APPLICANT: Carnegie Mellon University
School of Architecture, Department of Mechanical Engineering
Center for Building Performance and Diagnostics

Solicitation: A Renewal Proposal to the DOE/EERE/NETL for a EERE Congressionally Directed Project

TITLE: Advanced Building Efficiency Testbed, ABET:
The Intelligent Workplace Energy Supply System, IWESS

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STATEMENT OF PROJECT OBJECTIVES

Advanced Building Efficiency Testbed, ABET:
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1. PROJECT OBJECTIVES

The objective of this project is to develop energy supply systems, ESS's, that will provide power, cooling, heating, and ventilation to a building based on solar energy and a renewable fuel. In this coming year the project will be focused on the Intelligent Workplace, the IW, as a building space, solar thermal energy, and bioDiesel fuel. This ESS will be integrated within itself, with the IW, and with the occupants by an advanced operating and control system. It will be effective in providing for the health, productivity, and comfort of the IW occupants. This ESS technology and approach developed for the IW will be scaled and adapted to a broad range of building types and locations. This ESS technology, suitably developed, will be efficient in its use of energy, economic to install and operate, scalable, and adaptable to a broad range of buildings and locations. The required energy for operating a building with the architectural features incorporated in the IW and with an ESS will be one sixth or less of that for a conventional building. The results of this project – disseminated, commercialized, and deployed – will significantly reduce the energy consumption of buildings in the U. S. and will promote productive economic activity.

2. PROJECT SCOPE

The U. S. DOE/EERE Building and Solar Technologies Programs address the building, its components, and the components of its HVAC and solar energy supply systems. The program recognizes the value of integration in maximizing the effectiveness and efficiency of building operation. This proposed ABET/IWESS program integrates an innovative building space – Carnegie Mellon's Intelligent Workplace, the IW – with an ESS that provides power, cooling, heating, and ventilation as required in that space.

The ESS that the ABET/IWESS program has designed for the IW, the IWESS, comprises 4 components:

- a solar thermal heat supply with an absorption chiller.
- a bioDiesel fueled engine generator with equipment for heat recovery from its exhaust and from its coolant and a steam driven absorption chiller.
- both convective and radiant cooling/heating units in the IW.

- a ventilation unit comprising an enthalpy recovery wheel, an air based heat pump, a desiccant based dehumidification/heating wheel, and a supply fan.

This program has selected, installed, commissioned, and tested these individual components of the ESS. The program has also developed overall performance simulations of the IW and IWESS that have been used to evaluate various overall system configurations; equipment designs; operating condition selections; and operational strategies, algorithms.

In the next year of the program, the integrated operation of the IWESS components with the IW will be accomplished. The heat supplies from the solar thermal receivers and the engine generator will be used

- in summer to produce chilled water in the absorption chillers for the cooling/heating units in the IW and to regenerate the desiccant of ventilation unit.
- in winter to provide hot water for the cooling/heating units and to provide for air heating in the ventilation unit.
- year around, to supply steam or hot water to the building grids when the heat supply from the IWESS exceeds the needs of the IW.

This integration work will require minimal modification of piping but significant effort in the planning and programming of operating algorithms to automate the operation of the integrated system components and to evaluate their performance.

In addition to this work on IWESS integrated operation, efforts will be extended and expanded in the scale up and adaptation of IWESS technologies for several possible building sites: the Building as Power Plant, the BAPP, on the Carnegie Mellon campus; a new building on the Laredo site of Texas A&M University; and an existing building on their main campus.

Finally for the next year, efforts will be initiated in several key areas

- the detailed consideration of expanding IWESS technologies to include solar photovoltaic and high temperature fuel cell power generation; and energy storage – thermal: geologic and phase change; electrical: batteries.

- the planning of intensified effort in computerized operations, control, and diagnostic systems; in the business aspects of commercialization and deployment; and in the policy aspects of building ESS's.including legislation, regulation, and codes. Relevant departments in Carnegie Mellon, in the DOE, and elsewhere will be consulted to determine how best to proceed in future work on these topics.

3. TASKS TO BE PERFORMED

3.1 For the Fiscal Year 2008

The following tasks will be carried out in the following fiscal year, 1 October 2007 to 30 September 2008, by graduate students and a research engineer under the general supervision of the project director. These tasks deal with each of the ESS components, with performance simulation of the of integrated ESS operations, and with preparations for future work dealing with scale up and adaptation of ESS technology and with its dissemination, commercialization, and deployment.

The general tasks dealing with ESS work in the four years beyond 30 September 2008 will also be outlined below.

3.1.1 Task 1: Integrate the Operation of the Solar Thermal System into that of the IW

The solar thermal receivers circulate a heated propylene glycol water solution either to an absorption chiller or to a heat exchanger; this system produces either chilled or heated water. Performance testing of all these units will be completed at the conclusion of the current U. S. DOE/ABET contract. This solar thermal system will now be used to supply either the chilled or heated water used in the cooling/heating units of the Intelligent Workplace, the IW, or in its ventilation unit. The integrated system will be commissioned and operated; its performance will be evaluated.

3.1.1.1 Task 1.1: Make Necessary Preparations for Integrated Operation

Adjustments in chilled/heated water piping will be made. Improved control of the solar reflector focusing on the absorber pipe will be pursued. Most important, the operation/control of the system will be planned and programmed with the necessary algorithms for automatic operation of the system to make optimal use in solar heat in cooling/heating/ventilating the IW and to report the performance of the system.

3.1.1.2 Task 1.2: Commission, Operate the Integrated Solar-IW System; Report Its Performance

After commissioning, the integrated system will be operated both in the heating and cooling seasons in the IW. The amount of incident solar radiation collected and used will be measured. Necessary repairs and maintenance will be noted. Adjustments and improvements in the system and particularly in its operating/control system will be made.

3.1.2 Task 2: Complete the Testing, Initiate the Integration of the bioDiesel Fueled Engine System into the IW

The bioDiesel fueled engine system generates electric power and recovers thermal energy in heat exchangers as steam from the engine exhaust and as hot water from its coolant. The electrical output of the engine generator is connected in parallel with the utility supply to the IW. Commissioning of this system will be completed at the conclusion of the current U. S. DOE/ ABET contract. This system will then be tested to determine its performance over its operating range; and next, the integration of the heat components of the system into the operation of the IW will be initiated.

3.1.2.1 Task 2.1: Complete Testing of the Engine Generator, Heat Recovery System

The performance of the engine and of its heat recovery exchangers will be measured at maximum power and at design and part loads; the measurements will include the fuel flow, heat recovered as steam and heated water, and the emissions in the exhaust gas: NO_x, CO, CO_2, VOC's, and particulates of various sizes. BioDiesel fuels produced from four different feed stocks will be evaluated.

3.1.2.2 Task 2.2: Integrate the Engine, Heat Recovery, IW Systems

The piping connections between the engine heat recovery exchangers, the steam driven absorption chiller, and the IW cooling/heating units and ventilation unit will be opened and the combined operation of the integrated system explored. Planning and programming of appropriate algorithms for the automated control and performance evaluation of the integrated system will be initiated.

