INDUSTRIAL ASSESSMENT CENTER PROGRAM
FINAL PROGRESS REPORT

PROJECT PERIOD:	**September 30, 2016 TO December 31, 2021**
AWARD NUMBER:	**DE-EE0007711**
CENTER LOCATION:	**Indiana University Purdue University Indianapolis**
DIRECTOR NAME:	**Jie Chen**
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The Indiana University Purdue University Indianapolis (IUPUI) Industrial Assessment Center (IAC) was established on Oct. 1, 2011. This funding period covered the second five years (2016-2021). The missions of the center for this period were 1) to train the energy efficiency workforce, 2) to help small and medium size companies to be more energy efficient, and 3) to develop technologies for small and medium size companies to improve energy efficiency. The center worked diligently to fulfill the missions.

TASK 1: Conduct Industrial Assessments, to include a variety of plant types, sizes and commercial/school facilities, as well as coverage of the geographic area defined.

Industrial Assessments

1. IUPUI IAC had contracted 18 assessments per year during this funding period. We have completed the committed number of assessments until the 2020 budgetary period when COVID-19 pandemic occurred.

	2017	2018	2019	2020	2021	Total
Assessments Completed	18	18	18	16	9	79
Reports	18	18	18	16	9	79

Uploaded to Rutgers						
Implementation Reports Completed	18	18	18	16	4	74

2. We had done 8 water treatment plants during the budgetary period.

Cybersecurity Assessments

We had also promoted cybersecurity in manufacturing and encouraged them to have their companies audited by our cybersecurity team during our energy assessments. We had completed six Cybersecurity audits during this period after receiving the invitation by the companies.

Other activities related to the cybersecurity:

- Developed a risk assessment Plan
- Developed a risk assessment process
- Developed a risk assessment website
- Implemented protocol for embedding cybersecurity team in the energy audits if the company
- shows interest in cybersecurity audit
- Created new Cybersecurity presentation for delivery
- Created new Cybersecurity Framework (CSF) walkthrough template
- Created new Company Information Template
- Modified risk assessment template

Other Assessments

We have also done 13 of energy audits, which were part of our effort to engage the community, promoting energy efficiency, and provide training to our center students. These were not manufacturing facilities, thus were not on IAC records.

1. Covanta Energy
2. Butler Univ. – Ross Hall.
3. IUPUI – Taylor Hall
4. Regal Beloit Plant
5. Kurry Indian Restaurant
6. Pollack LLC
7. Hurco Companies
8. El Ranchito Restaurant
9. Hyderabad House Restaurant.
10. Biehle Electric Inc..
11. Carl Sandberg High School
12. Advisor Realty Office
13. Meyer Plastics
14. Amri-Can in Argos, IN
15. Hoosier Hills Food Bank in Bloomington, IN

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COVID-19

Developed new protocols for both energy and cybersecurity assessments and IAC safety protocol under COVID-19 pandemic. The center had been trying hard to recruit companies and continued our assessments using the new protocols during the pandemic.

TASK 2: Provide educational opportunities, training, and other related activities for IAC students.

1. ***The training mission is executed by strengthening the following training programs:***

- Graduate Certificate of Energy Management and Assessment (GCEMA)
- Masters of Science in Mechanical Engineering (MSME) with Concentration in Energy
- Bachelor of Science in Mechanical Engineering (BSME) with Concentration in Energy
- Bachelor of Science in Energy Engineering (BSEEN)
- Combined BS EEN/ MS ME
- A training program for IAC students

2. ***Curriculum:***

Four graduate level courses were taught annually

- ME50101 Energy Assessment of Industrial Processes
- ME50102 Energy Management Principles
- ME50103 Industrial Energy Assessment: Tools and Applications
- ME50106 Industrial Energy Audit

The curriculum can be accessed by students in the Bachelor of Science in Energy Engineering (BSEEN) program, BSME, and MSME programs. The courses are offered regularly to train students who want to create career in energy efficiency through the GCEMA program; who want to receive BSEEN degrees; and who want to be engineers but have strong interests in energy efficiency. We promote the courses aiming at having more engineers to be trained on energy efficiency, which will influence their future employers to act on it. The department's BSEEN program benefits from these courses and the associated real world engineering case studies, which enhance student learning.

