
AC 2012-4589: IIT CAMPUS AS A SUSTAINABILITY LIVING LABORATORY FOR EDUCATION AND RESEARCH FOR STUDENTS

Prof. Hamid Arastoopour, Illinois Institute of Technology

Hamid Arastoopour is presently Henry R. Linden Chair professor of energy and Director of the Wanger Institute for Sustainable Energy Research (WISER) at Illinois Institute of Technology (IIT). He is also professor of chemical and mechanical engineering at IIT. His research expertise is in computational fluid dynamics (CFD) of multiphase flow and particle technology, an area motivated by pharmaceutical and energy and environmentally related applications and documented in more than 100 publications and 13 U.S. patents. He has developed an international reputation for his research in the areas of computational fluid dynamics, fluid particle systems, and fluidization. His computational work has shortened the time lag from laboratory- to commercial-scale for fluid/particle and fluidized bed systems. He currently serves on the editorial board of the Powder Technology Journal. He has received several AIChE awards including the Donald Q. Kern Award in Heat Transfer and Energy Conversion, the Fluor Daniel Lectureship in Fluidization and Fluid/Particle Systems, the Ernest W. Thiele Award, and the Fluidization Process Recognition Award. He is also a Fellow of AIChE.

Mr. Mohamed Shahidehpour, Illinois Institute of Technology

Mr. Joseph Clair P.E., Illinois Institute of Technology

Joseph Clair currently serves as the Director of Campus Energy and Sustainability for the Illinois Institute of Technology. In this position, Clair documents and coordinates programs for resource efficiency, environmental protection, and stewardship, while implementing an overall strategic sustainability vision and plan for the Institute. Working cooperatively with students, faculty, and staff, Clair supports the ingenious and tenacious push for true sustainability coming from all aspects of the university. In 16 years in the construction business, Clair has worked as a contractor, designer, construction manager, commissioning authority, and now owner, seeing all ends of the building business. In each of these capacities, Clair has attempted to bring practical, effective solutions to construction issues resulting in better building performance, more cost effective construction, and better cooperation among designers and contractors. His respect for the knowledge, skills, and contributions of all members of the construction and building operation team has allowed him to build bridges between traditionally adversarial groups, resulting in improved building performance. As part of his responsibilities at IIT, Clair serves as the implementation Project Manager for the Perfect Power/DOE smart-grid project.

IIT Campus as a Sustainability Living Laboratory for Student Education and Research

Abstract

As one of its key initiatives, WISER has developed a collaborative program with IIT academic colleges and the Office of Campus Energy and Sustainability (OCES) to achieve its mission of making IIT the most sustainable urban campus in our nation and utilizing the IIT campus as a living laboratory for education and research for both graduate and undergraduate students. At IIT campus, we are committed to significantly reducing greenhouse emissions; focusing on creative strategies for improving energy performance in buildings; reducing the need for carbon-based fuels in the energy supply; and encouraging occupant behaviors that reduce the net environmental impact of the campus. Through our unique requirement for all undergraduate students to enroll in two Interprofessional Projects (IPRO) courses, and the simultaneous offering of a broad array of graduate and undergraduate research projects, IIT students are getting involved in many ongoing energy and sustainability initiatives using campus energy and sustainability operations as a real-world and practical laboratory. These projects include: micro grid (smart grid) and renewable energy production such as solar and wind, food composting, recycling, and sustainable built environment.

Introduction

National security, and economic vitality and growth, depend upon adequate future energy supplies. Global reserves of non-renewable, conventional energy resources are of increasingly limited availability at continuously rising prices. It is in the national interest to focus university initiatives in technology and research on the sustainability of the energy supply and related areas.

Launched in 2008, IIT's Wanger Institute for Sustainable Energy Research (WISER) represents the culmination of more than six decades of the university's research endeavors in the area of energy and sustainability. IIT traces its roots in the energy arena to the 1940s and its

affiliation with the Institute of Gas Technology, which in 1985 led to a partnership with Gas Research Institute and the formation of an energy research program at IIT. Today, WISER is contributing significantly to national energy and sustainability research and education. More than 50 nationally recognized faculty in energy and sustainability research areas are part of WISER, representing university disciplines that span engineering, design, architecture, business, psychology, the sciences, and law.

