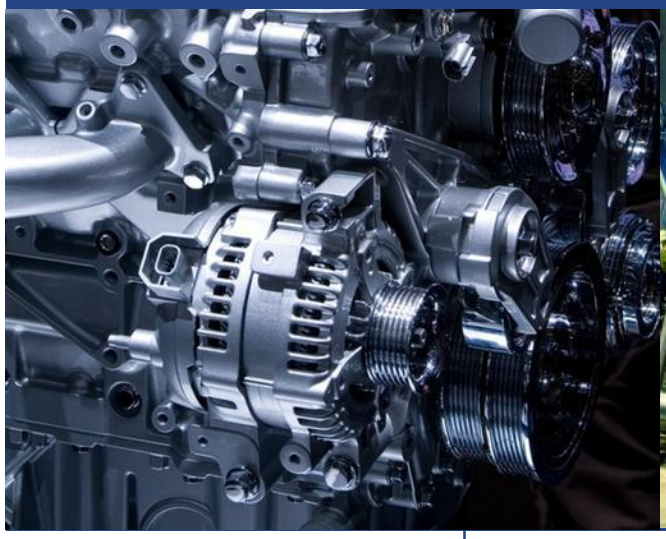
Saving Energy, Building Skills

Industrial Assessment Centers Impact

March 2015



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This report was authored by Roland Stephen, Elizabeth Tennant, Christina Freyman, Jennifer Ozawa, John Chase, and Dan Querejazu at the Center for Science, Technology, and Economic Development at SRI International.

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Notice

This report provides an overview and analysis of the IAC program based on the best professional judgment of the staff at SRI International. The findings and observations contained in this report are those of the authors and do not necessarily reflect the views of any particular interviewee or of the Department of Energy or any other federal agency.

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Executive Summary

The Industrial Assessment Centers program has had a measurable impact on energy saved, carbon avoided, and energy efficiency skills developed

The Department of Energy's Industrial Assessment Centers (IAC) program provides energy efficiency assessments to small- and medium-sized manufacturers across the United States. These comprehensive assessments of an industrial facility's major energy-consuming systems are led by engineering faculty from participating universities, with the extensive involvement of graduate and undergraduate students. As of 2014, the 24 IACs conduct approximately 500 energy audits or industrial assessments each year providing recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy.

The IAC program is an energy conservation and workforce development initiative of the Department of Energy's Office of Advanced Manufacturing, targeting the small to medium-sized manufacturers in the country. The goal of the IAC program is to:

- Increase the energy efficiency, productivity, sustainability, and competitiveness of U.S. manufacturers;
- Provide engineering students and students in related disciplines with applied experiences not available in the classroom;
- Develop the pipeline of energy engineers in the workforce; and
- Keep engineering faculty in contact with technology and challenges in industry

Goals of this Impact Assessment

The U.S. Department of Energy's Office of Advanced Manufacturing (OAM) engaged SRI International's Center for Science, Technology and Economic Development (CSTED) to assess the impacts of the IAC program. In keeping with the energy conservation and workforce development objectives described above, this assessment focused on the following evaluation questions:

- To what extent has the program improved energy efficiency at small- and medium-sized manufacturers?
- What is the program's contribution to training the next generation of engineers with experience in energy efficiency?

The objectives are evaluated by (1) calculating the energy saved by manufacturers from the implemented energy assessment recommendations, (2) calculating the effect on sales and employment of program participation, (3) measuring the impact on IAC alumni skills, and (4) measuring the impact on the energy efficiency workforce.

Evaluation Research Design

SRI's assessment of the IAC program impact on energy savings by manufacturers and IAC student alumni skills is intended to provide evidence of degree of impact. The data available for participant groups (manufacturers and students) varied widely, as does availability of data for potential comparison groups. Table E-1 summarizes the objective, the metrics investigated, the data sources used, and the findings from this study.

While we believe that many of the results of this assessment are generalizable to the participant population, because of our sample sizes and a subset of time periods, **we can report with high confidence only the impacts for participants included in the study.**

SRI built on our primary research activities to explore, in a limited way, the role the IAC program plays in the broader energy efficiency sector. The policy issue underlying the IAC program is the concern that small- and medium-sized manufacturers represent an underserved customer base that collectively consumes a significant amount of energy. We interviewed a deliberate sample of energy services firms to explore questions of overlap in services offered, customer base, and the IAC's role in the broader energy efficiency sector.[1] Since the representatives from energy services firms interviewed included those with experience of both the IAC program and private sector activities, they had a unique and useful perspective on the questions being addressed. The role of the IAC in the broader energy efficiency sector was not an evaluation question, and our findings are suggestive and intended to spur further discussion and research.

The data available on both participant groups (manufacturers and students) varied widely, as does availability of data for potential comparison groups. The investigation attempted to analyze data from the largest time period available; however, different data sources had different limitations and, therefore, different time periods were used. The time periods used are identified in the table below.

Table E-1. Summary table.

Objective	Metric	Data Source	Time Period Investigated	Findings
Increase the energy efficiency of small- and medium-sized manufacturers	Energy efficiency	IAC database SRI survey of IAC clients	FY1997-2013	**An estimated 54 million MMBtu of gross energy saved** **An estimated 6 million metric tons of gross carbon dioxide emissions avoided**
			FY2009-2013	**An estimated 21 million MMBtu of net energy saved**
Increase the productivity	Sales and employment	NETS data	2002-2012	**No evidence of increased sales or employment compared to matched untreated sample**
Develop next generation of engineers with experience in energy efficiency	Energy efficiency skills	SRI survey of IAC alumni	1990 - 2014	**IAC students graduate with specific, applicable energy efficiency skills (no control group)**
		SRI survey IAC alumni IAC student exit survey		**IAC students graduate and take jobs in energy efficiency fields, expanding the pipeline of energy efficiency engineers (no control group)**
		Resumes		**IAC graduates accumulate significantly more energy efficiency skills, with a higher market value, compared to two control groups**

[1] Deliberate sampling is useful for case studies, pilot studies, qualitative research, and hypothesis development, when no general claims are made based on the findings.

Findings

Firm Impacts: Saving Energy and Reducing Carbon Emissions

The IAC database is the primary data source for SRI's estimates of energy savings, because it is based on detailed measurement of all energy-consuming equipment and systems in the entire population of small- and medium-sized manufacturers that participated in the program. The IAC database also contains records of the implementation of IAC recommendations, collected 6-9 months after the energy audit during a follow-up interview. We therefore have a straightforward means of calculating gross energy savings: sum the energy savings estimates associated with all implemented recommendations for the study base years FY1997 to FY2013.

However, three issues arise related to these data: (1) implementation plans may change after the 6-9 month follow-up call; (2) they do not include information about persistence (how long are measures retained and how quickly do they degrade); and (3) they do not indicate what portion of implemented energy savings is attributable to the IAC program. To shed light on these questions, the SRI team designed and implemented a short web-based survey of IAC client firms that received assessments from FY2009 to FY2013. This time period was selected to reduce recall issues – as time passes it is becomes less likely that the key contact would still be at the firm and able to recall implementation of energy efficiency measures accurately.

Gross energy savings

Gross energy savings are the changes in energy consumption that resulted directly from all energy efficiency actions reported as taken by IAC participants (without consideration of whether they can be attributed to the program). **SRI estimates that small- and medium-sized manufacturers' implementation of IAC energy efficiency recommendations yielded gross energy savings of approximately 54 million MMBtu from FY1997 to FY2013**, under the conservative assumption that energy savings persist for one year following implementation. The sensitivity of this estimate to different assumptions about the accuracy of implementation records, as well as a discussion of persistence, can be found in the body of the report.

Gross carbon dioxide emissions avoided

For each energy efficiency recommendation, the IAC database tracks the associated change in energy consumption for different energy streams (i.e., electricity consumption, natural gas, different fuel oils, coal, etc.). Using implementation records from the IAC database, SRI multiplied the gross energy savings for each energy stream by the corresponding U.S. Energy Information Agency carbon coefficient to get our baseline estimate of overall carbon dioxide emissions avoided. **SRI estimates that implementation of IAC energy efficiency recommendations resulted in approximately 6 million metric tons of carbon dioxide emissions from small- and medium-sized manufacturers being avoided from FY1997 to FY2013.** Once again, these estimates are based on the conservative assumption that savings persist for only one year following implementation.[2]

Net energy savings

Net energy savings attempts to separate out impacts that are the result of other influences, e.g., energy efficiency measures that were under consideration even before the manufacturer received an IAC energy audit. Therefore, net energy savings is the portion of gross energy savings that is attributable to the IAC program.

The IAC database records include only information about gross, not net energy savings. Our evidence for what percentage of gross savings recorded in the database is in fact additional or attributable to the IAC program therefore relies on the SRI survey of IAC client firms who received assessments from FY2009 to FY2013. **Given the low survey response rate (26%) and potential for complex response bias, we urge caution in interpreting the net energy savings estimates presented here.** From the survey results, the team sought to estimate net energy savings for this sub-group of the IAC client population. To

[2] We use U.S. average emission coefficients for electricity generation (http://www.eia.gov/electricity/state/unitedstates/) and fuels (http://www.eia.gov/environment/emissions/co2_vol_mass.cfm).

do so, the energy savings associated with any energy efficiency measures implemented were removed if:

- The implementing firm indicated that they would have pursued energy audits from another provider in the absence of the IAC program (31% of responding firms), and/or
- The firm had plans in place to implement the energy efficiency measure prior to the IAC assessment (26% of energy efficiency measures) or did not know if plans were already in place (6%).

Savings from energy efficiency measures were included if survey respondents indicated they had no plans to implement prior to the IAC assessment (30%). If the respondent indicated that the energy efficiency measure was under consideration, but no definite plans or budget were in place to implement the measure (38% of energy efficiency measures), we calculated estimates based on a range of assumptions.

Based on these results, we were able to estimate the approximate net savings for the survey population. To calculate a reasonable range of net energy savings for the larger FY1997 to FY2013 IAC client population, we first calculate the ratio of net savings to IAC database gross energy savings estimated for the survey population. We then apply that net-to-gross ratio to the gross energy estimates for the full IAC database population, under a range of assumptions. **SRI estimates that small- and medium-sized manufacturers' implementation of IAC energy efficiency recommendations resulted in approximately 21 million MMBtu of net energy savings from FY1997 to FY2013.**[3]

Sales and employment

A final firm-level impact assessed by SRI was to what extent the savings that resulted from the energy efficiency recommendations adopted by IAC participants are associated with changes in sales and employment. SRI estimated changes in sales and employment of both IAC client firms and a comparison group of small- and medium-sized manufacturers. Panel data on establishment-level sales and employment for IAC and non-IAC manufacturing firms were drawn from the National Establishment Time-Series (NETS) Database and analyzed using establishment fixed effects. **SRI did not find evidence of increased sales or employment that can be reasonably attributed to the IAC assessments received by firms.** No statistically significant correlation is observed between IAC assessments and growth in establishment-level sales or employment.

Table E-2. Estimates for total energy savings and carbon avoided assuming energy savings from implemented recommendations persist for one year, FY1997-2013 (see body of report for a complete set of range estimates).

Metric	Total FY1997-2013	Source
Gross Energy Savings	**54 million MMBtu**	IAC database
Gross CO_2 Avoided	**6 million metric tons**	IAC database
Net Energy Savings	**21 million MMBtu**	IAC database SRI survey of IAC clients[4]

Workforce Impacts: Developing a Pipeline of Energy Efficiency Engineers

SRI's analysis of IAC program impact on the development of future energy efficiency engineers used a mixed-methods approach to answering key questions: qualitative data from interviews with current IAC program directors and at least one lead student from each current center, a survey of IAC alumni, the exit survey that many IAC students have taken since 2000, and SRI's novel text analytics-based approach to comparing IAC alumni

[3] This estimate is based on net-to-gross ratios that assume 50% of partially implemented measures and 50% of measures considered (but not planned for) pre-assessment can be counted towards net savings. A range of estimates based on different assumptions is provided in the Firm Impacts section of the full report.

[4] The net energy savings estimate is calculated by applying net-to-gross ratios derived from the IAC client survey to gross energy savings estimates from the IAC database. This estimate is based on net-to-gross ratios that assume 50% of partially implemented measures and 50% of measures considered (but not planned for) pre-assessment can be counted towards net savings. A range of estimates based on different assumptions is provided in the Firm Impacts section of the full report.

resumes with two comparison groups. These analyses yield evidence of four major impacts of the program:

IAC students graduate with specific, applicable energy efficiency skills.

Figure E-1 below presents survey responses of IAC alumni about specific skills they gained from participation in the IAC program. 100% of respondents chose at least one skill.

IAC students graduate and take jobs in energy efficiency fields, expanding the pipeline of energy efficiency engineers.

The IAC program appears to be training the next generation of energy efficiency engineers. Fifty-three percent of alumni surveyed had a first job related to energy efficiency. Many IAC students probably would have gone into energy efficiency careers due to preexisting interests even if they had not participated in the program: 60% of alumni said they got involved with the IAC because they were interested in energy efficiency issues. Other students became involved with the IAC for reasons unrelated to energy efficiency: 25% indicated that they became involved because it was an interesting opportunity, but not central to their future career plans. **70% of those students who became involved with the IAC center for non-energy reasons said their experience made them more interested in energy efficiency careers.** Furthermore, **about 40% of the respondents that were not interested in energy efficiency coming into the IAC program went on to have careers in the energy sector.**[5]

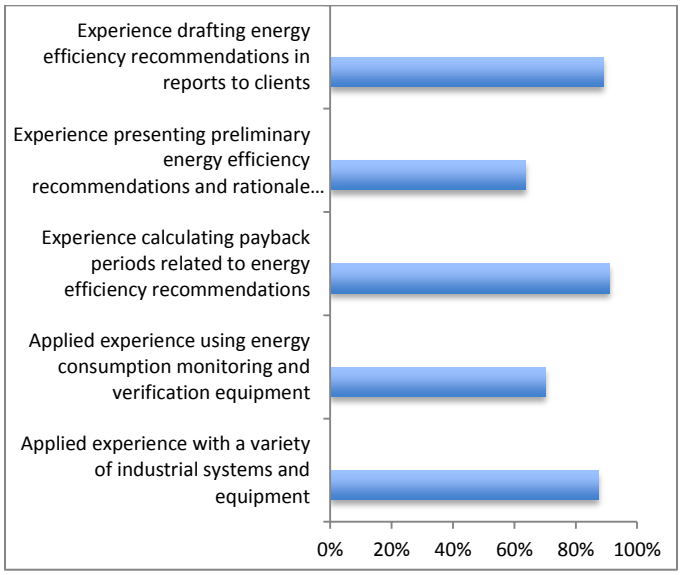


Figure E-1. Percent of IAC alumni respondents who indicated each skill was gained through the IAC experience. Respondents could choose any or none. N = 109 ***Source: IAC alumni survey.***

IAC students graduate with skills that are more highly valued in the job market than students with comparable degrees.[6]

Table E-3 presents SRI's findings from our text-analytics based resume' analysis. In addition to the IAC participants, two comparison groups were developed. The "energy" comparison group is comprised of energy professionals identified based on job titles and matched to the total time in workforce characteristics of the IAC participant sample. The "cohort" comparison group was selected based on: university, degree, major and graduation date +/- 2 years. **Our findings indicate that IAC graduates accumulate more energy efficiency skills, with a higher market value, than either of the two comparison groups** (see Appendix A, page A12, for a the statistical significance of these findings)**.**

SRI also analyzed career paths, in order to assess IAC alumni participation vis-à-vis that of other energy professionals in the energy efficiency workforce over time. **IAC graduates enter the energy efficiency workforce sooner than the "energy" comparison group, and stay in the energy efficiency workforce longer than the comparison group.**

Table E-3: Graduates with Valuable Energy Efficiency Skills

	IAC Participants	"Energy" Comparison	"Cohort" Comparison
Number of energy efficiency skills per resume	8.9	5.5	4.3
Value of energy efficiency skills associated with each resume	$72,964	$66,754	$69,947

[5] No control group of peers was surveyed regarding their experience and subsequent employment, which limits the value of these findings.

[6] As measured by a recently developed skills valuation methodology developed by the Brookings Institution

Table E-4: Graduates Taking Jobs in Energy Efficiency

Group	Time of Entry into first EE Job (days from entry into workforce)	Portion of total career spent in EE
IAC Participants	856 days	42%
"Energy" Comparison	1634 days	28%

Exploratory: The Role of the IAC Program in the Energy Efficiency Sector

The IAC program targets small- and medium-sized manufacturers, because these companies are believed to lack the information, the resources, or a combination of the two, to seek out and purchase industrial energy audits from the private sector. As a result, these companies miss the opportunity to identify and adopt energy efficient practices and technologies that could contribute to their bottom line. While small- and medium-sized manufacturers account for a smaller share of energy consumption compared to large industrial firms, in the aggregate they represent half of the total energy consumed in the industrial sector. The existence of these barriers to the adoption of energy efficiency measures by these manufacturers, even though they consume a significant amount of energy, underlies the rationale for the IAC program.

This assessment includes a limited, exploratory analysis of the specific role the IAC program plays in meeting this need, and the relationship of this program to the work of other Energy Service Companies (ESCOs) and programs. The analysis is based on in-depth interviews with seven ESCOs, and survey answers from a sample of IAC client firms. While these findings are exploratory and subject to possible selection bias, they suggest the following:

- Small industrial clients are a limited market for ESCOs.
- The IAC program provides services to small industrial clients who would not otherwise seek out such services.
- The IAC program provides services that are complementary to other energy services.
- The IAC program provides ESCOs with a high quality pool of recruits.

Overview: Industrial Assessment Center Program

Background

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Industrial Assessment Center (IAC) program provides energy efficiency assessments to small- and medium-sized manufacturers performed by faculty and students and engineering and technology schools across the U.S. These assessments are in-depth evaluations of an industrial facility's major energy-consuming systems led by engineering faculty from participating universities, with extensive involvement of graduate and undergraduate students.

The IAC program has been funded by the federal government since 1976, when it was called the Energy Analysis and Diagnostic Center program at the Department of Commerce. The program is now administered through the Office of Advanced Manufacturing (OAM) in EERE. A field manager at the Center for Advanced Energy Systems at Rutgers, The State University of New Jersey, manages the program**.** The field manager contract is a competitively awarded 5-year contract. The Field Manager provides coordination and technical facilitation of all centers participating in the IAC Program, including monitoring the technical performance of each center, coordinating center activities, improving center performance and providing feedback to the centers and the DOE Project Officer. The Field Manager is also responsible for providing technical training and support to existing and new centers as needed.

The IAC program awards five-year grants through a competitive process to institutions of higher education with an accredited engineering or technology program. The number of institutions supported by the program fluctuates as a function of available funding and program management priorities. The program started small in 1976 and has supported as many as 30 centers in the past. The most current funding period started in fiscal year (FY) 2012 – 24 centers were funded out of more than 70 applications. (The 24 university-based IAC programs are shown in Figure 1, which illustrates the general geographic placement of the IACs.) In each funding period, some incumbent institutions are awarded grants while others are not, and new institutions are awarded grants. In 2012, four centers were new centers while the remainder had been funded since at least the previous cycle. Figure 2 displays the distribution of centers as a function of the number of years they have provided assessments. While many centers were established over the last two funding cycles, others have been around for two or more decades.

Figure 1. Participating universities with IACs for the period 2012 to 2016. ***Source: http://iac.rutgers.edu***

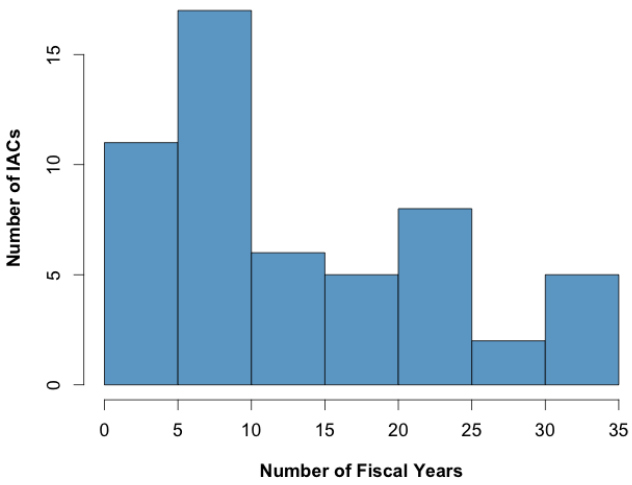


Figure 2. Years different IACs have been supported by the program FY1981 to 2013. ***Source: IAC database.***

Though the field manager provides training and report oversight, each center implements its own set of activities to meet the goals of the program. Roughly 17,000 assessments have been conducted since the program began. As of 2014, the 24 DOE-supported IACs across the country conduct approximately 500 energy assessments of industrial facilities each year.

The IAC program's objectives have been modified through the life of the program; however, the following objectives generally encompass the overall goals of the program through time:[7]

- Increase the energy efficiency, productivity, sustainability, and competitiveness of U.S. manufacturers;
- Provide engineering students and students in related disciplines with applied experiences not available in the classroom;
- Develop the pipeline of energy efficiency engineers in the workforce; and
- Keep engineering faculty in contact with technology and challenges in industry

Firms eligible for assessment must meet the following criteria:

- Fall within Standard Industrial Codes (SIC) 20-39
- Be located less than 150 miles from a participating university
- Have gross annual sales below $100 million
- Have fewer than 500 employees at the plant site
- Have annual energy bills of more than $100,000 and less than $2.5 million
- Have no professional in-house staff to perform the assessment

Major Activities of the IAC Program

Conducting Assessments

IAC assessments are conducted in the same way, with minor variations, by all the centers. They begin with a baseline assessment of the facility, informed by a standard pre-assessment form returned by the client. This form includes size of plant and plant layout, industry type (classified by Standard Industrial Classification (SIC) or North American Industry Classification System (NAICS) code) and process description, production levels, units and dollars, operating hours, a one year history of utility bills, and a list of major energy consuming equipment.

A 12-month analysis of a facility's utility bills (some centers try to obtain 24 months where possible) is critical to a manufacturer's participation. However, firms view this information as very sensitive and are reluctant to share more than is required by DOE for participation in the program.[8] The team also analyzes the manufacturing process, design, and other documentation. This activity informs the strategy for the next step, the visit to the plant.

The subsequent visit to the facility by the IAC team begins with a brief meeting and tour of the plant, during which the IAC team becomes acquainted with the facility, equipment, and priorities of firm management. During this tour, the IAC team is identifying potential recommendations for savings. Recommendations range from replacing light fixtures and tuning air compressors to installing new, more energy efficient pumps or furnaces.

[7] IAC Funding Opportunity Description. Funding Opportunity Announcement. DE-FOA-0000490. 2011.

[8] An unknown, but significant, number of manufacturers did not end up receiving assessments because they did not want to give the IAC center these data.

The IAC team then proceeds with the systematic measurement of individual components of the energy systems in the plant. Some IAC directors have developed their own tools and loggers, which they employ during the visit. Some obtain permission to leave their tools in place for a week in order to obtain a longer-term measurement of the energy used. These measurements from the field are used to calculate energy used based on mathematical models developed by university faculty. Some teams share potential recommendations with the client on the day of the visit and some take the opportunity to gauge their interest in particular recommendations the team may suggest.

The measurements taken and the estimates of energy consumed by individual pieces of equipment are the baseline for estimating the impact of the implementation of a particular improvement. That impact and those savings are compared to the cost of the improvement, which is estimated through a variety of means such as by asking the client, by applying previous knowledge of similar installations elsewhere, or researching third-party sources that provide the specifications and costs of new equipment.

The resulting industrial assessment includes a list of efficiency measures with estimated costs, estimated energy savings, and a return on investment (ROI). Once the report is delivered to the client, the center follows up with a phone call within two weeks (in practice usually right away so that the findings are still fresh in the minds of the recipients). The client is invited to ask questions and seek clarification if necessary. Centers then contact each participating manufacturer 6-9 months later to find out which of the recommendations have been implemented. The follow-up is the only formal contact required by the program, and this self-report by clients of the measures implemented, planned to be implemented, or in the process of being implemented is the only systematic information the program has about the degree to which program recommendations are implemented.

The results of assessments, the number and character of recommendations, the potential energy savings they represent, and the number of recommendations actually adopted by clients are reported and compiled by the technical Field Manager at the Center for Advanced Energy Systems at Rutgers University. These data are reviewed and aggregated, yielding a complete and consistent record of the activities of the IACs.

FY1997-2013 Industry Analysis by SICs

Participating manufacturers are spread all over the country, as shown in Figure 2 below.[9]

From fiscal years 1997 to 2013 ninety-eight percent of IAC assessments clients were in industries categorized as manufacturing according to the Standard Industry Classification System (SIC codes 20-39, as reported in the IAC database). The number of assessments received by firms in different manufacturing industries from FY1997 to 2013, by major SIC group, are listed in Table 1. The industries that received the most assessments include: Fabricated Metal Products, Except Machinery & Transport Equipment (SIC 34); Food and Kindred Products (SIC 20); and Rubber and Miscellaneous Plastic Products (SIC 30). The non-manufacturing industries that received the most assessments from FY1997 to 2013 assessments included Wholesale Trade (SIC 50-51); Electric, Gas, and Sanitary Services (SIC 49); and Mining and Quarrying of Nonmetallic Minerals, Except Fuels (SIC 14). The specific SIC industry groups that account for the most total implemented energy savings over the fiscal years 1997 to 2013 period are presented in Table 2. Note that there is high variation in the energy savings per implemented recommendation across these industries.

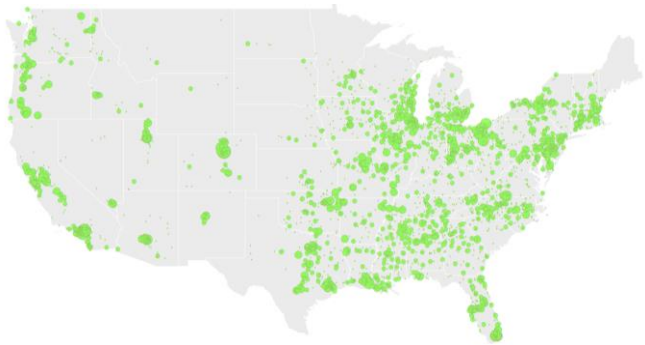


Figure 2. Geographical location of manufacturers who participated in the IAC program between FY2002 and FY2013. Each green dot represents a client. *Source: IAC database.*

[9] Zip codes were only available for manufacturers served by IACs since 2002

Table 1. Number of IAC assessments by SIC Major Group, FY1997-2013. *Source: IAC database.*

SIC Code	SIC Major Group	Number of Assessments
34	Fabricated Metal Products, Except Machinery and Transportation Equipment	1170
20	Food and Kindred Products	1092
30	Rubber and Miscellaneous Plastics Products	1023
35	Industrial and Commercial Machinery and Computer Equipment	900
33	Primary Metal Industries	668
28	Chemicals and Allied Products	534
37	Transportation Equipment	529
26	Paper and Allied Products	514
24	Lumber and Wood Products, Except Furniture	490
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment	469
32	Stone, Clay, Glass, and Concrete Products	369
27	Printing, Publishing, and Allied Industries	337
25	Furniture And Fixtures	236
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks	225
22	Textile Mill Products	216
39	Miscellaneous Manufacturing Industries	152
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials	102
29	Petroleum Refining and Related Industries	102
31	Leather and Leather Products	37
21	Tobacco Products	9

Table 2. Estimated gross energy savings implemented by SIC Industry Group, FY1997-2013. *Source: IAC database.*

SIC Code	SIC Industry Group	Gross Energy Savings (MMBtu)	# of Recs Imple-mented	Gross Energy Savings (MMBtu) per Rec
3295	Minerals and Earths, Ground or Otherwise Treated	2,148,708	177	12,140
3089	Plastics Products, Not Elsewhere Classified (NEC)	1,952,527	4,398	444
2819	Industrial Inorganic Chemicals, NEC	1,808,900	467	3,873
2621	Paper Mills	1,638,344	456	3,593
3714	Motor Vehicle Parts and Accessories	1,335,985	1,682	794
2911	Petroleum Refining	1,105,560	95	11,637
2421	Sawmills and Planing Mills, General	892,851	936	954
2436	Softwood Veneer and Plywood	851,077	166	5,127
2895	Carbon Black	718,804	26	27,646
3679	Electronic Components, NEC	714,472	486	1,470

Trends in Recommendations

Using the IAC database, we are able to investigate and identify implementation patterns for different kinds of firms and recommendations. Note that all results in this section are based on the IAC database energy savings estimates and implementation records, which as we discuss in detail later in the report, provide an imperfect but best available picture of long-term implementation.

The relationship between firm size (defined as employment) and implementation patterns is somewhat nuanced: larger firms do not have significantly higher implementation rates, in terms of energy savings or percentage of recommendations. However, more savings are typically recommended to larger firms and thus, on average, larger firms do implement more energy savings per assessment than smaller firms.

All recommendations entered into the IAC database are categorized according to a detailed, multi-level taxonomy. From this, we are able to identify what categories of recommendations are most frequently recommended and implemented. In Table 3 we present the frequency of recommendations implemented, as well as the rate of implementation for each of the high-level Energy Management recommendation categories.

On average, the IAC recommendations related to energy management that are implemented by firms represent less energy savings (in MMBtu per recommendation) than those that are not implemented: average savings per implemented recommendation is 1,830 MMBtu, compared to 2,520 MMBtu for all recommendations (FY1997-2013). However, there is high variation in the size of recommendations (in terms of energy savings) implemented and of those not implemented. For some categories of recommendation, measures implemented are in fact above average in size while in others (i.e., alternative energy and electrical power) recommendations are typically very large, but rarely implemented.

Table 4 provides a picture of these trends for different categories of Energy Management recommendation and Table 5 presents the specific recommendations that account for the highest levels of implemented gross energy savings.