3. ***Center training program:***

Admission to IAC:

- Students apply for center positions.
- The applicants are interviewed to identify qualified candidates.
- The candidates are required to be trained through the training program.
- The students who successfully complete the training and one energy audit are admitted to be the center students.

A training program for center students

- New students are required to go through three training sections
    a. IAC industrial assessment process
    b. Equipment training
    c. Analysis and report
- Each of them is required to do one mandatory training audit and receive a passing grade

4. Class projects:

We took the education mission of IAC seriously. Faculty tried to provide the students the best training opportunities within our energy engineering programs, which include incorporating real-world engineering projects in the curriculum. Class projects were assigned to the students in these classes with real-world engineering projects. Totally 63 projects were assigned during this funding period. These projects by the year were:

2017

ME50101:

1. Students completed 3 energy related projects for Citizen Energy

ME50102:

2. Students completed 4 Air Handling unit (AHU) projects for campus facility

2019

ME50101

8. Students completed three energy related projects for Citizen Energy, Ryobi Die Casting, and campus building as a part ME 50101 class project

ME50502:

9. Students completed energy modeling of seven campus building and identifying potential energy saving as class project for ME50102.

ME 50103:

10. Students completed audits at: Ray Skillman Motorsports, Phillips 66 Gas Station on
11. Ohio St., Sims-Durkin Associates Engineering, Bway Corporation, Butler University's Pharmacy
12. Building, Marian University-Library Building, IAV Automotive Engineering Inc., and Marion
13. University–Health Science Building.

2020

ME 50101: Students were working on the following class projects:

14. Cummins Solar Thermal Washer
15. CO2 based Occupancy Detection
16. Storing Energy Through the Use of Gravitational Potential
17. Renewable greenhouse Capacitors
18. HVAC Energy Reductions
19. Urban Energy Production: Using city processes and citizen activity
20. IUPUI Retro-Commissioning Review
21. Arcamed Energy Efficiency Improvement
22. The Effects of Temperature, Production and Occupancy on Electrical Maximum Demand
23. Systematic Approach to ISO 50001 Ready

EEN 26000: Students have completed the following class projects

24. Net Zero Cities
25. Smart Grids & Sustainability
26. Hydrokinetics Progress Report
27. The Setup differences Between a PV power plant and a CSP power plant
28. Fusion Energy and the current future outlook of its integration into everyday power generation
29. Modular Construction
30. Applications and benefits of biogas and biomethane in a growing world

ME 50101: Students were working on the following class projects

31. Economizers and different control logics to engage the economizer in AHU's for different climate zones for IUPUI campus.
32. Predicting Condensing Heat Recoverable Values

2021

ME 50101: Students completed the following class projects

33. Economizers and different control logics to engage the economizer in AHU's for different climate zones for IUPUI campus. The project was sponsored by campus facility engineer.
34. Predicting Condensing Heat Recoverable Values
35. Energy Reduction Opportunities in Compressor Systems

ME 50103:

36. Two students worked on a project for Cummins Engine Co. to identify energy saving opportunity for Cummins Auxiliary Motors.
37. Analysis of Home Automation
38. Systems, Industrial Boiler Flue Gas Analysis and Equipment for Efficiency Improvement
39. Industry 4.0: A Revolution
40. Motor Variable Frequency Drives Energy Savings
41. Utilizing Energy Efficient Motors in Industrial Facilities to Improve Energy Efficiency Wave Energy
42. Conversion Efficiency Improvements

EEN 34500: the students worked on the following project as part of course assignment,

43. Langsdale Solar Power for Citizen Energy
44. Solar Pumps
45. Residential Use of Solar Energy with a Focus on Tesla's Solar Roofs
46. Energy Storage Systems for Residential Homes
47. Algae and Kelp into Biofuel
48. Fourth Generation Biofuels

EEN 26000: the students worked on the following project as part of course assignment,

49. Emerging Solar Energy and Storage
50. Sustainable Energy for developing countries
51. Renewable Energy In Syria
52. Investigating Butler University best options to incorporate solar energy
53. Decarbonization: Approach and Solutions
54. Solar District Cup Project

ME 50101: the students are working on the following projects,

55. Electric Rate Calculator for the state of Indiana
56. Energy Recovery from Wastewater Treatment Facilities
57. Energy optimization protocols (EOP) on HVAC system
58. Energy scheduling of active buildings
59. Investigation on the effect of working fluid in organic Rankine cycle for low temperature waste heat recovery.