The vision of WISER is a world with energy and water security, sufficient and affordable sources of clean energy and water, and a sustainable climate and water to ensure quality of life, social and economic well-being, and the preservation of natural resources and the environment for future generations. The WISER approach to energy and sustainability uses a least-cost strategy to improve the reliability, security, and affordability of energy and water. It aims to improve energy efficiency and conservation, emphasizing decarbonization of fuels and waste minimization. WISER goals include: launching initiatives such as making IIT campus a living sustainability laboratory for the students that will expand the interdisciplinary perspective of the research and education activities in the energy and sustainability area; setting a new high standard of excellence in energy and sustainability education in partnership with industry, national and research laboratories, and universities; and attracting more women and minority students and faculty by creating a welcoming and diverse community within WISER.

Energy and sustainability educational programs at IIT include: Environmental Management and Sustainability, Power Engineering, Environmental Engineering, and the Energy, Environment and Economics specialization offered at both the undergraduate and graduate levels. In addition, IIT's signature Interprofessional Projects (IPRO) program, a hands-on undergraduate program that engages multidisciplinary teams of students in projects based on real-world topics, features a number of projects each semester in areas related to energy and sustainability, and a range of activities that utilize IIT campus as a living laboratory.

IPRO

Teamwork, innovation, and complex problem-solving skills make successful professionals—and reflect the overall performance of their organizations. Since 1995, the IPRO team project courses at IIT have been teaching students how to excel in the workplace by

providing them the practical tools that can make a difference in their professional and personal lives.

The IPRO program joins together students from various academic disciplines to work as a team to tackle a real-world problem. Students from architecture, engineering, and humanities may create low-cost sustainable housing. Students from chemistry, chemical engineering, business, and law may develop best practices in CO₂-reducing technologies. Such learning reinforces traditional education methods, providing students a richer academic experience.

Each IPRO course is organized as a team of 5-15 students from the sophomore to graduate level. All projects are designed with goals that can be completed in one semester. However, many projects continue over multiple semesters and years, with continuing areas of investigation. No two semesters are ever alike. An Entrepreneurial IPRO (EnPRO) has the added dimension of business planning and new venture analysis. The IPRO program offers students the opportunity to solve real-world problems while engaging with IIT faculty and key stakeholders in the decision-making process:

- Many corporate and community partners participate in and sponsor projects
- Students, faculty, alumni, and various organizations propose project topics
- EnPROs pursue ideas with a business
- Sustainability IPRO projects aim to create a sustainable world through exploration of technologies, behaviors, and practices that change our way of thinking, working, and living

Energy and Sustainability Living Laboratories

As intellectual centers of innovation and progress, universities are well positioned to take the lead on sustainability. The university campuses not only can reduce their own environmental impact but also can serve as role models for their larger communities.

Numerous campus sustainability initiatives have been launched in recent years. Universities and colleges are increasingly choosing to participate in state and nationwide sustainability networks that emphasize knowledge sharing and collaboration within and among institutions, such as: Alliance to Save Energy and American College & University Presidents' Climate Commitment (ACUPCC). Today, faculty and students need a testing ground where they can

see their ideas become reality; a campus looking to make rapid, controlled change requires innovators willing to try new ideas. WISER has implemented a number of processes to allow the IIT campus to serve as a testing ground for ideas in energy and sustainability. All projects including IPROs and initiatives on-campus will include aspects that increase the students' ability to interact with and learn from campus- wide energy and sustainability programs and initiatives.

In this paper, we will discuss a few campus living laboratories/ initiatives namely: micro grids and renewable energy, composting, transportation, and recycling and reusing. These facilities not only will be used by students as a learning experience, but also are designed to motivate them to create new initiatives.

Micro Grid - In 2004-2006, the distribution system at IIT suffered 12 unplanned power outages that disrupted academic and administrative activities and damaged several operations and pieces of research equipment. The outages were due to partial or complete loss of utility supply and malfunctions of aged cables and other distribution components at IIT. The lack of system redundancy and the unavailability of replacement components prolonged the outage durations at IIT. In 2005, the Galvin Electricity Initiative led a campaign to implement a perfect power system at IIT with the objective of establishing a micro grid that is environmentally friendly, fuel efficient, robust, and resilient, with self-healing capability. The micro grid at IIT would empower the campus consumers to control their daily power consumption, in response to the real- time price of electricity. The IIT micro grid enhances its efficacy and operational reliability by applying a real-time reconfiguration of power distribution assets, real-time islanding of critical loads, and real-time optimization of power supply resources.