3.1.3 Task 3: Complete the Commissioning and the Testing, Initiate the Integration of the Fan Coil Cooling/Heating Units in the Southern Section of the IW, the IWs

The radiant mullion pipe cooling/heating arrangements in the IWs have not provided adequate cooling, thermal comfort, for the IW occupants in summer. A fan coil system with advanced controls has been designed and procured. Detailed plans for its installation have been prepared; and competitive bids from contractors, received. The fan coil cooling/heating units with their advanced instrumentation and controls will have been installed at the conclusion of the current U. S. DOE/ ABET contract. This system will be then be commissioned, tested, and integrated with the IW operation. The performance of the fan coil system in terms of effective and energy efficient operation will be measured and compared with projections from a computer simulation of the system. Adjustments in the state of the art control system and a modified control system will be explored as a means for improving system performance.

3.1.4 Task 4: Continue the Integration of the Ventilation Unit with the IW

A ventilation unit has been procured, installed, tested, and integrated in the operation of the IW. This unit comprises an enthalpy wheel for the fresh air supply; an air based, electrically driven heat pump for air cooling/heating; an active desiccant wheel for air dehumidification in summer and air heating in winter, regenerated and heated by natural gas combustion product gases. This unit will have been installed, tested, integrated, and its performance evaluated and documented at the conclusion of the current U. S. DOE/ ABET contract. The use of natural gas has been determined to be largest cost in the operation of this ventilation system. The work will then be to design, procure, install, test, and evaluate an exchanger that will enable heat available from the solar or the engine systems to regenerate the desiccant and to heat the ventilation supply air. Further consideration will also be given to the replacement of the heat pump system with an exchanger provided with cooled/heated water from the solar or engine systems. Both replacements will reduce the capital and operation costs of the system and eliminate the current problems of cycling in the heat pump compressor and noise from condenser fans.

3.1.5 Task 5: Transition, Extend, Apply IWESS Performance Simulations

Computerized simulations, based on fundamental scientific and engineering principles, have been carried out using the Trnsys-Comis code platform to calculate the performance of various IWESS systems in the IW. These simulations include models of IWESS components, of the IW with its internal and external environments, and of the overall operating and control system. Completed simulations at the conclusion of the current U. S. DOE/ ABET contract will include: the solar cooling/heating of the IW throughout a year; the automated window/vent opening in the spring/fall for hybrid ventilation; the bioDiesel fueled engine power generation with heat recovery for IW cooling/heating/ventilation throughout a year; and the fan coil office cooling/heating in the IW throughout a year. These simulations have proved useful in systems and equipment design, in establishing operating conditions, and in evaluating operational and control algorithms. Three years ago, experts in simulating solar systems and their control recommended Trnsys for our use. Subsequently, the Comis simulation code was added for ventilation calculations in the IW. Trnsys component models were supplied to us by ORNL/TESS for our work with CHP systems. Carnegie Mellon has added a number of IWESS component models for use in Trnsys: special heat exchangers, fan coils, engine generators, and control algorithms. We have been advised to convert to Energy Plus code as the standard adopted by the U. S. DOE. Further work will be carried out in extending and adapting the simulations and preparing for their use in ESS design and evaluation.

3.1.5.1 Task 5.1: Prepare a Transition to EnergyPlus for IW and IWESS Simulations

A plan will be formulated and adopted for the transitioning the ABET/IWESS simulation work to Energy Plus – Contam.. This plan will consider both the existing simulations and those to be accomplished in the future both for the IW and for other building spaces to be considered.

3.1.5.2 Task 5.2: Extend the Window/Vent Opening Study to Include the Ventilation Unit Control

The window/vent opening simulation considered only the turning off/on the ventilation unit when windows/vents were open/closed. This study will be extended to include a more extended and detailed control of the ventilation unit including its enthalpy recovery wheel, supply fan, heat pump, and desiccant/heating wheel. The energy consumption of the ventilation unit might well be reduced by individual operation/control of its features dependent on occupancy and the external and internal IW air temperatures and humidities.

3.1.5.3 Task 5.3: Develop IWESS Simulations as Design Tools

The IWESS simulations have been carried out as aids in IWESS performance analysis. Planning will be carried out and initial work will be done to extend and adapt these simulations as ESS equipment and systems design tools. This effort will require input/output provisions in the simulation programs to facilitate their use in desing.

3.1.6 Task 6: Scale Up, Adapt the IWESS to Other Buildings in Other Places

The Intelligent Workplace Energy Supply System, the IWESS, was initiated to gain the knowledge and experience required to specify, install, and operate an advanced energy supply system to provide power, cooling, heating, and ventilation in a new building to be constructed on the Carnegie Mellon campus. The architectural design of this building, the Building as Power Plant, the BAPP, is near completion. Financing is being sought. Based on preliminary work at the University of Maryland now underway under the current U. S. DOE/ ABET contract, an ESS for the BAPP will be designed; a configuration will be selected, equipment specified, a layout provided, and its operation detailed.

The Texas A&M University, TAMU, has participated in the ABET/IWESS project since its inception. They have studied the performance of the IW, particularly its radiant mullion and panel cooling/heating units and its air infiltration. Two opportunities for scale up and adaptation of IWESS have been identified at TAMU: a new building to be constructed at their Laredo site and an existing building on their campus. Further work: plan, specify, detail, cost, evaluate, justify.

These efforts will provide experience in scaling up and adapting the knowledge gained and the lessons learned in installing and operating the IWESS. Different building, location, circumstances.

3.1.6.1 Task 6.1: Design, Specify an ESS for the BAPP

3.1.6.2 Task 6.2: Assist in the Design and Specification of an ESS for a Building at TAMU

3.1.7 Task 7: Disseminate, Commercialize, Deploy IWESS Technologies

In order to realize the full benefits of this ABET/IWESS project in significantly reducing the energy consumed in U. S. buildings and in providing enhanced economic activity, the knowledge gained and the lesson learned must be disseminated. The DOE/EERE has recognized the need for such an effort and now plans to set up two regional application centers to disseminate their technical developments The technical advances achieved must be commercialized. And the technology represented in IWESS – distributed power generation and combined cooling, heating, and power, CHP, production for buildings – must be deployed.

To date, dissemination has been fostered through presentations, publications, and the IWESS website. Over ten presentations, seven publications including an absorption chiller design guide, and two PhD theses have been published and are available on the IWESS website. Six graduate students have been or are being trained. This effort will be continued. But further work will be explored and planned for dissemination through education – students, professionals, and the public.

Eight commercial firms have donated substantial equipment items and/or services to the IWESS project. Six additional firms have been involved in a substantial way. These firms have continued to work closely with the program so that there are existing channels for commercializing the advances made in the work. Further work will be considered and planned in consultation with the Carnegie Mellon business school to further commercialization through existing businesses and entrepreneurship.

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Deployment, first addressed through the BAPP and Laredo projects, needs to be planned and facilitated through a number of efforts: the preparation of design guides, procedures, and tools for ESS components and systems; contacts in architects, builders, and developers; efforts with legislators, regulators, and code writers regarding provisions for increased effectiveness and efficiency of buildings.