60. Predicting Condensing Heat Recoverable Values
61. Rescheduling high demand event to reduce demand charges: California Pellet Mill plant
62. Coincidence Factor Study
63. Evaluation of compressor air as energy storage.

5. Student organized seminar series:

Starting in 2018, students have been encouraged to conduct research on issues related energy assessments, do internship, and be trained on DoE software tools. They are required to present their research finding in the weekly center meetings. Totally 81 projects were presented during this funding period. These projects were:

2018

1. Design Enhancement of a Solar Power Satellite
2. HVAC system Introduction
3. Internship experience with TRC Worldwide Engineering
4. Oak Ridge National Laboratory Internship Experience
5. “DOE Race to Zero” competition 1 and Fisconic technology
6. “DOE Race to Zero” competition 2 and Fisconic technology

2019

7. IAC Mobile Estimator App
8. New Recommendations
9. MEASUR Demonstration
10. Microgrid Model
11. Real-time Wireless Energy Management
12. State of World Energy and Energy Efficiency (present & future)
13. Piezo-electricity
14. Distributed generation
15. Smart grids and energy management
16. Energy Advancement Opportunities in Developing Countries
17. The impact of vehicle to grid technology on the power grid
18. Compressed-Air Storage system
19. Transformer Enclosure Investigation
20. Nano-fluid Heat Transfer
21. Geothermal energy and its uses
22. Solar roadways
23. Space based solar power
24. Nuclear Technology: Implementation into Today's Society
25. Hydropower and the future of hydropower
26. The Actual State of Supply and Demand of Energy in Angola
27. Railroad Transportation and Energy Harvesting
28. Thorium based nuclear power
29. Chiller heat recovery using heat pump
30. Diesel hybrid systems
31. Thermo-acoustic
32. Sacrifice Zone

2020

33. Design Enhancement of a Solar Power Satellite
34. HVAC system Introduction

35. Internship experience with TRC Worldwide Engineering
36. Natural Gas Utilities - Extraction, Refinement, and Distribution, student presenter: Brian Lay
37. Net-zero energy buildings, student presenter: Jitlekha Tubsuri
38. Energy efficiency and utilization as it relates to cloud computing, student presenter: Asher
39. Ensmenger
40. Natel Energy hydro-power technology, student presenter: Juan Pablo Giovannone
41. Geothermal heating and cooling, student presenter: Cal Ormanovich
42. Oak Ridge National Laboratory Internship Experience
43. Design of Heat Exchanger, student presenter: Akshay Pukale,
44. Brownfield Remediation, student presenter: Morgan Mitchell/Juelma Domingos
45. Wind Turbine Blades, student presenter: Corey Miller, Nano Composite for
46. EnergyPlus Demonstration, student presenter: Glorio Singui,
47. Energy storage in Indiana, , student presenter: Raunak Kelshiker
48. Use of thorium and the decline/increase in nuclear power generation in different countries along with potential uses in the future such as for space exploration and extraterrestrial colony bases, student presenter: Ebin Daniel
49. Modular construction on the environment in comparison with traditional construction
50. Methods, student presenter: Ahmad AL Taher
51. Feasibility in scaling wind turbines to increase US renewable energy footprint, student presenter: Jason Sizen
52. Evaporative Cooling as a means for energy recovery, student presenter: Glorio Singui
53. Micro-grids and how they relate to electrical distribution systems, student presenter: Curtis Syswerda
54. Non-Energy AR Research, student presenter: Raunak Kelshiker
55. In-Depth Electrical Rate Structure Research for Electro-Spec, student presenter: Ali Salarmoradi
56. Nickle Electroplating Power Glitch, student presenter: Matthew Blubaugh
57. Summer Internship experience at IPL, student presenter: Cal Ormanovich
58. Energy Recovery from Waste treatment plants, student presenter: Raunak Kelshiker
59. Rebate Structures, student presenter: Julia Cilleruelo Fernandez del Moral