Figure 1 shows the configuration of the ComEd distribution network (main grid) that feeds IIT. Here, the IIT demand is supplied by three 12.47 KV circuits fed from the Fisk substation (owned by ComEd.) The peak load at IIT is approximately 10 MW. IIT's 4.16 KV distribution system consists of 12.47/4.16 KV transformers, supply/feeder breakers, and building transformers. The Siegel Hall building within the IIT micro grid is considered as the pilot building for the deployment of the perfect power system. The building is fed through the primary feeder, which is backed up by a secondary (redundant) feeder equipped with an automatic switch. The power is further stepped down to 120 V in the building.

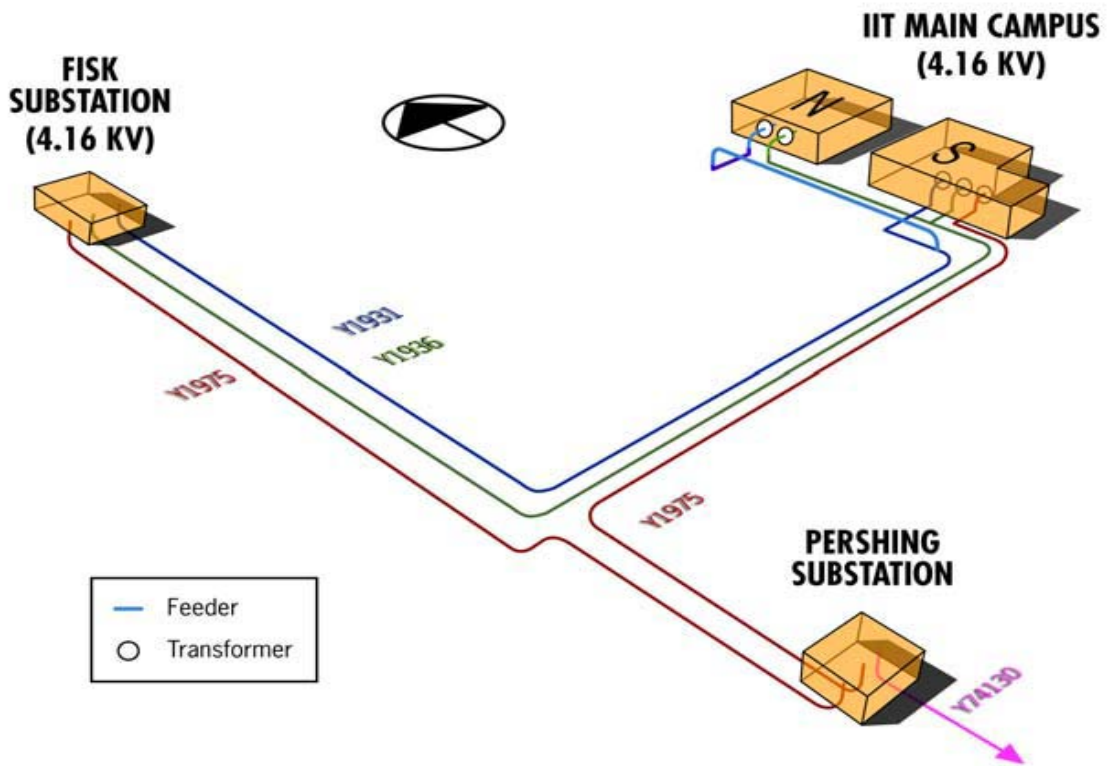


Figure 1. ComEd system configuration feeding IIT substations

In Figure 2, the IIT micro grid consists of seven loops. The North Substation feeds three loops while the South Substation supplies energy to the remaining loops. Each building is supplied by redundant feeders which are normally energized to ensure that the building is fed by an alternate path in the case of an outage. The HRDS at IIT utilizes Vista underground closed loop fault-clearing switchgear with SEL-351 directional over-current protection relays. The fault isolation takes place in a quarter of a cycle by automatic breakers. The communication system is via fiber optic cables that facilitate the coordination between switches.

