☐ Internal Documentation	Internal documentation identifying space conditioning during non-working hours. Must include logged data showing space temperature maintained in non-work hours.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Plant operating hours
- Size of conditioned space

Emissions Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected HVAC systems before and after reducing space conditioning. Sufficient data should be provided to clearly show reduced HVAC energy usage. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Thermostat Data*	Data logged by a thermostat system showing that spaces are not conditioned in non-working hours. Sufficient data should be provided to clearly show reduced HVAC energy usage. Should also include pictures or screenshots of thermostat programing.
☐ Independent Auditor	Documentation from a third party auditor verifying that temperatures are not maintained in off peak hours.
☐ Data Logging	Low-cost temperature and humidity sensors are available. Sufficient data should be provided to demonstrate that spaces are not conditioned in non-work hours.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Required for All Implementation Verification Options:

- Current plant operating hours
- Current size of identified spaces

Continuing Verification Options:

☐ Sub-metering	Sub-metered electrical data for affected HVAC systems. Sufficient data should be provided to clearly show continued reduction in HVAC energy usage. NOTE: Might require cooperation with electricity provider to add appropriate sub-metering capabilities.
☐ Thermostat Data*	Data logged by a thermostat system showing that spaces are not conditioned in non-working hours. Sufficient data should be provided to clearly show continued reduction in HVAC energy usage.
☐ Independent Auditor	Documentation from a third party auditor verifying that temperatures are not maintained in off peak hours.
☐ Data Logging	Low-cost temperature and humidity sensors are available. Sufficient data should be provided to demonstrate that spaces are not conditioned in non-work hours.

*Preferred Method

Texas A&M University
Industrial Assessment Center

Emissions Verification Procedure:

AR Code 2.7442: Keep Doors and Windows Shut When Not In Use

Company Information

Company Name: _____

Location: _____

Products: _____

_____

_____

Assessment Recommendation (AR) Identification

☐ Independent Auditor*	Documentation from a third party auditor identifying fenestration that is being left open when not in use. Should include locations of doors and windows as well as time of day.
☐ Internal Documentation	Internal documentation identifying fenestration that is being left open when not in use. Should include locations of doors and windows, time of day, and picture/video demonstrating the persistence of the problem.

Implementation of AR

Required for <u>All</u> Implementation Verification Options:

- Documentation of a plan to keep doors and windows shut when not in use

Emissions Verification Options:

☐ Independent Auditor*	Documentation from a third party auditor showing that a program to keep fenestration closed has been implemented as well as verification that doors and windows not current in use are closed.
☐ Photography/Video	Time-lapse photography or video of identified doors and windows demonstrating persistence of closing when not in use. Enough data must be provided to clearly demonstrate new practices.
☐ Data Logging	Low cost data logging sensors are available. Sensors must log the opening of identified doors and windows. Enough data should be provided to show the persistence of program to keep fenestration closed when not in use.

Continuing Verification of AR

Due to the nature of this assessment recommendation, continuing verification of emissions reductions is required. Annual submission of data will show the persistence of savings.

Required for All Implementation Verification Options:

- If amended, documentation of plan to keep doors and windows shut when not in use

Continuing Verification Options:

☐ Independent Auditor*	Documentation from a third party auditor showing that a program to keep fenestration closed continues to be implemented as well as verification that doors and windows not current in use are closed.
☐ Photography/Video	Time-lapse photography or video of identified doors and windows demonstrating persistence of closing when not in use. Enough data must be provided to clearly demonstrate continued persistence of new practices.
☐ Data Logging	Low cost data logging sensors are available. Sensors must log the position of identified doors and windows. Enough data should be provided to show the persistence of program to keep fenestration closed when not in use.

*Preferred Method