Table 3. Number of energy management strategies recommended and implemented by IACs, FY1997-2013. ***Source: IAC database.***

	Number Implemented	Number Recommended	Percentage Implemented
Motor Systems	11,493	21,730	53%
Building and Grounds	8,934	20,373	44%
Thermal Systems	3,398	9,241	37%
Operations (Energy)	1,435	2,858	50%
Combustion Systems	1,373	3,407	40%
Electrical Power	824	2,754	30%
Ancillary Costs	713	1,503	47%
Industrial Design	76	245	31%
Alternative Energy Usage	6	98	6%
TOTAL Energy Management	**28,252**	**62,209**	**45%**

Table 4. Gross energy savings implemented and recommended by IAC energy management strategy, FY1997-2013 ***Source: IAC database.***

	MMBtu Implemented	MMBtu Recommended	% of MMBtu Implemented
Motor Systems	14,849,030	30,585,538	49%
Thermal Systems	13,933,347	50,019,508	28%
Building and Grounds	11,127,143	25,896,794	43%
Combustion Systems	6,613,927	21,580,334	31%
Operations (Energy)	2,711,794	5,135,880	53%
Industrial Design	1,256,549	2,302,060	55%
Electrical Power	1,175,553	18,343,662	6%
Ancillary Costs	28,129	874,766	3%
Alternative Energy Usage	2,630	2,028,495	0.1%
TOTAL Energy Management	**51,698,101**	**156,767,038**	**33%**

Table 5. IAC recommendations that account for the highest total gross energy savings, FY1997-2013. ***Source: IAC database.***

Recommendation	MMBtu Imple-mented
Eliminate leaks in inert gas and compressed air lines/ valves	5,096,268
Utilize higher efficiency lamps and/or ballasts	4,014,978
Repair and eliminate steam leaks	2,161,737
Repair or replace steam traps	1,794,371
Insulate bare equipment	1,509,961
Use most efficient type of electric motors	1,487,331
Use more efficient light source	1,414,154
Turn off equipment when not in use	1,326,671
Analyze flue gas for proper air/fuel ratio	1,148,444
Use multiple speed motors or afd for variable pump, blower and compressor loads	1,145,792
Redesign process	1,029,003
Reduce the pressure of compressed air to the minimum required	1,021,711
Preheat boiler makeup water with waste process heat	943,221
Implement a regular maintenance program to reduce emissions from leaky valves and pipe fittings	711,311
Establish burner maintenance schedule for boilers	679,521
Use optimum size and capacity equipment	652,617
Repair leaks in lines and valves	636,887
Utilize energy-efficient belts and other improved mechanisms	631,509
Adjust burners for efficient operation	605,220
Eliminate or reduce compressed air used for cooling, agitating liquids, moving product, or drying	595,038

Students

A second major focus of the IAC program is to educate and train engineering students in assessing industrial energy efficiency practices and performance. Students usually come to participate in the program in one of these ways: (1) apply to participate in the program or (2) take a course in which they participate in assessments as part of an academic program. Students are key contributors to IAC energy assessments and IAC center operations. They participate fully in site visits, analyze plant-level data, and generate recommendations and reports, although the IAC director has ultimate responsibility for the overall quality

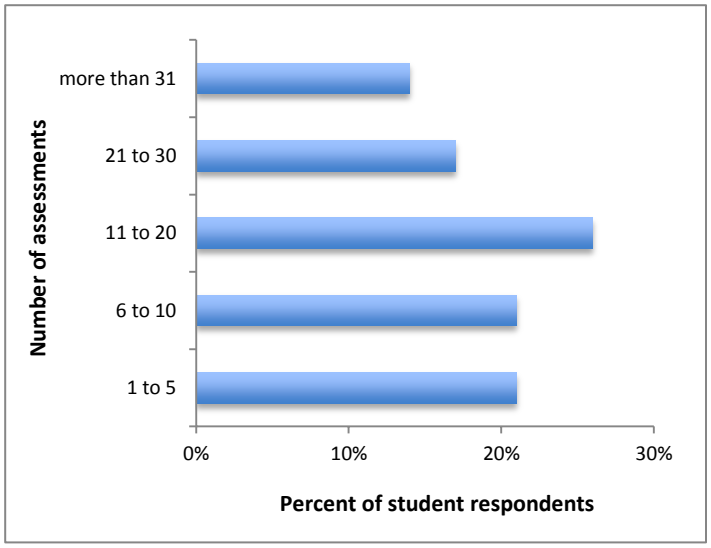


Figure 3. Number of assessments IAC students participated. ***Source: IAC student exit survey. N=806 students participating from 1990-2014.***

of each assessment. While assessment methods are relatively consistent among centers, specific activities used to train students vary widely. These activities include:

- Formalized training (such as workshops)
- Academic courses
- Student-to-student knowledge transfer
- "On the assessment" training

All centers use a mix of these methods. Some centers rely heavily on students enrolled in an academic course. In this model the enrolled students do a few assessments each and are "supervised" by graduate students supported by the IAC center. Other centers rely on a few students who are employed by the center and participate in many assessments. Yet other centers use a mixture of approaches. This heterogeneity of approaches is reflected in Figure 3, which displays an even spread of the number of assessments per student: 21% of student respondents on the student exit survey participating in less than 5 assessments and 14% participating in more than 31 assessments. Both undergraduates and graduate students participate in the program. According to the IAC student exit survey, more than half of the students were pursuing a bachelor's degree while participating in the program. Most of the remaining students were pursuing a master's degree and a small percentage (~5%) was pursuing a

doctoral degree. More than half of the participating students were pursuing a mechanical engineering degree (66%) while 16% were pursuing an industrial engineering degree. The remaining respondents were pursuing a variety of engineering degrees including electrical engineering, engineering management, and civil engineering degrees.

Key Goals of this Impact Assessment

The U.S. Department of Energy's Office of Advanced Manufacturing (OAM) engaged SRI International's Center for Science, Technology, and Economic Development (CSTED) to assess the impacts of the IAC program as a whole. In keeping with the two main objectives described above, this assessment focused on the following objectives with key sub questions:

1. To what extent has the program affected energy efficiency at small- and medium-sized manufacturers?
   a. Has the IAC program served its target population?
   b. To what extent has the IAC program and the recommendations produced resulted in actual energy savings by the target population?
   c. To what extent has the energy saved by IAC participants resulted in changes in sales and employment?

2. What is the program's contribution to training the next generation of engineers with experience in energy efficiency?
   a. To what extent has the IAC program increased the number of energy efficiency-related skills in engineering graduates?
   b. To what extent has the IAC program induced an increase in the number of engineering graduates going into energy efficiency
   c. What has been the impact of the program on energy services firms and their workforce needs?

The objectives are evaluated by (1) calculating the energy saved by manufacturers from the implemented energy assessment recommendations, (2) calculating the effect on sales and employment of program participation, (3) measuring the impact on IAC alumni skills, and (4) measuring the impact on the energy efficiency services. This evaluation took place been July 2014 and November 2014.

Organization of the Report

The rest of this report is organized as follows:

- The next chapter outlines data sources and the different methodological approaches necessary to complete this complex evaluation.
- The following two chapters represent the heart of the report, outlining the methods employed to assess energy and workforce impacts, together with the findings.
- The next chapter sketches the larger market environment within which the IAC program operates, and highlights its contributions to various aspects of energy efficiency services.
- The conclusion provides a brief review of the findings, and identifies some areas of the program suitable for additional focus.
- The appendices provide more detail on methodology (research design, sampling, and other data collection), a literature review on good practices for the evaluation of energy efficiency programs, and survey instruments with frequency tables.

Assessment Methodology and Descriptive Results

This section provides an overview of the evaluation plan used to assess the IAC program impacts. Please see Appendix A for a detailed description of the approach and methods used.

Evaluation Research Design

To assess the impacts of the IAC program, SRI employed a mixed-methods approach that included interviews, surveys, and quantitative approaches.[10] The assessment focused on impacts realized by the manufacturers and the IAC student alumni. Where possible, these impacts were compared to a counterfactual – what would have occurred without the IAC program? In addition, as an exploratory task, SRI investigated the impacts on energy services firms. The data available on both participant groups (manufacturers as defined above and students) varied widely, as does the availability of data for potential comparison groups. Table 6 summarizes the groups investigated in this study. The investigation attempted to analyze data from the largest time period available; however, different data sources had different limitations and, therefore, different time periods. These are highlighted in the paragraph and tables below.

Where data availability allowed, SRI estimated the differences between a group that participated and a group that did not participate.[11] As displayed in the table, SRI employed this approach for student skills and manufacturer sales and employment analyses since comparison groups could be constructed from available data.

Some participants could not be evaluated using a comparison group approach.[12] However, pre-participation and post-participation data on energy usage were available; these data were used to estimate the effect of the IAC on implemented energy efficiency measures.[13] To estimate what would happen without the IAC program, a retrospective post-participation measurement was used to investigate if participants would have received similar services from other sources.

While all other approaches used random sampling of the participant population in an effort to obtain impact data, because of resource constraints SRI only investigated in a limited way the impact of IACs on the energy services sector. SRI employed a non-experimental approach with a deliberate sample of energy services firms. While this

[10] A mixed-method design is defined as including at least one quantitative method and one qualitative method. Greene, J.C., V.J. Caracelli, and W.F. Graham, *Toward a Conceptual Framework for Mixed-Method Evaluation Designs.* Educational Evaluation and Policy Analysis, 1989. **11**(3): ppp. 255-274.

[11] Also known as a comparison group quasi-experimental approach.

[12] A comparison group for energy use in comparable manufacturers does not exist because non-participating companies will not release their energy usage data to researchers.

[13] This method is also known as a quasi-experimental single group approach with a counterfactual.

Table 6. Groups investigated in this study.

Participant Group	Metric	Counterfactual Method	Data Source	Date Range Available	Date Range Used	Notes on Use
Manufacturers	Energy efficiency	Quasi-experimental single group (pre-test, post-test)	IAC database	FY1981-2013	FY1997-2013	A major change occurred in 1996 in how data were collected.
			Survey of clients	FY2002-2013	FY2009-2013	To minimize measurement error due to recall and non-response due to changes in staff
	Sales and employment	Quasi-experimental comparison group (pre-test, post-test)	NETS data	2002-2013	2002-2013	Addresses for clients only available from 2002 on
Students	Energy efficiency skills	Quasi-experimental comparison group (post-test only)	Resumes	1990-2014	1990-2014	All available universe

approach provides context for the program, the specific analysis is less rigorous than the quasi-experimental approaches used for other pieces of the study and possibly subject to selection bias.

Each of these methods has its limitations. The pre-participation and post-participation evaluation design allows for specific outcomes to be attributed to the program; however, selection bias has the potential to bias the impacts in a positive direction. Manufacturer participants may have been predisposed to increasing their energy efficiency and so may have implemented more recommendations than a randomly selected participant may have. In addition, these self-selected manufacturers may have achieved similar results by receiving services from other programs if the IAC program had not existed, or they may have implemented energy efficiency improvements without any outside intervention when compared to a randomly selected non-participant.

For student outcomes, there is only post-participation data, so one cannot know if pre-participation differences caused the observed impacts. Selection bias is a concern because students who enter the program are probably more likely to be interested in energy efficiency careers. The use of a comparison group match on specific characteristics (including proxies for interest in energy efficiency) mitigates but cannot wholly remove predispositions that may bias the outcomes. The analysis cannot conclude that all measured outcomes in students are solely attributed to the IAC program. However, the survey of participants can gather data to suggest attribution of impacts to the program as self-reported by participants.

These methods were implemented following an overarching project plan, but were applied and managed by different task leaders to mitigate any bias that specific individuals may have had. While the qualitative tasks were iterative (the interviews informed the survey instruments), the quantitative tasks focusing on the analysis of energy data and analysis of student resumes were done independently of the qualitative tasks. This "triangulation" approach employs multiple sources of data, observations, and analytical methods to investigate if the program achieved impacts related to its overall objectives. The goal

of triangulation is to strengthen the validity of the overall findings through congruence and/or complementarity of the results from each method. The essence of triangulation logic is that the methods represent independent assessments of the same phenomena and benefit from offsetting sources of bias and measurement error.[14] Each method alone (survey versus interviews versus resumes) may possess design issues that affect the validity of its findings (see Table 7); however, results from all methods combined may produce enough evidence to produce a strong judgment regarding a program's impacts.[15] A matrix of all sources of data used in this study and their support is displayed in Appendix D.

While we believe that many of the results of this assessment are generalizable to the participant population because of our sample sizes and a subset of time periods, **we can report with high confidence only the impacts for participants included in the study.**

Data Sources

IAC database. The IAC program has a carefully managed data set that contains detailed information about those firms and facilities that have received assessments from currently and previously funded IACs. As of September 2014 the database included over 16,000 records of assessments performed by the IAC program between 1981 and 2014, and detailed information about the over 124,000 recommendations made as a part of these assessments. Because the IAC directors and students follow up with participating firms, this database has nearly 100% coverage. Energy usage information is gathered before participation and then after participation, so the evaluation involving these data can be considered a pre-test, post-test evaluation single group quasi-experimental design.[16] In this report, energy calculations were done for clients served from FY1997 to 2013 due to data quality issues with pre-1997 data related to how electricity usage was reported. The sales and employment analysis includes firms that received assessments from FY2002, when the IAC began maintaining identifying information for clients, to FY2011, the last year in which impacts could credibly be captured in the NETS database (description below).

Manufacturer survey. To augment the data contained in the IAC database, a random sample of 710 clients was drawn from the pool of the 2,158 manufacturers that participated from FY2009 to FY2013. This date range was chosen to minimize measurement error related to recall error, which increases with time.

NETS database. The National Establishment Time-Series (NETS) database provides longitudinal data from January 1990 to January 2012 on various dynamics of the U.S. economy.[17] Because sales and employment data are gathered for the time period before participation and the time period after participation *and* a comparison group was employed, the evaluation involving these data can be considered a pre-test, post-test evaluation comparison group quasi-experimental design. The IAC database only included address information for manufacturers that participated in 2002 or after; therefore, the analysis using the NETS database was limited to the 2002 – 2012 time period.

IAC alumni database and student exit survey. The alumni database is maintained by a program manager at Oak Ridge National Laboratory. All IAC students are supposed to sign up with the database and take an exit survey. The database included an uneven distribution of alumni based on participation year, with much heavier representation from alumni who graduated after 2000 when the database was started. Recently, alumni could request an IAC certificate by joining the database and filling out the survey. Therefore, only a small fraction of the alumni in

[14] Greene, J. and C. McClintock, *Triangulation in Evaluation: Design and Analysis Issues.* Evaluation Review, 1985. **9**(5): p. 523-545. Hammersley, Martyn (2008). Troubles with triangulation. In: Bergman, Manfred Max ed. *Advances in Mixed Methods Research*. London: Sage, pp. 22-36.
Wolf, F., *Enlightened Eclecticism or Hazardous Hotchpotch? Mixed Methods and Triangulation Strategies in Comparative Public Policy Research.* Journal of Mixed Methods Research, 2010. **4**(2): p. 144-167.

[15] Lockheed Martin Energy Services Energy Solutions Group. Impact Evaluation of the U.S. Department of Energy's Solar Decathlon Program. Dec 2012. http://www1.eere.energy.gov/analysis/pdfs/solar_decathlon_impact_report2012.pdf

[16] *Designing Evaluations*, U.S.G.A. Office, Editor 2012, U.S. Government Accountability Office: Washington, DC

[17] While NETS data are available from 1990, our period of analysis begins in 2002, when the IAC began collecting identifying information for client firms.

Table 7. Threats to pre-test/post-test single group design.

Research Design & Measurement Issues	Manufacturers (how addressed issues)	Participating Students (how addressed issues)
Research Design Issues:		
Rival Influences		
Self-selection	Measurement of counterfactual through survey of participants to assess what they would have done in absence of the intervention.	Comparison to matched-group comparison group. Multiple sources were used to develop a judgment of success.
Exposure to external influences	Respondents received services at different points in time, reducing the likelihood that a particular event affected everyone in a non-random way.	Comparison to matched-group comparison group. Respondents received services at different points in time, reducing the likelihood that a particular event affected everyone in a non-random way.
Testing	"Pre-test" instrument did not include any specific recommendations	Not applicable.
Instrumentation	Identical instruments were used.	Identical instruments were used.
Mortality	Multiple sources were used to develop a judgment of success.	Not applicable.
Regression	Random sample.	Random sample.
Measurement issues		
Self-report		
Recall errors for retrospective data	A firm's specific recommendations were displayed on the survey to aid in recall.	Not applicable to resumes; College is a good anchor for recall in the surveys.

the database graduated before 2000 as shown in Figure 4, which displays the entry years of the respondents to the exit survey as well as the number of respondents who indicated that year.

For this assessment of alumni impact, a random sample of 500 students was drawn from the alumni database of 2,299 students. Of these, 14 did not have email addresses and 391 had email addresses that bounced. Through web searches and contacting alumni through LinkedIn, email addresses for more than 200 alumni in the original sample were gathered, for a total of 352 working email addresses for alumni in the original sample of 500. These alumni were invited to take a survey on their participation in the IAC program. These surveys collected retrospective, self-reported data that are vulnerable to recall error. Since recall error increases with time, older alumni may have weaker recalls of their participation in the IAC program.

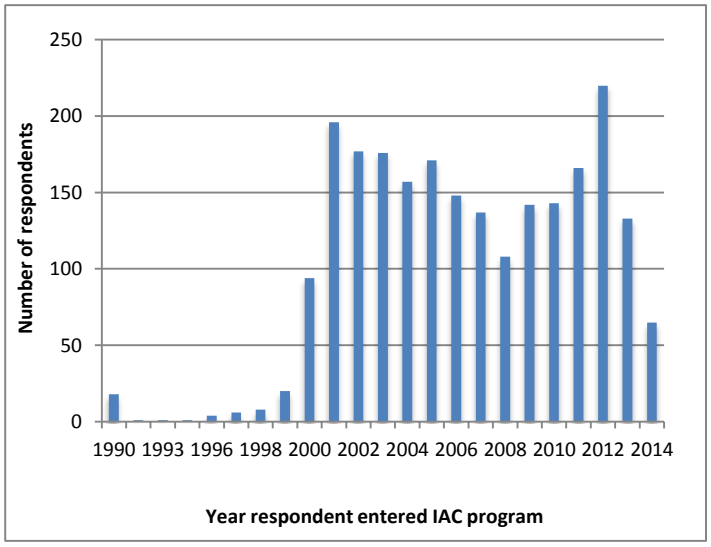


Figure 4. Entry year of IAC students. ***Source: IAC student exit survey. N=806 students participating from 1990-2014.***

Resume sources. Resumes were gathered from IAC alumni in the sample as described above. Resume participants were compared with two comparison groups. A "cohort" comparison group was selected based on university, degree, major, and graduation date +/- 2 years. A second comparison group of energy professionals was identified from the Indeed database based on searching of job titles.[18] Comparison group resumes were downloaded from the online resume database Indeed.com. Indeed.com is a popular resume website where people post their resumes for public viewing. Two comparison groups were developed based on matching characteristics in the Indeed database. 5,248 resumes were identified through this search query. A random sample was drawn from this universe using proportionate allocation based on career length so that the distribution of the career length of the comparison group was not statistically different from that for the participant group. (See Appendix A for more details.)

Research Objectives

Two main research objectives guided this study and are listed in Table 8, which describes the types of research questions used to measure the outcomes for participating manufacturers.

This report addresses the evaluation questions stated above by laying out the connections between program inputs, activities, impacts on energy saved, and student skills developed. Figure 5 displays a simplified logic model that illustrates the theoretical logic by which the program works to achieve its objectives.[19] The model was built from the results of the interviews described above. The goal of the logic model is to illustrate the most important external influences on desired program outcomes and to help develop a design that convincingly rules out the most plausible alternative explanations for the observed results.

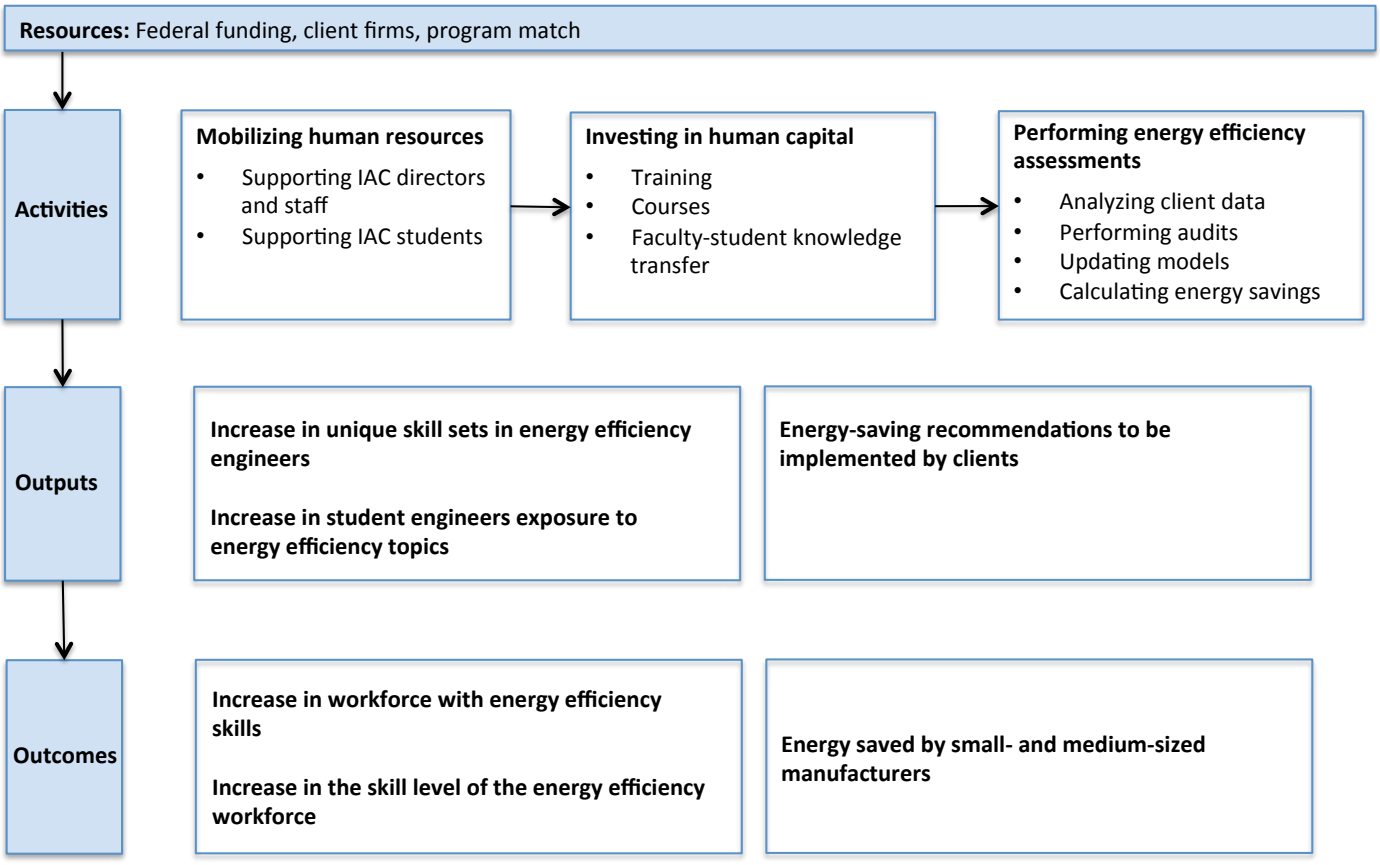
[18] IAC participant resumes were reviewed to identify relevant job titles for the "energy" comparison group. A Boolean query was created based on common job titles found in this review. A manual review of search results identified a high degree of false positive results due to the frequent occurrence of the phrase "high energy manager" in many non-relevant resumes. Exclusionary language was added to the query to eliminate those results. The final query used was: ("Energy Efficiency Engineer" OR "Energy Manager" OR "Energy Engineer" OR "Energy Audit" OR "Energy Auditor") NOT "Industrial Assessment Center" NOT "high-energy manager" NOT "high energy manager."

[19] McLaughlin, J.A. and G.B. Jordan, *Using Logic Models*, in *Handbook of practical program evaluation.* J.S. Wholey, H.P. Hatry, and K.E. Newcomer, Editors. 2010, Jossey-Bass: San Francisco. p. 55.

Table 8. Research objectives

Objective	Metric	Data Source
Increase energy efficiency at small- and medium-sized manufacturers	Energy efficiency	**IAC database** **SRI survey of IAC clients**
Increase productivity	**Sales and employment**	NETS data
Develop next generation of engineers with experience in energy efficiency	**Energy efficiency skills**	SRI survey of IAC alumni
		SRI survey IAC alumni IAC student exit survey
		Resumes

Figure 5. Program logic model.



Data Collection

Table 9 summarized the sample design for the data collection activities.

Qualitative interviews with IAC directors and students. Every IAC director from each IAC was interviewed either at a site visit or through a telephone call. The interview data informed the development of the survey instruments, and supported and provided context for interpreting the quantitative energy savings estimates and the student career path data, as well as providing information about program impacts.

Qualitative interviews with representatives of Energy Services Companies (ESCOs) located in the West, Midwest, and Mid-Atlantic regions. SRI asked the IAC directors and IAC alumni to identify companies that would be willing to participate in an interview; many, but not all, of the ESCO interviews were with employees who are IAC alumni. These companies spanned a variety of business models, from those with a primary focus on energy efficiency consulting to those with a primary focus on energy performance contracts and engineering design, retrofits, and auditing. The purpose of the interviews was to gauge where the IAC energy audits fit into the broader energy efficiency sector landscape and to what extent, if any, IACs overlap with private sector firms in providing energy audit services to the same target customers. In total, SRI conducted seven phone interviews with ESCO representatives in October 2014. This was not meant to be statistically representative, but to provide context to the report.

Quantitative analysis of the IAC database. This analysis was supported by literature reviews, director interviews, and results from the client survey to assess energy savings impacts.

Quantitative analysis of a survey of a random sample of 710 clients on their specific recommendations and experience with the program. Because of the confidentiality assured all companies participating in the IAC program, the SRI team had to obtain permission directly from the clients before sending them a survey about their recommendations. About 40% of sampled firms gave their permission to be included in the survey, and email invitations were sent to these firms. At least two reminders and a follow-up call were sent to non-respondents who received the invitation. A total of 182 firms submitted completed surveys, for a total response rate of about 26%. The respondents include firms from 36

Table 9. Sample size design and response rates.

Group Investigated	Interviews Sought or Survey Invitations	Response Rate	Sample Design
IAC directors	24	100%	Universe of all IAC directors funded in 2014
Participating manufacturers	710	26%	Random sample drawn from the universe of manufacturers that participated in the program from FY2009 to 2013
Energy services firms	9	100%	Sample of convenience for non-statistical purposes
IAC alumni	500	85 resumes; 113 surveys	Random sample drawn from the universe of 2,299 alumni in the IAC alumni database
Non-participant college graduates	1,500	301 resumes	Matched on the 500 drawn on institution, graduation date +/- 2 year, and major
Non-participant energy professionals	5,248	867	A weighted sample based on career length from universe of energy professionals whose resumes were posted on Indeed.com in Fall 2014

states. These firms received their assessments from 30 different IACs. The respondent firms represent 127 different industries (as defined by 6-digit NAICS codes); nearly all (about 98%) were in manufacturing. Table 10 displays the difference between the respondents and non-respondents. As shown, the only statistically significant difference between the two groups is the number of IAC recommendations implemented as indicated in the initial program follow-up database.

The response rate is not consistent across years: it declines from 42% for firms that received assessments in FY2013 down to 12% for firms that received assessments in FY2009. In some cases, firms that received assessments in earlier years were no longer in business. For other manufacturers, turnover was high and new personnel were not familiar with the IAC audit, especially for clients served more than two years ago. As a result, the causes and size of non-response bias likely shifts somewhat over years, such that temporal trends observed in the survey data are unlikely to be reliable.

Table 10. Descriptive statistics for client firm respondents versus non-respondents.[20] P-value indicates the results of an independent t-test between groups. N=710 *Source: IAC database participating manufacturers FY1997-FY2013.*

	Respondents	Non-respondents	p-value
Mean number of employees	215.1	191.2	0.260
Mean sales (USD)	$124 million	$64 million	0.094
Mean # of IAC recommendations implemented	4.0	3.4	0.007
Mean energy savings implemented from IAC recommendations	7,312 MMBtu	6,431 MMBtu	0.598
Mean cost savings implemented from IAC recommendations	$49,980	$54,480	0.673

[20] All statistics presented in this table are based on the IAC database, not on client survey responses.

Given these modest response rates, survey results may not be considered as representative of the broader IAC client firm population. For example, the higher implementation rates observed in respondent firms suggest that these firms may have been more engaged with, interested in, or happy with the results of their IAC assessments. If so, we would expect that our results might overestimate the positive impacts of the program.

Nonetheless, because we are able to identify the respondent firms within the IAC Assessment Database, useful comparisons can be drawn between results from the database and results from the survey that are internally valid to the respondent population. Due to possible response bias and measurement error, we do not recommend that such findings be directly applied to the entire IAC client firm population. However, the survey results do provide some suggestive insights into how we might think about longer-term implementation, net energy savings, and persistence.

Quantitative and qualitative analysis of the survey of a sample of alumni as described above. 23% of alumni in the sample responded.[21] Some non-response will be random since some invitations may get caught in spam filters or people may delete the invitations for reasons unrelated to their IAC experience. However, because the survey asked about the effect of the IAC program on the student's subsequent career, there may be systematic non-response bias due to a likelihood that those who felt the IAC had a large impact on their career would be more motivated to respond to the survey. The magnitude of the potential bias is unclear; therefore, to be conservative, we do not generalize the results to the entire alumni population. This is reflected in Table 11, which displays some descriptive statistics about the respondent group and non-respondent group based on information contained in the database from which the sample was drawn. Both groups had similar majors; however, respondents tended to be closer to their entry date, and more likely to have been lead students during their participation, to have done a larger

[21] We consider non-working email addresses to be a non-response. If these emails were removed then the response rate would be 32%.

number of assessments, and to have a certificate than were non-respondents.

Analysis of resumes from participants and non-participants. This analysis provided additional insight into the career impact of IAC participation. Resumes are a rich source of detail about individual career paths, and people usually share their resumes freely. 85 individual resumes were obtained from alumni directly while 24 resumes were found on the online resume site Indeed.com, where they were posted by the author for public viewing. All personally identifiable information was discarded prior to analysis.

Table 12 displays the descriptive statistics for the alumni whose resumes were included in the analysis and those whose resumes were not included. As for the survey, the two groups were different along these dimensions, so care should be taken when attempting to apply any of the results to alumni outside of the respondent groups.

Table 11. Descriptive statistics for alumni survey respondents versus non-respondents. P-value from an independent t-test of means. N=500 ***Source: IAC alumni database and exit survey of participating students 1990-2014.***

	Respondents	Non-respondents	p-value
Top two majors	Mechanical Engineering [61%] Industrial Engineering [15%]	Mechanical Engineering [62%] Industrial Engineering [17%]	
Mean entry date in years since 2014	7.17	8.95	< 0.0001
Percent lead student	36%	29%	0.0135
Mean number of assessments	12.1	7.6	< 0.0001
Percent with certificate	61%	40%	< 0.0001
Count	113	387	

Table 12. Descriptive statistics for alumni resume respondents versus non-respondents. P-value from an independent t-test of means. N=500 ***Source: IAC alumni database and exit survey of participating students 1990-2014.***

	Respondents	Non-respondents	p-value
Major	Mechanical Engineering [58%] Industrial Engineering [25%]	Mechanical Engineering [63%] Industrial Engineering [14%]	
Mean entry date in years since 2014	7.3	8.9	< 0.0001
Percent lead student	41%	28%	< 0.0001
Mean number of assessments	15.7	6.6	< 0.0001
Percent with certificate	65%	39%	< 0.0001
Count	**109**	**391**	

Firm Impacts: Saving Energy and Reducing Carbon Emissions

This section reports on the impacts of the IAC program on firms, including energy savings and carbon avoided. Findings are based on the information gathered by IAC centers from their clients before and after participation, as recorded in the IAC Assessment Database, as well as SRI's survey of client firms. We also draw on interview and site visit data for context.