3.1.8 Task 8: Project Management and Reporting

Management in this project has the prime responsibility of directing the work of the PhD candidate graduate students and the research associates who supervise and/or conduct the work described in the individual tasks. In the coming year, the integration of the IWESS components into an effective and efficient system will be the focus of the work. This focus will benefit from additional technical input in the areas of process operation, control, and

diagnostics. Ways of securing this input from various departments in Carnegie Mellon and in other schools will be explored by the management.

Commercialization and deployment are areas that might well benefit from the input of the Carnegie Mellon business school; their interest and possible future participation will also be explored. In addition, the Department of Engineering and Public Policy has been considering the laws, regulations, and codes dealing with cogeneration systems. Their involvement will carefully be considered by management.

The routine tasks of reporting, quarterly reports and informal monthly reports, will be maintained by management. An effort to capture and present time and money expenditures on the various tasks of the project from Carnigie Mellon's Oracle accounting system will be mounted.

3.2 For the Fiscal Years 2009 to 2012

The four years of the ABET/IWESS program beyond 30 September 2008 have general task areas that will receive further, continuing definition as the program proceeds.

3.2.1 Task A: Extend Evaluation of IWESS Integration, Up Grade Operations/Control

Improvements in the overall operations/control system for the IWESS will probably be required. The present equipment control systems of the individual IWESS components are programmed in Johnson Metasys, Automated Logic Ikon, Siemens Apogee, and a proprietary Broad system. Work on the integration of these disparate systems and on equipment and systems diagnostics will be carried out.

3.2.2 Task B: Evaluate, Install, Test, Integrate Additional IWESS Components

Several additional components might well be added to IWESS for test, evaluation, and possible integration. A 25 kW solar voltaic installation is now installed on a Carnegie Mellon building in Pittsburgh, off campus. The operating measurements and performance information from this installation might well be connected with the web; and its performance analyzed and compared with that of the IWESS solar thermal installation.

Funds from the Pennsylvania Department of Environmental Protection or from the U. S. DOD may become available to purchase and install high temperature solid oxide fuel cell with a heat recovery exchanger.

Energy storage is a significant consideration in solar energy systems. Geothermal storage in a bore hole or in phase change material, and battery electrical energy will be considered.

Air filtration and "decontamination" is another significant area of technology that has only been peripherally considered in the ventilation and fan coil components of the IWESS; further consideration of this feature for installation in present IWESS components, the ventilation unit and fan coils, will be given.

3.2.3 Task C: ESS, Building Performance Simulations

The transition of the IWESS simulation platform to EnergyPlus will be implemented. The capabilites of this and auxiliary platforms for building air flow computations and for system operations/control will be explored and considered. The simulation capabilities will be extend to capital and operating cost estimation. CFD simulations of ventilation and fancoil air flow in IW spaces will be carried out.

3.2.4 Task D: BAPP and Laredo Building ESS's

The ESS for these buildings will be designed including their equipment, instrumentation, and control systems. Their installation and operating performance will be monitored, evaluated, and reported. The design process will be carefully documented to provide a template for equipment and systems design guides, procedures, and tools. The evaluation of the ESS's performance will include their effectiveness in providing a healthy and comfortable environment for the building occupants and an efficient use of energy.

3.2.5 Task E: Dissemination, Commercialization, Deployment of ESS Technology

At Carnegie Mellon, dissemination equates to publications and education. Presentations and publications will be pursued. Bulletins and brochures will also be prepared and published for public distribution. And of course, the web site will be maintained and refined. A web based course in ESS's for advanced buildings will be developed and offered in cooperation with cooperating universities. This course for graduate/under graduate students in engineering and architecture, based on the IWESS, will use the IWESS components for demonstration, laboratory work, and projects. Similarly the overall systems simulations will be adapted as teaching tools for demonstration and project work. The National Science Foundation will be asked to fund the development of this course. The course will also be adapted as an offering to professionals in the ASME, ASHRAE, AIA, etc interested in continuing education.

Commercialization in the IWESS program to date has meant dealing with equipment manufacturers and service providers to procure and install system components and working

with these organizations to recognize and adopt the results of the work. This approach seems to have worked. But further efforts in commercialization and entrepreneurship will be approached in cooperation with Carnegie Mellon's business school to seek additional, innovative approaches to commercialization.

Deployment will be initiated by the work on the BAPP and Laredo buildings. And it will further be promoted, in part by the activities in dissemination and commercialization and also by providing equipment design guides for each of the IWESS components, systems design guide lines and procedures, and design tools based on the ESS system simulations. In addition, a study will be carried out by Carnegie Mellon's Department of Engineering and Public Policy that will deal with policy, legislative, regulatory, and code issues involved with building ESS's. It will suggest how deployment might be facilitated by efforts in these areas.

3.2.6 Task F: ESS Equipment Cost Reduction: Integration Modularization, Standardization

Deployment of ESS technology will depend not only on its effectiveness and efficiency, but also on its associated equipment and installation costs. The various components of the IWESS will be examined; ways of reducing their costs will be identified and explored. For example, the ventilation unit might better be adapted to ESS operations by omitting the air based heat pump and the gas burner: replacing them with two finned coil exchangers; one for cooling, one for heating. Chilled and heated water from the heat recovery system would replace electric power for the heat pump and natural gas for the burner. These modifications will reduce the equipment and operating costs and the size of the ventilation unit. It will simplify the operation and control of the unit. Further reductions in equipment and installation costs could be achieved by modularizing and standardizing the ventilation unit. Each of the IWESS components will be carefully examined to identify cost reductions. An overall cost estimates will be prepared for revised, standard ESS installation.

PROJECT NARRATIVE

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PROJECT NARRATIVE

Advanced Building Efficiency Testbed, ABET:
The Intelligent Workplace Energy Supply System, IWESS

1 Introduction

The IWESS is a system that supplies power, cooling, heating, and ventilation for the occupants of the Intelligent Workplace, the IW. This supply is based on the use of solar heat and a renewable liquid fuel. The primary components of the IWESS include solar thermal receivers and a Diesel engine generator, both providing heat in various forms to absorption chillers, fan coil and radiant cooling/heating units, and a desiccant based ventilation unit. The operation of all these components is integrated both with the IW building space and with grids for power, steam, and chilled and heated water.

2 Objectives

The objective of the ABET/IWESS project is to develop, demonstrate and facilitate the deployment of energy supply systems, ESS's, for buildings that will provide a healthy and comfortable environment for the occupants of the building, that will reduce the energy required for operating a building by a factor approaching 2, and that can be confidently scaled and modified to meet the requirements of a wide range of new and existing buildings. The energy requirement of an ESS in a building incorporating the advanced architectural features of the IW will require an eighth or less that of a conventional building. This project will, therefore, have significant impact on reducing the energy required by buildings in the U. S.

Further information on the objectives and scope of the ABET/IWESS project are presented in the accompanying Statement of Project Objectives, SOPO. Further information on the IW and the IWESS are available from the IWESS website under construction, http://cms-staging.andrew.cmu.edu/iwess/.