2021

60. Non-Energy AR Research, student presenter: Raunak Kelshiker
61. In-Depth Electrical Rate Structure Research for Electro-Spec, student presenter: Ali Salarmoradi
62. Nickle Electroplating Power Glitch, student presenter: Matthew Blubaugh
63. Geothermal Energy, student presenter: Matthew Blubaugh
64. Energy Production in a City, student presenter: Ebin Daniel
65. Modular/Small scale reactors – Next generation of energy production, student presenter: Amal Bhaskaran
66. Effect of production, temperature and occupancy on Maximum Electrical Demand, student presenter: Jitlekha Tubsuri
67. Boiler Flue Gas Heat Recovery, student presenter: Juan Giovannone
68. Electric Rate Deciding Calculations, student presenter: Ali Salarmoradi
69. Waste Water Treatment Research, student presenter: Raunak Kelshiker
70. Fusion Energy, student presenter: Colin Hunter
71. ISO 50001 Ready Navigator, student presenter: Cal Ormanovich
72. Modular/Small scale reactors – Next generation of energy production, student presenter: Amal Bhaskaran

73. The Effects of Temperature, Production and Occupancy Electrical Maximum Demand, student presenter:Jitlekha Tubsuri
74. Organic Rankine Cycle, student presenter: Saman Taheri
75. Waste Heat Recovery, student presenter: Saman Taheri
76. Electro Spec Case Study, student presenter: Matthew Blubaugh
77. Solar Energy Systems for Citizen's Group, student presenter: Julia Cilleruelo & Amal Bhaskara
78. Modular/Small scale reactors – Next generation of energy production, student presenter: Amal Bhaskaran
79. Electrical Utility Analysis Training, student presenter: Ali Salarmoradi,
80. Internship Experience – ABTC, student presenter: Colin Hunter
81. Energy Management Policy - Cummins Internship Experience, student presenter: Julia Cilleruelo

Please indicate the number of students per fiscal year:

	2017	2018	2019	2020	2021	Total
Students Participating in the Program	22	21	21	21	13	98
Student Certificates Awarded	5	8	2	8	3	26

TASK 3: Overall project management and administrative tasks

Personnel:

Management team: Our center has one director, two assistant directors, and one lead student

Center staffs: 10 – 20 graduate or undergraduate students per year and two faculty specialists

Specialists: Our center has two specialists: One for cybersecurity and the other one for development of an industrial internet of thing (IIOT) based energy management system.

Center management:

Weekly management meeting – a regular meeting for the management team to conduct project review, resolve center issues, and plan for the center

Weekly center meeting - regular meeting for the center students to meet to discuss energy assessment related issues, student presentations, and center related issues

Center infrastructure building:

Office and lab- The center has secured a newly renovated office (475 sq.ft.) and a 150 sq.ft. lab with computers, monitors, printers, and furniture. The center also secured a 500 sq.ft. lab space for developing the IIOT based energy managed system.

Equipment- The center is fully equipped with equipment, which is adequate for completing quality industrial assessments of the small and medium size manufacturing companies.

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Project management:

A process has been used to ensure quality and on-time delivery of the report as well as Implementation survey, which includes:

1. An on-line registration site was built to collect necessary company information for assessing the qualification of the manufacturing companies based on the IAC qualification criteria.
2. An assistant director is the point of contact to the manufacturing company and makes the initial contact and will be supervising each industrial assessment. The assistant director is responsible for the quality of the audit, the quality of the final report, as well as the implementation survey.
3. Establishment of a four step industrial assessment process
    - Four-step Process
        i. Pre-Assessment information Gathering
        ii. Pre-Assessment Analysis
        iii. On-site Assessment
        iv. Post Assessment
    - Details of the one Day On-site Assessment
        i. Introduction
        ii. Q & A
        iii. Plant Tour
        iv. Meeting room debriefing
        v. Review notes and brainstorm (Lunch)
        vi. Refine List of opportunities to be investigated
        vii. Data Gathering
        viii. Exit Interview
    - Details of the Post-assessment Report
        i. Conduct engineering and financial analysis
        ii. Deliver an IAC Report
        iii. Executive Summary including summary of Recommendations
        iv. Plant Description
        v. Process Description
        vi. Resource Charts and Tables
        vii. Major Energy Consuming Equipment
        viii. Best Practices
        ix. Description of Individual Energy Saving Recommendations