Key Terms and Definitions

Evaluations of energy conservation and efficiency programs focus primarily on two impacts: (1) Estimates of **gross energy savings** and (2) estimates of **net energy savings.** Depending on the type of program(s) under review, evaluations may also look at other non-energy benefits and outcomes, such as avoided emissions, increased/decreased maintenance costs, or job creation. Evaluations may also include estimates of the **persistence** of energy savings, but typically they do not because of the high costs and complexity of measurement.

The energy efficiency impacts presented in this evaluation of the IAC program were informed by guidelines laid out by the Environmental Protection Agency and the National Action Plan for Energy Efficiency in the 2007 publication, *Model Energy Efficiency Program Impact Evaluation Guide,*[22] and the 2012 update, *Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group*,[23] and a number of other guides and reports reviewed by SRI in developing the study methodology. See Appendix A for a discussion of this review, including the different methods typically used to calculate gross energy savings, net energy savings, and persistence.

Gross energy savings are the change in energy consumption (or demand) from program-promoted actions taken by participants, regardless of the extent to which the program influenced their actions. Estimates of gross energy impacts involve a comparison of changes in energy use over time among participants who installed measures against some baseline level of usage.

Net energy savings are the portion of the change in energy consumption attributable to the program.

[22] National Action Plan for Energy Efficiency (2007). *Model Energy Efficiency Program Impact Evaluation Guide*. Prepared for the Environmental Protection Agency and the Department of Energy.

[23] State and Local Energy Efficiency Action Network. (2012) *Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group*. Prepared for the Environmental Protection Agency and the Department of Energy.

Estimating net energy impact typically involves assessing free-ridership and spillover. "Free-ridership" refers to the portion of energy savings that participants would have achieved through their own initiatives and expenditures without participating in the program. Participant "spillover" refers to the situation where a participant installed equipment prompted by the program, and then installed additional equipment due to program influences, but without direct program support. The comparison between net and gross savings is called the net-to-gross ratio (NTGR).

Gross savings and net savings estimates focus on first-year savings, so evaluations looking for energy savings beyond the first year of installation require an analysis of persistence. Definitions for persistence are not nationally consistent, but the concept generally encompasses both the retention and performance degradation of energy efficiency measures.

The National Renewable Energy Laboratory's (NREL) Uniform Methods Project identifies two major components to account for persistence: (1) effective useful life and (2) savings persistence. Effective useful life (EUL) is the median number of years that a measure is in place and operational after installation. Savings persistence is the percentage of change in expected savings due to changed operating hours, changed process operations, and/or the performance degradation of equipment efficiency relative to its baseline efficiency. Persistence studies are both costly and time-consuming, and are not typically included in impact evaluations of energy efficiency programs.

Firm Impact Estimates

The IAC database is the primary data source for the estimates of energy savings, implementation patterns, and other key outcomes presented in this chapter. Because the IAC approach is based on detailed measurement of *all* relevant equipment of the whole population that participates in the program, the energy savings estimates associated with each IAC recommendation are exceptionally robust. We therefore have a straightforward means of calculating high-quality estimates of deemed gross energy savings: essentially, we sum the savings estimates associated with all implemented recommendations for the fiscal years 1997-2013.

Yet these data are subject to three key limitations: (1) the final collection of data through a follow-up phone call, the moment at which the implementation status of recommendations is recorded, typically occurs 6-9 months after the assessment, (2) they do not provide insight into what might have happened in the absence of the IAC program, and (3) they provide no information about persistence: how quickly do energy efficiency measures degrade, and how long are they retained? In order to shed light on these and other questions, the SRI team designed and implemented a short web-based survey of a sample of firms that received IAC assessments from FY2009 to FY2013 (see Appendices A and C for details).

Findings from the SRI client survey are utilized to (1) better understand the sensitivity of gross energy savings estimates to different assumptions about implementation, (2) provide insight into the counterfactual (what would a firm have done otherwise) and therefore net savings rates, and (3) better understand the persistence of implemented measures. However, with a modest response rate of about 26%, the survey results should not be interpreted as representative of the entire IAC client population, but instead as illustrative of how the program works for some firms. Additional details about the survey instrument and protocol can be found in Appendix C. In addition, interviews with client firms and IACs are used for purposes of context and interpretation throughout this section, but are not a primary source of evidence in estimating outcomes.

Gross Energy Savings

SRI's gross energy savings estimates are based on the exceptionally robust deemed savings estimates from the IAC database, summed for all **implemented recommendations**. An *implemented* recommendation is defined as in place at the time of the follow-up call or with definite plans in place for completion within 12 months of the call (and not more than 24 months from the assessment date). The IAC database does not distinguish between a measure that is partially versus fully implemented, and does not account for changes in implementation plans after the follow-up call.

To better understand how sensitive our gross energy savings estimates might be to these data gaps, we examine the results of the SRI client survey in comparison to the IAC database records. According to the IAC database, the client survey response group implemented approximately 49% of recommendations. In the survey, these respondents indicated that they had implemented 20% of recommendations in full and 30% of recommendations in part. Respondents also reported that while most recommendations were implemented within a year (67%) or two (25%), the remaining 8% of recommendations were implemented more than two years after the assessment, as shown in Figure 6.

Note, of course, that most FY2013 respondents were not yet at the two-year mark at the end of the survey. In fact, for approximately 5% of the recommendations queried, respondents indicated that they had not implemented because they had not had time to do so. It is also notable that there is not perfect agreement between recommendations reported as implemented in the IAC database and those reported as implemented in the survey. For example, about 24% of recommendations recorded as *implemented* in the IAC database were reported as *not implemented* in the survey. In addition, survey results suggest that some of the results recorded as *implemented* in the survey database are reported as *implemented in part* in the survey. One plausible explanation for this discrepancy is that plans for implementation, as reported at the time of the follow-up phone call, may change or become delayed later on. This is consistent with findings from SRI's interviews with clients and center directors, who indicated that decisions and plans for implementation typically are not firmly settled at the time of the follow-up call. However, we also cannot discount measurement error in the survey results, as we were asking companies to recall detailed information about actions that took place up to five years earlier.

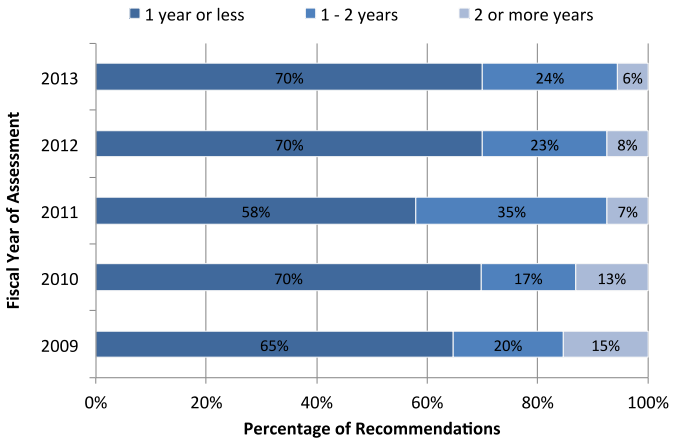


Figure 6. Length of time manufacturers took to implement recommendations according to surveyed clients. *Source: SRI Clients Survey Results*[24] *Clients participating between FY2009-FY2013.*

Overall, these results suggest that the IAC database may underestimate the number of recommendations eventually implemented, but also that the level of energy savings calculated for each recommendation may be an overestimate due to partial implementation in some cases. In the case of the survey response group, for example, the database estimates gross energy savings of 1.3 million MMBtu. (This is a one-year estimate and does not take into account possible persistence of savings in future years.) We can then recalculate gross savings assuming different levels of partial implementation, as presented in Table 13.

Based on different assumptions about the percentage of savings realized by partial implementation, gross energy savings from the survey group may in fact range from a lower bound of 0.7 million MMBtu (assuming 0% savings from partial implementation) to an upper bound of 1.7 million MMBtu (assuming full savings from partial implementation). These are of course outer bounds; by definition we would not expect partial implementation to result in no savings or full savings. We therefore also present the results for the more reasonable assumptions of 25%, 50%, and 75% partial implementation. It is clear from this analysis that total energy savings is sensitive to

[24] Note that the results pictured are only for recommendations marked as implemented in a preceding survey question and exclude responses where the respondent did not know the answer or did not respond. See the appendix for a full tabulation of survey results.

Table 13. One year implemented energy savings estimates in MMBtu for the survey respondents. *Source: SRI Clients Survey Results*[25] *Clients participating between FY2009-FY2013.*

	Total Energy Savings Implemented by Survey Respondents (MMbtu)
IAC Database (baseline estimate)	**1.33 million**
IAC Client Survey *Assumptions:*	
Lower bound: *0% partial implementation*	**0.67 million** (51% of baseline)
25% partial implementation	**0.93 million** (70% of baseline)
50% partial implementation	**1.19 million** (90% of baseline)
75% partial implementation	**1.45 million** (109% of baseline)
Upper Bound: *100% partial implementation*	**1.71 million** (129% of baseline)

the assumptions we make about levels of implementation, and it is not clear whether the energy savings calculated from the IAC database are being underestimated or overestimated, as different sources of measurement error may have bias in different directions.

As we have stated elsewhere in this report, with a response rate of 26% there is the potential for a response bias in our survey results. For example, it may be that firms that got more value from the program and implemented more savings were more likely to respond to the survey. Indeed, there is evidence in the IAC database that the survey response group implemented a higher percentage of recommendations (49%), compared to the average firm (44%) during the FY2009 to FY2013 period. Firms that responded to the survey also implemented more gross energy savings per firm (7,312 MMBtu) than the average firm (6,688 MMBtu) for the FY2009 to 2013 period. Yet we are not seeking to extrapolate the rates of implementation from the survey to the entire IAC firm population, but instead to gauge the difference between implementation as reported in the IAC database and the survey. While with a low response rate there is always a threat of response bias, it is not clear that firms responding to the survey would be likely to systematically under- or over-report implementation compared to the overall population. These results therefore provide an imperfect, but best available, basis for estimating a range of likely outcomes around our point estimates of gross energy savings from the IAC database. We present both the point and range estimates for gross energy savings in Table 14 by applying the percentages from the survey response group sensitivity analysis to the entire population used to estimate savings (FY1997 to FY2013). In interpreting these ranges, again note that the lowest (51% of baseline) and highest (129% of baseline) range estimates are outer bounds based on assuming 0% and 100% savings for partially implemented measures. Estimates of 70% to 109% of the baseline, yielding gross savings of 37.6 to 58.6 million MMBtu, are likely more realistic.

Carbon Dioxide Emissions Avoided

In addition to estimating gross energy savings, we estimate the associated carbon dioxide emissions avoided by implemented changes in energy consumption. For each recommendation, the IAC database tracks the associated change in energy consumption separately for different energy streams (i.e., electricity consumption, natural gas, different fuel oils, coal, etc.). Using implementation records from the IAC database, we can then multiply the gross energy savings for each energy stream by the appropriate carbon coefficient to get our baseline estimate of overall carbon dioxide emissions avoided.[26]

[25] Note that the results pictured are only for recommendations marked as implemented in a preceding survey question and exclude responses where the respondent did not know the answer or did not respond. See the appendix for a full tabulation of survey results.

[26] We use U.S. average emission coefficients for electricity generation (http://www.eia.gov/electricity/state/unitedstates/) and fuels (http://www.eia.gov/environment/emissions/co2_vol_mass.cfm).

Table 14. One-year estimates of total energy savings and carbon avoided. ***Source: IAC database. Manufacturers who participated during the indicated years***

	Total Energy Savings FY2009 to 2013 (MMBtu)	Total Energy Savings FY1997 to 2013 (MMBtu)	CO_2 Avoided FY2009 to 2013 (metric tons)	CO_2 Avoided FY1997 to 2013 (metric tons)
IAC Database (baseline estimate)	**14.4 million**	**53.8 million**	**1.70 million**	**6.11 million**
Range Estimates				
51% of baseline	7.4 million	27.4 million	0.87 million	3.12 million
70% of baseline	**10.1 million**	**37.6 million**	**1.19 million**	**4.28 million**
90% of baseline	**13.0 million**	**48.4 million**	**1.53 million**	**5.50 million**
109% of baseline	**15.7 million**	**58.6 million**	**1.85 million**	**6.66 million**
129% of baseline	18.6 million	69.4 million	2.19 million	7.88 million

Net Energy Savings

The IAC database records include only information about gross, not net energy savings. Our evidence for what percentage of gross savings recorded in the database can be attributed to the IAC program relies on the SRI survey of IAC client firms. The survey explores two different aspects of the counterfactual: would firms have gotten a similar assessment from another source in the absence of the IAC, and would they have implemented some of the efficiency measures even if they had not received an assessment?

About 69% of firms surveyed indicated that they would not have sought an energy assessment that year if the IAC program had not been available to them.[27] When asked why they would not have sought such an assessment, the most frequently cited reasons were that the budget was not available (34%), it was not a priority (26%), or they did not think of it (14%). Of the firms that indicated they would have sought an assessment, most reported that they would likely have utilized a private firm or a utility rebate program if the IAC program had not been available.

Findings from IAC faculty, students, and client firms indicated that assessments not only brought new ideas to the table, but also provided impetus and impartial evidence for proceeding with opportunities the firm may have been aware of but had no immediate plans to proceed with. The SRI survey of IAC client firms therefore asked firms to indicate, for each recommendation implemented, if they had plans to take the recommended action prior to the IAC team site visit. For about 26% of recommended actions, respondents indicated that specific plans and budgets were already in place. For 68% of recommendations, plans were not in place, but it should be noted that in slightly more than half of these cases, the idea was under consideration. For the remaining 6% of recommendations, the respondents were not sure if plans were in place.

Based on these results from the survey, we are able to estimate the approximate net savings and net-to-gross savings ratio for the respondent firms. To produce these estimates, we remove savings from recommendations to firms that indicated they would have sought an assessment from another source. We also remove savings from recommendations that respondents indicated were already planned at the time of the assessment. In this case, we find that the one-year net energy savings are about 62% of the gross energy savings estimate for the

[27] This result excludes the 15 respondents who responded that they were not involved in the decision-making process

survey response group. If we wish to be more conservative and assume that about half of the recommendations that were not planned but under consideration would have been implemented in the absence of the IAC program, the net-to-gross ratio (NTGR) would be about 43-44%.[28]

These NTGRs are based entirely on implementation as reported in the SRI client survey: we divide net energy savings from the survey results by the gross energy savings estimate from the survey. However, if we are interested in the approximate net savings from the larger IAC population, we can instead compare the net energy savings from the survey to the baseline gross energy savings estimates *from the IAC database* for the survey respondent group. By then applying that ratio to the gross energy estimates in the IAC database for the entire IAC client participant population (FY2009 to FY2013) we can generate a rough estimate of net energy savings for the program. We present these results for a range of assumptions in Table 15

Once again, given the low survey response rate (26%) and potential for complex response bias, we urge caution in applying the net-to-gross ratios derived from the survey analysis to the entire IAC client firm population. We know that the survey group has slightly higher implementation rates, in terms of recommendations and gross energy savings, than the FY2009 to FY2013 IAC client population overall, but in this case our concern is whether this or other characteristics under- or over-represented in the survey response group correlate with the net-to-gross or net-to-baseline ratio. A regression analysis of the survey group (the only group for which we have direct net-to-gross and net-to-baseline estimates) does not indicate a correlation between implementation levels as recorded in the IAC database (gross energy savings implemented, or % of recommendations implemented) and either the net-to-gross or net-to-baseline energy savings ratios.[29] This analysis is by no means conclusive (there may be important unobservable characteristics that we do not have data on), but based on the available data we do not find evidence that the net-to-baseline calculations are biased in a specific direction.

Table 15. One-year estimates of total energy savings and carbon avoided. ***Source: IAC database. Manufacturers who participated during the indicated years***

		Total Energy Savings (MMBtu) FY2009 to 2013			Total Energy Savings (MMBtu) FY1997 to 2013		
Gross Energy Savings IAC Database (baseline estimate)		**14.4 million**			**53.8 million**		
Net Energy Savings Range Range estimates based on SRI Client Survey		*Partial Implementation Savings*			*Partial Implementation Savings*		
		25%	*50%*	*75%*	*25%*	*50%*	*75%*
Percentage of recommendations considered pre-assessment that would have been implemented without IAC	*75%*	3.1 million	4.3 million	5.4 million	11.7 million	15.9 million	20.1 million
	50%	4.2 million	5.5 million	6.9 million	15.6 million	20.6 million	25.6 million
	25%	5.2 million	6.8 million	8.3 million	19.4 million	25.2 million	31.1 million

[28] A range is given because the exact result depends upon the assumptions made for calculating the gross energy estimate, as discussed previously.

[29] No results significant at the 10% level, using heteroskedasticity-consistent estimation of the covariance matrix.

Persistence

Rigorous estimates of the persistence of energy savings are complex, costly, and time-consuming, and are not included in most energy efficiency impact evaluations. **The information gathered in this analysis is not sufficient to accurately estimate the persistence of energy savings from the IAC program.** The IACs do not typically collect data beyond the 6-9 month follow-up call, and even if clients are surveyed at a later date (as with the SRI client survey), firms do not measure and track detailed information on persistence. Still, we were able to gather some limited information about the persistence of savings from the client survey and interviews, which we present in this section.

Interviews with the IAC directors, staff, and clients revealed that measuring and tracking the persistence of efficiency modifications made from IAC recommendations is very difficult. IACs do not systematically ask their clients about persistence, nor does the timing of the follow-up phone call (6-9 months after the recommendations are given to clients) allow for any sort of meaningful data collection on persistence. IAC directors and staff also commented that the majority of their clients base their decision on whether or not to invest in IAC recommendations on two-year cost/savings estimates, and rarely account for or track energy savings beyond two years.

IAC directors noted that persistence could be influenced by a number of factors, including the type of modification, type of industry, and facility personnel. Benefits from fixing air leaks will degrade over time, while lighting upgrades generally provide long-term savings, and motor replacement savings typically last the life of the new motor. However, in some industries, such as electronics manufacturing, industrial processes may change rapidly, rendering modifications obsolete before the end of their operating lives.

When asked to speculate on the persistence of IAC recommendations, IAC directors and staff were hesitant to place a number on persistence, given the lack of data and number of factors involved. Many responded by saying they were confident that measured persistence was "at least a few years," and around 5-10 years on average for longer-term modifications, such as lighting or motors.

Results of the SRI survey of IAC client firms also suggest that implemented measures are typically retained over the zero to five-year period measured by the survey. In fact, less than 2% of recommendations that clients had implemented were reported as no longer in place at the time of the survey, although some of the remaining recommendations were only partially in place or the respondent was not sure if they had been retained. We see no clear evidence of a decline in recommendation retention over time. However, given the weaker response rates from the earlier years of the survey period (there are fewer respondents for the earlier assessment years), these results should be interpreted with caution.

Survey and interview data, as well as findings from the literature, all support the hypothesis that the estimated useful life of energy efficiency measures installed based on IAC recommendations may last for several years. Yet this does not necessarily mean that the *actual, additional savings* from those recommendations would persist for such an extended period. There may be some decrease in the level of savings over time as equipment ages or processes and procedures evolve.

We therefore take a conservative, scenario-based approach to calculating the persistence of energy and cost savings achieved through the implementation of IAC assessment recommendations, calculating estimated gross savings assuming persistence of one, two, and three years with deterioration of savings rates of 10%, 25%, and 50% per year. **Note that we have no empirical evidence to suggest what rate of savings persistence is appropriate;** Table 16 **is merely intended to be illustrative of what 2-year and 3-year savings rates might look like under different assumptions about energy savings over time.**

Table 16. Scenarios for multi-year persistence of implemented energy savings estimates in MMBtu.

Annual rate of decrease in persistence of savings	1-year Gross Energy Savings (MMbtu)	2-year Gross Energy Savings (MMbtu)	3-year Gross Energy Savings (MMbtu)
0%	53.8 million	105 million	153 million
10%	53.8 million	99.8 million	143 million
25%	53.8 million	92.2 million	128 million
50%	53.8 million	79.4 million	104 million

Summary Statistics

From FY1997 to FY2013, over 9,000 assessments have been performed and over 75,000 recommendations made through the IAC program. According to the database 44% of those recommendations were implemented by firms, mobilizing over half a billion dollars in private investment in energy efficiency from FY1997 to FY2013. This yielded an average of nearly half a million BTUs in gross energy savings per federal dollar invested. A summary of program statistics, for both the FY1997-2013 and more recent FY2009-2013 periods is presented in Table 17 below.

The size of client firms served has remained stable over the years, with 125 being the median number of employees per client firm from FY1981 to 2013. As intended, this program has served small and medium sized manufacturers.

Table 17. Summary program statistics. ***Source: IAC database for the indicated years.***

	FY2009 - 2013	FY1997 - 2013
Number of IAC Assessments	2,158	9,343
Number of Recommendations made to firms	17,329	75,210
% of Recommendations Implemented	44%	44%
Share of Recommended Savings Implemented (MMBtu)	33%	33%
Total Program Budget (2013 US Dollars)	$25.3 million	$112 million
Total Private Investment Mobilized (2013 US Dollars)	$156 million	$563 million
Average 1-Year Gross Energy Savings (MBTU) per Program Dollar (2013 US Dollars)	576	481
Average 1-Year Gross Energy Savings (MBTU) per Dollar Invested* (2013 US Dollars)	80	80

***Includes program dollars and private investment mobilized**

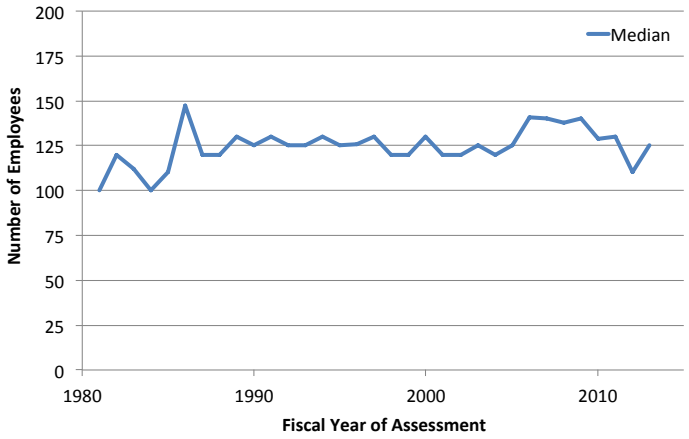


Figure 7. Median employment of firms that received IAC assessments from FY1981 to 2013. ***Source: IAC database for indicated years.***

Analysis of Firm Sales and Employment

The IAC database, supplemented by the relevant literature, interviews with IACs and their clients, and the results of SRI's IAC client survey help us to better understand how the IAC program facilitates energy savings by participant firms. In this section, we will seek to extend this analysis by examining whether participating in an IAC assessment is correlated with establishment-level increases in sales and/or employment.

The hypothesis to be tested is grounded in a straightforward theory of firm behavior under competitive conditions. All other things being equal, when a firm derives savings from an energy efficiency improvement it has the effect of lowering the firm's costs, at the margin. In that event, the firm may do one of several things—it may increase output/sales, it may hire more workers, it may pay its workers more money, or it may take increased profits. In practice, a firm may do a mix of all of these things. If the further assumption is made that firms under competitive conditions maximize output—then we should expect to observe increases in sales and employment as a result of lower marginal costs of production.

Valid estimates of such impacts require detailed data on employment and sales over time, for both IAC-served firms and a credible comparison group of firms outside the program. Panel data on establishment-level sales and employment by IAC and non-IAC manufacturing firms are drawn from the National Establishment Time-Series (NETS) Database and analyzed using establishment fixed effects. This approach allows us to control for unobserved heterogeneity, or differences across establishments that do and do not receive assessments (as long as those differences are constant over time). We define establishments that received IAC assessments between FY2002 and FY2011 as the "treatment" group and all other small- to medium-sized U.S. manufacturing establishments active during the analysis period as the control group. However, due to data quality issues, only about 55% of the treatment group was successfully identified and another 12% removed from the control group.[30]

In sum, we do not find evidence of increased sales or employment that can be reasonably attributed to the IAC assessments received by firms as shown in Table 18. No statistically significant correlation is observed between IAC assessments and growth in establishment-level sales. While assessments are somewhat correlated with increased growth in employment, these results are most likely due to selection bias: they both (1) occur too soon (we would not expect an IAC visit to instantaneously generate establishment growth) and (2) the intensity of implementation and savings do not correlate with higher growth in sales and employment. When we adjust the dependent variable to allow for a reasonable window for change (4-5 months from the IAC team visit), the correlation between assessments and higher growth in employment disappears. It is therefore likely that the relationship we see is due to time-variant selection bias. For example, it may be that during periods of higher-than-average employment growth firms are more able to devote time to the IAC process, or that new managers brought in during growth periods are more likely to seek IAC assessments.

[30] Detailed discussion of the process and results for identifying the IAC treatment group can be found in Appendix A.

Table 18. Analysis of sales and employment growth with establishment fixed effects. ***Source: Analysis of NETS data for FY2002-2011 participant firms***

Dependent Variable: Annual Percentage Growth in Employment			
	Coefficient	**SE**	**T-Stat**
IAC Site Visit *	-11.93	18.08	-0.660
Implemented Energy Savings (MMBtu) *	-0.001	0.000	-1.116
Implemented Savings (USD) *	0.000	0.000	-0.425
Dependent Variable: Annual Net Growth in Employment			
	Coefficient	**SE**	**T-Stat**
IAC Site Visit *	1.956	1.551	1.263
Implemented Energy Savings (MMBtu) *	-0.0001	-0.000	-2.940
Implemented Savings (USD) *	0.000	0.000	1.882
Dependent Variable: Annual Percentage Growth in Sales			
	Coefficient	**SE**	**T-Stat**
IAC Site Visit *	-1,390	11,640	-0.119
Implemented Energy Savings (MMBtu) *	0.0001	0.351	0.0003
Implemented Savings (USD) *	0.002	0.061	0.0272
Dependent Variable: Annual Net Growth in Sales			
	Coefficient	**SE**	**T-Stat**
IAC Site Visit *	483.22	1,847	0.262
Implemented Energy Savings (MMBtu) *	0.0414	0.056	0.743
Implemented Savings (USD) *	0.0042	0.010	0.430

* All independent variables are lagged such that 4-17 months have passed between the IAC site visit and the observation of the dependent variable

Note: A more detailed presentation of the methodology, definitions, and findings can be found in Appendix A.

Workforce Impacts: Developing a Pipeline of Energy Efficiency Engineers

Background

A programmatic goal of the IAC program is to create a new generation of energy efficiency engineers that possess a unique blend of engineering and energy management expertise, combined with hands-on experience obtained by working directly with small- and medium-sized industrial and manufacturing facilities across the country.

The IAC funding opportunity announcement[31] specifically states that each center should provide extensive training for undergraduate and graduate engineering students in industrial processes, energy assessment procedures, and energy management principles. Led by IAC-affiliated faculty and staff, these IAC students perform energy assessments that will result in energy savings, waste reduction, and sustainability and productivity improvements for manufacturers. Moreover, the students interact with plant and corporate management; prepare executive-level briefings and plant-specific reports containing detailed recommendations for operational and energy management improvement; and, through follow-on activities, facilitate continuous improvement in energy management at these facilities. For many of the alumni that responded to SRI's survey (65%), this program was the only opportunity they knew of at their school to gain applied energy efficiency engineering experience.

Our analysis uses a combination of data drawn from interviews with every current program director and lead students from nearly all of the current centers,[32] a short survey of IAC alumni, the exit survey that many IAC students take, and comparison of IAC participants' resumes with a comparison group's resumes.[33] These analyses together yield evidence of four major impacts of the program:

[31] IAC Funding Opportunity Description. Funding Opportunity Announcement. DE-FOA-0000490. 2011.

[32] The goals of these open-ended interviews were to obtain context for the program and to inform instrument creation. In this section, where we cite that directors said something, it does not imply that every director was asked this question (and that some directors said the opposite). It means that the specific comment theme came in the indicated interviews.

[33] More details of the methods of this report are found in Appendix A.

- **IAC students tend to graduate with specific, applicable skills in energy efficiency.**
- **IAC students tend to graduate and take jobs in energy efficiency fields, expanding the pipeline of energy efficiency engineers.**
- **IAC students tend to graduate with skills that are more highly valued in the energy efficiency job market than comparison students.**
- **IACs create and produce curriculum to train many students annually in state-of-the-art energy management techniques**

Each of these findings is supported by the conclusions of multiple methods. Please see Appendix D for a display of the table.

IAC Workforce Impacts

IAC students graduate with specific, applicable skills in energy efficiency.

Energy efficiency management skills are taught in a variety of ways. Many IACs have a course for credit in which students are taught methods and skills and perform audits as part of classwork. At other IACs, energy efficiency skills are taught through formalized but not-for-credit training classes. At yet other IACs, skills are taught through an experienced student-new student mentoring approach. Some IACs use a combination. 100% of alumni responses stated that alumni had obtained at least one skill related to energy efficiency from their participation in the IAC program. 99% of IAC alumni resumes included one or more energy efficiency-related skill, compared to 95% of the "cohort" comparison group.

Students in the IAC program are trained to use energy consumption equipment, take measurements, and analyze their data to develop recommendations. Directors specifically praised this hands-on approach that characterizes the IAC student experience. As one director said, "in the classroom we teach engineering; in the Center we teach them to be engineers." Another director said that students couldn't even point out an air compressor at first and that the IAC program has allowed them to become familiar with how a lot of different systems work, see them firsthand, and see where things are located. Students get a feel for what needs to be measured, how to measure, and how to quantify. The program gives students a perspective that cannot be gained in classroom.

IAC alumni agree; Figure 8 on page 30 shows the different skills alumni reported that they received from the program. Other skills that alumni said they obtained include:

- Understanding load use profiles of equipment that draws power
- Applied experience with a variety of lean engineering practices to improve productivity
- Knowledge of a broad set of manufacturing processes/products
- Experience identifying energy efficiency recommendations
- Using energy audit equipment
- Direct experience implementing U.S., state, and local energy policies

Some of the skills that the IAC program imparts could also have been gained though co-operative programs or internships. The IAC program, however, is distinguished by the wide variety of manufacturers with which students work. Directors specifically stated that the program enables students to gain practical experience working with different types and scales of industrial systems, employing many different types of machines and processes, in a wide variety of manufacturing sectors.