2.1 Current Status

At the end of this fiscal year, when all of the currently available funds from the DOE/EERE/NETL 2006 Congressional Earmark will be exhausted, all of the IWESS components will have been installed and commissioned. These include:

- a 25 kW solar thermal receiver heat supply with an associated hot fluid driven absorption chiller.
- a 30 kW bioDiesel fueled engine generator with its associated steam generator, absorption chiller, and heat exchanger for hot water production.
- a fan coil system with its state of the art controls and in addition the radiant mullion pipe and ceiling panel cooling/heating units. .
- a 2500 cfm fresh air supply, ventilation, unit with an enthalpy recovery wheel, an air based heat pump, and a desiccant dehumidification/heating wheel.

In addition, performance testing of the solar thermal cooling/heating system and of the ventilation unit over their ranges of operation will have been completed, including confirmation of their mathematical performance models. Comprehensive system performance simulations have been programmed that calculate the annual performance of the solar thermal cooling/heating system and of the bioDiesel fueled cooling/heating/power system. These simulations include the IW with its the fan coil cooling/heating units and the ventilation unit of the IW coordinated by an overall operating system responding to internal and external conditions. These simulations have been exercised to determine the effectiveness, and efficiency of the IWESS and its proposed operating system.

2.2 Past Funding, Support

The funding for the IWESS program to date includes

- Advanced Building Systems Integration Consortium, ABSIC, start up funding: about $100 k
- Congressional Earmarks 2004, 2005, 2006 from the U. S. DOE: $950 k, $750 k, $990 k
- U. S. DOD: $100 k
- Pennsylvania DEP; $287 k

a total of $3,177k.

Equipment and service donations have been provided by Astorino Engineers, Broad Air Conditioning, LTG Fan Coils, Semco, Siemens Building Technologies, Somfy, Traco Windows. The value of these donations has been estimated to be in excess of $250 k.

2.3 Other Major Participants

All of these three university and college participants have been involved from the initiation of the ABET/IWESS program.

The Texas A&M University has been involved through their detailed and comprehensive studies of the performance of the radiant mullion pipe and ceiling panel cooling/heating units of the IW. They have also studied air infiltration in the IW and advised on commissioning of the installed IWESS systems. Three presentations and publications and one thesis have resulted from their work. Their results have and will contribute significantly to extend and improve the simulation and control work of the program. They are also now exploring the application of the architectural features of the IW and the engineering features of the IWESS in a new and in an existing building of their university.

Sierra Nevada College/Milwaukee School of Engineering have been involved through an initial study of the environmental and code implications of the IWESS. They made significant contributions in preparing specifications and securing bids for the procurement of the bioDiesel engine generator system. Their current focus is on the emissions in the exhaust from the engine.

The University of Maryland has consulted on the selection of Trnsys as the simulation tool for the IWESS program. They are currently using their broad understanding of cooling/heating/ventilation/power generation components to advice on the design of an ESS for the Building as Power Plant, the BAPP.

2.4 Accomplishments

The IWESS with its four major components has been conceived, designed, procured, installed, and tested. This system and its equipment components demonstrate advanced technologies for supplying power, cooling, heating, and ventilation to a building that can reduce its consumption of energy from fossil fuels and the energy grids by a factor of two. This system provides for further integration and development of the equipment and its operation/controls; for the preparation of design guidelines and procedures; and for the training of students through laboratory work and projects leading to dissemination and deployment of the technology.

Eight presentations, six publications, and two theses have resulted from this work. Six PhD candidates in the Center for Building Performance and Diagnostics have been supported and trained in the design of buildings and building systems that are effective, efficient, and economic. Two interns from international schools of engineering and architecture have been accommodated and educated. One research associate has been trained and has received extensive experience in the simulation of buildings, their energy supply systems, and their control. These simulations have proved valuable in the configuration of the system, the design of the equipment, and the specifications for operations.

3 Projected Program for Fiscal 2008

Performance testing of the bioDiesel engine generator with its heat recovery equipment and controls will be carried out: engine fuel flow, power output, steam and hot water production, exhaust emissions at design and part loads. Likewise, testing of the fan coil system with its advanced controls will be conducted: chilled and heated water and power consumption for the cooling/heating depending on the building loads, set and set back temperatures, space occupancy, and external ambient conditions.

In addition, operation of these units and of the solar thermal and ventilation units of the IWESS will be integrated with each other and with the IW through the various energy grids. Minimal equipment and piping modifications will be required: perhaps, a hot water exchanger for desiccant regeneration in the ventilation unit. The programming of integrated component controls with carefully crafted algorithms will be required to coordinate the operation of the IWESS components and of the grids based on conditions internal and external to the IW. Data analysis for overall performance evaluation and for alarms and diagnostics will also be programmed. The work on systems simulation will be extended. Efforts on ESS's scale up and adaptation, will be expanded; and on ESS technology dissemination and deployment, initiated.

The project tasks outlining this program are presented in the accompanying Statement of Project Objectives, SOPO, and in the task schedule that follows.

4 Projected Program for Fiscal 2009 through 2012

The proposed ABET/IWESS program beyond Fiscal 2008 will deal with the extension of IWESS technology, with its scale up and application to new and existing buildings, and with its dissemination, commercialization, and deployment. The approach, described in six tasks, is outlined in the accompanying Statement of Project Objectives, SOPO, and in the task schedule following.

5 Merit Review Criteria Discussion

5.1 Criterion 1 Concept

The key aspect of this program is integration. The components of the IWESS are integrated in an overall energy supply system, ESS that is in turn integrated with a building space of advanced design, the IW. The IWESS components and the IW are existing, state of the art technology; but their integration, installation, operation, and evaluation has and will produce

technical innovation, in both the individual components and in their operating/control system. This integration and innovation has the potential to reduce to an eighth the energy required to operate a building. Furthermore, the technical developments of this program in turn integrated with the detailed demonstration, dissemination, commercialization, and deployment efforts proposed in this program provide the promise of an approach to significantly reduce the consumption of energy in U. S. buildings.

5.2 Criterion 2: Approach

Certainly, improved architecture and improved energy supply system arrangements are the key to reducing the consumption of energy in buildings that now account for 40 % of the primary energy, 55 % of the natural gas, and 70 % of the electrical energy consumed in the U. S. The approach of this project involves a building space of advanced design and a selection of state of the art components to supply power, cooling, heating, and ventilation to this space. Obviously, while the choice of this space and these components will not correspond to the multitude of applications, this integrated approach will provide a specific example of benefits and a valuable pattern for the scale up and design of ESS systems for a variety of buildings.

The task definitions, schedule, budget, and manning (and of course womanning) of the program with the PhD candidate students having an engineering background are based on three years of experience with the ABET/IWESS program.

5.3 Criterion 3: Feasibility

The resumes of the persons involved in this project are attached. Working with an engineering firm and with installation contractors, they have been responsible for the modeling, design, installation, commissioning, test, and evaluation of each of the individual components of the IWESS system and for the simulation of the performance of the overall system. They will now continue with the integration of components and the IW as an overall system. No additional components will be required for the IWESS, but possible additions will be considered. Additional students and faculty will be recruited in the area of control for integrated operation and diagnostics and in the areas of business and public policy for commercialization and deployment.