- Follow-up to Report

4. Establishment of a cybersecurity assessment process
    - Pre-assessment information gathering
    - Self-evaluation using the Industrial Control Systems Cybersecurity Assessment Tool
    - Acquiring the permission for a cybersecurity audit
    - Once received permission, an on-site assessment is scheduled
    - On-site assessment and data collection
    - Post-assessment analysis
    - Development of the assessment report
    - Provision of an IAC Cybersecurity Awareness tool in the IUPUI IAC website, https://iaciupui.sitehost.iu.edu/cybersecurity-assessment/ and provision of technical help on need-basis
5. Organization of audit team – A team of 5 – 6 students consisting of a team lead student, a safety engineer, and an equipment engineer along with three group leads (electric, thermal, and industrial) and group members. The qualification of the lead student relies on the student's overall experience and quality of work.
6. Responsibility of the lead student - The team lead is responsible for organizing pre-assessment analysis, pre-assessment meeting; leading the audit; organizing post-assessment analysis and final report; and submitting the final report.
7. The center directors are responsible for implementation survey.
8. Time management – A spreadsheet was built for each audit. It details the tasks, the deadlines, and responsible personnel. The progress shown in the spreadsheet is evaluated in the weekly center meeting.
9. Center weekly meeting – The center has weekly meetings to discuss the progress of each audit. The lead student is responsible to report progress, discuss issues, and propose solutions. The faculty and center students have a chance to comment, a learning process that benefits everyone.
10. Evaluation of the student performance – The lead student is responsible to evaluate the team members. He/she is also evaluated by the center lead student and the director after submission of the report based on the 10 criteria established for assessing student's qualification for the DOE certificate.
11. DOE certificate – A center student who completed at least six audits, satisfactorily served as the team lead student for at least once, and served professionally in the center were approved for receiving the DOE certificate. Totally 26 students have received DOE Certificates.
12. Documentation – A secured Microsoft Team account was built for documenting center files.

Center staff training:

1. Faculty
    a. Participated in local Association of Energy Engineer meetings.

   b. Faculty actively participated in Association of National Association of Power Engineers (NAPE) activities.
   c. Participated in meeting of Industrial Energy Efficiency/CHP Working Group, par of State Energy Efficiency Action Network of US DOE.
   d. Directors have participated in all annual director meetings.
   e. Directors have regularly participated in local energy efficiency related conference.
2. Students
   a. Students are encouraged to participate in the Webinars organized by Rutgers.
   b. Students are required to give technical talks on energy efficiency during the weekly center meetings

TASK 4: Promote and increase the implementation of assessment recommendations and employ innovative methods to assist in accomplishing these goals.

The center has been seeking effective ways to increase the implementation rate. The focus has been on engaging the companies we audited after submission of the final report. The following measures were taken:

1. Offering free technical support for questions in our reports
2. Conducted 7 month implementation follow up call and completed the implementation survey at 10 months

TASK 5: Promote the IAC Program and enhance recruitment efforts for new clients, expanded geographic coverage and reaching non-participating small and medium enterprises in the region

The center has been working very hard to promote energy efficiency and IAC services. We learned from our practice and constantly seeking new ways to recruit new clients. Followings are the activities:

1. Built up good working relationship with utilities – We have been working closely with utility companies, such as AES Indiana, Duke Energy, HoosierEnergy, CenterPoint Energy, Citizens, Ameren Illinois ,… etc. to recruit new clients and analyze energy bills
2. Reached out potential clients by giving technical presentations and setting up booth in energy efficiency related conferences e.g., Indiana Energy Management Conference, “Built Environment” workshop, ASHARE seminars, Association of National Association of Power Engineers (NAPE), giving seminars or talks to AEE local chapter meetings and Hoosier Energy Efficiency Seminars
3. Worked with faculty and student in School of Business to develop recruitment strategies and methods
4. Worked with the state and city government offices to keep them informed on our center activities
5. Created and updated continuously an informative website for educating public, recruiting

new companies, and promoting IAC services

6. Explored promotion using social media including: LinkedIn, Facebook, Twitter, Blog, and salesforce
7. Reached out to high school students by giving a lecture presentation on energy and energy engineering
8. Organized an energy Lab for high school student camp at IUPUI
9. Compiled a database that consists of lists of companies contacted, responded, not responded

TASK 6: Approaches to deliver IAC services in the areas of Smart Manufacturing, Cybersecurity, Energy management systems and Wastewater and water facilities**.**

The small and medium sized manufacturing companies do not have professional energy efficiency personnel. They need tools to effectively manage their energy use. Our center has been exploring the method to effectively monitor energy use, detect anomaly, provide energy efficiency related options, and enable real-time assessments. We have been developing energy efficiency strategies that can be used in an Industrial Internet of Thing (IIOT) based energy management platform. We have developed the following strategies:

1. Developed a working IIOT based energy management platform
2. Demand forecasting model for implementing peak shaving strategy
3. Lighting
4. Air handling unit control based on occupancy
5. Compressor system modeling
6. Compressor power use forecast model

TASK 7: Coordinate and integrate Center activities with other Center and IAC Program activities, DOE's Advanced Manufacturing programs and other EERE programs, as well as with any other specific partners/collaborations identified in the Statement of Project Objectives**.**

The center has been exploring ways to collaborate with other centers in energy efficiency. We have been focused on both education, promotion, and research. The activities include:

1. Worked with the UIC IAC to conduct an audit that UIC was not allowed to do due to COVID
2. Worked closely with MEP for joint energy audits
3. Worked with CLEAResult, an energy management company, for finding clients
4. Worked with Pat Brown at UIC-IAC to develop a "IAC Regional Resource Council"

TASK 8: Other tasks or special projects, as needed, and as determined by DOE to be advantageous to the program and in furtherance of IAC Program goals

List of our IAC Publication 2016-2021

Patent

1. Razban, A., Wu, D., Amini, A., Chen, J., "Forecasting and Managing Daily Electrical Maximum Demands", U.S. Pat. No. 10,977,586, April 13, 2021.

Refereed Journals

1. Taheri, S. and Razban, A., "Learning-based CO2 concentration prediction: Application to indoor air quality control using demand-controlled ventilation", Building and Environment 205, Article 108164, Nov. 2021, https://doi.org/10.1016/j.buildenv.2021.108164
2. Trautman, N., Razban, A. and Chen, J., "Overall Chilled Water System Energy Consumption Modeling and Optimization Condenser Water Energy Consumption Optimization", Applied Energy, volume 299, Oct. 2021, https://doi.org/10.1016/j.apenergy.2021.117166
3. Wu, D. Bahrami, B., Razban, A. and Chen, J., Air Compressor Load Forecasting using Artificial Neural Network, J. Expert Systems with Applications, Vol.168, Article 114209, April 2021, https://doi.org/10.1016/j.eswa.2020.114209
4. Vance, D., Razban, A., Schubert, P., Weissbach, R., "Investigation into Sizing Photovoltaic with Energy Storage for Off-Grid Transactive Scenarios", "Special Issue "Renewable Energy and Energy Storage Systems", Energies 2021, 14(4), 1062; https://doi.org/10.3390/en14041062
5. Ligade, J. and Razban, A., Investigation of Energy Efficient Retrofit HVAC Systems for a University: Case Study, Sustainability 2019, 11(20), 5593; https://doi.org/10.3390/su11205593
6. Razban, A., Khatib, A., Goodman, D., Chen, J., Mechanical modeling of air handling unit subsystem in a commercial building, Thermal Science and Engineering Progress 11 (2019) 231-238, https://doi.org/10.1016/j.tsep.2019.03.019.
7. Wu, D. Amini, A., Razban, A. and Chen, J., ARC algorithm: a novel approach to forecast and manage daily electrical maximum demand, J. of Energy, Volume 154, 2018, Pages 383-389, https://doi.org/10.1016/j.energy.2018.04.117 (invited paper).

Refereed Conference Proceedings

1. Blubaugh, M., Razban, A. and Chen, J., "Demand-Controlled Ventilation Energy Savings for Air Handling Unit, Proceedings of Applied Energy Symposium: MIT A+B (Energy Proceeding, Vol. 15), Boston, MA., 2021, Volume 15: Technology Innovation to Accelerate Energy Transitions | Energy Proceedings (energy-proceedings.org)
2. Momeni, M. , Wu, D., Razban, A. and Chen, J., "Data-driven Demand Control Ventilation Using Machine Learning CO2 Occupancy Detection Method", Proceeding of ECOS 2020, the 33 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, pp. 2047-2058, June 29-July 3, 2020, Osaka, Japan.
3. Dalvi, A., Razban, A., El-Mounyari, H., El-Mekkawy, T. and Promyoo, R. "Integrated System Model of District Cooling for Energy Consumption Optimization", Proceeding of ECOS 2020, the 33 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, pp. 1709-1719, June 29-July 3, 2020, Osaka, Japan.
4. Wang, B. and Razban, A., "Systematic energy and exergy efficiency study and comparison between direct fired and indirect fired heating systems", Proceeding of ECOS 2019, the 32 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, pp. 645-656, June 23-28, 2019, Wroclaw, Poland.
5. Bahrami, B., Trautman,N., and Razban, A., "Compressed air energy storage for demand management in industrial manufacturers", Proceeding of ECOS 2019, the 32 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, pp. 677-690, June 23-28, 2019, Wroclaw, Poland.

