Final Technical Report

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Executive Summary

Provide a brief executive summary which includes a discussion of 1) a summary of the center's accomplishments; 2) how the effort contributed to energy savings in the U.S.; and 3) how the project is otherwise of benefit to the public. Note: This section can be cut and pasted into the online DOE Form 241.3 in the Description/Abstract section.

Over the five-year period (2002-2006) the Oklahoma State University Industrial Assessment Center (IAC) performed energy assessments for 106 different clients, writing 835 recommendations, for a total of $23,937,099 in potential estimated annual savings. IAC clients served consisted of small and medium-sized manufacturers ranging from food manufactures to foundries. The OSU IAC served clients in Oklahoma, Kansas, Missouri, Arkansas, and Texas.

In addition to client service, student training and instruction was a major accomplishment. The OSU IAC employed (and trained) 12 baccalaureate-level students, 17 masters-level graduate students, and 7 doctoral-level graduate students. Most are practicing in the energy management area. Training was focused on both energy assessment and safety.

Safety training was both center-based training as well as on-site training. Energy management related training was focused on classroom (for academic credit) work at both the undergraduate and graduate level. IEM 4923 (Energy and Water Management) was developed to serve both the IAC as well as non-IAC students. It was delivered once per year, with enrollments of typically 10 to 20 students. This course was required for IAC student employees, both undergraduate and graduate. This course was patterned after the AEE CEM (five-day) course for practicing professionals. IEM 4923 required each student to attend at least one on-site assessment and write at least one recommendation for their client's report. Hence, a hands-on approach was practiced.

Advance level courses were used to train graduate students. Two courses played major roles here: IEM 5923 (Advanced Energy and Water Management) and IEM 5943 (Hazardous Material and Waste). Graduate student participation in these courses helped the IAC to gain additional perspectives in on-site assessment and resulting recommendations.

Numerous hands-on demonstration/training was conducted by directors and graduate students in order to gain proficiency in using the combustion analyzer, IR camera, logging equipment, light metering equipment, and other equipment. Instruction included usage and basic maintenance.

While undergraduate students worked with the coursework and on-the-job training, graduate students were expected to do more. A typical MS student was required to complete a 3-hour independent study in some interesting facet of energy management under the supervision of a director. PhD students were expected to complete from three to six hours of independent study work in the energy management field, as well as center their dissertation research in the general area of energy/productivity/quality management. During the project period, two PhDs were completed, with several more near completion.

Task Summary

Summarize the IAC's activities by task for the entire period of funding.

Task 1: Conduct Industrial Assessments, to include a variety of plant types and sizes and well as coverage of the geographic area defined in the Annual Workplan Industrial Assessments: *Provide a summary of the assessments performed over the life of the award. Include overall number of assessments, types of businesses assessed, number of ARs, and any other related info.*

All Years – 2002-2006

Over the five-year period (2002-2006) the Oklahoma State University Industrial Assessment Center (IAC) performed energy assessments for 106 different clients, writing 835 recommendations, for a total of $23,937,099 in potential estimated annual savings. An overview of assessment performance is provided in Tables 1 through 6. Table 1 presents summary statistics for all 106 clients. Details can be found in the Rutgers IAC Website and database.

Table 1. Summary of performance for years 2002 -2006.

Oklahoma State University
IAC 5-year performance summary

Year	Clients	ARs	Recommended Savings
All	106	835	$23,937,099
Average per client		7.88	$225,822

First Year – 2002

The first year of the contract produced assessments for 20 different clients. A few of the assessments were two-day assessments. The work produced 151 different recommendations for a total of $9,762,622 in potential estimated annual savings. During this year, both energy and productivity recommendations were written.

While all of the assessments were challenging, one of the most notable assessments was OK650. This assessment was performed at a carbon black plant in Kremlin, Oklahoma. This plant was a large energy user, who used raw materials as an energy source. The result of the client's process was a massive waste heat output. A cogeneration recommendation was written for this client. However, the client was not interested in managing such a massive project. In hindsight, this would have been a great opportunity for an ESCO or other third party.

Table 2. Summary of performance for 2002.

Oklahoma State University
IAC 5-year performance summary

Year	Client	ARs	Recommended Savings
2002	OK633	9	$857,539
	OK634	10	$73,335
	OK635	11	$45,171
	OK636	6	$216,512
	OK637	5	$14,510
	OK638	7	$23,738
	OK639	6	$62,829
	OK640	4	$19,601
	OK641	7	$333,751
	OK642	9	$305,889
	OK643	7	$183,880
	OK644	5	$232,354
	OK645	6	$97,723
	OK646	8	$30,914
	OK647	10	$379,728
	OK648	11	$295,301
	OK649	5	$419,971
	OK650	6	$5,818,423
	OK651	10	$277,865
	OK652	9	$73,588
	Total	151	$9,762,622
	Average	7.55	$488,131

Second Year – 2003

Assessment work in 2003 also included productivity recommendations, in addition to strictly energy reduction recommendations. During 2003, the IAC worked with 23 different clients, producing 190 recommendations at a value of $4,582,834 in potential estimated annual savings. Once again all clients presented challenges.