6 Project Timetables

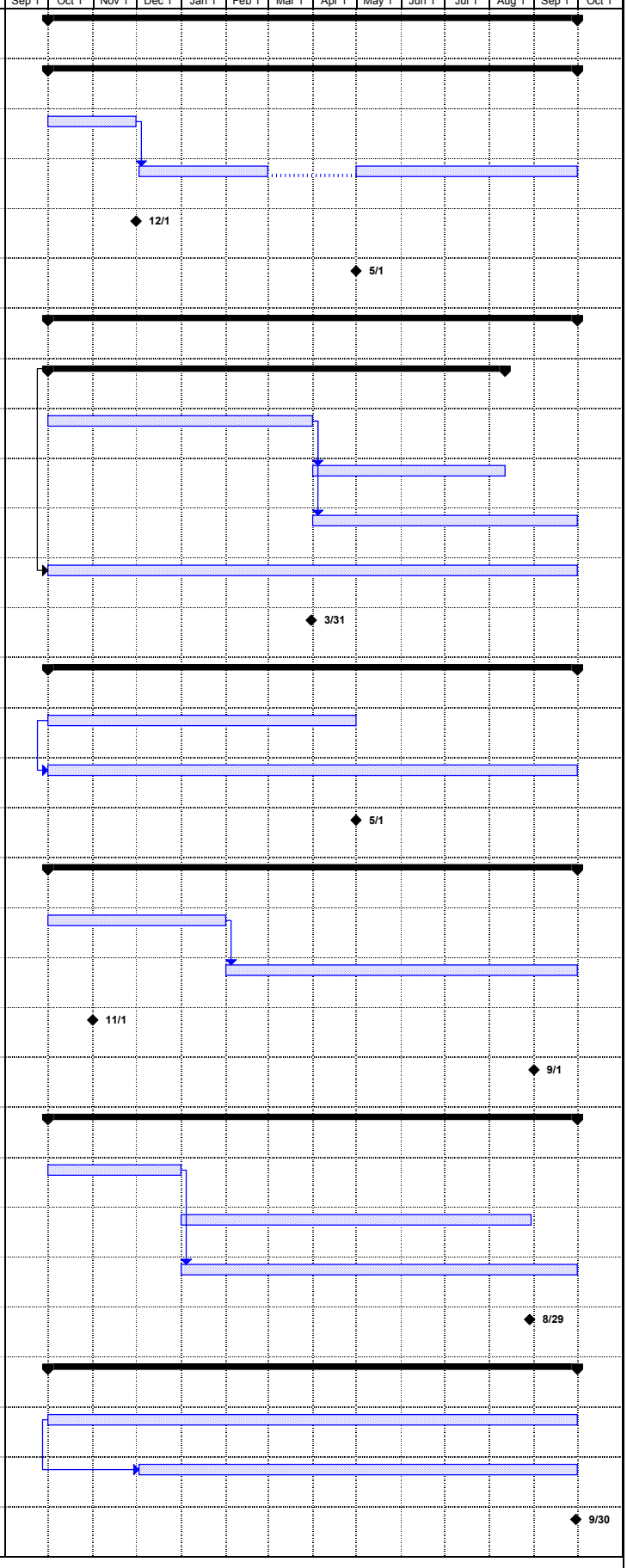
Timetables for the ABET/IWESS project in Fiscal 2008 and in the subsequent four years, Fiscal 2009 through 2012, follow. These timetables present information on milestones, deliverables, and decision points.

6.1 Fiscal 2008

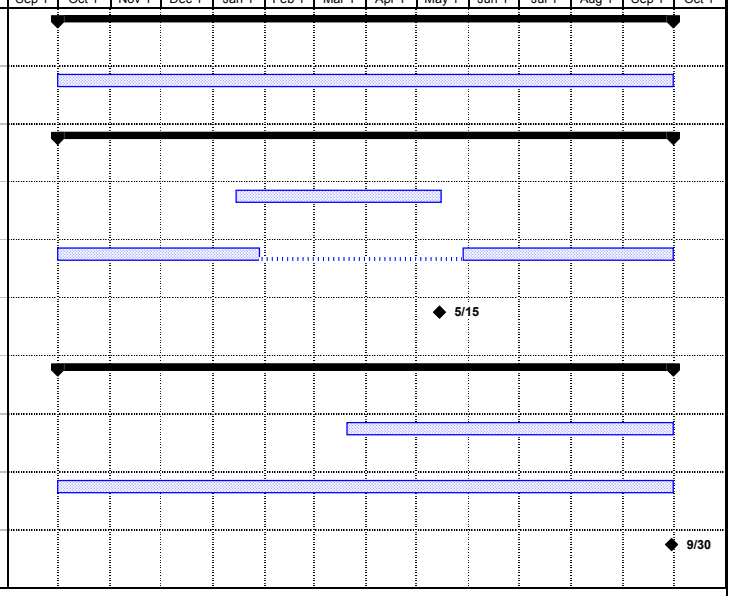
Advanced Building Efficiency Testbed, ABET:
The Intelligent Workplace Energy Supply System, IWESS

Carnegie Mellon University
Cemter for Building Performance and Diagnostics
Fri 6/22/07

ID	Task Name	Days	Start	Finish
1	**Fiscal Year 2008**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
2	**Task 1: Integrate the Operation of the Solar Thermal System into that of the IW**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
3	1.1. Make necessary Preparations for Integrated Operation	45 days	Mon 10/1/07	Fri 11/30/07
4	1.2. Commission, Operate the Integrated Solar-IW System; Report Its Performance	174 days	Mon 12/3/07	Tue 9/30/08
5	Milestone 1.1	0 days	Sat 12/1/07	Sat 12/1/07
6	Milestone 1.2	0 days	Thu 5/1/08	Thu 5/1/08
7	**Task 2: Complete the Testing, Initiate the Integration of the BioDiesel Fueled Engine System into that of the IW**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
8	2.1. Complete Testing of the Engine Generator, Heat Recovery System	**226 days**	**Mon 10/1/07**	**Mon 8/11/08**
9	2.1.1. BioDiesel Testing for Different Load Conditions	131 days	Mon 10/1/07	Mon 3/31/08
10	2.1.2. Testing other BioDiesel	95 days	Tue 4/1/08	Mon 8/11/08
11	2.2. Integrate the Engine, Heat Recovery, IW Systems	131 days	Tue 4/1/08	Tue 9/30/08
12	2.3. Simulation and Performance Evaluation	262 days	Mon 10/1/07	Tue 9/30/08
13	Milestone 2	0 days	Mon 3/31/08	Mon 3/31/08
14	**Task 3: Complete the Commissioning and the Testing, Initiate the Integration of the Fan Coil Units in the IW South**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
15	3.1. Complete Testing of the Fan Coils	153 days	Mon 10/1/07	Wed 4/30/08
16	3.2. Integrate into the IW for Testing and Evaluation	262 days	Mon 10/1/07	Tue 9/30/08
17	Milestone 3	0 days	Thu 5/1/08	Thu 5/1/08
18	**Task 4: Continue the Integration of the Ventilation Unit with the IW**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
19	4.1. Necessary Preparations for Integration (Change Burner to Coil, Change Heat Pump to Coils)	89 days	Mon 10/1/07	Thu 1/31/08
20	4.2. Integrate into the IW for Testing and Evaluation	173 days	Fri 2/1/08	Tue 9/30/08
21	Milestone 4.1	0 days	Thu 11/1/07	Thu 11/1/07
22	Milestone 4.2	0 days	Mon 9/1/08	Mon 9/1/08
23	**Task 5: Transition, Extend, Apply IWESS Performance Simulations**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
24	5.1. Prepare a Transition to Energy Plus for IW and IWESS Simulation	66 days	Mon 10/1/07	Mon 12/31/07
25	5.2. Extend the Window/Vent Opening Study to Include the Ventilation Unit Control	174 days	Tue 1/1/08	Fri 8/29/08
26	5.3. Develop IWESS Simulations as Design Tools	196 days	Tue 1/1/08	Tue 9/30/08
27	Milestone 5	0 days	Fri 8/29/08	Fri 8/29/08
28	**Task 6: Scale up, Adapt the IWESS to Other Buildings in Other Places**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
29	6.1. Design, Specify an ESS for the BAPP at CMU	262 days	Mon 10/1/07	Tue 9/30/08
30	6.2. Assist in the Design and Specification of an ESS for a Building at TAMU	217 days	Mon 12/3/07	Tue 9/30/08
31	Milestone 6	0 days	Tue 9/30/08	Tue 9/30/08