6. Vance, D., Razban, A., Schubert, P., Weissbach, R., "Developing a PV and Energy Storage Sizing Methodology for Off-Grid Transactive Microgrids", Proceedings of Applied Energy Symposium: MIT A+B May 22-24, 2019 • Boston, MA.
7. Ligade, J., Sebastian, D. and Razban, A., "Challenges of Creating a Verifiable Building Energy Model", ASHRAE Transactions (2019) 125 20-28, 2019 ASHRAE Winter Conference & AHR Expo, Atlanta, GA, January 12–16, 2019.
8. Ayoub, A., Razban, A. and Chen, J., "Modeling of Industrial Air Compressor System Energy Consumption and Effectiveness of Various Energy Saving on the System", Proceedings of ECOS 2018, the 31 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, June 17-21, 2018 Guimaraes, Portugal.
9. Wu, D., A., Razban, A. and Chen, J., "Energy Audit Quick Estimator: A User-friendly Mobile Estimator for Energy Auditors", Proceedings of ECOS 2018, the 31 International Conference on efficiency, optimization, simulation and environmental impact of energy systems, June 17-21, 2018 Guimaraes, Portugal.
10. Wu, D., Amini, A., Razban, A. and Chen, J., A Novel Approach to Forecast and Manage Daily Electrical Maximum Demand, Proceedings of ECOS 2017, The 30th International Conference on Efficiency, Cost, Optimization, Simulation and environmental impact of Energy Systems, July 2-6, 2017, San Diego, CA.
11. Razban, A., Edalatnoor, A., Goodman, D., and Chen, J, Energy optimization of air handling unit using CO_2 data and coil performance, Proc. of the ASME 2016 International Mechanical Engineering Congress and Exposition (IMECE2016), Nov. 2016, ISBN: 978-0-7918-5059-6, doi:10.1115/IMECE2016-66271
12. Goodman, D., Chen, J., Razban, A., and Li, J., Identification of key parameters affecting energy consumption of air handling unit, Proc. of the ASME 2016 International Mechanical Engineering Congress and Exposition (IMECE2016), Nov. 2016, ISBN: 978-0-7918-5059-6, doi:10.1115/IMECE2016-66258

Refereed Abstract Conference

1. Razban, A., Various Energy Consumption Saving in Industrial Air Compressor System, Indiana Energy Management Conference, Indianapolis, IN, Aug. 2018
2. Razban, A., Bachelor of Science in Energy Engineering at IUPUI, 3rd National Energy Education Summit, Washington, DC., Jan. 2018
3. Razban, A., Lowering Utility Bills by using Demand Peak Shaving, Indiana Energy Management Conference, Indianapolis, IN, Aug. 2017
4. Razban, A., Lowering CO_2 emission by Reduction in Energy Consumption", Indiana Environmental Conference, Indianapolis, IN, Oct. 2016
5. Razban, A., Increasing Company's Profits by Managing Energy Consumption, Indiana Energy Management Conference, Indianapolis, IN, Aug. 2016
6. Razban, A., Energy Management Graduate Certificate at IUPUI, 2nd National Energy Education Summit, Washington, DC., June 2016

Poster Session

1. Wu, D. , Bhattacharjee, A., Chien, S., Razban, A., and Chen, J., An Integrated Remote Monitoring and Controlling Platform for Improving Industrial Energy Efficiency, Technology's 2nd Annual Leadership Symposium, Indiana University Purdue University Indianapolis, Oct. 2017.

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TASK 9: Other Achievements of Program

- IUPUI IAC received the 2019 DoE Industrial Assessment Center of Excellence Award presented by the Department of Energy's EERE, July 2019
- The center student, Allen Wu was selected as the recipient of the 2018 Industrial Assessment Center Outstanding Student Award
- The center student, Abdul Hadi Ayoub was selected as the recipient of the 2019 Industrial Assessment Center Outstanding Student Award