Table 3. Summary of performance for 2003.

Oklahoma State University
IAC 5-year performance summary

Year	Client	ARs	Recommended Savings
2003	OK653	7	$102,642
	OK654	7	$243,060
	OK655	5	$124,182
	OK656	6	$93,328
	OK657	9	$696,304
	OK658	10	$154,933
	OK659	8	$454,508
	OK660	9	$102,197
	OK661	9	$146,088
	OK662	8	$20,475
	OK663	7	$90,131
	OK664	11	$516,142
	OK665	9	$36,789
	OK666	8	$243,177
	OK667	11	$26,921
	OK668	13	$323,720
	OK669	7	$126,478
	OK670	7	$167,463
	OK671	7	$127,235
	OK672	9	$65,272
	OK673	7	$582,327
	OK674	5	$50,203
	OK675	11	$89,259
	Total	190	$4,582,834
	Average	8.26	$199,254

Third Year -- 2004

The third year of the OSU contract was another challenging year. During 2004, the IAC worked with 24 different clients. The IAC produced a total of 195 recommendations, yielding a potential estimated savings of $5,001,869 on an annual basis. Of all the clients during 2004, one client stood out from the rest. This client located in Vici, Oklahoma was a company started by a Japanese immigrant to produce iodine. The process extracted iodine from water brine in an old oil field. One recommendation included uaing warm water/brine (as extracted from the ground) to power a chiller to cool the incoming brine (into the process), thereby increasing the yield of from the plant. The magnitude of this creative recommendation overwhelmed the client.

The OSU IAC was awarded the Center of Excellence (top center) for 2004. This was an unexpected honor considering the outstanding performance of many centers in the program. To this day, the award is proudly displayed in our trophy case.

Table 4. Summary of performance for 2004.

Oklahoma State University
IAC 5-year performance summary

Year	Client	ARs	Recommended Savings
2004	OK676	7	$103,179
	OK677	8	$43,277
	OK678	10	$48,243
	OK679	8	$101,377
	OK680	9	$148,128
	OK681	5	$415,881
	OK682	13	$37,264
	OK683	7	$67,459
	OK684	8	$68,844
	OK685	7	$349,493
	OK686	9	$111,557
	OK687	6	$18,255
	OK688	8	$32,675
	OK689	7	$8,157
	OK690	6	$124,925
	OK691	7	$370,757
	OK692	11	$820,368
	OK693	9	$631,952
	OK694	6	$1,206,784
	OK695	7	$91,294
	OK696	8	$50,546
	OK697	9	$40,222
	OK698	12	$72,721
	OK699	8	$38,511
	Total	195	$5,001,869
	Average	8.13	$208,411

Fourth Year -- 2005

The fourth year brought additional challenges necessary to maintain performance. At this point in the program, centers were discouraged from working up pure productivity recommendations for clients. A more strict energy savings focus was taken. With this revised focus, a total of 19 clients were served, yielding a total of 156 recommendations with a value of $2,045,980 in potential estimated annual savings. In comparison with the earlier years, dropping the productivity recommendation effort reduced the average savings per client.

About this same time, the IAC began to focus on environmental issues more heavily in its reports. This focus took the form of estimated carbon dioxide savings corresponding to the energy savings. This feature was helpful to our students in training and awareness, but did not seem to make a large impact on our clients.

Table 5. Summary of performance for 2005.

Oklahoma State University
IAC 5-year performance summary

Year	Client	ARs	Recommended Savings
2005	OK700	13	$512,667
	OK701	6	$89,710
	OK702	7	$50,686
	OK703	8	$187,803
	OK704	10	$41,418
	OK705	8	$55,294
	OK706	7	$37,370
	OK707	7	$23,741
	OK708	7	$78,032
	OK709	12	$27,875
	OK710	8	$27,200
	OK711	8	$252,270
	OK712	12	$117,318
	OK713	7	$196,858
	OK714	6	$151,759
	OK715	9	$48,863
	OK716	7	$44,108
	OK717	6	$47,950
	OK718	8	$55,058
	Total	156	$2,045,980
	Average	8.21	$107,683

Fifth Year -- 2006

The fifth year was perhaps the most challenging. The major challenge was the upcoming re-compete and how to deal with what appeared to be (an ultimately were) reduced budgets. The impending reduced budgets created both morale issues in the IAC as well as the beginning of personnel scale-backs in number of students employed as well as time in appointments.