The following tables present a summary of the skills extracted from the resumes of IAC participants and two comparison groups. For this study, the Brookings Institution provided a dictionary of nearly 9,000 skills, including the average salary of job postings associated with those skills.

Table 19. Energy efficiency skill summary.

	IAC Participants	"Energy" Comparison	"Cohort" Comparison
Number of energy efficiency skills per resume	8.9	5.5	4.3
Value of energy efficiency skills associated with each resume	$72,964	$66,754	$69,947

Table 20. IAC participant energy efficiency skills comparison.

Skill	IAC Participants	"Energy" Comparison	"Cohort" Comparison
Energy Efficiency	39%	26%	3%
Energy Audits	28%	23%	2%
Energy Assessment	26%	3%	1%
Installation	21%	34%	15%
Industrial Engineering	19%	2%	22%
Calculation	19%	14%	16%
Optimization	18%	6%	13%
Inspection	17%	23%	9%
Data Collection	17%	4%	6%
Renewable Energy	17%	11%	6%

Table 21. Most common skills appearing on resumes.

IAC Participants		"Energy" Comparison		"Cohort" Comparison	
Mechanical Engineering	67%	Repair	24%	Mechanical Engineering	65%
Management	60%	Mechanical Engineering	17%	Communication Skills	12%
Research	51%	Communication Skills	11%	Repair	12%
Energy Efficiency	39%	New Construction	7%	Oracle	6%
Energy Audits	28%	Energy Management System	4%	Calibration	4%
Energy Assessment	26%	Oracle	4%	Python	4%
Installation	21%	Contract Negotiation	4%	Milling	4%
SIMULATION	20%	Facility Management	3%	Capacity Planning	3%
Leadership	19%	Power Distribution	3%	Business Process	3%
Industrial Engineering	19%	Recruiting	3%	Android	3%

Table 22. Most common energy efficiency skills appearing on resumes.

IAC Participants		"Energy" Comparison		"Cohort" Comparison	
Energy Efficiency	39%	Installation	34%	AutoCAD	41%
Energy Audits	28%	Energy Efficiency	26%	Industrial Engineering	22%
Energy Assessment	26%	Inspection	23%	Calculation	16%
Installation	21%	Energy Audits	23%	Six Sigma	16%
Calculation	19%	Energy Management	19%	Installation	15%
Industrial Engineering	19%	Energy Conservation	18%	Optimization	13%
Optimization	18%	AutoCAD	16%	STATISTICA	13%
Data Collection	17%	Calculation	14%	Process Improvement	12%
Inspection	17%	Renewable Energy	11%	Mechanical Design	10%
Renewable Energy	17%	Weatherization	11%	Validation	10%

Source for all tables presented in this box: Resumes of participants and control groups.

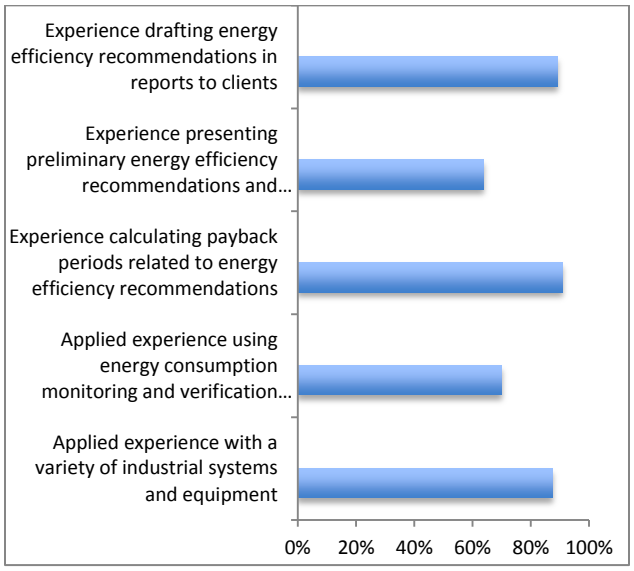


Figure 8. Percent of respondents that indicated each skill was gained through the IAC experience. Respondents could choose any or none. N = 109. *Source IAC: alumni survey.*

As detailed in the methodology chapter, two comparison groups were developed based on matching characteristics in the Indeed database. A "cohort" comparison group was selected based on: university, degree, major, and graduation date +/- 2 years. 301 resumes matching these criteria were identified. A second comparison group of energy professionals was identified from the Indeed database based on searching of job titles.[34] 5,248 resumes were identified through this search query. To make a more robust comparison, a subset of these resumes was selected to match the total time in workforce characteristics of the IAC participant sample. The final energy professional comparison group therefore consisted of 867 resumes. The specific skills that IAC graduates listed in their resumes were significantly different from those of the comparison groups and include more skills directly related to energy efficiency (see Appendix A).

[34] IAC participant resumes were reviewed to identify relevant job titles for the "energy" comparison group. A Boolean query was created based on common job titles found in this review. A manual review of search results identified a high degree of false positive results due to the frequent occurrence of the phrase "high energy manager" in many non-relevant resumes. Exclusionary language was added to the query to eliminate those results. The final query used: ("Energy Efficiency Engineer" OR "Energy Manager" OR "Energy Engineer" OR "Energy Audit" OR "Energy Auditor") NOT "Industrial Assessment Center" NOT "high-energy manager" NOT "high energy manager."

IAC students graduate and take jobs in energy efficiency fields, expanding the pipeline of energy efficiency engineers.

The IAC program appears to be training the next generation of energy efficiency engineers. Alumni surveyed reported that 53% had a first job related to energy efficiency. Of course, many IAC students probably would have gone into energy efficiency careers due to preexisting interests even if they had not participated in the program: 60% of alumni said they got involved with the IAC because they were interested in energy efficiency issues. However, many other students became involved with the IAC for reasons unrelated to energy efficiency: 25% indicated that they became involved because it was an interesting opportunity, but not central to their future career plans. 70% of those students who became involved with the IAC center for non-energy reasons said their experience made them more interested in energy efficiency careers. About 40% of the respondents that were not interested in energy efficiency coming into the IAC program went on to have careers in the energy sector. This was also reflected in the student interviews, illustrated by one student's comment that he came to college interested in agriculture manufacturing, but through the IAC program became interested in lighting. Alumni also echoed this, with these illustrious comments:

- *I didn't originally think buildings or HVAC sounded that interesting before. But then I realized how exciting the building and energy industry was - and how much of an impact optimization could make on the financial health of a building owner!*
- *The opportunity to work in the IAC focused my academic and career interest from mechanical engineering in general to energy efficiency in buildings more specifically. It brought practical, real world, and hands-on applications to all that seemingly theoretical thermodynamic and heat transfer coursework.*
- *My experience with ONE (1) IAC audit was possibly the event [that] most influenced my decision to pursue a career in the energy efficiency / construction profession. Everything I learned and*

saw shaped what I wanted to do with my professional life.

Analysis of career trajectories extracted from resumes of IAC program participants and a comparison group of energy efficiency professionals shows that IAC alumni: (1) tended to enter the energy efficiency field earlier in their careers and (2) stayed in energy efficiency for a greater portion of their careers, both in absolute terms and when corrected for the earlier entry point (see Table 23).

IAC students graduate with more highly valued skills in the energy efficiency job market than comparable students.

IAC program participation is associated with energy efficiency skills that are highly valued by employers. Most alumni (72%) indicated that the skills they obtained in the IAC program helped them get their first job. Directors agreed that the program improved career prospects for participants. Many directors said graduates of the IAC program receive multiple job offers and go to work for energy auditing consulting companies, utilities with energy efficiency programs, state energy offices, manufacturing companies, city governments with energy managers, national labs, etc. This is supported by the results in the IAC student exit survey – the more assessments the student performed, the more job offers they reported receiving.

Table 23. Entry into and persistence of participation in the energy efficiency workforce.

Group	Time of Entry into First EE Job (days from entry into workforce)	Portion of Total Career Spent in EE	Portion of Career Spent in EE Subsequent to First EE Job
IAC Participants	856 days	42%	54%
"Energy" Comparison	1,634 days	28%	48%

IAC students stated that they received "real-world" experience during their participation in the program, and this applied experience is what makes employers value IAC graduates, as illustrated by the following quotes from alumni:

- *I was hired to conduct energy audits primarily. If I didn't have that experience then I guarantee I wouldn't have even gotten an interview. Many companies I dealt with then, and still deal with today, aren't looking to place new graduates of a mechanical program in a role higher than "CAD Monkey".*
- *I started at the IAC as a freshman. The internship experience helped me get other internships (including the company at which I now work full time) and scholarships, which built up my resume. In addition, the practical experience increased my confidence and maturity as well as my understanding of engineering, operations and maintenance, and business goals.*
- *I believe I was able to enter my field at a higher level (more than strictly entry-level) because I worked for the IAC, and I believe I received more consideration for a position because of my IAC experience. I still see the benefits of IAC experience more than 10 years after leaving the system, both personally (my coworkers still recognize the value of my previous experience) and in the larger industry. I am now responsible for hiring engineers for an energy services consulting organization, and we prioritize and seek out people with IAC experience, going so far as to post our positions on IAC job boards and granting almost automatic interviews to people with IAC on their resumes. It's not only me, it's also my coworkers who did not work for IAC that recognize the value of an IAC employee.*

Analysis of the skills-related language used in IAC participant resumes shows that IAC participant resumes include both: (1) more energy efficiency-related skills and (2) more highly valued energy-efficiency skills. On average, the resumes of a matched group of energy efficiency professionals included 5.5 energy efficiency-related skills while a cohort-matched group included an average of 4.3 energy efficiency-related skills per resume. In contrast, IAC

participants showed an average of 8.9 energy efficiency-related skills on their resumes.

A recently developed skills valuation methodology developed by the Brookings Institution shows that the specific mix of energy efficiency-related skills included on IAC participant resumes carries a statistically significant premium in the job market. Compared to a matched group of energy efficiency professionals, IAC participants showed an average 9% skill premium. Compared to a cohort-matched group, IAC participants showed a 4% skill premium.

IACs appear to develop and employ curricula to train many students annually in energy management techniques.

IACs employ a mix of different training models. At some centers, students are trained directly through their participation in the center, while at others, students take energy efficiency courses that include participation in IAC audits as part of the coursework. Centers employing the direct training model tend to include a more limited number of students, each of whom conducts a relatively large number of audits. Universities employing the course-based models tend to include a larger number of students who conduct a relatively small number of audits. Some universities employ a mix of both models. And while IAC alumni survey respondents who participated in a larger number of assessments indicated that their IAC experience made them more interested in energy efficiency careers (Figure 9). Figure 10 shows that the more assessments student participated in the more they indicated that the IAC experience helped them get a job.

Whether the IAC experience is incorporated into coursework or not, directors report that their IAC experience makes them better professors as they incorporate things they do and learn during audits into their classes. The IAC program has also spurred the development of new master's and senior-level undergraduate courses with an emphasis on energy conservation.

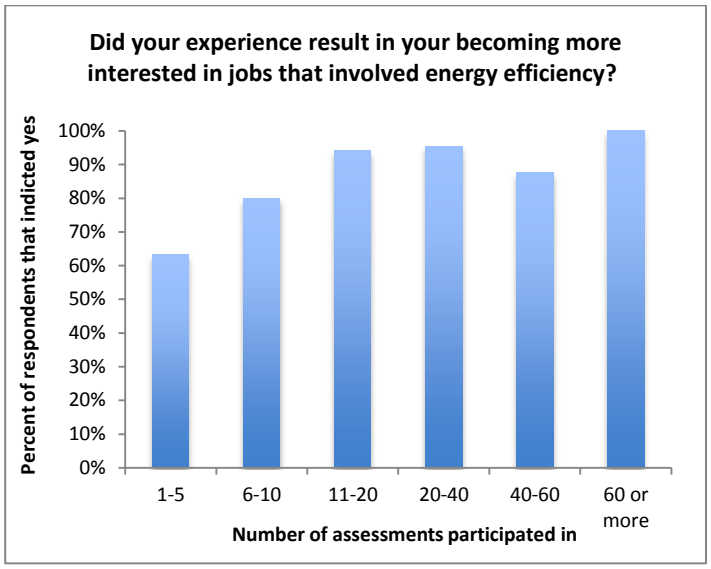


Figure 9. Percent of alumni respondents that said their experience with the IAC increased their interest in energy efficiency. N=109 ***Source: IAC alumni survey. Questions as indicated in legend.***

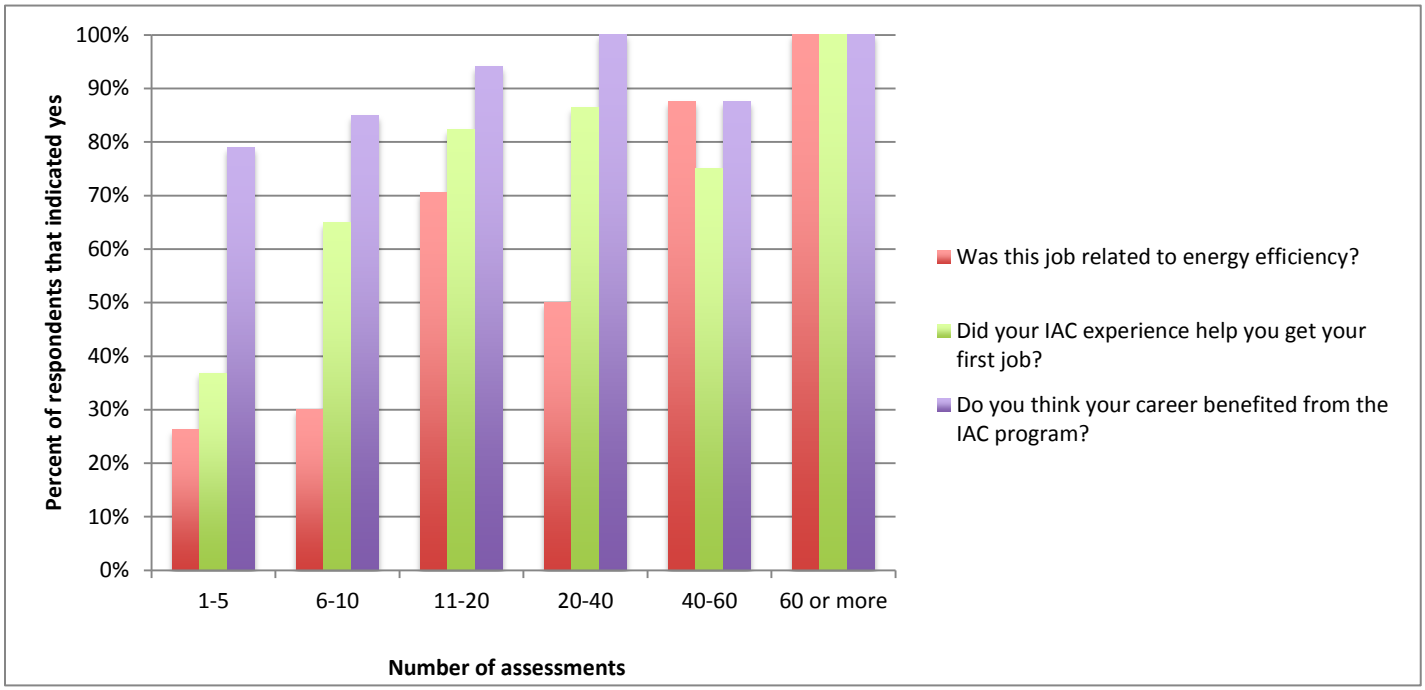


Figure 10. Results of the alumni survey as a function of number of assessments. N=109 ***Source: IAC alumni survey. Questions as indicated in legend.***

Exploration: The IAC Program and the Energy Efficiency Sector

The IAC program targets small- and medium-sized manufacturers, because these companies are believed to lack the information, the resources, or a combination of the two, to seek out and purchase industrial energy audits from the private sector. As a result, these companies miss the opportunity to evaluate and adopt energy efficient practices and technologies that could contribute to their bottom line. While small- and medium-sized manufacturers account for a small share of energy consumption compared to large industrial firms, in the aggregate they represent half of the total energy consumed in the industrial sector.[35] The existence of these barriers to the adoption of energy efficiency practices by these manufacturers even though they consume a significant amount of energy underlies the rationale for the IAC program.

A quick scan of the literature supports this premise. A United Nations Industrial Development Organization (2011) paper identifies the following barriers to adoption of energy efficiency improvements by SMEs: a lack of information about energy efficient opportunities; higher relative costs to obtain data on energy consumption and relevant benchmarks; a lack of time, resource and expertise to address 'non-core' issues; and an aversion to investment risk, whether related to uncertainty about technical performance, energy prices or some other source.[36] Other papers also refer to a lack of staff resources or energy expertise, capital constraints, and a dearth of expert information on energy efficiency opportunities as barriers to greater energy efficiency improvements being implemented by small- and medium-sized manufacturers.[37]

While the scope of this assessment is to quantify the program's effect on energy efficiency savings and its contribution to training the next generation of energy efficiency engineers, it is also useful to explore how the IAC program fits into the broader energy efficiency landscape. What is the extent to which certain market

[35] Daniel Trombley (2014). *One Small Step for Energy Efficiency: Targeting Small- and medium-Sized Manufacturers*. American Council for an Energy-Efficient Economy.

[36] United Nations Industrial Development Organization (2011). *Barriers to industrial energy efficiency: A literature review*. Working paper.

[37] See Price and Lu (2011). *Industrial energy auditing and assessments: A survey of programs around the world*. European Council for an Energy Efficient Economy 2011 Summer Study, and Daniel Trombley (2014). *One Small Step for Energy Efficiency: Targeting Small- and medium-Sized Manufacturers*. American Council for an Energy-Efficient Economy.

failures or firm characteristics continue to serve as impediments to the adoption by small- and medium-sized manufacturer of energy efficiency practices and technologies?

As the U.S. energy services sector has expanded significantly over the past few decades, policy makers might wonder whether the IAC program is still warranted and whether this small- and medium-sized manufacturer customer base is still underserved. For this reason it is helpful to better understand the market failure addressed by the IAC program, and whether or not the IAC program overlaps with the private sector in terms of the services being offered and customers served.

Answering these questions rigorously would require a separate and substantial study. However, SRI wanted to contribute to this discussion in a limited way in order to provide context for the impacts reported in the previous sections. We addressed some of these questions in our interviews with IAC directors, students, client companies, alumni, and representatives of energy efficiency firms. We also included questions on the survey of a sample of IAC client companies in which we asked about their motivation for seeking an energy audit and their selection of an IAC to perform the audit as opposed to other possible providers.

This section first describes national trends in the U.S. energy efficiency sector, looking specifically at the market for energy services companies, or ESCOs. It then presents SRI's findings from a very limited number of interviews with ESCOs to explore where the IAC energy audits fit into the broader energy efficiency sector landscape and to what extent, if any, IACs overlap with private sector firms in providing industrial energy audits to the same customers. As reported below, SRI's findings suggest that the IAC program fits into the landscape in several useful ways.

The Broader Energy Efficiency Sector

Increasing recognition of the important role that energy conservation plays in sustainable growth and development have supported expansion of the energy efficiency services sector. The market is dynamic, and new business models and financing instruments have been developed over the last 30 years in response to federal, state, and municipal energy conservation mandates. The target clients in this market tend to take a long-term view of the cost savings associated with improving the energy efficiency of heating, cooling, lighting, and other systems in commercial, residential, and industrial buildings. Key players in this broad and diverse market include:

- Electric utilities,
- Building equipment manufacturers, such as Noresco (Carrier), Honeywell Building Solutions, and Johnson Controls, and
- Energy services companies, also called ESCOs.

In this section, we look specifically at energy services companies, or ESCOs, that provide a range of services to private and public sector clients, from identifying cost-effective energy saving opportunities through implementing these recommendations.

ESCOs perform varying intensities of energy audits, or feasibility studies, which identify energy saving opportunities and calculate the payback period associated with the investment to take advantage of each opportunity. These can range from walk-throughs of buildings at the lowest level of audit to in-depth analysis of past utility bills, measurement of energy usage by different systems over a period of time at the client site, identification of opportunities to save energy and reduce waste streams, and calculation of payback periods. Depending on a particular ESCO's business model and market segment, energy audits may be provided at cost or even as a "loss-leader," to line up future business that may bring the higher margins that an ESCO can make on equipment sales, engineering design services, retrofits, and financing of these capital improvements.

Because of the longer time horizon required to realize the payback for many energy-saving initiatives, the target market for ESCOs in the U.S. are state and federal government agencies, municipalities, universities, K-12 schools, hospitals, and other large commercial, industrial, and residential customers.

Within the ESCO segment of the market, companies can be further disaggregated and categorized by their focus on core expertise in one or more of the following services:

- Identifying and evaluating energy-saving opportunities
- Developing engineering designs and specifications
- Managing the project from design to installation to monitoring
- Arranging for financing
- Training staff and providing ongoing maintenance services
- Guaranteeing that savings will cover all project costs

Energy assessments, or audits, are only one part of this larger set of possible energy services, and it is only in the area of audits that significant overlap with the private sector is likely. In fact, there are several kinds or levels of energy audits, to which the services provided by the IAC program make a contribution, as shown in the discussion in the following section.

Energy Audits

The objective of an energy audit is to identify all the major uses of energy in a facility and to maximize the energy efficiency of these systems without reducing output. Energy audits establish an energy consumption baseline, quantify energy usage according to its discrete functions, benchmark energy usage with similar facilities under similar weather conditions, and identify energy cost reduction opportunities. In the U.S., the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) set the industry standard for the categorization of different degrees of energy audits. ASHRAE is a global, member-based organization that focuses on building systems, energy efficiency, indoor air quality, refrigeration, and sustainability within industry. ASHRAE defines three levels of energy audits:

- ASHRAE Level 1: Walk-Through Analysis
- ASHRAE Level 2: Energy Survey and Analysis
- ASHRAE Level 3: Detailed Analysis of Capital Intensive Modifications

Table 24. ASHRAE Breakdown of Different Levels of Energy Audit by Service and Price. ***Source: ASHRAE and SRI interviews of ESCOs for price estimates***

Type of Audit	Details	Price Range
Level 1	• Brief on-site survey of the facility • Savings and cost analysis of low-cost/no-cost energy efficiency measures • Identification of potential capital improvements that require further analysis	~ $0.05-$0.08/SF OR ~$2,000-$5,000
Level 2	• Detailed on-site survey • Detailed energy usage breakdown • Savings and cost analysis for different energy efficiency measures • Identification of potential energy efficiency measures and require further data collection and analysis	~$0.10-$0.15/SF OR ~$8,000-$12,000
Level 3	• Analysis of capital-intensive energy efficiency measures/projects identified in Level 2 • Detailed field analysis and data collection • Extensive engineering analysis • High-accuracy savings and cost analysis and calculations	~$0.25-$0.50/SF OR ~$20,000-$100,000+

Key Findings from Interviews with ESCOs

SRI conducted a limited number of exploratory interviews with representatives of ESCOs located in the West, Midwest, and Mid-Atlantic regions. SRI selected these subjects by asking IAC Directors and IAC alumni to identify companies that would be willing to participate in the interview; many, but not all, of the ESCO interviews were conducted with employees who are also IAC alumni. While a deliberate sample of this kind limits the more general inferences that can be drawn from the results, it increases the qualitative richness of the answers. Since the subjects included those with experience of both the IAC program

and private sector activities, they had a unique and useful perspective on the questions being addressed.

These companies represented a variety of ESCO industry segments and business models ranging from a primary focus on energy efficiency consulting to energy performance contracts and engineering design, retrofits, and auditing. SRI conducted these interviews to explore where the IAC energy audits fit into the broader energy efficiency sector landscape and to what extent, if any, IACs overlap with private sector firms in providing energy audit services to the same target customers. In total, SRI conducted seven phone interviews with ESCO representatives in October 2014. Topics that SRI asked these firms about included:

- Key products and services offered
- Target customers
- Prices charged for different levels of energy audits
- Where the IAC energy audits fall in the range of energy audits offered by the private sector
- Other programs that offer free or subsidized energy audits
- Perceived benefits of, and competition arising from, the IAC program

1. Industrial clients represent the smallest market for ESCOs

The seven ESCOs described their target market as including K-12 schools; universities; hospitals; commercial buildings; municipal, state, and Federal government agencies; and industrial firms. However, while most of the ESCOs could remember having worked for a few industrial clients in the past, these were large firms and represented the smallest market share for these ESCOs. The one exception was a startup ESCO in the Midwest, focusing on energy efficiency consulting.

ESCO representatives interviewed cited a number of reasons for the limited representation of manufacturing firms in their customer base:

- The energy saving time horizon and payback period for their target customers is 10-plus years, while manufacturing clients tend to look for a 2-3 year payback period.
- State and Federal government agencies, universities, etc., are good customers, because they are responding to top-down energy efficiency mandates and goals for energy savings over a long period of time.
- Given the 2-3 year payback period that small and medium-sized manufacturers are interested in, it is difficult for energy efficiency engineers or maintenance directors to get the $8,000 - $12,000 investment from corporate to do a Level 2 audit.
- For manufacturers, implementing some of the big energy saving recommendations may require taking systems involved in production offline in order to replace equipment. small- and medium-sized manufacturers may not be able to afford to do that, and they may also be wary of introducing an untested piece of equipment into a highly optimized production process.

When asked specifically about the share of total business coming from industrial clients, two companies said less than 10-15 percent of their business in dollar terms came from industrial clients. Another ESCO representative said his company had not had an industrial client yet, and a fourth said they had not had an industrial client for 7-8 years. The other three had had a few industrial clients, but these were large industrial clients.

2. IAC energy audits fall within the ASHRAE Level 1-plus to Level 2 range

When SRI described an IAC energy audit to ESCO representatives, all seven interviewees indicated that the IAC energy audit was in between an ASHRAE Level 1 audit, a walk-through energy audit that identifies no cost/low cost energy savings opportunities, and an ASHRAE Level 2, an energy survey and analysis involving measurements of energy consumption and calculation of the payback period associated with energy saving opportunities beyond 2-3 years.

3. IACs play a synergistic, enabling role in the energy efficiency sector

As mentioned, representatives of all seven ESCOs agreed that, in general, small- and medium-sized manufacturers are operating on such tight margins that they do not

generally invest the estimated $8,000 to $12,000 for a Level 2 energy audit. The representative of the small energy efficiency-consulting firm that actively targets manufacturers in the Midwest said that even for larger manufacturers an energy audit is a tough sell. In his experience, commercial clients may spend $500,000 a year on energy consumption, and will set aside $20,000 to $30,000 for an energy audit to identify energy savings over a 5-10 year period. In contrast, potential manufacturing clients may spend over a million dollars on energy consumption, but will balk at investing $10,000 in an energy audit even if they can save 33 percent of their utility bill. These manufacturers are also looking for an 18-month to two-year payback period.

SRI's survey of IAC client companies also supports the finding of weak market demand from small- and medium-sized manufacturers. Approximately 70% of firms surveyed indicated that they would not have sought an energy assessment that year if the IAC program had not been available to them. [38] However, as an ESCO representative pointed out, because an energy audit can identify significant "bottom line" energy savings for small- and medium-sized manufacturers (which are energy-intensive companies), it's something they should be doing to help them be more cost competitive.

When asked about the role that a regional IAC plays in the energy efficiency market, all of the ESCO representatives stated that the IAC's provision of no cost energy audits to small- and medium-sized manufacturers would likely stimulate demand for equipment vendors and other providers of energy efficiency-related services. A couple of the interviewees who had a relationship with a local IAC said that an IAC audit had set up follow-on work for them. The IAC audit provides a solid baseline Level 2 audit, but it's still an audit performed largely by college students. When companies get serious about implementing some of the more capital-intensive recommendations, they look for a professional audit. Only one ESCO representative could think of a case where the IAC performed an audit for a company that the ESCO would have liked as a client. However, he also said that more often the original IAC audit "opens the door for more work."

[38] SRI survey of IAC client companies.

4. IACs have a positive workforce impact on ESCOs who hire IAC alumni.

SRI's interviews suggest that the IAC program gives students very applied experience performing audits, using data loggers, calculating energy savings and payback periods, writing up recommendations, presenting preliminary recommendations to clients, etc. Nearly all of the ESCO representatives interviewed said they had hired more than one IAC alumni. In the case of the small energy efficiency company, Eight out of 11 of the company employees were IAC alumni, including the founders. In many of the large ESCOs, representatives stated that they had encountered 3-5 IAC alumni at their current job, as well as previous jobs at companies like McKinstry, Johnson Controls, and Siemens. Interviewees estimated that if it takes 3 months to "onboard" a typical new hire, the IAC experience cuts this training time in half.

IAC alumni who are currently working in the energy services sector said their companies turn to IACs to recruit industry-ready, entry-level energy engineers. Some of the interviewees stated that IAC alumni graduate with skills equivalent to capital-grade professional engineers. Energy services companies that employ IAC alumni will recruit other IAC students because these graduates are well trained in energy auditing processes, various energy efficiency analysis techniques, and can recommend energy savings' measures and next steps to clients.

SRI's interviews with ESCOs also indicate that IAC graduates require significantly less on-the-job training and are able to hit the ground running in comparison to other entry-level energy engineers without IAC experience. One interviewee said that IAC engineers would require just a month of on-the-job training while non-IAC engineers would require two to three months of training. As the following quotes illustrate, IAC engineers are a valuable and cost-efficient, industry-ready resource:

- *The IAC provides good applied skills. When someone is looking to hire, they want someone who is trained on latest technologies, and the IACs provide this*.
- *Companies get capital grade PE engineers from IACs. IAC students do a good job and there are no*

other programs like the IAC that trains the next round of energy engineers.

- *IAC students sometimes do up to 50+ audits and are more seasoned than other engineers.*
- *The IAC is a major resource for talent. There aren't many schools with energy engineers ready to go. IAC students have already provided audits, written reports, used loggers: they are ready for the industry and just need to learn additional technologies used on the job.*
- *The private energy efficiency industry thinks that IACs help trim on the job training costs since IAC alumni have field experience in comparison with someone who doesn't and those (non-IAC) candidates take time to ramp up.*

5. IAC energy audits are much broader in scope than energy audits offered by utilities.

In addition to the DOE-funded IAC program audits, some utilities and state energy programs also offer no cost energy audits through third-party vendors to their customers. Utilities that adopt energy conservation targets typically offer such audits in conjunction with rebates for replacement of lighting, HVAC, or other equipment. However, it is important to note that SRI's interviews with IAC directors, lead students, and IAC client companies indicate that utility-sponsored audits are much narrower in scope than IAC audits. While IAC audits include all energy-consuming industrial systems in a plant, utilities' audits are really focused on the particular systems targeted by the rebates.