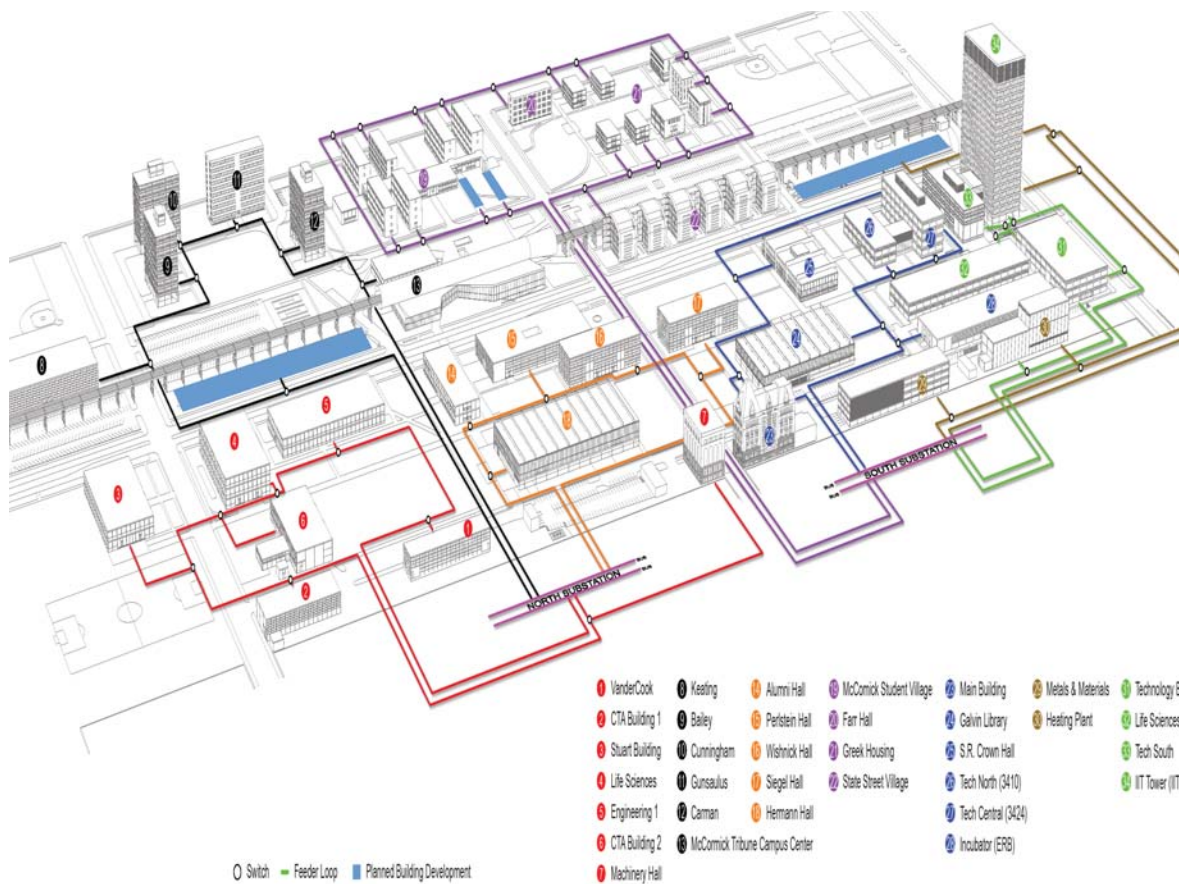


Figure 2. IIT distribution system layout based on HRDS

The IIT micro grid generation includes combustion turbines connected to the North Substation as well as renewable energy sources. The IIT micro grid is also equipped with an 8 MW gas-fired power plant that includes two 4 MW Caterpillar engines. The micro grid generation is used for reliability and economic improvements in main grid-connected and island modes.