Nevertheless, the fifth year served 20 clients. Performance included 143 recommendations for a value of $2,543,794 in potential estimated annual savings.

Table 6. Summary of performance for 2006.

Oklahoma State University
IAC 5-year performance summary

Year	Client	ARs	Recommended Savings
2006	OK719	7	$74,149
	OK720	6	$39,498
	OK721	6	$26,061
	OK722	9	$28,073
	OK723	9	$86,383
	OK724	11	$103,557
	OK725	5	$78,490
	OK726	11	$149,917
	OK727	8	$163,688
	OK728	7	$134,143
	OK729	5	$19,517
	OK730	7	$40,421
	OK731	7	$119,207
	OK732	8	$54,883
	OK733	7	$17,937
	OK734	7	$73,954
	OK735	5	$122,667
	OK736	6	$718,047
	OK737	5	$181,880
	OK739	7	$311,322
		143	$2,543,794
		7.15	$127,190

Task 2: Promote and increase the adoption of assessment recommendations and employ innovative methods to assist in accomplishing these goals. *Provide a summary of the efforts used to promote the adoption of ARs, including any available overall adoption statistics.*

The OSU IAC constantly struggled (and still struggles) to increase implementation rates. The goal is to get 50% of our recommendations implemented. The actual implementation rate varies a great deal between clients. For example, some clients tend to implement most all recommendations, while others implement virtually no recommendations.

Implementation follow-up calls suggest that a number of factors are responsible, including capital budgets and in-house expertise. However, the most likely factor is the progressiveness of the client and its organization. When the IAC recruits clients it is difficult to distinguish between progressive and non-progressive clients. Even in the closing meetings, it is hard to tell what a client will likely do in its approach to working the final report.

Essentially, the IAC uses two approaches to help implementation (adoption of the recommendations). First, we work as hard as possible to explain to clients what we are likely to recommend. Then, we stress that other clients have gained significant savings from similar recommendations. We attempt to get our student author (a single point of contact between the IAC and the client) to communicate on a regular basis during the report writing phase.

Second, we tend to wait as long as possible for executing the implementation report. We have found that a six-month call is simply too short for getting higher levels of implementation. Some clients must wait about a year in order to get capital or manpower or other resources to address many recommendations.

Task 3: Promote the IAC Program and enhance recruitment efforts for new clients and expanded geographic coverage. *Describe efforts to promote the IAC program and expand the reach of the center.*

Over the course of the contract our IAC planned and executed a number of strategies for recruitment of new clients. Working from recent manufacturing data bases, primarily the Harris Database, we developed mass mailings with our brochure and a letter to potential clients. This method yielded a number of clients, but the numbers were a small proportion of the number of flyers we sent out.

We worked with regional utilities to some degree and gained a few clients from them. This strategy seemed most effective in 2005 and 2006. During these years energy prices were moving up and utilities seemed to pay more attention to our services.

We worked through the Oklahoma MEP organization. Here we worked with Applications Engineers and Manufacturing Extension Agents (MEAs). These are two groups in Oklahoma that compose the bulk of the directed resources for the State of Oklahoma as far as the national MEP resources are concerned. This partnership seemed to work well for us. Here, we provided energy assessment expertise for the MEP folks. They had virtually no interest in energy

assessment as far as their normal services. They used us for energy conservation purpose for their larger clients. In addition to the Oklahoma MEP folks, we worked a limited amount of clients through the Texas MEP organization (TMAC – Northwest Texas Center).

To some degree we relied on cold calls to what we considered good potential clients. This was a hit and miss strategy, but worked well when we could connect with the right person at the potential client's organization. The right person usually turned out to be a financial or maintenance based person.

Perhaps the most gratifying means to gain new clients was through word of mouth from satisfied clients (talking to other potential clients). This along with responses from client attendees at short presentations/workshops helped to boost our morale and yield motivated clients.

Task 4: Provide educational opportunities, training, and other related activities for IAC students. *Summarize education, training and other any other activities for the students. Include overall number of students that participated during the course of the award.*

Training IAC students was a major part of our IAC work during the contract period. We focused on both energy assessment and safety training.

Safety training was both off-site and on-site training. We developed a brief, but highly focused, training document for all center employees as well as course-based students who were required to participate in assessments (from IEM 4923).

Energy related training was focused on classroom (for academic credit) work at both the undergraduate and graduate level. IEM 4923 (Energy and Water Management) was developed to serve both the IAC employed students as well as non-IAC employed students. It was delivered once per year, with enrollments of typically 10 to 20 students. This course was required for IAC student employees, both undergraduate and graduate. Due to offering times, a few undergrads could not schedule the course before they came to work for us in the IAC. This was especially true for younger students, as IEM 4923 was essentially a senior level course (also available for graduate credit). This course was patterned after the AEE CEM (five-day) course. IEM 4923 also required each student to attend at least one on-site assessment and write at least one recommendation for the client report. A hands-on approach was practiced.