The Role of IACs in the Energy Efficiency Sector: Market Failures Addressed

This exploratory investigation, which includes the ESCO interviews, the IAC client company interviews and survey, and the IAC Director and student interviews, suggests that the IAC program does indeed target a customer base not well served by the private sector: small- and medium-sized manufacturers. It suggests that imperfect information is the key reason why the market fails these small- and medium-sized manufacturers. Unless a small or medium-sized manufacturer conducts significant research on its own, e.g., calling different ESCOs and seeking input from colleagues internally and in their professional network, they have very limited information about: (1) the firms that provide comprehensive industrial energy audits, (2) the price and quality of the audits performed by these firms, and (3) the "bottom line" cost savings and time horizon in which small- and medium-sized manufacturers can expect a return from implementing the identified energy efficiency opportunities. At the same time, SRI's analysis of IAC data and IAC client company survey responses indicate that, given a set of energy saving recommendations, small and medium-sized manufacturers do implement these recommendations, and they result in energy savings for the company.

SRI's interviews with IAC client companies indicate that small and medium-sized manufacturers are most familiar with HVAC and other equipment vendors who may provide an energy audit of a particular system as a sales tool. A key reasons cited by IAC client companies for their interest in a university-based energy assessment is the perception of the university's objectivity: the university has the requisite expertise, but is not trying to sell any follow-on services or equipment to these companies.[39] The IAC energy audits identify unbiased energy saving opportunities that the company can implement or not, depending on the availability of resources and competing corporate priorities. There is no "hard sell."

In addition to addressing a marked failure caused by imperfect information, this limited investigation also suggests that the IAC program generates positive externalities of three kinds (a positive externality is a benefit that is enjoyed by a third party who is not a party to the original economic transaction). The reduction in pollution and greenhouse gas emissions resulting from implementation of IAC recommendations is a positive externality benefiting the larger public. Similarly, the applied industrial experience gained by university students who participate in IAC energy audits has benefitted ESCOs that later employ IAC graduates. Companies spend significantly less time training IAC alumni compared to other engineering graduates, and this is a direct cost saving to these firms. Finally, by raising the level of information shared by small- and medium-sized

[39] SRI interviews with IAC client companies during IAC site visits.

manufacturers about the benefits of energy efficiency the IAC assessments foster other energy services transactions that might not otherwise occur.

Definitively answering how well the IAC program addresses the market failure for small- and medium-sized companies in the energy services sector is outside the scope of this assessment, although it could be considered in the future as an important subject for a separate study. However, this limited inquiry makes a helpful contribution by mapping the context within which the IAC program operates, and the different ways in which it contributes to increased energy efficiency and increases in the energy efficiency workforce.

Conclusions

This report is based on a rich and comprehensive set of research activities and analytical approaches, including:

- Participation in the annual IAC director's meeting
- Site visits with five IACs
- Interviews with directors at all other presently funded centers
- Interviews with students
- Interviews with client firms
- A survey of a sample of client firms
- Interviews with staff from the program's Technical Management Center at Rutgers
- Interview with staff from the IAC alumni group at Oak Ridge National Laboratory (ORNL)
- Detailed analysis of the IAC database at Rutgers
- Analysis of IAC student graduate exit surveys
- Analysis of a survey of a sample of IAC graduates
- Analysis of a sample of IAC graduate resumes, together with two control groups
- Analysis of panel data on sales and employment by IAC and non-IAC manufacturing firms
- Interviews with energy services companies

In addition, the research team reviewed earlier studies of the program, other studies of energy efficiency programs, and other background materials, including federal funding announcements. In particular, the IAC program benefits from the work of the Technical Management Center at Rutgers, which carefully maintains complete longitudinal data regarding program activities and outputs. The work of the alumni group at ORNL is also an indispensible contribution to understanding the impact of the program on students.

The data available on both participant groups (manufacturers as defined above and students) varied widely, as does availability of data for potential comparison groups. The investigation attempted to analyze data from the largest time period available; however, different data sources had different limitations and, therefore, different time periods were used. The time periods used are identified in the table below.

Findings

The findings from this research indicate that the IAC program had a measurable impact on energy saved and energy efficiency skills developed. (See Table 25.)

Target Clientele

The IAC program targets a group of companies who could benefit from increased energy efficiency but who are not well served by the private sector: small- and medium-sized manufacturers. These firms fail to seek out and adopt energy efficiency practices due to imperfect information. Unless they conduct significant due diligence on their own, e.g., calling different service providers and seeking input from colleagues internally and through their professional network, these companies have very limited

Table 25. Summary table.

Objective	Metric	Data Source	Time Period Investigated	Findings
Increase the energy efficiency of small- and medium-sized manufacturers	Energy efficiency	IAC database SRI survey of IAC clients	FY1997-2013	**An estimated 54 million MMBtu of gross energy saved** **An estimated 6 million metric tons of gross carbon dioxide emissions avoided**
			FY2009-2013	**An estimated 21 million MMBtu of net energy saved**
Increase the productivity	Sales and employment	NETS data	2002-2012	**No evidence of increased sales or employment compared to matched untreated sample**
Develop next generation of engineers with experience in energy efficiency	Energy efficiency skills	SRI survey of IAC alumni	1990 - 2014	**IAC students graduate with specific, applicable energy efficiency skills (no control group)**
		SRI survey IAC alumni IAC student exit survey		**IAC students graduate and take jobs in energy efficiency fields, expanding the pipeline of energy efficiency engineers (no control group)**
		Resumes		**IAC graduates accumulate significantly more energy efficiency skills, with a higher market value, compared to two control groups**

information about the value of an energy audit and about how to obtain one from private providers.

At the same time, SRI's analysis of IAC data and the IAC client survey responses indicates that, given a set of energy saving recommendations, small- and medium-sized manufacturers will implement many of those recommendations and benefit from energy and cost savings. The IAC program directly addresses this market failure by providing reliable information at low cost to these firms, who then act on the information provided.[40]

Energy Savings

The energy efficiency recommendations implemented by client companies yielded an estimated gross energy savings of 54 million MMBtu between fiscal years 1997 and 2013, and estimated net energy savings of 21 million MMBtu for the same time period (under the conservative assumption that energy savings persist for only one year following implementation).

These energy efficiency savings represent over 480 MBTUs annually in gross energy savings for every Federal dollar invested in the program (2013 inflation-adjusted dollars, for FY1997 to FY2013).

IAC recommendations have mobilized over half a billion dollars of private investment in energy saving recommendations between FY1997 and FY2013.

Energy Efficiency Workforce

The IAC program has increased the number of students who pursue energy efficiency careers and has imparted skills to them that are highly valued by the private sector.

The IAC program is contributing to a larger pipeline of energy efficiency engineers. SRI's survey of IAC alumni found that 70% of students who became involved with the IAC program said their experience made them more interested in energy efficiency careers. In addition, about 40% of the respondents who did not have a stated interest in energy efficiency coming into the IAC program went on to have careers in the energy sector.

IAC students graduate with skills that are highly valued by the private sector. In SRI's resume skills analysis, the specific skills that IAC graduates listed in their resumes

[40] While IACs provide their services at no cost, there is a price paid by IAC clients in terms of staff time required, in addition to the costs of any specific energy efficiency recommendation.

were significantly different from those of the comparison group. IAC alumni include more skills and more valuable skills directly related to energy efficiency in their resumes.

Recommendations

After analyzing the data and reflecting on the findings, the team identified three areas in which changes to the program could be considered. These changes could improve the impact of the program, and improve the quality of information available for future assessments.

Energy Savings

High Value Recommendations

A recurring subject for discussion at IAC director meetings is the percentage of IAC recommendations that are adopted. It is important to note that small- and medium-sized manufacturers' adoption rates are a function of payback period, availability of corporate resources, and sustainability mandates that may be coming down from original equipment manufacturers (OEMs), such as Siemens or Honda, or big box retailers, such as Wal-Mart. In the short term, IAC interviews find that SMEs tend to implement low-cost or no-cost IAC recommendations first, and are opportunistic about higher-cost investments.

However, SRI's interviews with IAC directors and client companies also point to examples of implementation of "big ticket" items that result in significant energy savings but require more time to line up investment or to wait for the availability of manufacturer or utility rebates. Company representatives interviewed indicated that the identification of a range of energy saving recommendations, even ones that require more significant investment and have longer payback periods, were valuable to them. SRI's client company survey found that while 67% of the implemented recommendations were put in place within one year, 33% of recommendations took a year or more to implement.[41] For this reason, assessment teams should not shy away from substantial recommendations with longer payoffs if the opportunity to propose them arises.

Follow-Up

One of the most important and somewhat intractable challenges facing the program is follow-up. Naturally, once the assessment is complete, client company staff has only a limited interest in responding to requests for feedback. But this feedback is critical for making accurate assessments of implementation rates. This is compounded by the fact that a 6-9 month timeframe for contacting clients will likely underreport the implementation of high-value recommendations, which may take more time and planning to fund.

Following up a second time, for example after two years, may capture the implementation of higher value recommendations. However, a second follow-up assessment brings with it its own set of difficulties. After that lapse in time, personnel may have changed, the firm may have moved or gone out of business, and the institutional memory of the assessment and any implementation activities may be significantly degraded. In addition, follow-up takes time and resources. One solution might be to do rigorous long-term follow-up, including measurement of persistence if possible, but only with a small random sample of IAC client firms.

Tracking Graduates

The IAC Forum, at Oak Ridge National Laboratory, has developed a complete set of practices for tracking IAC students until they leave the program. These include the valuable exit survey reported above. However, it is harder to follow graduates after they go off and pursue their careers. It is to the credit of the program, and indicative of the sentiment towards it of those who participated, that over 500 graduates belong to a LinkedIn group of alumni. However, it would be very helpful for future program assessments if graduates were more comprehensively tracked over time, so that at least current contact information is available. Something as simple as systematically obtaining email addresses beyond college email accounts (gmail, yahoo, etc.) and using them on an occasional basis to communicate with alumni would be helpful.

[41] Percentages exclude respondents who did not respond or did not know when the recommendation had been implemented.

Appendix A: Additional Information on Methodology

Program Circumstances

While the IAC program dates back to the 1970s, data on recommendations implemented (and hence energy saved) have only been collected since 1981. Interviews with the field manager revealed that the data they considered most reliable were collected from 1997 on due to changes that were made to the reporting of electricity use and savings to better reflect the method of billing by most electric utilities. In the past, the average cost of electricity (per kilowatt-hour) was used; starting in FY1997 this value was broken up into electric consumption (kwh), demand charges (kw-month/year), and other electric fees.[42] Per each company's agreement with the IAC, the company's participation in the program is public information; however, all data collected and recommendations given are confidential. SRI International signed a non-disclosure agreement with the IAC field manager to obtain information about each client. In addition, SRI obtained verbal or email agreements from specific clients to send each client a survey asking about its specific recommendations. This was needed to reduce recall issues related to the recommendations given to each client.

IAC programs are not required to maintain records of students who participated in the program; however, since 2000 the program has strongly encouraged participants to sign up with the IAC student database, managed by a program manager at Oak Ridge National Laboratory. This database tracks students, and once a student completes six assessments, the student is issued an IAC certificate. Students who participated in the program prior to 2000 are able to register with the database and obtain a certificate retroactively.

Research Questions

This ex post facto design evaluation focused on assessing the impacts of the IAC program. Table A-1 displays the three guiding research questions. While the federal funding announcement for the program

[42] Muller, M. and W. Clark. *Savings generated by the Industrial Assessment Center Program: Fiscal Year 1999.* https://iac.rutgers.edu/redirect.php?rf=99an_rep.

listed the specific goals, open-ended interviews were conducted to gather impacts and to develop the project's research questions. Where possible, a comparison group of non-participants was constructed in an attempt to measure the outcomes that would have occurred without the IAC program. As mentioned in the body of the report, this was done for students; however, no one, including SRI, has been able to construct a comparison group of firms with their energy usage data. Firms consider these data to be propriety and only release this information to the IAC program as a condition of participation and under strict confidentiality. Appendix A reviews the methods of the evaluation. The following tables (A-1 and A-2) summarize the research questions and analysis groups detailed in the main report.

Table A-1. Research questions , approach, and data source.

Research Question	Quantitative Approach Data Source	Qualitative Approach Data Source
To what extent has the program impacted energy efficiency at small- and medium-sized businesses?		Director interviews Client survey
Has the IAC program served its target population?	IAC database	
To what extent has the IAC program resulted in specific energy saving recommendations being implemented at the target population?	IAC database Client survey	Director interviews Client survey
To what extent has the energy saved by IAC participants impacted sales and employment?	Fixed effects analysis of sales and employment of participant firms compared to non-participant firms	
What is the program's contribution to training the next generation of engineers with experience in energy efficiency?		
To what extent has the IAC program increased the number of energy efficiency-related skills in engineering graduates?	Analysis of skills on resumes of participants compared to non-participants	IAC director interviews Alumni survey
To what extent has the IAC program induced engineering graduates to enter into an energy efficiency-related job?	Analysis of skills on resumes of participants compared to non-participants	Alumni survey
What has been the impact of the program on energy services firms and their workforce needs?		Interviews with firms

Table A-2. Objectives and outcomes.

Objective	Relevant Outcomes Measured
Manufacturer energy savings	Gross energy savings Net energy savings
Imparting unique energy efficiency skills to student	Resume skills Student-reported skills on survey
Increasing energy efficiency workforce	Resume job listing Student reports on survey

Evaluation Research Design

Comparison Groups

It was the desire of the team to use quasi-experimental methods where possible. These designs usually consist of measurements taken before participation and after participation and, ideally, a comparison group closely matched to participants on key characteristics such as size, energy usage, industry, geography, major, graduation year, and institution. The difference in the outcomes of the participant group and the comparison group can be attributed to the program, as the comparison group represents what would have happened to the participant group without the IAC program.

As shown in the Table A-3, two participant groups were studied: manufacturers and students. The data for recommendations implemented by manufacturers were collected throughout the program, though as described above and below, we used a survey of manufacturers that participated between FY2009 and FY2013 to inform the analysis of the energy-related numbers. Pre-participation information was collected through the IAC assessments – IACs did not make recommendations that a manufacturer already had implemented. Therefore, for all recommendations, the pre-participation value would be "not implemented." The post-participation survey response on whether a recommendation was implemented after the assessment was delivered is the value recorded for implemented – yes, no, or planning to.

As detailed in Appendix B (Background), comparison groups for the evaluations of energy saved were not available. Instead, the standard is for evaluation to construct a counterfactual based on a survey of participants.

Table A-3. Details about comparison groups.

Participant Group	Comparison (Non-participant) Group
Manufacturers	
IAC clients sales and employment	Non-IAC client manufacturers
Students	
IAC student resumes	Comparison group matched on school, graduation year, and major
	Comparison group based on energy efficiency career

Firm Comparison Group Construction

We define establishments that received IAC assessments between FY2002 and FY2011 as the "treatment" group and all other small- to medium-sized (500 employees or less) U.S. manufacturing establishments active during the analysis period as the control group. However, data quality and disambiguation issues made treatment group identification difficult. SRI utilized exact and fuzzy matching searches on names, addresses, and zip codes (and combinations thereof), supplemented by manual searches of the Hoover's database, to identify potential matches. The search results were then reviewed by hand for verification and disambiguation. In total, about 55% of the treatment group was successfully identified, and another 12% (including possible matches that could not be confirmed or disambiguated) were removed from the control group. It is therefore the case that about one-third of treated firms are in fact included in the control group, but given that these firms represent only about 0.1% of the control group, any attenuation bias should be small. Of greater concern is the possibility that our ability to identify firms in the NETS database might be correlated with the dependent variable, and this may indeed be the case to a limited extent. However, anecdotal evidence indicates that many of the difficulties encountered are from data quality issues not likely to be strongly correlated with outcomes. For example, companies may formally change names but continue to be known locally by their former titles; roads may be known by multiple names; establishments may have multiple access points and therefore addresses; and IACs may use different abbreviations, spellings, or versions of company names than the NETS database.

Alumni Data Comparison Group Construction

The alumni database does not include pre-participation information related to the impacts of the program; therefore, this project constructed a comparison group based on a match of university, major, and about the same graduation year. Since we expect that student volunteers are more interested in energy conservation and the environment than randomly selected college graduates, potential differences between the groups, if they exist, can bias the results in favor of the desired treatment outcomes. To account for this possibility, a second comparison group was used, consisting of energy efficiency professionals whose resumes were posted on Indeed.com during the Fall of 2014.

Samples and Data Collection

Table A-4 summarizes sample design. The sample sizes were developed from considerations of cost, predicted response rates, and statistical power of the test.

Table A-4. Sample size design.

Group Investigated	Interviews Sought or Survey Invitations	Response Rate	Sample Design
IAC directors	24	100%	Universe of all IAC directors funded in 2014
Participating manufacturers	700	26%	Random sample drawn from the universe of manufacturers that participated in the program from FY2009 to FY2013
Energy services firms	9	100%	Sample of convenience for non-statistical purposes
IAC alumni	500	85 resumes; 113 surveys	Random sample drawn from the universe of 2,299 alumni in the IAC alumni database
Non-participant college graduates	1,500	301 resumes	Matched on the 500 drawn on institution, graduation date +/- 2 year, and major
Non-participant energy professionals	5,248	867	A weighted sample based on career length from universe of energy professionals whose resumes were posted on Indeed.com in Fall 2014

Methods

The quantitative analysis described above, limited to the described databases, cannot account for the reality that the services delivered and other activities of each IAC are likely to be similar, but not identical. The major consequences of these differences were accounted for through a combination of site visits and telephone interviews with all currently funded IAC centers. These visits and interviews provided detailed information about inputs, activities, outcomes, and impacts, and the relationships among them that would not emerge from the quantitative data analysis.

Because IAC program clients are generally drawn from those firms within a distance of 150 miles from a center, each site visit, where possible, included a limited number of client visits wherever possible. Site visits to selected centers informed a subsequently developed telephone interview protocol that was used in interviews with centers that were not visited. The results were integrated with the results of client surveys and the data analysis described above.

For budget- and time-related reasons, only five sites were visited. Locations were chosen to maximize the diversity based on geographic and institutional characteristics. All remaining center directors and selected staff were interviewed over the phone. These activities informed the development of the client and alumni surveys. The site visit protocol is contained in Appendix C.

The IAC database includes information on the location, size, and industrial sector and sub-sector of every client firm served. The detailed data in the IAC database can reveal a great deal of information regarding the effects of the IAC program activities and recommendations. We supplemented this information with a firm survey (described below) that asked about persistence of these recommendations. Our analysis of the IAC database includes which recommendations are most

commonly implemented, which recommendations result in the greatest efficiency gains, and differences in implementation patterns between different types of firms.

The SRI team designed and implemented a short web-based survey of firms that received IAC assessments from FY2009 to FY2013. The web survey was designed to gather more detailed and longer-term information about implementation and persistence. The survey frame was limited to firms served in the past five fiscal years so that respondents could be expected to remember their actions reasonably accurately. This pool is comprised of approximately 2,158 firms. A statistically valid sample of 710 firms from this group was invited to participate in the survey via phone or email, to give SRI permission to confidentially discuss which recommendations they received, and to confirm their email address. Until they accepted or declined, the SRI team made two attempts to contact the firms by phone and also by email (if a valid email address was available). Note that email addresses were more frequently available for firms that had received their assessments recently, and contact information was more often up to date for those firms as well. In the case where the original contact person was no longer with the firm, a reasonable effort was made to identify that person's replacement or another employee who was involved with the assessment process, although this was not always possible. These factors likely contributed to the lower response rates observed for earlier assessments.

283 firms agreed to be included in the survey, and email invitations were sent to each of these firms (with the exception of three firms that instead received phone calls). At least two reminders and a follow-up call were sent to non-respondents. A total of 182 firms submitted completed surveys, for a total response rate of about 26%. The response rate is not consistent across years, but declines from 42% for firms that received assessments in FY2013 down to 12% for firms that received assessments in FY2009. In some cases, firms that received assessments in earlier years were no longer in business. For many manufacturers, turnover was high and new personnel were not familiar with the IAC audit, especially for clients served more than two years ago. As a result, the causes and size of non-response bias likely shift somewhat over the years, such that temporal trends observed in the survey data are unlikely to be reliable.

Records of IAC recommendation implementation in the IAC database also reveal differences between firms that responded to the survey versus firms in the sample that did not respond. On average, respondent firms implemented more recommendations and more energy savings than non-respondent firms. Respondent firms implemented about 40% of recommended energy savings, versus 35% in non-respondent firms. (See Table A-5 for all descriptive statistics and statistical test between the groups. The right column displays the p-value for an independent t-test between the means – only the difference in the number of implemented recommendations was statistically significant). Which group generated more cost savings as a result of implemented measures depends on the measure of central tendency utilized: respondent firms had a higher median but lower average cost savings per firm.

Table A-5. Descriptive statistics for client firm respondents versus non-respondents. *Participant years FY2009 to FY2013*[43]

	Respondents	Non-respondents	p-value
Mean number of employees	215.1 (254.4)	191.2 (220.5)	**0.260**
Median number of employees	142.5	125	
Mean sales (USD)	$124 million ($471 million)	$64 million (128 million)	**0.094**
Median sales (USD)	$39.5 million	$30.0 million	
Mean # of IAC recommendations implemented	4.0 (2.47)	3.4 (2.71)	**0.007**
Median # of IAC recommendations implemented	4	3	
Mean energy savings implemented from IAC recommendations (standard deviation)	7,312 MMBtu (19,917)	6,431 MMBtu (17,858)	**0.598**
Median energy savings implemented from IAC recommendations	2,482 MMBtu	2,040 MMBtu	
Mean cost savings implemented from IAC recommendations (standard deviation)	$49,980 (102,996)	$54,480 (170,632)	**0.673**
Median cost savings implemented from IAC recommendations	$23,020	$19,910	

[43] All statistics presented in this table are based on the IAC database, not on client survey responses.

Given these modest response rates, survey results should not be considered as representative of the broader IAC client firm population. For example, the higher implementation rates observed in respondent firms suggest that these firms may have been more engaged with, interested in, or happy with the results of their IAC assessments. If so, we would expect that our results might overestimate the positive impacts of the program. Nonetheless, because we are able to identify the respondent firms within the IAC Assessment Database, useful comparisons can be drawn between results from the database and survey results that are internally valid to the respondent population. Due to possible response bias and measurement error, we do not recommend that such findings be directly applied to the entire IAC client firm population. However, the survey results do provide some suggestive insights into how we might think about longer-term implementation, net energy savings, and persistence.

The survey was formulated using tested methods to maximize response rates (short survey instruments with clear instructions and reliable wording, and personalized follow-ups as necessary). Brevity was relied on heavily to encourage responses. The survey instrument includes open-ended and structured-response items. Questions focus on program implementation and satisfaction. The instrument was drafted and reviewed by SRI staff members trained and experienced in industry surveys; the draft instrument was pre-tested with four different client firms. The survey was administered by our team using LimeSurvey. Data analysis used the LimeSurvey software, Microsoft Excel, R, and SAS. Statistical tests were used where appropriate to compare the sample characteristics versus the universe characteristics and to compare group outcomes. All interviews were done by SRI staff. The surveys were coded by SRI staff in LimeSurvey and hosted on LimeService.com. Unique invitations with unique tokens were issued to invitees to avoid multiple submissions and to facilitate a higher response rate through the use of targeted reminders. Respondents were assured confidentiality.

We further extended this analysis by examining whether participating in an IAC assessment is correlated with economic growth of establishment-level increases in sales and/or employment. Valid estimates of such impacts require detailed data on employment and sales over time, for both IAC-served firms and a credible comparison group of firms outside of the program. Panel data on establishment-level sales and employment by IAC and non-IAC manufacturing firms were drawn from the 2012 National Establishment Time-Series (NETS) Database and analyzed using establishment fixed effects. This approach allowed us to control for unobserved time-invariant heterogeneity across firms that do and do not receive IAC assessments. For example, we expect that the firms that receive assessments on average have more proactive management, or conversely have less internal capacity or access to private sector energy services. Such characteristics would of course also matter to an establishment's efficiency and overall performance, such that standard OLS regression estimates of program impact would be inconsistent due to selection bias. Post-specification tests do in fact indicate that pooled OLS estimates are biased due to unobserved heterogeneity. If we assume that such characteristics are reasonably time-invariant, a fixed-effects analysis controls for these differences by allowing a unique intercept, or individual fixed effect, for each establishment.

Student Impacts

A separate and important impact of the IAC program is its effects on the careers and contributions of the students who participate. Analysis of participants and non-participants provide insight into the career impact of IAC participation. This project utilized two sources of data on student impacts –analysis of alumni resumes and an alumni survey.

To obtain an accurate representation of the student population as well as a high response rate, we drew a random sample from the pool of names. There were about 2,299 students who participated in an IAC in mid-2014; therefore, to obtain a margin of error of 5% at a 99% confidence level, assuming a response distribution of 50%, a sample of 500 was drawn. This enabled us to focus our efforts on obtaining high response rates (through direct, individual contact) while also being able to attempt to characterize the population that did not respond. A random sample of 500 students was drawn from the alumni database of 2,299 students. Of these, 14 did not have email addresses and 391 had email addresses that bounced. Through web searches and contacting alumni through LinkedIn, emails for more than 200 alumni were gathered, for a total of 352 working email addresses.

Resume Analysis

Despite multiple attempts to reach the randomly selected participants directly, only 85 resumes were received. To supplement these resumes, a search of the online resume database Indeed.com was conducted. An additional 24 resumes associated with non-responding sampled participants were identified, bringing the total participant resume count to 109.

Two comparison groups were developed based on matching characteristics in the Indeed database. A "cohort" comparison group was selected based on: university, degree, major, and graduation date +/- 2 years. 301 resumes matching these criteria were identified. A second comparison group of energy professionals was identified from the Indeed database based on searching of job titles.[44] 5,248 resumes were identified through this search query. To make a more robust comparison, a subset of these resumes was selected to match the total time in workforce characteristics of the IAC participant sample. The final energy professional comparison group therefore consisted of 867 resumes.

To control for potential bias introduced by varying career lengths between the IAC participant sample and the two comparison groups, a stratified random subset of the comparison groups were drawn to match the career length characteristics of the sample group. The figure below shows the distribution of career lengths (in days) calculated from resumes in each of the three groups. The Kolmogorov-Smirnov test tests the null hypothesis that 2 independent samples were drawn from the same continuous distribution. Results for the KS test indicated that the IAC Participant and "cohort" groups did not deviate significantly from each other (D=0.077, p=0.7299) while the "energy" group was drawn from a different population (D=0.4016, $p < .0001$).

[44] Job titles included: "Energy Efficiency Engineer", "Energy Manager", "Energy Engineer", and "Energy Auditor"

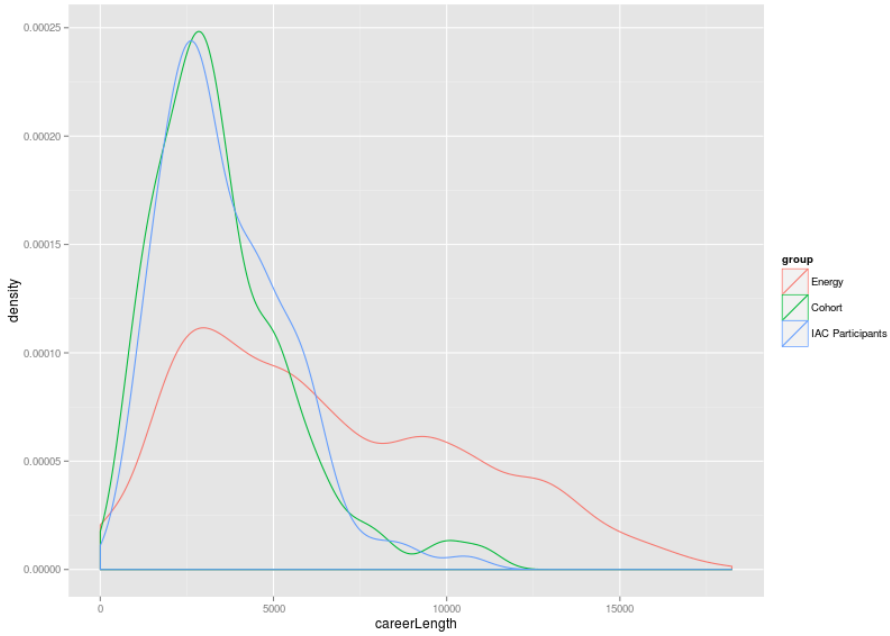


Figure A-1. Career length of different universe of each comparison group compared to the IAC participant group. ***Sample Source: Resumes, participant years 1990-2014.***

Because the significantly increased length of careers for many individuals in the "energy" group could confound metrics related to skill valuations and career trajectories, a "career-length-corrected energy" group was drawn from the broader "energy" group. The process used was:

1. Calculate deciles for the IAC participant" group.
2. Randomly sample an identical number of resumes from the "energy" group for each decile range from the IAC participant group.

The figure below shows that the career lengths of the resulting "career-length-corrected energy" comparison group are similar to the IAC participant group. Results from the KS test indicate that IAC participant groups and the "career-length-corrected energy" group do not deviate significantly from each other. (D=0.0845, p=0.4547)

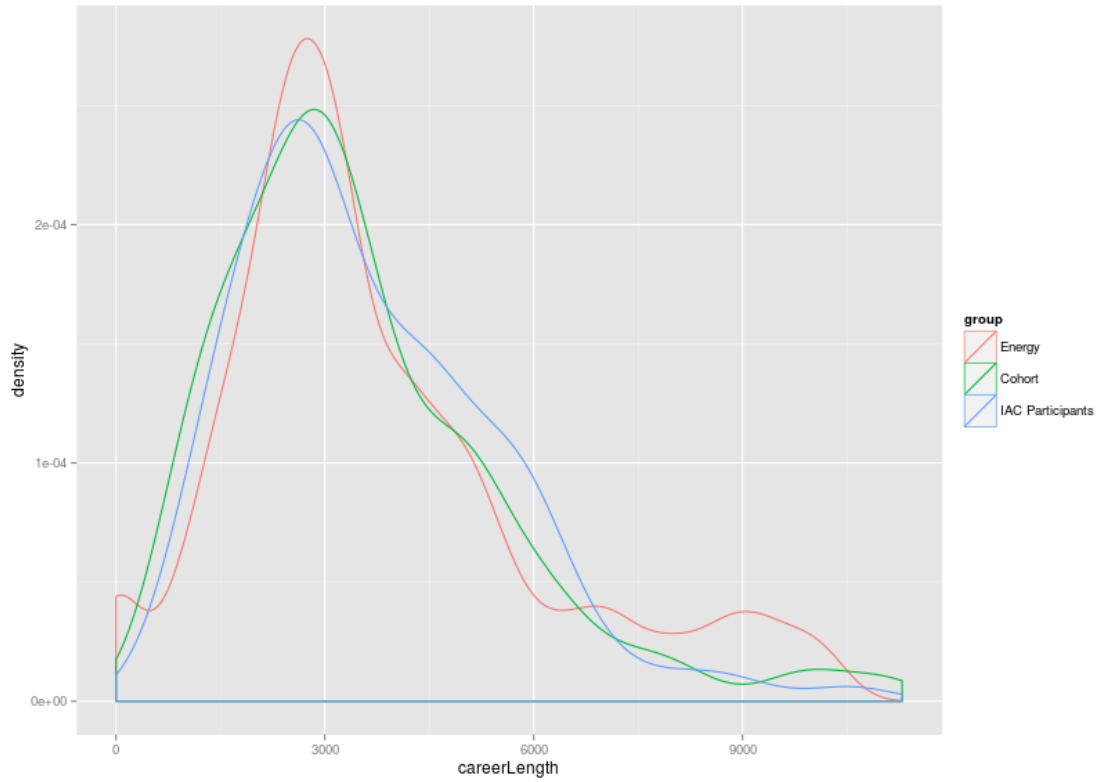


Figure A-2. Career length of resulting comparison group compared to the IAC participant group. ***Sample Source: Resumes, participant years 1990-2014.***

Skills Analysis

To assess the impact of program participation on skills, skills were extracted from each resume's "summary" or "overview," job descriptions, and "skills" sections. The Brookings Institution developed the list of skills used for this analysis for a recent study of the STEM workforce.[45] Of the approximately 9,000 skills identified in the Brookings study), SRI identified approximately 400 that were closely associated with energy efficiency activities. The analysis presented in this report is based on the energy efficiency-related skills only. Each skill extracted from a resume is associated with a value derived from Brookings analysis of millions of job postings. Metrics employed in the study include the number of skills identified on each resume, the total value of skills included on each resume, and the average value of skills included on each resume.