ID	Task Name	Days	Start	Finish
32	**Task 7: Disseminate, Commercialize, Deploy IWESS Technologies**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
33	7.1 Presentations, Publications, and the Web Site	262 days	Mon 10/1/07	Tue 9/30/08
34	7.2. Education efforts	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
35	7.2.1. University Courses	88 days	Tue 1/15/08	Thu 5/15/08
36	7.2.2. Public Level	175 days	Mon 10/1/07	Tue 9/30/08
37	Milestone 7	0 days	Thu 5/15/08	Thu 5/15/08
38	**Task 8: Project Management and Reporting**	**262 days**	**Mon 10/1/07**	**Tue 9/30/08**
39	8.1. Control, Commercialization, Technology Effort	138 days	Fri 3/21/08	Tue 9/30/08
40	8.2. Reporting	262 days	Mon 10/1/07	Tue 9/30/08
41	Milestone 8	0 days	Tue 9/30/08	Tue 9/30/08



6.1.1 Millstones and Deliverables

Milestone 1.1:
December 1, 2007
Ming Qu, a Ph.D. Candidate, is expected to complete the solar system testing for heating and cooling. She will provide her Ph.D. Thesis on the basis of the test results and simulation analysis.

Deliverables:
- Monthly Report
- Quarter Report
- Solar System Performance Report
- Solar System Design Guide

Milestone 1.2:
May 1, 2008
Necessary piping for integrating the solar systems into the IW will be completed, and the solar system be automated and tested with the IW for heating mode over the winter.

Deliverables:
- Monthly Report
- Quarter Report
- Performance Report for the Integrated Operation

Milestone 2:
March 31, 2008
Fred Betz, a Ph.D. Candidate, is expected to complete the bioDiesel engine generator and heat recovery system testing for one bioDiesel fuel (or more depending on fuel availability) for four different load conditions. He will summarize the performance of the total system testing by March 31st, 2008.

Deliverables:
- Monthly Report
- Quarter Report
- BioDiesel Engine Generator and Heat Recovery System Performance Report

Milestone 3:
May 1, 2008
Yun Gu and Viraj Srivastava, Ph.D. Candidates, are expected to complete the commissioning and testing of fan coil system. Yun Gu will write a performance report and Viraj Srivastava will

summarize the outlines of plan for further testing of control features to improve the effectiveness and efficiency of fan coil system.

Deliverables:

- Monthly Report
- Quarter Report
- Fan Coil System Performance Report
- Plans to improve the performance by controls

Milestone 4.1:
November 1, 2007
Chaoqin Zhai, a Ph.D. Candidate, is expected to complete the desiccant dehumidification ventilation and heat recovery system testing for heating and cooling seasons and finish her Ph.D. thesis on the basis of testing results and simulation analysis.

Deliverables:

- Monthly Report
- Quarter Report
- Ventilation System Performance Report
- Ventilation System Design Guide

Milestone 4.2:
September 1, 2008
A finned coil will be added to integrate the ventilation system with the heat sources from solar and BioDiesel heat recovery systems. Proposed work also includes consideration of the replacement of heat pump by a heating/cooling coil to integrate into the IW.

Deliverables:

- Monthly Report
- Quarter Report
- Ventilation System Performance Report
- Suggestions for the Manufacturer for Future Products

Milestone 5:
August 29, 2008
The IWESS simulation will be transferred from TRNSYS to EnergyPlus platform, IWESS components will enrich EnergyPlus library. Natural ventilation and several different combine ventilation modes will be studied in EnergyPlus tools. All the simulation work will lay the ground to provide ESS design tools in the next several fiscal years.

Deliverables:

- Monthly Report
- Quarter Report
- Annual Performance Analysis Report using Energy Plus
- Completed BCT16 Absorption Chiller component model for Energy Plus
- Completed Concentrated Solar System component model for Energy Plus
- Completed SEMCO Ventilation component model for Energy Plus

Milestone 6:

September 1, 2008

The concepts developed and the lessons learned from an integrated IWESS will be transferred to the BAPP at CMU and a building at TAMU. Preliminary engineering and studies on the ESS for the two buildings in different climates will be conducted using the computational models developed from IWESS. A study report will be published for the two buildings at the end of this fiscal year.

Deliverables:

- Monthly Report
- Quarter Report
- Preliminary ESS engineering and Analysis Report for the BAPP
- Preliminary ESS engineering and Analysis Report for the Building at TAMU

Milestone 7:

May 15, 2008

The IWESS concepts, experience, knowledge, and practice will be publicized through higher education, technical papers, and keynote speeches from college students, professionals, and the public people. In this fiscal year, a web based course among different Universities will be organized for undergraduate level architectural, mechanical, and other related field students.

Deliverables:

- Monthly Report
- Quarter Report
- Publications in Conference Proceedings, Journals, and Web Sites
- An Outline of Teaching Material for University Course
- Keynote Presentations for the Public

Milestone 8:

September 30, 2008

A framework for component integration in the IW will be accomplished in this fiscal year. The integrated controls system, the area of potential commercialization, current and future technology efforts will be pointed out for the next fiscal year.