Renewable energy sources include wind and solar generation. An 8 kW Viryrd wind turbine is installed on the north side of the campus. PV cells are to be installed in 2012 on building rooftops to supply portions of the campus load. A 500 kWh ZBB storage (unit?) is installed on campus to increase the reliability and efficiency of the IIT micro grid. Moreover, several electric vehicle charging stations are deployed on campus to utilize the micro grid energy storage and provide green energy for on-campus electric vehicles.

A major element of the IIT micro grid is the intelligent perfect power system controller (IPPSC). The IPPSC, which is the campus master controller, applies a hierarchical control to manage the campus electricity distribution system by integrating SCADA to ensure reliable and economic operations of the IIT micro grid. The IPPSC coordinates the operation of HRDS controllers, on-site generation, storage, and individual building controllers. Intelligent switching and the advanced coordination technologies of IPPSC through communication systems facilitate rapid fault assessment and isolation in the micro grid.

The IIT micro grid participates in real-time electricity markets. Once the real-time price exceeds 7-8 cents per kWh (marginal cost of micro grid generation), the micro grid generation can serve the IIT load. The on-site generation can provide demand response and increase the reliability level of the perfect power system. The provision of spinning reserve and day ahead load response is also offered by the IPPSC.

Composting - This project started as an idea among students at Illinois Institute of Technology to find innovative ways to deal with everyday issues at the university. Since 2005, IIT has sought to reduce the amount of trash leaving campus, aiming to reduce the generation of solid waste and recycle more of it. A group of students identified food waste as an area in which the university could make significant improvement. Under the sponsorship of the Office of Campus Energy and Sustainability, these students and a guiding faculty member reviewed the process of food waste generation at Main Campus, identified obstacles and opportunities in addressing the possibility of recycling the waste, and developed a solution that would minimize the amount of material sent to the landfill. This project, managed under the Interprofessional Projects (IPRO) program at IIT, identified a framework for implementing an on-site, organic waste composter at Illinois Institute of Technology.

Around the time of this process, the Wanger Institute for Sustainable Energy Research (WISER) responded to an opportunity from Cook County to discuss how Cook County could improve their performance using ideas that IIT planned to implement at its campuses. Through this discussion, Cook County and WISER identified the on-site composter project as a possible, tangible opportunity to highlight the collaboration. Recognizing that implementation of the composter would reduce the need to truck waste from campus and compost to campus, both

parties agreed that the project met the goals of the Energy Efficiency Block Grant Program, and should move forward. During the last two years, a composter facility was designed and constructed and it is currently operational. We are planning to use this facility and have developed several IPRO projects to assess the efficiency, economic feasibility, and sustainability impact of the composting at IIT and elsewhere.

Transportation - In 2009, IIT replaced three aging campus vehicles with electric ones as part of an initiative called “Greening the Fleet.” This year, a solar-powered charging system was installed in the Facilities Building to power these campus vehicles sustainably. In addition, IIT has recently launched a program with B-Cycle to introduce bike sharing to the IIT Main Campus. The program allows B-Cycle members to use shared bicycles for an unlimited number of two-hour rides.

Recycling and Reusing - IIT has placed recycling infrastructure in every campus building . We significantly enhanced our recycling program by launching of the addition of composting, increased engagement with the IIT community, improved signage on multi-stream collection bins and initiation of a full waste audit,. In addition, water bottle refilling stations allow students to refill any water bottle without touching the fountain and, in turn, reuse their water bottle.

Conclusion and Future Work

The goal of IIT WISER and the Office of Campus Energy and Sustainability is to make IIT the most sustainable urban campus in the nation and to make IIT campus a living laboratory for energy and sustainability education and research for both graduate and undergraduate students. To achieve this goal, several initiatives and major energy and sustainability programs have been launched including: micro grid and renewable energy production facilities, composting facility, and sustainable transportation and recycling initiatives. These programs also are designed to motivate students to learn and to create new initiatives.

Through our IPRO program (team project-based courses) and individual graduate and undergraduate research and projects, students will use these campus facilities in energy and sustainability as a living learning laboratory.

As part of the campus-wide laboratory, future programs will include: geothermal energy storage as a solution to the campus heating and cooling energy use; green building operations and maintenance standards that will improve the indoor environmental quality of all buildings; the on-campus urban agriculture project that will provide green areas and food for the campus; and rooftop rainwater harvesting to reduce lost storm water and water campus green spaces.