[45]Rothwell, Jonathan. "Still Searching: Job Vacancies and STEM Skills." Brookings Institution. July 2014. http://www.brookings.edu/~/media/research/files/reports/2014/07/stem/job%20vacancies%20and%20stem%20skills.pdf

Table A-6. Descriptive statistics of resume analysis.

	Sample Resumes	Matched Comparison Group	"Energy" Comparison Group
Number of resumes	109	301	1815
Mean career length (days)	3,607	3,508	3,765
Number of skills on resume	23	19	19
Number of energy efficiency skills on resume	9.0	4.3	5.4
Number of jobs on resume	5.1	4.1	4.8
Number of energy efficiency jobs on resume	1.6	0.1	1.2

Career Trajectory Analysis

To analyze career trajectories, SRI developed an automated text classifier to identify jobs associated with energy efficiency based on the job title and the job description extracted from resumes. The text classifier was tested against a randomly selected sample of 200 job descriptions that were classified by a human analyst. Against this test set, the classifier achieved 96% accuracy. Because most jobs included in resumes include a start and end date, metrics such as an individual's total time in an energy efficiency job and start date of an individual's first energy efficiency job can be calculated in a straightforward fashion.

Statistical Methods

Many of the resume metrics presented in this study are group means of individual resume characteristics. To verify the significance of any differences reported, a series of t-tests were conducted (displayed in Table A-7).

Table A-7. Statistical testing of differences between groups.

Metric	Sample	Energy	Cohort	t-test p-value
Mean number of days from start of career to first EE job	856	1634		1.6e-07
Mean number of days from start of career to first EE job	856		1146	0.2398
Mean share of career time spent in EE jobs	42%	28%		2.2e-16
Mean share of career time spent in EE jobs	42%		4%	2.2e-16
Mean share of career time spent in EE jobs after first EE job	54%	48%		0.1155
Mean share of career time spent in EE jobs after first EE job	54%		6%	2.2e-16
Number of EE skills	8.9	5.5		9.6e-09
Number of EE skills	8.9		4.3	3.3e-13
Mean value of EE skills	72964.98	66754.02		5.1e-09
Mean value of EE skills	72964.98		69947.66	0.0277

Alumni Survey

A short alumni survey was sent to the 353 working email addresses in the sample. 113 alumni took the survey; 109 submitted complete responses. (See Appendix C for the survey instrument and frequencies.) Closed-ended results were analyzed with standard statistical techniques while open-ended responses were reviewed and used as context throughout the report.

Overlap between the Populations

While the same sample was used to contact alumni for their resume and to take the survey, 10% of the total alumni provided a resume and took the survey; 10% took only the survey; and 10% only provided a resume (as displayed in Table).

Table A-8. Percent of sample alumni who were in each respondent group.

	Count	Percent of Total Sample
In both samples	59	12%
Resume only	49	10%
Survey only	54	11%
Grand Total	162	33%

Appendix B: Background

Background for Impact Evaluations of Energy Efficiency Programs

The energy efficiency impacts presented in this evaluation of the IAC program are primarily drawn from guidelines laid out by the Environmental Protection Agency (EPA) and the National Action Plan for Energy Efficiency in the 2007 publication, *Model Energy Efficiency Program Impact Evaluation Guide,*[46] and the 2012 update, *Energy Efficiency Program Impact Evaluation Guide*.[47] This EPA guide provides a framework that government agencies, regulatory bodies, and organizations can use to define their "institution-specific" or "program/portfolio-specific" evaluation requirements. The guide defines a standard evaluation planning and implementation process, describes several standard approaches that can be used for calculating energy savings, defines terms, and provides advice on key evaluation issues. This guide was created by distilling the approaches and best practices of numerous guides, protocols, papers, and reports from the last 30 years, including the *International Performance Measurement and Verification Protocol* (IPMVP), California Public Utilities Commission's (CPUC) 2006 publication *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals,* CPUC's 2004 publication *California Public Utilities Commission Evaluation Framework*, and others.

SRI also reviewed a number of other guides and reports when establishing its methodology, including the National Renewable Energy Laboratory's (NREL) 2013 publication, *Uniform Methods Project:*

[46] National Action Plan for Energy Efficiency (2007). *Model Energy Efficiency Program Impact Evaluation Guide*. Prepared for the Environmental Protection Agency and the Department of Energy.
[47] State and Local Energy Efficiency Action Network. (2012) *Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group*. Prepared for the Environmental Protection Agency and the Department of Energy.

Methods for Determining Energy Efficiency Savings for Specific Measures,[48] as well as numerous energy efficiency program evaluations.

Evaluations of energy conservation and efficiency programs primarily focus on two impacts related to energy savings: (1) Estimates of **gross savings** and (2) estimates of **net savings.** Depending on the type of program(s) under review, evaluations may also look at other non-energy benefits and outcomes, such as avoided emissions, increased/decreased maintenance costs, or job creation. Evaluations may also include estimates of the **persistence** of energy savings, though rigorous persistence estimates are not normally included in energy efficiency program evaluations.

Calculating Gross Savings

Gross energy savings are the change in energy consumption (or demand) that results directly from program-promoted actions taken by participants, regardless of the extent to which the program influenced their actions. This is the physical change in energy use after taking into account factors not caused by the efficiency actions, such as weather or operating hours. Estimates of gross energy impacts involve a comparison of changes in energy use over time among participants who installed measures with some baseline level of usage. These baseline levels may be taken from facility energy use prior to program participation, energy use in comparable facilities, codes and standards, or direct observation of conditions in buildings not addressed by the program.

The EPA guide identifies three approaches to calculating gross energy savings:

1. **Deemed savings**. Savings are based on stipulated values, which come from historical savings values of typical projects. In this approach, there are no, or limited, measurement activities, and only the installation and operation of the efficiency measures are verified. This approach involves multiplying the number of installed measures by the estimated (deemed) savings per measure.
2. **Measurement and verification (M&V).** A representative sample of projects in the program is selected, and the savings from those selected projects are determined and applied to the entire population of projects.
3. **Large-scale data analysis**. Statistical analyses are conducted on the energy usage data (typically collected from the meter data on utility bills) for all or most of the participants and possibly non-participants in the program. This approach is primarily used for residential programs with relatively homogenous participants and measures, when project-specific analyses are not required.

Of these three approaches, deemed savings seems to be the predominant method of estimating gross energy savings in large-scale industrial, commercial, and residential energy efficiency program evaluations. The 2013 report, *Evaluation of the Hawaii Energy Conservation and Efficiency Programs,*[49] was an impact evaluation, process evaluation, market assessment, and baseline study of eight business and residential energy efficiency programs in Hawaii. The eight programs use the deemed savings approach based on the historical savings of different efficiency modifications. The program evaluation

[48] Tina Jayaweera and Hossein Haeri. (2013) *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. National Renewable Energy Laboratory.
[49] Evergreen Economics. (2013) *Evaluation of the Hawaii Energy Conservation and Efficiency Programs*. Prepared for the State of Hawaii Public Utilities Commission

compared utility meter energy use data to the claimed savings from a sample of program participants to verify the claimed energy savings of the program. The 2011 report, *Evaluation of the Non-Residential Smart $aver Prescriptive Program in North and South Carolina,*[50] was an evaluation of several programs that provide rebate incentives to customers for installing qualifying high-efficiency lighting, cooling, motors or pumps, and these programs also use the deemed savings approach. Projected efficiency measure savings for lighting fixtures were based on fixture wattage data developed by Franklin Energy Services, and HVAC savings were based on the Ohio Technical Reference Manual (TRM). These savings were then multiplied by the facilities' annual operating hours, which were self-reported by the clients, to create the overall estimate for gross savings. The evaluation found the algorithms used by the program tracking database used to record energy savings to be in error, and recommended a revised set of savings estimates for each efficiency measure in the program database.

The 2010 report, *Process and Impact Evaluation for the Colorado Business Cooling Efficiency Program,*[51] was an evaluation of a program that provides rebates to non-residential customers for a range of qualifying HVAC equipment to lower up-front costs and decrease the payback period of efficient equipment. The program also uses the deemed savings approach, calculating savings based on algorithms from Xcel Energy's Cooling Efficiency Program's Technical Resource Manual (TRM) to estimate the energy savings for end-use cooling measures. The evaluation found the algorithms used by the program to be consistent with algorithms used in similar programs.

The 2011 report, *Evaluation of the 2009 Energy Conscious Blueprint Program*,[52] reviewed a program that provides technical assistance and financial incentives to customers and their contractors to increase the energy efficiency and performance of lighting systems, industrial processes, HVAC systems, motors, and other energy use components of C&I buildings. This evaluation used the M&V approach, visiting a sample of program participants to verify installation of the program-qualifying equipment and conduct spot measurement and data logging of the installed equipment. Evaluators then calculated the difference between company-reported savings and evaluated savings to adjust the gross savings of the program. The 2008 report, *Impact Evaluation of 2005 Custom HVAC Installations*,[53] reviewed a program that provides technical and financial assistance to commercial and industrial customers for equipment and building energy efficiency improvements through the Energy Initiative and Design 2000plus programs. This evaluation also used the M&V approach from a sample of program participants, using the results to adjust the overall gross savings estimates of the program.

Net Energy Savings

The net energy impact is the percentage of the gross energy impact attributable to the program. Estimating net energy impact typically involves assessing free-ridership and spillover. "Free-ridership" refers to the portion of energy savings that participants would have achieved through their own initiatives and expenditures without participating in the program. Participant "spillover" refers to the situation where a participant installed equipment through the program in the past year and then installed additional equipment due to program influences, but without direct program support. The difference between net and gross savings is called the net-to-gross ratio (NTGR).

[50] Nick Hall, Brian Evans and John Wiedenhoeft. (2011) *Evaluation of the Non-Resident Smart $aver Prescriptive Program in North and South Carolina*. Prepared for Duke Energy.
[51] PA Consulting Group. (2010) *Process and Impact Evaluation for the Colorado Business Cooling Efficiency Program*. Prepared for Xcel Energy.
[52] Global Energy Partners. (2011) *Evaluation of the 2009 Energy Conscious Blueprint Program*. Prepared for the Connecticut Energy Efficiency Board.
[53] DMI. (2008) *Impact Evaluation of 2005 Custom HVAC Installations*. Prepared for the National Grid USA Service Company.

The EPA guide identifies four primary approaches to calculating the NTGR:

1. **Self-reporting surveys**. Information is reported by participants and non-participants, without independent verification or review.
2. **Enhanced self-reporting surveys**. The self-reporting surveys are combined with interviews and independent documentation review and analysis.
3. **Econometric methods**. Statistical models are used to compare participant and non-participant energy and demand patterns. These models often include survey inputs and other non-program-related factors such as weather and changes to energy costs. When a control group of non-participants is used, the savings indicated are "net" of free riders and participant spillover.
4. **Deemed net-to-gross ratios**. NTGR is estimated using information available from evaluations of similar programs.

In 2003, five northeastern utilities (National Grid, NSTAR Electric, Northeast Utilities, Unitil, Cape Light Compact) sponsored an effort to develop standardized sampling techniques, data collection approaches, survey questions, survey instrument(s), and an analysis methodology to determine free-ridership and spillover factors for C&I programs, resulting in the report, *Standardized Methods for Free-Ridership and Spillover Evaluation*.[54] The report created standardized survey instruments and analysis designed to estimate free-ridership (using a customer survey), spillover (using a customer survey), and non-participant spillover (using a survey of participating design professionals and vendors) that the sponsors could use to find free-ridership and spillover impacts.

A 2008 study, *2007 Commercial and Industrial Programs Free-ridership and Spillover Study*,[55] specifically looked at free-ridership and spillover from Connecticut Light & Power's Energy Conscious Blueprint, Energy Opportunities, and Small Business programs using the Standardized Methods methodology. They used a survey of 579 program accounts (one customer could have multiple accounts) and found free-ridership and spillover rates for each type of modification (e.g., lighting, cooling, heating, refrigeration, etc.) offered by the three programs, but did not calculate overall the NTGR of the programs. *Evaluation of the 2009 Energy Conscious Blueprint Program* based free-ridership and spillover rates for each type of modification offered by the programs on the rates reported in the *2007 Commercial and Industrial Programs Free-ridership and Spillover Study*. Evaluators then used those rates to calculate the NTGR for each type of project offered by the program.

Hawaii Energy Conservation & Energy Efficiency Programs Evaluation used the deemed net-to-gross ratio approach. Evaluators assembled a set of values for free ridership and spillover from the available evaluation reports from the four states that conduct the most extensive free-rider and spillover assessments. From those values, they estimated the free-rider rate for each program by averaging the values found from each state. The report found an overall NTGR of 73% for the eight programs under evaluation.

[54] Pamela Rathburn, Carol Sabo and Bryan Zent. (2003) *Standardized Methods for Free-Ridership and Spillover Evaluation*. Prepared for National Grid, NSTAR Electric, Northeast Utilities, Unitil, and Cape Light Compact.
[55] Pamela Rathburn, Laura Schauer, Jeremy Kraft and Eric Rambo. (2008) *2007 Commercial and Industrial Programs Free-ridership and Spillover Study*. Prepared for Connecticut Light and Power.

The report, *PacifiCorp Energy FinAnswer 2008 Idaho Program Evaluation*,[56] reviewed a program that promoted energy efficient design, construction, and retrofitting of commercial and industrial processes and buildings. Evaluators used the self-reported survey approach. To find the NTGR, they only quantified free-ridership (not spillovers), which was achieved through telephone surveys with program participants who had completed projects through the program. The evaluation found a NTGR of 75% based on the free-ridership survey results. The 2011 report, *Evaluation of the Non-Residential Smart $aver Prescriptive Program in North and South Carolina*, also used the self-reported survey approach. In a survey of a sample of former program participants, evaluators asked three questions related to free-ridership and two questions on spillover. The report found a NTGR ratio of 70% based on the survey results.

Calculating Persistence

Gross savings and net savings estimates focus on first-year savings, so evaluations looking for energy savings beyond the first year of installation require an analysis of persistence. Definitions for persistence are not nationally consistent, but the concept generally encompasses both the retention and performance degradation of energy efficiency measures, while changes in codes and standards, capital-planning cycles, or the impact of market progression can also reduce net savings. Together, these factors can be used to estimate how the claimed persistence values reported by efficiency programs can be updated based on evaluated savings values.

The National Renewable Energy Laboratory's (NREL) Uniform Methods Project identifies two major components to account for in persistence: (1) effective useful life and (2) savings persistence. Effective useful life (EUL) is the median number of years that a measure is in place and operational after installation. Savings persistence is the percentage of change in expected savings due to changed operating hours, changed process operations, and/or the performance degradation of equipment efficiency relative to the baseline efficiency option.

The Uniform Methods Project outlines two main approaches used by evaluators to find persistence estimates:

1. **Database or Benchmarking Approach**. This approach entails developing and regularly updating a database of information on measure life and performance degradation. This approach is usually based on some combination of engineering judgment, experience with energy efficiency measures, and information on local and regional conditions, which are used to create detailed tables of measure lives. These values are then used as deemed values for persistence and applied to produce estimates of the energy savings over time.
2. **Periodic In-Field Studies**. This approach entails performing in-field studies of program participants from previous years. These studies rely on surveys or on-site visits to determine whether the measure is still in place and operable, or on statistical analyses using regression-based methods to generate retention models that estimate the survival or failure rates of energy efficiency measures.

It should be noted that persistence studies are both costly and time-consuming, and rigorous persistence analyses are not part of the EPA guidelines, nor are they normally included in impact

[56] The Cadmus Group. (2010) *PacifiCorp Energy FinAnswer 2008 Idaho Program Evaluation.* Prepared for PacifiCorp.

evaluations of energy efficiency programs. Rather, full studies of measure life, retention, or persistence of savings typically focus solely on those measures.

Many energy efficiency program impact evaluations will rely entirely on EUL to calculate persistence (sometimes called lifecycle savings). These EUL values may come from manufacturer data, engineering databases, or other sources. However, EUL often fails to take into account factors beyond an efficiency measure's estimated operating life, such as periodic capital upgrades, changes to codes and standards, or other factors. It also fails to consider counterfactual situations, in which participants may have eventually made the same efficiency modification(s) without participating in the program.

Evaluation of the Hawaii Energy Conservation and Efficiency Programs based its persistence analysis entirely on the EUL of efficiency measures used in its programs. EUL values were based on manufacturer data and a review of other EUL reports and publications. However, the evaluation did not list the EUL values used by the program. Similarly, *Evaluation of the Non-Residential Smart $aver Prescriptive Program in North and South Carolina* calculated lifecycle savings based on only EUL assumptions. EUL values were provided by Franklin Energy Services, a third-party energy efficiency program management company. These EUL values ranged from eight to ten years for lighting efficiency upgrades.

PacifiCorp Energy FinAnswer 2008 Idaho Program Evaluation calculated lifecycle savings based on EUL derived from a number of sources, including DEER 2008, ACEEE, and the *Measure Life Report* prepared by the consulting firm, GDS Associates. The average EUL for energy efficiency measures used in the program was 14.58 years. *PacifiCorp Energy FinAnswer 2005-2008 Utah Program Evaluation* used the same methodology and found an average EUL of efficiency measures of 13.79 years for efficiency measures used in the program.

Several impact evaluations reviewed by SRI had no analysis of persistence, including *Process and Impact Evaluation for the Colorado Business Cooling Efficiency Program*, *Evaluation of the 2009 Energy Conscious Blueprint Program*, and *Impact Evaluation of 2005 Custom HVAC Installations*. In these evaluations, only first-year savings were calculated with no analysis of savings after the first year.

Appendix C: Instruments and frequency tables

This document is designed as a guide for interviews conducted with IAC directors, staff, faculty, students & clients. It is not intended to be used as the basis for a structured interview. Topics will not necessarily be addressed in the order presented below. Interviewers will probe and follow-up as needed. The purpose of this guide is to help ensure that a series of similar topics are addressed in all interviews. We expect that the general topics will be addressed and details will be collected where applicable.

You are invited to participate in a research project to study the implementation of the Industrial Assessment Center (IAC) Program and assess the impact of the program. SRI International is conducting this project on behalf of the Department of Energy, supported through the IAC field office at Rutgers University. You are being interviewed because of your involvement with the program. The questions we will ask are solely intended to provide information about your experience and will not be used to evaluate any specific individual, project, or institution. Participation in this interview is completely voluntary. No personal information will be collected and no one will be identified in any published reports without their written permission. By continuing with this interview or survey you are giving your consent. If you have any questions about the interview please ask me now. If you have any questions about our use of human subjects please contact Judy Sheenan at humansubjects@sri.com.

Site visit and interview protocol – Directors

I. Purpose of study

Thank you for agreeing to be interviewed as part of our project. The goal of the project is to study and assess the activities, outputs, outcomes and impact of the IAC program.

II. **General Information**

1. How long has your center been funded by DOE?
2. What other forms of support, if any, does your center receive (including in-kind support, other matching support)?
3. Do you partner with other organizations? (e.g., utility companies, state energy offices, etc.)
4. Where is the center housed (college, unit)?

5. Who makes up the staff of your program?
6. Roughly how much work does each staff member devote to IAC program-supported projects? (10%, half, most?)
7. How many faculty are engage on an annual basis by your center?
8. What do you think is the relative importance of the different goals of your center (training students, saving energy, raising productivity)?

III. Students

1. How many students are engaged with the Center on an annual basis?
2. How do students hear about the Center?
3. How do you choose which students are involved with the Center?
4. Do you turn students away?
5. What practices with student have been the most successful? (e.g., in engaging students, getting good work out of students)

IV. Clients/Potential clients

1. How do clients hear about your services?
2. Do you feel you reach all those that could benefit from your services?
3. Are most of your clients in your MSA, or your region, or from some other specific geography?
4. Are most of your clients in a specific sector/sub-sector of the economy?
5. Do you think these clients are typical of your geography and their sector/sub-sector? If not, why not?
6. In your opinion, what are your most effective methods for informing potential clients of your services?
7. Is there a specific type of client that you devote a great deal of your time to? Why?
8. Are there firms that apply that you turn away due to lack of resources?
9. Are there firms that inquire about services but do not end up applying for services?

V. Competition

1. Are there private firms in the area that provide the same services as you?
2. What differentiates your services from these private firms?
3. Would your clients use these private firms? Why/why not?

VI. Activities/Outputs

1. Please walk us through the nuts and bolts of the assessment process.

a. How do you calculate energy savings?
b. How do you calculate cost of implementation?
c. Do you ever follow up with clients to measure the relationship between the estimated cost of implementation and actual cost of implementation?
d. Do you ever follow up with clients to measure the relationship between the calculations and actual energy saved?

2. Do you track or assess these outputs beyond reporting required by the DOE? If so, how?
3. Do you perform and publish energy efficiency research?

VII. Outcomes

1. What do you consider to be the outcomes of your center?
2. Do you think clients should be followed up more than just at 6-9 months?
3. What do you think is the persistence of recommendations are? (i.e., how long do these recommendation save money? Will vary)
4. Do you track or assess these outcomes beyond required reporting by DOE? If so, how?

VIII. End

1. Do you have any other feedback or information you would like to share?
2. May we follow-up with you if we have any other questions?

Site visit and interview protocol – Students

1. Please walk us through the assessment process from start to end, focusing on your role(s) in the process.
2. Why did you apply to the IAC program?
3. What are your career goals? Have they changed as a result of your experience with the IAC program?
4. Are there any aspects of your experience with IAC that have been particularly useful to you? Please explain.
5. If they suddenly doubled the IAC's funding, what should be done with the money?

Client Survey Questions and frequency tables

The SRI client survey contains two types of questions; questions 1-5 are asked at the recommendation level and 6-10 at the assessment level. The survey instrument is customized for each assessment client so that the recommendation-level questions are asked in reference to each individual recommendation the client received from their IAC assessment. Each of these responses is counted individually in the frequency tables for questions 1-5 below. For the firm-level questions (6-10), the respondent answers only once, in reference to the overall IAC assessment experience. Also, we include some branch-path questions, so respondents are only asked to respond to questions deemed relevant based on prior responses. These cases are indicated in the notes.

Instructions for Question 1 & 2:

Below is a list of recommendations from the IAC assessment report that you received. For each of the recommendations listed, please indicate both if you implemented the recommendation and, if so, whether or not the recommended measures are still in place.

Please choose the appropriate response for each item:

1. Was this recommendation implemented?

Answer	Count	Percentage
Yes, in full	312	20.4%
Yes, in part	460	30.1%
No	529	34.7%
I don't know	45	2.9%
No answer	180	11.8%

2. If the recommendation WAS implemented, is the equipment/process still in place?

Answer	Count	Percentage
Yes, in full	409	53.0%
Yes, in part	287	37.2%
No	10	1.3%
I don't know	7	0.9%
No answer	59	7.6%

Note: Only includes recommendations marked implemented (Response to Q1: "Yes, in full" or "Yes, in part")

Instructions for Question 3 & 4:

For each of the recommendations listed below, please indicate how long it took to implement the recommendation and if you had plans to implement the recommended measures prior to the IAC team's site visit.

Please choose the appropriate response for each item:

3. How long after receiving the IAC assessment report did you implement this recommendation?

Answer	Count	Percentage
1 year or less	496	64.2%

1 - 2 years	188	24.4%
2 or more years	60	7.8%
I don't know	19	2.5%
No answer	9	1.2%

Note: Only includes recommendations marked implemented (Response to Q1: "Yes, in full" or "Yes, in part")

4. Did your firm have plans to take this action prior to the IAC team's site visit in [*Fiscal Year of Assessment*]?

Answer	Count	Percentage
Yes, specific plans and budget were already in place	183	23.7%
No, but it was under consideration	262	33.9%
No	210	27.2%
I don't know	41	5.3%
No answer	76	9.8%

Note: Only includes recommendations marked implemented (Response to Q1: "Yes, in full" or "Yes, in part")

5. For each of the recommendations listed below, please indicate why the recommendation was not implemented.

Please choose the appropriate response for each item:

Answer	Count	Percentage
Need more time (plan to implement in future)	68	12.9%
Technically not feasible	107	20.2%
Budget not available	93	17.6%
Payback insufficient / payback period too long	125	23.6%
Insufficient staff time	46	8.7%
Cost higher than estimated	9	1.7%
Alternative measure implemented	8	1.5%
Overlooked/ forgotten	10	1.9%
Other (comment below)	42	7.9%
I don't know	19	3.6%
No answer	2	0.4%

Note: Only includes recommendations marked NOT implemented (Response to Q1: "No")

Open-ended responses:
If you selected "Other" for one or more recommendations above, please specify:

1. Air conditioning was not used for personnel, but for equipment, therefore hours of the day is irrelevant. Lighting was recommended to be brighter than "minimum necessary" but we disagreed and actually increased lighting levels and efficiencies.
2. If we turn off the air compressors it is likely that they will not re-start, because they are so old. This will result in interuption in production which is why they stay on.
3. Vending is outsourced and not our equipment.
4. we already use t-5 and t-8 fluorescent lighting in our facility. all areas that are low traffic utilize sensors.
5. Employee morale.
6. No heat added to the building Process heat only.
7. Improved circulation pull heat from upper areas & requires more ac.
8. lights were installed before the assesment
9. air conditioning was on timer at the time of the evaluation so the evaluation overlooked the fact and the recommendation was not useful
10. By 15 year contract with utility provider, we are not allowed to generate and/or purchase existing

provided utilities from any other source.

11. Owner feels that the temperature and comfort of employees more important than the savings.
12. The oven is used for one specific customer. This customer is going away in the next 1-2 years.
13. As motors need to be replaced will consider more efficient replacements. May not happen due to cost of new versus availability of used.
14. In all of the "other" selections above, we will/ have been replacing items as we can, but it is a long process. We have plans to implement photocells in warehouse areas, and as part of segmented lighting upgrades throughout the facility. We have been switching out to higher efficiency belts, but are limited due to requirement of vendors.
15. This was in reference to our welding machines. When one breaks down, we are going to replace it with energy efficient welder. No welder has broken down since audit.
16. Not sure what "Develop a repair/replace policy" is.
17. Lighting not feasible due to electrical classifications in the plant.
18. The vending machines are not owned by us and we would need the supplier to install energy efficient units.
19. New to company still sorting through previous managers information
20. No payback. Non air conditioned space
21. Reschedule plant operations or reduce load to avoid peaks: Due to our manufacturing schedule, it would be difficult to change hours of production. This is something we may look at in the future, but for now we cannot implement this change.
22. Analyze flue gas for proper air/fuel ratio: When we consolidated some of the plant space, we decommissioned the boiler.
23. Not under our control
24. Negative reaction from people impacted
25. Eliminate/reduce an operation - I don't know which recommendation this refers to.
26. On our to do list but have not implemented.
27. Production schedules which equipment runs.
28. "Cooler equipment was removed.
29. Oven equipment was also removed. (kilns)
30. Reducing lighting would deemed aesthetic/safety risk.
31. Consideration of increased heat load to work space was not considered in the recommendation.
32. The PSB Co Dayton, Ohio plant is a powder and e-coating job shop. The economic climate has not afforded the investment into new and improved capital equipment since the 2007 down turn in finished metal parts. The economic climate, razor thin margins, increasing utilities and Affordable Care Act unintended consequences have become the perfect storm surrounding the long-term viability of the operation.
33. Lower temperature... - Puerto Rico temperatures are almost even throughout the year.
34. Clean or color roof... - Suggestion based on wrong assumptions that invalidate proposed solution.
35. Equipment shutdown occurs when practical
36. We could not find a reputable contractor to perform the integration of all 6 major air compressors.
37. We do not have the technical resource internally to do this work.
38. Upgrade to Compressors currently under way. Once in place, we will reduce compressed air pressure.
39. AEP said we could not consolidate the electric meters
40. Plans were under consideration to reduce waste to landfill for composite wood scrap and 'nuisance powder' from powder coat operations. However, the cost to recycle these materials far exceeded the disposal cost to a landfill. We continually evaluate new technologies to reduce the costs of handling these wastes.

6. Did your company's other facilities implement any similar efficiency measures because you shared the IAC assessment report with them?

Please choose only one of the following:

Answer	Count	Percentage
Yes	33	18.1%
No	49	26.9%
We shared the report, but I do not know if anything was implemented.	42	23.1%
My company has no other facilities.	38	20.9%
I don't know	17	9.3%
No answer	3	1.6%

7. Is it likely that your facility WOULD HAVE sought an energy assessment in [*Fiscal Year of Assessment*] IF the IAC program HAD NOT been available to you?

Please choose only one of the following:

Answer	Count	Percentage
Yes	51	28.0%
No	116	63.7%
I was not involved in this decision-making process	15	8.2%
No answer	0	0.0%

8A. How would your facility most likely have obtained an energy assessment in the absence of the IAC program?

Please choose all that apply:

Answer	Count	Percentage
By hiring a private firm or consultant	26	51.0%
Through a utility rebate program	25	49.0%
Through a corporate program	7	13.7%
Local facility staff would have performed an assessment	7	13.7%
Through some other public or non-profit program	7	13.7%
I don't know	2	3.9%
Other *(open-ended comment field)*	0	0.0%
No answer	0	0.0%

Note: Only includes respondents who responded "Yes" to Q7

8B. Why is it not likely that your facility would have sought an energy assessment from another source within one year of the IAC assessment date?