Deliverables:

- Monthly Report
- Quarter Report
- A Summarization of Project Management, Commercial Feasibility Study, and Future Efforts

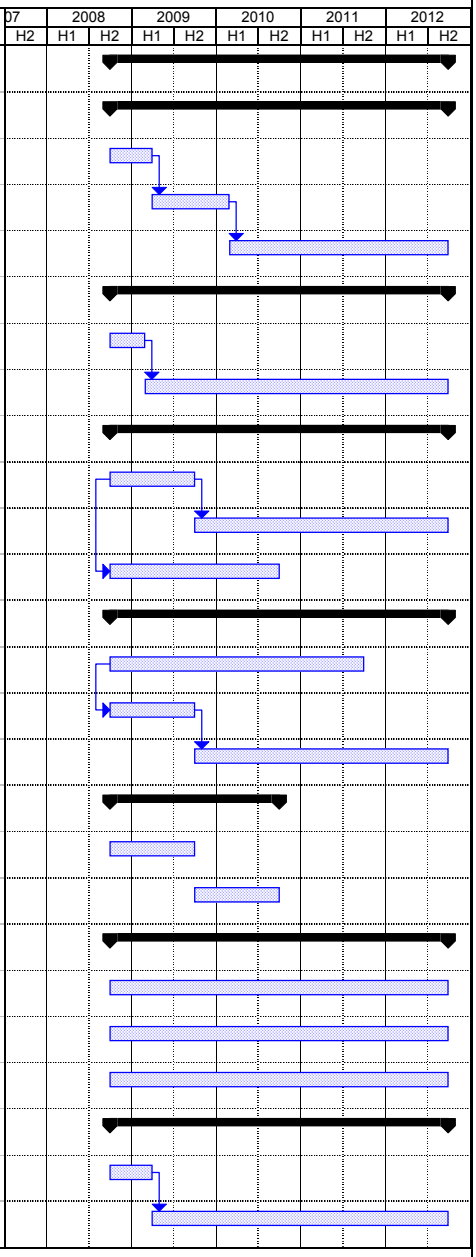
6.1.2 Decision Points

Decision will be made at the end of each fiscal year of funding. The questions that need to be answered in the affirmative are

- Does adequate progress be made on the tasks established for the year?
- Does ESS technology for buildings still appear effective and efficient?
- Does ESS technology still appear deployable based on economics and politics?

6.2 Fiscal 2009-2012

ID	Task Name	Days	Start	Finish
1	**Fiscal Year 2009 - 2012**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
2	**Task A: Extend Evaluation of IWESS Integration, Upgrade Operations/Controls**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
3	Standarization of Control Communication System	130 days	Wed 10/1/08	Tue 3/31/09
4	Develop Integrated Control Operation and Diagnostics Algorithm	238 days	Wed 4/1/09	Fri 2/26/10
5	Test Integrated Energy Supply System, Report	675 days	Mon 3/1/10	Fri 9/28/12
6	**Task B: Evaluate, Install, Test, Integrate Additional IWESS Components**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
7	B.1. Evaluate CMUExising Solar Voltaic Installation	108 days	Wed 10/1/08	Fri 2/27/09
8	B.2. Procure, Install, Test, and Integrate Solid Oxide Fuel Cell	935 days	Mon 3/2/09	Fri 9/28/12
9	**B.3.Install Thermal Storage Systems**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
10	B.3.1. Test, Integrate Solar Energy Storage	261 days	Wed 10/1/08	Wed 9/30/09
11	B.3.2. Procure, Install, Test, and Integrate Geothermal Storage	782 days	Thu 10/1/09	Fri 9/28/12
12	B.4. Install, Test, and Integrate Advanced Air Filtration	522 days	Wed 10/1/08	Thu 9/30/10
13	**Task C: Building Performance Evaluation**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
14	C.1. Energy Plus Simulation Models for IWESS Components and the IW	783 days	Wed 10/1/08	Fri 9/30/11
15	C.2. Computing Fluid Dynamics (CFD) Model for Fan Coils and the IW	261 days	Wed 10/1/08	Wed 9/30/09
16	C.3. Integrated Building Simulation Tools and Evaluations	782 days	Thu 10/1/09	Fri 9/28/12
17	**Task D: BAPP and Laredo Building ESS's**	**522 days**	**Wed 10/1/08**	**Thu 9/30/10**
18	D.1.BAPP ESS	261 days	Wed 10/1/08	Wed 9/30/09
19	D.2. Laredo ESS	261 days	Thu 10/1/09	Thu 9/30/10
20	**Task E: Dissemination, Commercialization, Deployment of ESS Technology**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
21	E.1. Web-based Course	1043 days	Wed 10/1/08	Fri 9/28/12
22	E.2. Publications	1043 days	Wed 10/1/08	Fri 9/28/12
23	E.3. Commercialization	1043 days	Wed 10/1/08	Fri 9/28/12
24	**Task F: ESS Equipment Cost Reduction: Integration Modulization, Standarization**	**1043 days**	**Wed 10/1/08**	**Fri 9/28/12**
25	F.1. Open Protocol for Control	130 days	Wed 10/1/08	Tue 3/31/09
26	F.2. Modularization, Standarization of IWESS Components for Integration	913 days	Wed 4/1/09	Fri 9/28/12



7 Personnel Resumes

Carnegie Mellon University

Research Staff

Volker Hartkopf
David Archer
John Wiss
Hongxi Yin
Sophie Masson

Technician Staff

James Jarrett

Ph.D. Student

Ming Qu
Chaoqin Zhai
Fred Betz
Viraj Srivastava
Yun Gu

University of Maryland

Reinhard Radermacher
Joe Orlando

Texas A&M University

David Claridge

Serra Nevada College/Milwaukee School of Engineering

Christopher Damm

Volker H. Hartkopf,
Ph.D. University of Stuttgart, 1989
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- Vordiplom in Architecture, University of Stuttgart, 1964
- Dipl. Ing., Architect, University of Stuttgart, 1969
- M. Arch., University of Texas, Austin. TX, 1972, (Fulbright Scholar, 1970-72)
- Dr. Ing.,(Ph.D.), University of Stuttgart, Germany, 1989.
- Dr. h.c., Sierra Nevada College, NV, 2004

Volker H. Hartkopf graduated with Dipl. Ing. from Technical University of Stuttgart in 1969; M. Architecture from University of Texas in 1972, and Ph.D. from University of Stuttgart in 1989. He is currently the Director of Center for Building Performance and Diagnostics at Carnegie Mellon University, A National Science Foundation Industry-University Cooperative Research Center (IUCRC)

Dr. Hartkopf teaches design and building performance in the professional, M.S., and Ph.D. programs. He has completed research and demonstration projects in Bangladesh, Canada, Germany, Peru, and the U.S. in industrial architecture, housing, commercial buildings, energy conservation, and whole building performance. He was instrumental in establishing North America's first multi-disciplinary graduate program in architecture, civil engineering, and urban affairs in 1975 with grants from the NSF and the Building Industry.

Since 1972, Dr. Hartkopf has been teaching and conducting research at Carnegie Mellon University. His work covers a broad range of activities: international initiatives, funded research and professional consulting on building systems integration, advanced technology, building performance, energy conservation, urban revitalization, third-world housing and disaster prevention. He has realized as an architect building projects in Germany, Bangladesh, Peru and the United States. He also led master planning efforts for Volkswagen A.G. and the City of Wolfsburg, Germany; EXPO 2000 Hanover and Berlin-Lichtenberg, Germany.

In 1975, Dr. Hartkopf co-initiated and subsequently directed the first multi-disciplinary program in Architecture, Engineering and Planning in the USA with grants from the National Science Foundation and the building industry. In 1981, he co-founded the Center for Building Performance and Diagnostics (CBPD) at Carnegie Mellon University.