Advance level courses were used to train graduate students. Two courses played major roles here: IEM 5923 (Advanced Energy and Water Management) and IEM 5943 (Hazardous Material and Waste). IEM 5943 was offered one time per year, while IEM 5923 was offered every two years. Graduate student participation in these courses helped our IAC to gain additional perspectives in on-site assessment and resulting recommendations.

Numerous hands-on demonstration/training sessions were conducted by directors and graduate students in order to gain proficiency in using our combustion analyzer, IR camera, our logging equipment, our light metering equipment, and other equipment. This instruction included usage and basic maintenance.

Our IAC employed both graduate student as well as undergraduate students. While the undergraduate students worked with the coursework and on-the-job training, our graduate students were expected to do more. A typical MS student was required to complete a 3-hour independent study in some interesting facet of energy management under the supervision of a director. PhD students were expected to complete from three to six hours of independent study work in the energy management field, as well as center their dissertation research in the general area of energy/productivity/quality management. During the project period, two PhDs were completed, with one more near completion.

A list of IAC student employees along with their final degree is provided below:

Zach Babb (BS)
Michelle Biby (BS)
Randy Bowler (BS)
Kaveta Chelliah (BS, MS)
Tommy Coulter (BS)
Robyn Grinsteiner (BS)
Denay Hamm (BS)
Jeremy Lee (BS)
Raymond Lininger (BS)
Scott Makintubee (BS)
Katie McLarty (BS)
Wade Svetgoff (BS)

Tanay Bapat (MS)
Abhijeet Barve (MS)
Vivin Kumar (MS)
CD Nayak (MS)
Kapil Pundir (MS)
Varun Ramanujam (MS)
Burhani Razvi (MS)
Megan Robinson (MS)
Abhijeet Sadhu (MS)
Probir Shah (MS)
Russell Simkins (MS)
Krishna Somayajula (MS)
Arvind Srihari (MS)
Seak Hwa Tan (MS)
Zhiliang Yaw (MS)
JooChing Yong (MS)
Alex Zhukov (MS)

Shankar Earni (PhD)
Scott Frazier (PhD)
Wisit Kumphai (PhD)
Daniel Navaresse (PhD)
Joyce Taylor (PhD)
Julio Vicencio (PhD)
Haiyan Zhao (PhD)

Students who worked in the IAC for one year or more generally found excellent opportunities to interview for energy conservation related jobs. Employers typically called on our IAC directors and students directly, although some were interviewed through normal career center means.

Task 5: Coordinate and integrate Center activities with other Center and IAC Program activities, DOE's Industrial Technologies programs and other EERE programs. *Summarize the integration activities with other centers, the ITP program, state programs, etc.*

The OSU IAC focused on DoE Best Practices tools and resources when possible. Best Practices tools, especially Motor Master were used in assessments and recommendations when possible. The Director attended the Air Challenge series and passed the certification test therein.

One non-IAC contract was executed with the Industries of the Future (forest products) in conjunction with a contract through the OSU Forestry Department. This was an interesting project, similar in nature to an IAC assessment at a cabinet manufacturer in Southeastern Oklahoma.

The OSU IAC worked with the University of Louisiana/Lafayette IAC in conjunction with a visit to their center and discussed how each center approached assessments. This extended show and tell interchange proved to be an interesting and educational experience – additional visits to other centers were anticipated, however, budgeted funds did not permit additional activities.

The OSU IAC coordinated with the IAC at University of Texas Arlington to select clients that were on the border between the two centers. Other interactions with centers to share recommendation expertise were executed by telephone, fax, and e-mail.

Task 6: Other tasks or special projects, as needed, and as determined by DOE to be advantageous to the program and in furtherance of IAC Program goals. *Briefly describe any other special projects or tasks performed for DOE under the award.*

Several minor tasks were completed that served to increase the exposure for the IAC Program and the OSU IAC. These tasks typically included developing short workshops for presentations at regional meetings of trade associations and other similar entities including utilities. Attendance at these events typically varied between 5 and 20 attendees. The typical format was to describe the IAC Program as well as EERE Programs and websites. These presentations were received well and sometimes resulted in additional clients for the IAC.

Other miscellaneous activities included making presentations at conferences and contributions to energy related journals. Typically, IAC resources were lacking to support these activities, and additional resources were added.

The directors and students associated with the IAC at Oklahoma State University would like to express their appreciation to the U.S. DoE for support over the duration of the contract. Our field supervisors and DoE oversight personnel were a pleasure to work with. Thank you for your support.