Please choose only one of the following:

Answer	Count	Percentage
Lack of a suitable service provider	8	6.9%
Budget not available	39	33.6%
Time not available	6	5.2%
Did not think it worthwhile (savings would not justify cost/effort)	11	9.5%
It was not a priority	30	25.9%
Did not think of it	16	13.8%

I don't know	0	0.0%
Other *(open-ended comment field, see below)*	6	5.2%
No answer	0	0.0%

Note: Only includes respondents who responded "No" to Q7

Open-ended responses to "Other":

1. We employ a full-time energy engineer
2. very few areas for us to improve upon. we are very conscious of saving energy where we can.
3. part of facilities engineering is to constant evaluate this versus other priorities
4. We conduct energy assessments internally twice each year
5. would not have been in our planning if we had not heard of the IAC assessment
6. Our company performs energy audits

9. Overall, how satisfied were you with the Industrial Assessment Center program?

Please choose the appropriate response for each item:

Answer	Count	Percentage
Very dissatisfied	6	3.3%
Dissatisfied	1	0.5%
Neither satisfied nor dissatisfied	12	6.6%
Satisfied	48	26.4%
Very satisfied	112	61.5%
Not applicable	3	1.6%
No answer	0	0.0%

10. Do you have any other comments or suggestions you would like to share with us? (optional)

Please write your answer here *(open-ended responses)*:

1. I think the team did a good job, handled themselves professionally.
2. there were suggestions made that were more of a theoretical nature that a lot of time was expended attempting to find sources for material that doesn't seem to exist.
3. The assessment done by the professors and the students from [IAC NAME OMITTED] gave us a boost to our sustainability program. We greatly appreciate their help.
4. Great Program. All interactions leading up to and since the event have been very professional. I think a lot more companies would participate if they had a great knowledge of the program.
5. Being a practicing engineer, the experience that the young engineers gain with this program is exceptional. While in engineering school, I never made the connection between capital investments, paybacks, and staffing. The experience was valuable to those engineers.
6. Some of your suggestions like "replacing all the windows with energy efficient models" sounds good but in reality would never pay for itself.
7. Many of the recommendations were already considered by facility engineers, but have not been done yet because they will be incorporated into projects to repair/rebuild equipment or facilities. It's easier to obtain funding for projects that directly affect mission capability, so energy and water conservation are incorporated into these projects.
8. As a plant that is 90% outdoors and uses mostly non-contact river water for cooling, it is difficult to find a lot of the traditional energy savings present in other industrial environments.
9. Good work, we still continue to implement when funding is available based upon the IAC Report. Thanks again.

10. I was not present during the assessment therefore I can only provide information that I know. I don't know who requested the assessment or why. I support the efforts of your group providing a service to help companies become more energy efficient and would welcome future surveys that I'm part of. Thank you
11. Best IAC we've had. Very professional and insightful.
12. The IAC program helped provide validation for the two projects (HID lighting retrofit, power factor correction) that had been proposed prior to the assement but not implemented due to limited support or available funding.
13. The industrial Assessment was very useful in that many of the projects we had identified before were able to get data from the assessment to back up moving forward with them. Currently at our facility, is is hard to get needed funds for implimenting these items. All of the suggestions will be implimented in time.
14. The electrical consumption information was not correct. This was previously reported!
15. The assessment completed for our facility was not accurate and a waste of our time. The suggestions and paybacks were incorrect. The students need to make sure they use accurate numbers before making recommendations. This program could actually hurt a small company if they spent money based on bad recommendations that really do not have any payback. Many small companies do not have people that are experts in these areas.
16. I thought everyone associated with the program did a great job. I appreciated the enthusiasm from the group and their creative ideas. Some of the ideas presented were outside of the box, which was something we needed to see. In our industry with our staff of longtime employees we need to see and examine different ways of doing things and test getting out of our comfort zone.
17. Anytime you all assess a situation concerning a savings please take all variables into consideration. The efficient lighting project that we implemented was a recommendation from an audit 9 years prior to this one. The ""Utilize higher efficiency lamps and/or ballasts"" project from the 2013 audit was not implemented because whoever quoted the lamps did not take into consideration the amount of foot candles lost from lamps hanging from such a high distance. Also, with these lights being outside no one did the proper pricing for the energy efficient cold weathered bulbs/fixtures that are needed for extreme conditions as we are in [LOCATION OMITTED]. That recommendation was useless as we had to price all new equipment and the small savings was not worth spending the money to kick off the project. Maybe the next audit will be more accurate, we look forward to you all coming out again. Thank you
18. The assistance from IAC was invaluable in obtaining grant for smaller boiler for plant.
19. I have reached out to the OSU staff for clarification on some items and the request were meet and they were anxious to help us succeed.
20. Over all it provided a nice snap shot of operations. It does raise awareness to some issues but ultimately we are restricted by the plant layout, equipment locations and production flow.
21. I was impressed with how fast the IAC team was able to understand the operation of the steam system and recognize opportunities for efficiency improvements. I wish they could have stayed another day to dig deeper into our condensate recovery and steam trap program.
22. I think that this program is very valuable.
23. Even if the recommendations are not implemented, gives the plant an opportunity to discuss these topics and find actions that can be taken to improve energy usage."
24. Very good program and glad we were able to take advantage of it.
25. Tie energy assessments to local utility company rebate programs. It would be helpful to have one stop shopping, whereby the energy assessment can evaluate savings, capital costs, and potential energy rebates.
26. Good group of people to work with. We worked very well together. It was good to find out we had already implemented some of the cost savings ideas that were available at the time. Also, they had some good ideas that we implemented.
27. They did a great Job ...I hope in the future there are more available to us .
28. I would suggest coordinating with [NAME OMITTED] to further enhance the benefits of this program.
29. The assessment was very helpful and informative to our company. It made us look at our energy consumption in a different way.
30. Enjoyed working with the IAC team - very responsibe and professional.

31. The assessment team was helpful and easy to work with, would have been nice to have more individuals with real world experience.
32. The [IAC NAME OMITTED] industrial assessment center was extremely beneficial to our company. Many of the recommendations and discussions that took place during the survey were either implemented or are still in the process of consideration (including a potential solar system installation)
33. It was a great offer to be able to have this done at no charge. We would not have pursued it on our own because of the potential cost. With our budget being extremely tight in today's manufacturing climate, it was very helpful that some of the recommendations were little or no cost. Many of the recommendations that we have not implemented are because they are higher cost and more analysis would have to be done.
34. I think [NAME OMITTED] runs a very good program. They give very sound suggestions with data and theory to back it up which is important when we try to justify projects (since capital is tight)
35. would like our other plant done
36. We did not receive the report from the assessment for over a year, and then only when someone contacted me to see if we had implemented any of the suggestions. They said someone apparently neglected to send it to us.
37. The IAC process was well worth the time and effort. It greatly assisted us in getting the traction we needed to obtain capital funding for variety of energy conservation projects.
38. We would recommend this group highly! They came in very organized and professional. Their report was comprehensive. Very obvious they were well trained.Great experience!
39. New to company
40. The program was very useful and had a very knowledgeable staff.
41. the group was very professional in their assessment of our facility but fun to be with I would recommend a similar program to other companies.
42. The group that did the assessment was very thorough but many of the items that I think they typically find we had already implemented.
43. The IAC team demonstrated serious inquiries and excellent questions concerning the operations of the plant which demonstrated they wanted to learn as much as they could as quickly as they could to make intelligent recommendations. The discussions that resulted from the inquiries usually led to other suggestions to address energy savings.
44. The assessment made us take a serious look at this alternative method but we could not meet our capital investment criteria to actually implement.
45. This program is a boondoggle by the university to apply general energy savings to all plants. The recommendation was reviewed by other experts and their assessment was that some of the conclusions were absolutely erroneous. In addition, the savings, while measureable did not address the 85% of the energy use in the plant that really needs a solution. The analogy would be my Chevy Flatbed with a 454 engine and dual quad Holley pumpers- I get 5 mpg. Don't worry about the 2% gain in mileage from correct tire air pressure. Let's fix the gas guzzling engine first. Think of the Pareto equation: 80% of the problem is in 20% of the source; work on the big contributor first.
46. Most consultants only give you Standard solutions (which help if you have overlooked something) if not you just get back in line with other budgeted items.
47. This was a great program that allowed college students manufacturing experience and allowed the facility to have new ideas and different ideas presented.
48. No
49. Everyone was very professional.
50. None.
51. The assessors should come back at least 2 more times as follow-up to see the issues so as to work around them for the next company they assess.
52. The assessment did not discovery any areas we were not already looking at.
53. The report was incredibly thorough and professional. I would recommend it to another company in a heart beat. We had other energy assessments done in the past by the utility and outside consultants. No one compares to what [IAC NAME OMITTED] did for us. I still reference it and it factors into our decision making.

54. The team was very friendly and knowledgeable. They did a good job explaining each recommendation they came up with. I would recommend this assessment to other companies.
55. The IAC Team from the [IAC NAME OMITTED] was very professional and a pleasure to work with. It was refreshing to see a team with such enthusiasm for the task at hand. I would recommend this type of survey to any industrial facility.
56. The evaluation was conducted very quickly so some details were missed. Also, at least one of the recommendations were not well thought out. However, the audit results provided an opportunity to push energy saving projects that we were already thinking about. The report allowed us to talk about energy savings and gave Management further confidence to move forward with energy saving projects.
57. Everyone I dealt with approached their work professionally and kept me up to date on status of the assessment throughout the entire process from what they needed prior to their onsite visit, the visit itself and the final report. Very customer friendly -- their finished recommendations were fully understandable and the documentation very well done.
58. Industries should take opportunities like this to refresh some of the "hold" projects and get a different perspective.
59. I recommend that future teams become more familiar with the facility in advance of their visit. During the opening meeting it became clear that our facility had already implemented several of the improvements that the team typically recommends.
60. One has to remember that these are students and sometimes they are not in touch with real life costs. but it is good to have a fresh set of eyes or someone who is not hung up in the old thoughts.
61. recommendations of equipment additions and or personnel was in our opinion not a just recommendation as the team was only visiting our facility for a short time. during this time the team was only able to make recommendations based on one type of product being ran through the shop. this product was newer and was being worked through the system to find and optimal way to do so. several of the recommendations were made on basis such as the one i mentioned above. we feel that for an accurate assessment much more time would be needed rather than just one or two days.
62. The students did a nice job in finding potential energy savings for our company.
63. The IAC students were very impressive with their knowledge of the above matters. They exceeded my expectations by far.
64. None.
65. The recommendations were all excellent opportunities for savings and improving our environmental stewardship. Implementation costs, internal costs to implementation, or access/agreeability of outside players were significantly understated. These factors, much more than the merit of the ideas, prevented their implementation.
66. this is a very effective tool, honestly our company doesn't have the manpower to see things like this through as needed (there were other suggestions made), however as we grow in sized (its been dramatic) and we become more sophisticated in our operations approach, another effort at an energy savings program should be taken
67. Although several of the items have not been implemented yet they are planned for the future. The assesment got us looking at energy much more that we previously did. Since the assesment we have worked on several energy saving projects mainly focusing on our refrigeration systems. Without this assesment I don't believe that energy usage would have been elevated to the importance at our facilities that it is currently at. Do not take the small amount of items implemented as a negative as they will be worked on in the future.
68. I have completed surveys like this 2 or 3 times. It would be nice if my reports were shared as readily as my contact information and participation in the survey.
69. Although this was a comprehensive assessment and was performed with high technical performance, we had already implemented/began to implement many of the changes/recommendations that the assessment brought to light. The assessment did not offer any additional insight into our energy efficiency because we had already implemented many evaluations/programs to address these issues.
70. The assessment team from the [IAC NAME OMITTED] was very professional, through and efficient.
71. Some of your suggestions like "replacing all the windows with energy efficient models" sounds good but in reality would never pay for itself.

72. Appreciate the study. Still plan to look into implementing some of the recommendations in the future.

Alumni Survey Questions and frequency tables

Did you participate in the IAC program as an undergraduate student, graduate student, or both?

Answer	Count	Percentage
Undergraduate (1)	61	56.0%
Graduate (2)	42	38.5%
Undergraduate and graduate (3)	5	4.6%
No answer	1	0.9%
Not displayed	0	0.0%

How much time did you spend participating in the IAC program?

Answer	Count	Percentage
0 (1)	1	0.9%
3-6 months (2)	17	15.6%
6-12 months (3)	17	15.6%
12-18 months (4)	22	20.2%
18-24 months (5)	30	27.5%
3 years (6)	16	14.7%
4 years (7)	3	2.8%
more than 4 years (8)	3	2.8%
No answer	0	0.0%
Not displayed	0	0.0%

How many IAC assessments did you participate in?

Answer	Count	Percentage
0 assessments (1)	2	1.8%
1-5 assessments (2)	19	17.4%
6-10 assessments (3)	20	18.3%
11-20 assessments (4)	34	31.2%
20-40 assessments (5)	22	20.2%
40-60 assessments (6)	8	7.3%
60 or more assessments (7)	3	2.8%
No answer	1	0.9%
Not displayed	0	0.0%

During your participation, were you ever designated as a "Lead Student"?

Answer	Count	Percentage
Yes, as a lead student of an audit	52	47.7%
Yes, as the lead student or co-lead student of the IAC	33	30.3%
No, neither	39	35.8%

Why did you become involved with the IAC?

Answer	Count	Percentage
Participation in an energy audit was offered as part of a class	13	11.9%

Interest in an energy efficiency career	66	60.6%
Interest in gaining "real world experience"	79	72.5%
An interesting opportunity to learn, but not central to my future career plans	26	23.9%
Work-study job	28	25.7%
Belief that it would give me an advantage in the job market	54	49.5%
Wanted to work with a specific faculty member/professor	23	21.1%
Other	4	3.7%
Open-ended other responses: 1. was not part of IAC 2. I needed a job and a friend recommended I try it out! 3. interest in efficiency and part of assistantship work 4. it is not just "real world experience" it is the opportunity to apply the engineering principles as you learn them and then you can go back to relearn and reapply which is unique.		

Did your experience result in your becoming more interested in jobs that involved energy efficiency?

Answer	Count	Percentage
Yes (Y)	92	84.4%
No (N)	17	15.6%
No answer	0	0.0%
Not displayed	0	0.0%

Whether you answered yes or no, please explain briefly:

Answer	85	78.0%
No answer	24	22.0%
Not displayed	0	0.0%

Open-ended responses with the corresponding previous response:

1. Yes — I came to know the value of energy efficiency and potential market.
2. Yes — I like energy based careers better than widget based careers.
3. Yes — My degree is in chemical engineering.
4. No — Did not participate in IAC, that I know of.
5. Yes — Although I haven't held a job related to energy efficiency since, I have kept an interest in the field, and used what I have learned to give suggestions to others and improve the efficiency of my own home.
6. Yes — Through participating in the energy audits I became more knowledgeable and more interested in industrial processes. I have since used this experience to work in the energy industry.
7. Yes — Yes, I really enjoyed energy efficiency and what I learned. It really made me want to work in that market.
8. Yes — Our team also focused on productivity, which was a nice introduction to an Industrial Engineering degree. The energy efficiency part was very educational and straightforward.
9. Yes — A great growth opportunity in a necessary and demanding employment field.
10. Yes — I was already interested in a career in the field, but the hands on experience was enjoyable and furthered my conviction that this was the field for me.
11. No — I wasn't uninterested in energy efficiency; I just ended up going into oil and gas when I graduated.
12. Yes — Very interested in energy and my current job is very similar to what I did at the IAC. I want to continue to be involved in energy and eventually

acquire a CEA. 13. Yes I wasn't previously specifically interested in jobs in energy efficiency or in manufacturing. 14. Yes I didn't have any interest in working in energy or manufacturing, now I am searching for a career in both. 15. Yes I was interested in environmental issues before working for the IAC, but after my experience with the group, I knew that energy efficiency was a career that I wanted to pursue. 16. Yes I am pursuing a career in the energy world. 17. Yes I thought I was asking for another job studying organic rankine cycles. I just needed to make some money. Prior to IAC I wanted to build more aerodynamic bicycles and components. 18. Yes 19. Yes I definitely was interested in energy efficiency before, but working at IAC confirmed that I wanted to pursue a career in that field. 20. Yes 21. Yes I became more interested in energy efficiency but followed my interest in civil engineering for my career. 22. Yes I remain interested in energy efficiency and practical, real world solutions. 23. Yes 24. Yes I have become more interested in optimization of energy systems. 25. No my academic path took me to another direction. It had no real connection to IAC. I was able to find work in the energy sector because of my participation in the IAC but chose to pursue an academic career for now. 26. Yes "I worked at Rutgers University as a graduate research assistant. Rutgers is the field manager (FM) for the IAC program from long time. The students working at FM should have experience and/or be capable of conducting an IAC style assessment themselves and produce the report. At Rutgers I reviewed the IAC engineering reports, provided programmatic metrics and provided technical resources for the IACs. I also trained Industrial Assessment Center Directors on DOE Best Practice Tools. We also conducted on an average 15-20 assessments per year through the New Jersey Manufacturing Excellence (NJME) program. I used IAC experience to conduct those assessments at small and medium plants in New Jersey. I received the following benefits while working at the Rutgers University: - Exposure to a wide range of industries, energy systems and solutions, - Direct experience implementing U.S., state and local energy policies, - Work in a consulting-office structure/environment, while completing graduate engineering degree 27. Yes It provided the opportunity to see the real-life benefits that results from the energy assessments. 28. Yes My experience taught me that energy efficiency is driving innovation in almost every industry. Striving to improve energy use leads to many other side benefits, like reduced pollution. 29. Yes We did some really great stuff that is very helpful to business. Although I did not pursue a career in energy efficiency I utilized the concepts in decisions I have had to make in industry. 30. Yes 31. No The job market was not as good for energy efficiency jobs. The experience was good in that I was able to walk through many different existing facilities. The experience was helpful during my interviews after college.		

32. Yes Upon seeing the IAC director speak about his work I was inspired to pursue a career in energy efficiency and advanced energy generation technologies. Working with the IAC gave me the experience and training I needed to be a success in the industry and to contribute to keeping our nation competitive through energy efficiency. 33. Yes I was interested in various ways engineering could be applied to sustainability, and energy efficiency was the natural choice for a Mech Engr. The IAC offered direct experience in that realm. 34. Yes It was a field that I got more interested in because of belief in global warming. 35. Yes 36. Yes 37. Yes 38. Yes 39. Yes IAC generated more interest in the energy efficiency industry for me, by letting me see the various things I can do in this field. I am an Energy Manager now and I always look back to the foundation provided to me by IAC and try to build on it. 40. No It didn't really have a positive or negative impact on my attitude towards a job involving energy efficiency. 41. Yes I was interest when I started and more interested after working at the IAC 42. Yes I really enjoyed the assessment trips as I got to learn about something entirely foreign to me each time. I also care a lot about both being efficient in general and protecting the environment so I found the work very fulfilling, although sometimes repetitive. 43. Yes The IAC experience helped me to learn the energy efficiency aspects and obtain real world experience that is crucial for any career. I took up a job in the ESCO industry and have been an energy professional ever since. 44. Yes The IAC program helped me look at energy in a new light. Although I don't work in energy this class definitely increased my interest in the field. 45. Yes Energy is one of the grand issue of the day, so any knowledge is transfer to my many different jobs. 46. Yes I was torn between a career in energy efficiency or renewable energy. Soon after joining the IAC I was aware that energy efficiency held more significance to my path. 47. Yes 48. Yes IAC gave me perspective of the sometimes hidden cost of energy in today's world 49. Yes Being able to apply energy efficiency concepts to a variety of processes was very interesting. 50. Yes I always wanted to work in energy efficiency. My experience helped me make sure that this was the right career path. 51. Yes I started to notice energy related topics such as lighting, envelope, electric load, etc. all of which is really relevant in everyday life. Such awareness is quite helpful in my current job as a MEP engineer. 52. Yes 53. Yes Prior to joining the iac team, I was interested and motivated to work in energy conservation. My experience with iac confirmed my interested in the field and provided me with the knowledge to get started. 54. No I became more focused in consulting 55. Yes 56. Yes I currently work in energy. And that helped me move to that choice.		

57.	Yes	I didn't originally think buildings or HVAC sounded that interesting before. But then I realized how exciting the building and energy industry was - and how much of an impact optimization could make on the financial health of a building owner!	
58.	Yes		
59.	Yes	I gained a better understanding and appreciation for the application of energy efficiency in real world circumstances, and also the obstacles to implementing such recommendations	
60.	Yes	The IAC experience make me aware of the importance of energy efficiency.	
61.	Yes	"It has helped me understand the energy needs of the facility in a better way and enriched my understand the energy usage of the facility	
62.	Yes		
63.	Yes	After working with the IAC, I had a much better understanding about energy efficiency. It was in the fore front of my mind whenever I would look at any process. Additionally, though I pursued a different vocation, my first post college job offer came from an energy efficiency company.	
64.	Yes	As I became experienced with energy efficiency audits it took out lot of unknowns about work life I may have if I took up a job in energy efficiency. At the same time it gave me experience so I would be better off than a fresh graduate.	
65.	Yes	I enjoyed the aspect of problem solving and making unique recommendations that were implemeted saving the company money	
66.	Yes	Yes, however I work in the Medical Device field.	
67.	Yes	This is the best practical experience one could ever wish for in industrial energy efficiency. I am a huge fan!	
68.	Yes	I was able to get a job after graduating because companies appreciated the experience I gained with IAC	
69.	No		
70.	No	It did not sway me either way.	
71.	Yes		
72.	Yes		
73.	No	In my Summer at the IAC, I didn't feel like things were organized well. The new students got a 'crash course' in energy efficiency. I think it was one week long. After that, we were kind of just thrown in to it. I felt uncomfortable at the audits, telling companies what they could do better with only a week of training. I mainly stuck to lighting, because that was easy enough and I felt comfortable discussing it. (Lighting and motion sensors). I think the training needs to be revamped, so the students have real tools to make the program worthwhile and not a waste of a time for the companies that participate. I haven't been with the IAC since Summer of 2008, so maybe the training has changed since.	
74.	Yes		
75.	Yes	I really enjoyed the investigation and problem solving involved in understanding the different manufacturing processes and determining how they could run more efficiently without effecting their product	
76.	Yes	Its been now over six years that I am working as an Energy Engineer, therefore the IAC experience was a great success for me. I actually got my first job as an Energy Analyst because of my two years of IAC-WVU experience.	
77.	Yes	Peaked my interest in energy consumption.	
78.	No	Civil engineering discipline changed from environmental (energy use is part of designs) to water resources (no electrical equipment)	
79.	No	The experience was great but this did not lead me to have more	

interests in energy efficiency. 80. Yes My job at the IAC and Anemometer Loan Program assisted me in getting a job in the wind industry. 81. Yes It was interesting work 82. Yes My passion for energy efficiency nurtured in IAC and I switched my career to energy efficiency. I cannot be thankful enough for the opportunity to be a part of IAC. IAC ROCKS !!! 83. Yes 84. Yes It was great to get hands-on experience in the field. 85. Yes 86. Yes 87. Yes 88. Yes The opportunity to work in the IAC focused my academic and career interest from mechanical engineering in general to energy efficiency in buildings more specifically. It brought practical, real world, and hands-on applications to all that seemingly theoretical thermodynamic and heat transfer coursework. 89. No This job was not directly linked to my interests. It was an experience booster. 90. Yes Participating in he IAC allowed me to unrest and the energy efficiency field and helped me find a career as an Energy Engineer. 91. Yes The IAC experience gave me a better appreciation for the energy we use in our day to day lives. 92. Yes I learned the basics of doing energy audits and I used those skills after graduation. 93. Yes Yes, gave me the experience to visualize in person the mechanical systems and there process during these visits and doing hand written energy saving calculations, helped me opened up new career opportunities not only in energy efficiency but also in the manufacturing/commercial industry. 94. Yes 95. Yes Liked the chance to evaluate real world systems to make a real difference. 96. Yes Mechanical Engineering is a wide field. I tried this aspect of practical thermodynamics, liked it, and pursued a career in energy efficiency. 97. Yes We are very wasteful when it comes to energy. Learning all if the different ways to save energy and being able to calculate return on investment based on specific projects was very impact flu and has lead me to drive those types of things in my home. 98. Yes Energy is becoming an integral component of nearly all plant eng jobs. 99. Yes 100. Yes 101. No "I was torn between two loves: mechanics and energy engineering. I really enjoyed thermodynamics and the HVAC course I took in college. It was very enjoyable, interesting, and I excelled in the courses. My professor recommended I join ASHRAE and also asked me if I'd be interested in a position as part of the IAC team at my university. I loved the work, but went into a different role career wise. I still work with energy, but not doing assessments. 102. Yes The idea of energy conservation is one that has a direct impact on everyone and is a concept that we can be proud to improve. 103. Yes The assessments I took part in at the IAC started my curiosity with the HVAC industry. 104. No There is not too much difference in working on energy savings or other types of jobs. I am now trying to get a PhD in ME. And I hope to get a		

faculty job if possible. 105. Yes I got the importance of energy efficiency for industries and the thrust give by management. 106. No My experience helped me realize that I was better suited for something else. 107. Yes My experience with ONE (1) IAC audit was possibly the event most influenced my decision to pursue a career in the energy efficiency / construction profession. Everything I learned and saw shaped what I wanted to do with my professional life, and I hope many other students get the same opportunity. 108. No An energy audit was substituted for my senior design course, which in my view was an unacceptable capstone to my engineering degree. I think that if I had participated in the IAC in a different context I would have had a difference reaction, but the experience only made me resent the discipline of energy audits. *109.* No I don't recall it having an influence on my career choice.		

Which of the following skills did you gain through the IAC experience? Select any that apply.

Answer	Count	Percentage
Applied experience with a variety of industrial systems and equipment	96	88.1%
Applied experience using energy consumption monitoring and verification equipment	77	70.6%
Experience calculating payback periods related to energy efficiency recommendations	99	90.8%
Experience presenting preliminary energy efficiency recommendations and rationale to maintenance supervisors, energy efficiency engineers, CFOs, CEOs, etc.	70	64.2%
Experience drafting energy efficiency recommendations in reports to clients	97	89.0%

Any other skills not listed above?

Answer	36	33.0%
No answer	73	67.0%
Not displayed	0	0.0%

Open-ended responses

1. Leadership and team management
2. Understanding load use profiles of equipment that draws power
3. Applied experience with a variety of lean engineering practices to improve productivity.
4. How to present myself to a client even though I was young and they might see me as young and inexperienced
5. Knowledge of a broad set of manufacturing processes/products
6. Experienced working on a team with various cultural backgrounds
7. Experience identifying energy efficiency recommendations
8. software programming
9. Using energy audit equipment
10. communications skills with employers/clients
11. Managing a team
12. Direct experience implementing U.S., state and local energy policies
13. Leading and/or working with team members
14. Team management.
15. Ability to manage a small team to accomplish yearly goals.
16. Experience drafting proposals for funding
17. Project management development
18. Quality Assurance Program; the report review and approval process

19. building a website and lighting system assessment tool 20. Seeing how different things are made 21. Working with a team (of students) 22. analyze energy consumptions/bills 23. Mostly a working knowledge of lighting basics that propelled me into my job 24. Experience leading a team 25. experience in leading a group of people for a task or activity 26. Project and team managing skills 27. The ability to think for overall system; and not getting caught up in individual heat balance equation 28. Writing good reports, brainstorming and arguing about recommendations 29. Mentoring other students at the IAC 30. Adaptability and innovation 31. Feasibility Analysis of measures 32. Experience working with utility energy efficiency programs to get incentives for client companies. 33. Working in an audit team 34. How to conduct energy efficiency walkthroughs of facilities 35. management of co-workers 36. Auditing		
Any other skills not listed above?		
Answer	24	22.0%
No answer	85	78.0%
Not displayed	0	0.0%
Open-ended responses 1. Report/project coordination 2. General comfort with using multiple energy unit metrics 3. Experience identifying waste in productivity. 4. Experienced traveling outside of personal vacations 5. Experience calculating energy savings for recommendations 6. management 7. Managing clients and schedules 8. Work in a consulting-office structure/environment, while completing graduate engineering degree 9. Exposure to utilities, vendors, and other agencies 10. Advanced application of computer spreadsheets. 11. Ability to research for myself and advance the industry's understanding of energy principals. 12. Leadership and manager development 13. Experience practicing safety in industrial facilities 14. basic energy improvement recommendation 15. Experience mentoring younger/newer team members 16. Process design critical eye development 17. The ability to relate value of energy efficiency with economics 18. Energy efficiency savings calculations 19. Presentation skills 20. Project management and developing training criteria for new student employees of the IAC. 21. Energy auditing documentation and energy estimation techniques 22. How to look for opportunities		

23. logistics of trips to audits 24. Rate Structures		
Any other skills not listed above?		
Answer	15	13.8%
No answer	94	86.2%
Not displayed	0	0.0%
Open-ended responses 1. Technical/industrial terminology 2. Experience identifying and eliminating safety concerns in a variety of production settings. 3. Experience conducting energy efficiency audits 4. Student guidance 5. Research of cutting-edge technologies 6. Ability to communicate with academic and industry peers. 7. Marketing development 8. Experience in technical writing 9. The ability to lead a group in an industrial setting to carry out particular task 10. Handling of various tools and equipment during the IAC site visits 11. Writing 12. Experience performing utility billing analysis and identifying cost savings through changes in contracts. 13. Researching recommended product/system types and formulating performance criteria 14. How to distinguish between useful measures and those that are not as valuable 15. marketing our services by phone and flyer		
Any other skills not listed above?		
Answer	6	5.5%
No answer	103	94.5%
Not displayed	0	0.0%
Open-ended responses 1. Exposure to manufacturing environments so my real-world job in a manufacturing environment was not a shock. 2. Experience leading teams to produce audit reports 3. model development 4. Confidence to create and build a team to accomplish a perceived need. 5. Experience communicating intent and results to many different people and roles. 6. Working with maintenance staff to identify operational or maintenance problems that are costly and impact energy consumption in a negative way.		
Were there other opportunities at your school to gain applied energy efficiency engineering experience?		
Answer	Count	Percentage
Yes (Y)	31	28.4%
No (N)	72	66.1%
No answer	6	5.5%
Not displayed	0	0.0%

In which sector was your first job out of school?		
Answer	Count	Percentage
Manufacturing company (1)	24	22.0%
Energy services consulting organization (2)	40	36.7%
Utility (3)	4	3.7%
State energy office (4)	2	1.8%
National laboratory (5)	2	1.8%
Other	38	34.9%
Open-ended other responses: 1. Power Plant Performance 2. Refining and petrochemicals 3. Engineering Firm & Manufacturing 4. Commercial Distributed Generation Pilot Program Manager 5. Retail 6. Oil and Gas - MWD 7. Technology Support 8. Civil Engineering 9. University 10. Engineering and Construction 11. Semiconductor 12. HVAC Consulting Engineering 13. Power Service 14. Still in school 15. Nuclear plant design company 16. Aerospace 17. ESCO 18. Graduate School 19. MEP 20. Consulting 21. Oil and gas 22. Nuclear engineering consulting 23. Industrial Automation Controls 24. Industrial Automation 25. health care 26. Department of Energy 27. Software Organization 28. Consulting engineer 29. Technology 30. Self-employed in a startup company 31. Transportation 32. Technology HDDs 33. Engineering Consultant 34. Research Lab 35. Medical 36. Mechanical Contracting 37. Film 38. Financial Services		

Was this job related to energy efficiency?		
Answer	Count	Percentage
Yes (Y)	57	52.3%

No (N)	51	46.8%
No answer	1	0.9%
Not displayed	0	0.0%
In what ways?		
Answer	46	42.2%
No answer	11	10.1%
Not displayed	52	47.7%

Open-ended responses with response to previous question:

1. Yes The job was similar. I was working on energy efficiency for commercial sector instead of industrial sector.
2. Yes Duh, power plant performance.
3. No
4. No
5. No
6. Yes Understanding the facility equipment and which circuits the machinery was on is key to supporting select loads with the distributed generation equipment that was being installed.
7. Yes Yes when I started I was tracking savings from performance contracts for commercial buildings. But that has grown to include monitoring energy real time and providing energy services to continuously track and work towards lowering building energy use.
8. No
9. No
10. Yes I perform energy audits.
11. No
12. No
13. No
14. No
15. Yes The job was for an energy efficiency consulting firm that implemented energy efficiency programs and conducted audits similar to the ones we did at the IAC. My primary task in my first year was to verify energy savings estimates and M&V plans submitted by performance contracting companies who were participating in an energy efficiency program, which was directly related to the experience I gained at the IAC. I still work in energy services consulting but now as an evaluator.
16. Yes electrification of equipment and transportation
17. Yes I conducted ASHRAE Level II audits. I also performed commissioning services for new construction.
18. No
19. Yes Conduct energy audits and analysis for commercial and industrial clients as well as design/build services for energy efficiency projects.
20. Yes I was an energy efficiency engineer and did almost all of the tasks I performed while at IAC
21. No
22. No
23. Yes
24. N/A
25. Yes I was working on supporting and developing state level energy effieicny rebate programs as a consultant
26. Yes I provide technical support to DOE AMOâ€™s Better Buildings, Better

Plants Partners (such as ArcelorMittal, GM, Novelis, etc.) through energy road map development, baselining analysis, In-Plant Trainings, field visits to investigate feasible measures to reduce process energy requirements. In addition, I provide monthly educational webinars to these plant users so that they can improve their energy and cost savings. I schedule In-Plant Trainings and contribute in developing In-Plant Training protocols, report template, and data collection mechanism. I also provide DOE with on-demand Better Plants metrics support - includes summary report reviews and quality control for BP annual reports. 27. Yes Teaching courses as well as developing other programs including energy efficiency concepts. 28. No 29. No 30. Yes I am an energy efficiency consultant. 31. No 32. Yes Was brought on into a small start up firm focusing on educational facility energy efficiency and independence. Skills from the IAC were directly transferable and allowed me to hit the ground running on my first day on the job. 33. Yes The company, Cascade Energy, was founded by the first IAC graduate at Oregon State, Marcus Wilcox. Everything we do is directly related to IAC work in one way or another. 34. No 35. No 36. Yes 37. Yes Conducting Energy Efficiency Audits 38. Yes 39. Yes In my first job out of school, I was a Mechanical Engineer for a small energy consulting firm. I conducted investment grade energy audits and provided clients with recommendations on LEED certification. I was also heavily involved with the building controls commissioning. 40. No 41. Yes I work for a company that is designing a small modular nuclear reactor. 42. No 43. Yes Building energy auditing, identifying measures, calculating energy savings estimates, paybacks and developing reports for the clients. 44. No 45. No 46. No 47. No 48. Yes Manufacturing of insulation 49. Yes I am studying energy efficiency at Stanford. 50. Yes 51. Yes I design HVAC and plumbing systems according to ASHRAE and LEED standards. 52. Yes Energy audits and technical project review 53. Yes I work in industrial lighting projects focused on replacing inefficient light technologies 54. No 55. Yes Energy Analyst 56. No 57. Yes I was a performance assurance specialist for an energy service and		

performance contracting team - performing measurement and verification on implemented energy efficiency strategies. And later moved into an official energy engineering role. 58. No 59. Yes 60. Yes I had enough experience to perform energy audits without training. 61. Yes 62. No 63. No 64. Yes Very similar to duties performed in IAC. Focused energy studies at heavy industrial clients. Energy simulations, production of reports etc. Energy equipment monitoring, fault detection and diagnostics software development. 65. No 66. No 67. Yes 68. Yes Energy efficiency utility programs 69. No 70. Yes I work for an energy consulting company looking at deemed and custom measures. I also work on the saturation of energy saving equipment in the market. 71. No 72. Yes The position was performing energy audits, implementation (design), and commissioning services. 73. No 74. Yes 75. Yes energy audits, energy efficiency measure implementation support, project M&V, renewable energy project evaluation, LCCA's 76. Yes We were energy efficiency consulting engineers working as sub-contracting engineers to ESCOs including Siemens, Noresco, Johnson Controls and so on. 77. No 78. No 79. No 80. No 81. No 82. Yes I do Evaluation, Measurement and Verification. IAC helped me to understand the implementation cycle of energy efficiency measures. While evaulating, I come across many energy efficiency measures that I did in IAC. 83. Yes "My job is an extension of what I did during the IAC program. I have provided energy engineering to industrial and agricultural businesses by identifying cost savings opportunities and prioritizing them by cost effectiveness and client needs. Many of my energy efficiency assessments resulted in project implementation and customer satisfaction. I have also assisted many clients with project development and commissioning of energy efficiency projects. I collaborate closely with utility energy efficiency staff to assist businesses with getting incentives to pay for energy efficiency projects. Utilities include Puget Sound Energy, Pacific Power and the Bonneville Power Administration’s Energy Smart Industrial Program assisting customers of Tacoma Power, Grays Harbor PUD amongst others. I have continued my understanding of developing baselines for energy consumption for individual equipment, systems or entire facilities through utility billing analysis, field audits and data logging. Capable of performing		

measurement and verification (M&V) of implemented projects I have co-developed and taught energy management trainings and webinars for various topics: Billing analysis, Energy 101, Motor-Driven Systems, Lighting, Power Factor Correction and Predictive Maintenance Technology. I also performed Level-1 combined heat and power (CHP) screenings and CHP Level-2 feasibility studies evaluating different interconnection configurations to maximize project economics and reliability. I have also been the technical lead on the Washington Farm Energy Pilot â€“ Performing audits on over 30 farms throughout our state. I have also provided energy engineering assistance to the Shared Resource Conservation Manager (SRCM) Program for customer partners of Puget Sound Energy one of the largest utilities in our state. In my startup company have been the Principal Investigator on National Science Foundation SBIR Phase II grant leading research and development efforts to develop a low-cost wireless sensor system for reliability for industrial motors. Managed a 2-year grant with a budget of $500,000. I have also developed core skills in maintenance and reliability engineering such as vibration analysis.		
84. No		
85. Yes		
86. Yes		
87. No		
88. Yes Providing building energy demand-side management services and writing energy auditing software.		
89. No		
90. Yes The job was with a company that performs energy audits and assessments for utility clients. Also we run evaluations on utility efficiency programs		
91. Yes I work for an independent energy efficiency consulting firm out of the Boston area. We conduct energy audits, provide technical support to the local electric and gas utilities.		
92. Yes I did energy audits for the consulting company.		
93. No		
94. Yes		
95. Yes We evaluate installed energy efficiency projects		
96. Yes I got a job funded by ARRA in 2009. The state block grant was used for energy efficiency (EE) in small cities and counties. Each applicant could pick EE from a list or have a customized project. The state of CA rushed to hire new scientist to manage the grants. It helped that I had project management classes too.		
97. No		
98. Yes I was tasked with energy reduction capital projects. Pump and motor efficiency, heat recovery, etc.		
99. Yes Providing energy efficiency solution to customers		
100. No		
101. No		
102. No		
103. Yes Designing specifying HVAC equipment/systems, auditing existing HVAC equipment/systems		
104. No		
105. Yes Designing and manufacturing energy efficient air conditioning systems		
106. No		
107. No		

108.No 109.No		
Did your IAC experience help you get your first job?		
Answer	Count	Percentage
Yes (Y)	78	71.6%
No (N)	28	25.7%
No answer	3	2.8%
Not displayed	0	0.0%
How?		
Answer	63	57.8%
No answer	15	13.8%
Not displayed	31	28.4%
Open-ended responses with response to previous question: 1. Yes 2. Yes Testing. 3. Yes I started at the IAC as a freshman. The internship experience helped me get other internships (including with the company I now work full time) and scholarships, which built up my resume. In addition, the practical experience increased my confidence and maturity as well as my understanding of engineering, operations and maintenance, and business goals. 4. No 5. Yes It was a section of my resume that was always asked about, and was a great talking point which I received positive feedback from. 6. Yes Interviewers were very interested to hear about the real-world experiences I had already 7. Yes Yes having all of that energy systems, auditing, and utility rate structure experience was a major benefit. No one can come straight out of college with better experience than that. 8. Yes My experience out of college was on par with someone with a year (at least) of work experience as an industrial engineer. 9. No 10. Yes The real world experience doing industrial audits made my employer confident that I would not need much additional training and could be profitable right away. 11. Yes It was a good addition to my resume out of college, even though it was a different field. 12. No 13. Yes My first job was as a manufacturing engineer. My IAC experience gave me enough knowledge and background in general manufacturing to be successful, even though my major wasn't in manufacturing and I only took one class in the area. 14. No 15. Yes I had pre-existing experience doing exactly what I was asked to do in my consulting work. I also had exposure to typical energy savings measures in industrial settings and instruction and experience with calculating energy savings and analyzing energy bills. 16. Yes Payback. Understanding of technology 17. Yes I was hired to conduct energy audits primarily. If I didn't have that experience then I guarantee I wouldn't have even gotten an interview. Many		

companies I dealt with then, and still deal with today, aren't looking to place new graduates of a mechanical program in a role higher than "CADD Monkey". I had one offer to do just that. I took another position.

18. No
19. Yes All three principals participated in the same program and had knowledge of the IAC experience.
20. Yes IAC experience gave me an advantage in terms of knowledge as well as getting shortlisted for in-person interviews.
21. No
22. No
23. Yes
24. N/A
25. Yes I got to know the company's director through his involvment in the IAC
26. Yes My program managers at ORNL knew my work activities at Rutgers. They wanted to hire somebody with the IAC skills. My initial work activities at ORNL were very similar to my work responsibilities at Rutgers. First few years at ORNL, my program evaluation and metrics activities supported AMO through measurement, documentation, evaluation and analysis of the impacts of technology delivery activities towards the goal of reducing energy intensity in the U.S. industrial sector.
27. Yes Numerous examples from the on-site visits could be discussed as part of real-world experience.
28. No
29. Yes It was on my resume and We talked about it during the interview.
30. Yes My boss is also an IAC alumni and I had many job offers based on my experience coming out of the IAC.
31. No
32. Yes The skills and knowledge I developed allowed me to confidently pursue a lead role in a small energy efficiency start up.
33. Yes I work for an industrial energy efficiency consulting company. The transition was pretty easy.
34. No
35. Yes
36. Yes
37. Yes The IAC experience was desired by the employer.
38. Yes
39. Yes "I was about to graduate when I heard about an opening in a small consulting firm and the open position was circulated through the company by the Director of IAC, who was also the Head of the Industrial Engineering Dept. at the time.
    I also got my current job through the network of IAC Alumni."
40. No
41. Yes I new what a Quality Assurance Program is, I had experience doing energy balance calculations, and I had an engineering job.
42. Yes General engineering experience and a good recommendation from a former employer.
43. N/A
44. Yes I ended up working for the Georgia Tech Economic Development Institute for a few months after graduation performing energy audits.
45. Yes Having a background with some broader experiences helped my market my skills to a broader range of companies
46. Yes I was knowledgeable of mechanical systems. My leadership role at IAC

set my resume apart. 47. Yes It was good, practical experience that was beneficial to my resume 48. Yes Hiring committee was glad to see that I had a real world understanding of projects, technology, timelines, and cost analysis. 49. Yes Added to my ability to get into the Stanford program that I am pursuing now. 50. Yes 51. Yes Being more aware of energy saving opportunities. 52. Yes 53. Yes Was recruited due to my lighting knowledge. 54. Yes Earned me a scholarship for grad school 55. Yes 56. Yes Experience 57. Yes I didn't even know there were energy service companies. I applied for a controls design engineering position and during my interview they asked about my energy experience at the IAC that was listed on my resume. They didn't have a posted energy job opening, but had been looking for someone and thought maybe I'd be interested. 58. No 59. Yes I was contacted by an energy efficiency professional through my IAC director, which ultimately led to me getting my current job. 60. Yes The company wanted someone with adequate experience and that helped me get my first job. 61. No 62. Yes 63. Yes The general job experience of the IAC contributed significantly to my work history. I was always able to illustrate a scenario of real world experience stemming from my time spent at the IAC. In addition I feel that the IAC certainly provided the skills mentioned above. Explicitly project managing and the development of the critical eye to view issues that need resolving. 64. Yes All the skills gained in IAC are very valuable for my job and employer. 65. Yes The travel and inspections help get me a job that will lead to field work in the near future 66. Yes Added to my resume and gave me first hand experience in several different manufacturing environments. 67. Yes 68. Yes Experience 69. No 70. Yes It was very similar to what I first started as. 71. Yes looks great on the resume, provided experiences about work situations to use during interview 72. Yes I was put in touch with the hiring manager by an IAC alum that was currently working for the company. The hiring manager was familiar with the IAC. 73. No 74. Yes 75. N/A 76. Yes The principal owner of the first job saw my resume on the shared IAC database which has resumes of IAC graduates seeking job. 77. Yes Although my first job was not directly related to energy efficiency/energy management, it was for a software company that developed time series data storage. This can be a huge asset for monitoring and visualization of energy usage. The company was impressed by my hands on		

work and saw how it could apply to how our customers utilize our products. 78. Yes Provided real world experience nearly equivalent to an internship 79. No 80. Yes The real world experience in the IAC helped me determine that I wanted to go into a field that has a positive impact. 81. No 82. Yes IAC is a well known program. My employer has very high regards for it and many of my co-workers have done this program. 83. Yes In the IAC program we collaborated with the WSU Energy Program - which is the technical arm of our States energy office (performing energy engineering work for businesses and public agencies). During the course of my IAC experience I developed a strong rapport and working relationship with the WSU Energy Program and they offered me a job. At first I did a summer internship and was hired as a permanent employee after graduation. 84. No 85. Yes 86. Yes 87. Yes 88. Yes IAC field and documentation experience showed I had already worked to understand client needs and potential solutions. 89. Yes It reflected well to show I was a well rounded individual. 90. Yes Direct experience in the energy efficiency field. Gave me the basis to become a strong candidate for such companies 91. Yes My company was looking for someone with experience in conducting energy audits in industrial facilities. Having conducted over 50+ energy audits at the IAC, I was able to contribute from day one. 92. Yes My IAC energy auditing experience was directly related to my first job. 93. No 94. No 95. Yes Provided experience with energy efficiency 96. Yes Direct experience in the skills they needed. 97. No 98. No 99. Yes Real work experience 100. Yes By working on large projects and general work experience. 101. No 102. Yes The knowledge gained by this experience allowed me to bring something to the table right away vs having to be completely trained. 103. Yes The IAC introduced me to the consulting engineering industry and having that experience on my resume helped me obtain multiple interviews right after graduation. 104. No 105. Yes 106. No 107. No 108. No 109. No		

Do you think your career benefited from the IAC program?

Answer	Count	Percentage
Yes (Y)	98	89.9%
No (N)	10	9.2%

No answer	1	0.9%
Not displayed	0	0.0%
How?		
Answer	79	72.5%
No answer	19	17.4%
Not displayed	11	10.1%

Open-ended responses with response to previous question:

1. Yes
2. Yes Resume experience.
3. Yes I had a head start on my peers for understanding industrial systems - compressors, heat exchangers, etc. translate directly from a manufacturing scale to refinery scale. I could also apply this understanding more quickly to new concepts and technologies, having had more practice "thinking like an engineer". Working in the field, I already knew what equipment looked like whereas some of my peers were seeing valves and fired heaters for the first time. I had also developed a diligent work ethic and had experience interacting with customers from maintenance to CEO level.
4. No
5. Yes It has given me more diversity as an engineer. I currently am a design engineer, but having experience in other engineering related fields has made me a more rounded problem solver, and I am able to communicate using a more broad knowledge base from the experience with IAC. Also, the communication, computing, and technical documentation skills have directly helped in my career.
6. Yes General understanding and comfort in using energy related concepts
7. Yes Yes it helped me gain experience to work in a field I really enjoy.
8. Yes I learned how to look for waste in every area of a production facility.
9. No
10. Yes I would not be at my current job if it wasn't for the IAC.
11. No
12. Yes I was able to transfer jobs after only one year in industry because I had two years IAC experience
13. Yes General manufacturing knowledge has been a big plus. Also, getting experience as an analyst/consultant and with generating recommendations and calculating paybacks has helped me a lot as a professional. I later got an MBA, and my IAC experience may have been part of what inspired me to do so.
14. Yes I gained a better grasp of how to approach a problem and then describe it in a written report to best communicate to someone with limited understanding of the science behind the problem.
15. Yes I believe I was able to enter my field at a higher level (more than strictly entry-level) because I worked for the IAC, and I believe I received more consideration for a position because of my IAC experience. I still see the benefits of IAC experience more than 10 years after leaving the system, both personally (my coworkers still recognize the value of my previous experience) and in the larger industry. I am now responsible for hiring engineers for an energy services consulting organization, and we prioritize and seek out people with IAC experience, going so far as to post our positions on IAC job boards and granting almost automatic interviews to people with IAC on their resumes. It's not only me, it's also my coworkers who did not work for IAC that recognize the value of an IAC employee.

16. Yes Above.
17. Yes The program provides an opportunity for a great foundation. I say "opportunity for a great foundation" rather than "a great foundation" because like any experience, you get out commensurate to what you put in. I went on every audit I was allowed and learned as much as possible. I think I could have done less and learned less if I had chosen to do so.
18. Yes
19. Yes It gave me skills and experience during school that most students do not have. I am still working for the company that gave me my first job. My IAC experience was a big reason I was hired.
20. Yes It laid the foundation for my career, helped me learn basic concepts while still in school and made me look better and knowledgeable in the job market. It shortened the time for on-the-job training and I used this time to be more innovative, applying already learnt and practiced ideas to the new scenario.
21. Yes Practice dealing with clients, gained understanding of industry, learned about production process of several pieces of equipment/machines/household items, and practiced responsibility to complete projects in a timely manner on my own schedule.
22. No
23. Yes
24. N/A
25. Yes It gave a lot of practical experience and on the ground knowledge of energy eficiency and industrial procedures.
26. Yes I graduated with the skills and abilities to conduct energy, waste, and productivity assessments, use instrumentation and diagnostic equipment, work safely in an industrial environment, and communicate successfully through written reports and presentations to clients. I even developed management skills by taking on leadership roles in the program. All of this valuable experience helped me to land a job even in a competitive job market.
27. Yes Exposure to different industry types, personnel at different levels in those companies, and EERE/DOE.
28. Yes I better understand how different engineering disciplines overlap, which has helped me determine how to fit into different industeries. It also has given me a passion and skill for improving almost any process, mechanical or human. Someday, I will be developing and delivering systems
29. Yes The skills listed above help me hit the ground running when I got my first job as an engineer.
30. Yes Right out of school I already had more experience than most other professionals who had been out in the field for several years. I was a leader from day one.
31. Yes The experience helped my confidence when it came to interviewing for my first job.
32. Yes There is no question that I would not have had the opportunities in my career without the IAC program. The expertise I gained through the IAC allowed me to start my career in a leading role in the company from my very first day. Since then I have used what I learned in the IAC every single day of my career and it has allowed me to advance to the Director of Engineering at a energy efficiency firm.
33. Yes It laid the foundation for everything I do now. From analysis to presenting results, I owe a ton to the IAC program for leading me down a career path that is both rewarding intrinsically and good for the environment and economy.

34. No 35. Yes 36. Yes 37. Yes Ability to identify energy saving opportunities. 38. Yes 39. Yes Absolutely. I learned the foundations required to build upon through my career. 40. No 41. Yes I got a job in energy immediately after graduating; left my IAC job on a Friday and started my new job on the following Monday. 42. Yes I am a better writer, communicator and driven engineer as a result of my experience with the IAC. 43. Yes Peaked my interest in the field and provided me the experience required to develop confidence. The IAC career website was the place where my employer found my resume about 6 years ago. 44. Yes It gave me experience. 45. Yes Having a background with some broader experiences helped my market my skills to a broader range of companies 46. Yes I worked in my first job for six months before accepting the commercial-industrial program manager position at a medium sized public utility. I would not have been selected for interviews had I not had the IAC experience. 47. Yes Practical work that I could leverage in getting a better job and being more experienced from entry level position 48. Yes I have a much broader understanding of industrial manufacturing from all the audits vs. a theoretical comprehension from a lab setting 49. Yes It is the most practical experience I have had thus far. I have drawn on this experience more than any of my other experiences as well. 50. Yes 51. Yes 52. Yes 53. Yes Knowledge is power 54. Yes "Grad school landed my current job 55. Yes Experience in auditing, energy savings analysis and understanding of systems 56. Yes Experience 57. Yes I wouldn't have known how exciting the energy industry could be, nor would I have had the experience that set me apart from other newly graduated engineers that would have had to have been trained from scratch. I had valuable experience so my first employer didn't have to expend as many resources getting me self-sufficient. After that, I am one of few experienced engineers in the earlier part of my career. I have found the job pool small - enabling me to secure advancements and opportunities I would not have had otherwise. 58. Yes It led to my current job in energy efficiency 59. Yes 60. Yes I have deeper technical knowledge than my colleagues at work who were not part of the IAC program. 61. Yes 62. Yes 63. Yes The IAC helped to provide the critical experience needed to develop as an engineer in real world applications. 64. Yes I started ahead of other students starting in the same area with a		

fresh graduate degree. Also, I learn quicker because of my earlier exposure. 65. Yes I was easily able to opbtain another internship that lead to a full time position 66. Yes 67. Yes 68. Yes Experience 69. No 70. Yes It helped me to get a job straight out of college. 71. Yes Learned a lot about sources of energy inefficiencies and was fortunate enough to get training on compressed air systems - I may not be using this directly now but there are many parallels between manufacturing and software development (current job). 72. Yes It gave me a view of the energy efficiency industry that I would not have otherwise gotten. From a practical standpoint, it got me in the door at my first employer. 73. Yes I think just the experience of writing professional reports and speaking in front of management were helpful. Even though they aren't directly related to energy efficiency, they are good skills to have when you work in 'the real world'. Again, I don't feel like I learned enough technical knowledge to consider that useful for my first job. 74. Yes 75. Yes helped me see a potential career path first-hand while i could still tailor my curriculum for different paths. helped me find a career that both stimulates and challenges me and that i feel passionately about 76. Yes Greatly. Without IAC, it was not possible for me where I am now. The energy efficiency field is amazingly great and it gives me a great satisfaction that I am doing something different than others. 77. Yes Professional consultation and writing experience. 78. Yes Provided real world experience nearly equivalent to an internship 79. Yes Although my career is not directly related to energy efficiency I can apply the principles to my current job to make sure that we are using energy efficiency standards in multiple areas. 80. Yes The IAC got me thinking about energy efficiency and renewable energy jobs that were available. I was able to get real job experience as an undergraduate student which helped to give me an advantage when applying for jobs. 81. Yes Proficient report writing, got used to professional meetings with managers, engineers, and technicians 82. Yes I got my job because of IAC. 83. Yes I wouldn't be in my current career as an energy engineer without the IAC program. The program was a great way to bridge what I was learning in the classroom and applying it to the real world. 84. Yes I gained people skills and learned more about performing calculations and writing reports by a certain deadline. 85. Yes 86. Yes 87. No 88. Yes The IAC program was a large stepping stone of work experience in my academic and professional path that lead from my university to another related summer internship which led to my first job which led to my second job at a DOE national lab, where I've recently celebrated my 20-year work anniversary and mostly recently led another DOE workforce development program in building energy efficiency.		

89. Yes Expanding your knowledge and skill set is priceless. 90. Yes It allowed me to join an energy efficiency firm and I am still working in the field. 91. Yes I have been employed in the consulting industry for the past 13 years. All I have done since graduating from the IAC is continued my work in the energy efficiency field. 92. Yes It got me into the energy field that I've stayed in. 93. Yes Yes it gave it me the opportunity to see some of my engineering courses such as thermodynamics, heat transfer and other engineering related courses applied to real world applications especially in the industrial, manufacturing and commercial industries. 94. Yes 95. Yes It helped me get an internship which turned into a job. 96. Yes I know how to do an energy audit. I know how to do the math of energy usage shown by the utility bill. These were skills wanted. 97. Yes Scientic writing is one I the hardest types I writing. It needs to be full of information and to the point. Writing te reports for the IAC allowed me to gain real world experience and to further develop this crucial skill when it c 98. Yes Confidence, experience and knowledge. 99. Yes A way to help me to find out what I really like to do in the future 100. Yes Yes and no. Jobs relating to energy seemed to be very difficult to find in Colorado at the time of my graduation. It helped in that I had job experience, but unfortunately due to the job market at the time it was difficult to get an energy related job. 101. Yes Well I gained extensive engineering experience and knowledge, expanded my technical writing skills, and have experience with cost savings and recommendations. 102. Yes The basic ROI process has been used throughout my career, as well as presenting in front of a group. 103. Yes Introduction into the world of energy assessments, industrial equipment, etc. 104. Yes Now I understand about the importance of clean energy. Therefore, I am doing research on wind energy. 105. Yes 106. Yes Engineering experience was obtained. I am now working in oil & gas and I still find lasting value from my IAC experience. 107. Yes After careers in both HVAC and HVAC controls contracting, I was able to make a career move (thanks to my experience in IAC) into an energy engineering role. It was the first job I loved, and where I felt I made a difference. 108. No 109. No		

Correlations - spearman

	Q3	p=value N=109
Q1	0.17372168	0.0708666
Q2	0.70201265	0.0000
Q3	1	
Q4.SQ001.	0.38372706	0.0000
Q4.SQ002.	0.2735949	0.0040

Q4.SQ003.	-0.36173291	0.0001
Q5.1.	-0.32206486	0.0006
Q5.2.	0.16868825	0.0795
Q5.3.	0.08546361	0.3769
Q5.4.	-0.12248356	0.2048
Q5.5.	0.0806181	0.4047
Q5.6.	0.09076916	0.3479
Q5.7.	0.17668659	0.0661
Q6	0.31292051	0.0009
Q7.1.	0.28913906	0.0023
Q7.2.	0.30686905	0.0012
Q7.3.	0.17302723	0.1730
Q7.4.	0.40617344	0.0000
Q7.5.	0.24103451	0.0116
Q8	0.03425465	0.7237
Q9.1.	-0.12668481	0.1896
Q9.2.	0.33215701	0.0004
Q9.3.	-0.24742787	0.0095
Q9.4.	0.08033017	0.4063
Q9.5.	-0.21803903	0.0228
Q10	0.31524511	0.0008
Q11	0.32939821	0.0005
Q12	0.21037815	0.0281

Appendix D: Findings of Potential Impacts

The table below displays the findings of potential impact on each participant group. “Supports” = supports achievement of objective. “Inconclusive” = is inconclusive regarding achievement of the objective.

IAC Program Objective	Outcome Representing the Objectives	Comparison Measured on the Same Outcome	Impacts Not Accounting for Rival Explanations	Impacts Accounting for Rival Explanations	Amount of Impacts Potentially Accounted for by Predispositions	Self-reported Experienced Outcome of the IAC Program
Increase the energy efficiency, productivity, sustainability, and competitiveness of U.S. manufacturers	Reported energy saving recommendations implemented	Single group: pre-test, post-test measures	53.8 MMBTU Supports	11.7-31 MMBTU Supports	42.1-22.8 MMBTU Supports	60% of participants said they would not have had a audit without the IAC program. Supports

IAC Program Objective	Outcome Representing the Objectives	Comparison Measured on the Same Outcome	Impacts Not Accounting for Rival Explanations	Impacts Accounting for Rival Explanations	Amount of Impacts Potentially Accounted for by Predispositions	Self-reported Experienced Outcome of the IAC Program
	Types of firms served	Not applicable	96% of participating manufacturers had 500 or less employees, 4% of participating manufacturers had >500 employees Supports	Not applicable	Not applicable	Not applicable
	Changes in participants' sales and employment	Comparison group match on firm characteristics	Increased sales and employment Supports	None Inconclusive	Increased sales and employment Inconclusive	Not applicable
To create the next generation energy engineers possessing a unique mixture of engineering and energy management expertise	Specific energy efficiency-related skills listed on alumni resumes	Comparison group: Post-test only measures	8.9	3.4 (Energy) 4.3 (Cohort)	5.5 (Energy) 4.3 (Cohort)	Not applicable
	Percent of alumni that entered IAC program for non-energy efficiency-related reasons that went into energy efficiency-related jobs attributed to the IAC	Not applicable	Not applicable	Not applicable	Not applicable	40% Supports

IAC Program Objective	Outcome Representing the Objectives	Comparison Measured on the Same Outcome	Impacts Not Accounting for Rival Explanations	Impacts Accounting for Rival Explanations	Amount of Impacts Potentially Accounted for by Predispositions	Self-reported Experienced Outcome of the IAC Program
	Percent of alumni that responded that their experience result[ed] in [them] becoming more interested in jobs that involved energy efficiency	Not applicable	Not applicable	Not applicable	Not applicable	84% Supports
	Attribution of specific skills to the IAC program	Not applicable	100% Supports	65% of those who answered no to the other opportunities question Supports	35%	100% of respondents attributed as least one energy-efficiency related skill to the IAC program. Supports
	Percent of alumni that went into a first job related to energy efficiency		52% Supports	71% that attributed their first job to their IAC experience Supports	26% that said their IAC experience did not help them get their first job. Supports	

Rival explanation means that would have obtained these services/skills from another source – this is the most conservative correction assuming that all students with the predisposition to increase their energy efficiency-related skills and all manufacturers with the predisposition to increase their energy efficiency would have obtained skills or recommendations from another source.