Between 1981and 1985, Prof. Hartkopf developed jointly with Vivian Loftness and Peter A.D. Mill, the Total Building Performance Evaluation Method at Public Works Canada whilst on an Executive Interchange Program. Based on the R & D needs in building performance, Prof. Hartkopf has created and directs the Advanced Building Systems Integration Consortium (ABSIC), an industry-university-government partnership dedicated to improving the quality of the workplace.

In 1990, he initiated, conceptualized, and raised the funds on a global basis for the Robert L. Preger Intelligent Workplace; a $4 million living and lived-in laboratory and demonstration facility. This project features unprecedented systems concepts for user satisfactions and productivity, organizational flexibility, technological adaptability, and energy & environmental effectiveness.

The Center for Building Performance and Diagnostics, an NSF/IUCRC, has been instrumental in the application of systems integration concepts, advanced technologies and performance-based decision making for significant building projects in the USA Germany, China, Korea and France. The CBPD team with Prof. Hartkopf's leadership has received numerous prestigious national awards for research. An award winning teacher and a frequent keynote speaker in Australia, Europe, Asia and the Americas, he has authored over 100 technical publications. He continues his consulting with such organizations as DaimlerChrysler, Volkswagen, Thyssen Krupp, Electricite de France, U.S. Department of State, U.S. Department of Energy, and Siemens.

Currently, Dr. Hartkopf is leading the Building as Power Plant (BAPP) project. The BAPP has been selected by the US Congress as the National Test-bed for Advanced Technology in Building. The 6,500 m2 project will be realized on the Carnegie Mellon Campus. The BAPP will integrate advanced energy-effective building technologies with innovative energy generation systems, such that all of the buildings energy needs for heating, cooling, ventilating and lighting, as well as equipment are met on-site, maximizing the use of renewable energies. Broader implementation of its concepts in industry and government here and abroad are expected. Dr. Hartkopf is a frequent keynote speaker worldwide; his speeches and works have been cited in the professional literature. He has contributed over 100 technical publications.

Selected Publications

- Hartkopf, V. and V. Loftness, "Global Relevance of Total Building Performance", *CIB-ATSM-ISO-RILEM 3rd International Symposium*, Tel-Aviv, Israel, Dec. 1996, *Automation in Construction 6* (1997), pp. 401-415

- Hartkopf, V. et al, Designing the Office of the Future: The Japanese Approach to Tomorrow's Workplace, N. Y., John Wiley & Sons, 1993

- Hartkopf, V., "Indigenous Building Techniques of Peru and Their Potential to Better Withstand Earthquakes", U.S. A.I.D., and Ministry of Housing & Construction, Peru, 1981

- Hartkopf, V., V. Loftness, and P. Mill, "The concept of total building performance and building diagnostics" *American Society of Testing and Materials, Special Technical Publication 901*, 1988, pp. 5-22.

- Volker Hartkopf, D. H. Archer, and Hongxi Yin; International Building Energy Forum; "A Fuel Cell Based Supply System for a Multi Purpose Building"; Proceedings of 2003 Shanghai International Building Energy Forum; Shanghai, China; March 12, 2003

David H. Archer,

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- Carnegie Institute of Technology: Chemical Engineering, Mathematics; BS, 1948
- University of Delaware: Chemical Engineering, Mathematics; PhD, 1953
- Carnegie Mellon University: Adjunct Professor, 1990-present
- Westinghouse Electric Research & Development Laboratories: Manager of the Process Engineering Department; Consulting Engineer, 1960-1990
- Carnegie Institute of Technology: Assistant Professor, Associate Professor, 1953-1960
- University of Delaware: Instructor in Chemical Engineering, 1951-1953
- U. S. Department of Energy, National Energy Technology Laboratory; Westinghouse Power Systems: Siemens Westinghouse Fuel Cell Division; Calderon Energy; BP: Consultant, 1990-present
- National Academy of Engineering, 1987; Westinghouse Order of Merit (highest corporate achievement award, for work in fuel cell and coal gasification development)

David H. Archer, a member of the National Academy of Engineering, graduated with a Ph.D. in chemical engineering and mathematics from the University of Delaware. He is a retired consulting engineer with the Westinghouse Electric Company, and is currently Adjunct Professor at Carnegie Mellon University. Dr. Archer has performed substantial work in both industry (working at Westinghouse as an engineer, supervising engineer, department manager, and consulting engineer), and in academia (teaching at both the University of Delaware and Carnegie Mellon University for almost ten years). He has considerable experience in research and management related to chemical engineering, as well as experience with combustion and plant management.

Archer's distinguished career has included research and development at Westinghouse Electric related to fossil and nuclear fuel processing and power generation. His work has been sponsored by the US Department of Energy, the US Air Force and NASA. He received the

Westinghouse Order of Merit and was elected to the National Academy of Engineering for his work on the development of solid oxide power systems.

For 13 years, Professor Archer initiated and directed a program to develop a coal gasification, hot gas cleaning, gas turbine based power generation system -- including the design, construction, and operation of a fluidized bed coal gasification, hot gas cleaning process development unit, PDU; the development of processes and equipment for the removal of H2S, particulates, and alkali compounds from the low BTU fuel gas product; the test of modified gas turbine combustors on low BTU fuel gas; the analysis and test of the effects of corrosives and particulates on gas turbine expanders. This program was sponsored by the U. S. Department of Energy -- approximately $85 million. The coal gasification and hot fuel gas cleaning technology developed in this program is now being installed as the Pinon Pines Power Station of Sierra Pacific Power.

More recently, Archer served both on the ASME Committee preparing the PTC 47 Integrated Gasification Combined Cycle Performance Test Code and PTC 50 Fuel Cell Power Systems; he served on the National Research Council Committees reviewing the U. S. DOE/NETL Vision 21 Program and overseeing the destruction of the U.S. Army's stockpile of chemical weapons.

Professor Archer has had fourteen years experience teaching at a university level. His courses include metallurgy, thermodynamics, fluid flow, heat transfer, process control, engineering analysis, thermal analysis, and energy conversion. Professor Archer's recent overall Faculty Course Evaluations scored 4.5 out of 5.0. While serving the Department of Mechanical Engineering, Archer has also worked with the School of Architecture of Carnegie Mellon in its Advanced Building System Integration Consortium (ABSIC) to develop design and evaluation techniques for advanced energy supply systems to deliver efficient, economic cooling, heating, ventilation air, and hot water in buildings.

Selected Publications

- Ming Qu, David H. Archer and Hongxi Yin, A linear parabolic trough solar collector performance model, Proceedings of Energy Sustainability 2007, June 27-30, 2007, Long Beach, California
- Ming Qu, David H. Archer, Hongxi Yin, and Sophie Masson, Solar Absorption Cooling and Heating System in the Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Sophie V. Masson, Ming Qu, David H. Archer, Performance modeling of a solar thermal system for cooling and heating in Carnegie Mellon University's Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Chaoqin Zhai, David H. Archer and John C. Fischer, The Performance of an Energy Recovery Wheel in Ventilation of CMU's IW, Proceedings of IMECE2006: ASME

International Mechanical Engineering Congress and Exposition, November 5-10, 2006, Chicago

- Xiangyang Gong, David E. Claridge, David Archer, Infiltration Investigation of a Radiantly Heated and Cooled Office, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- Xiangyang Gong, David E. Claridge, David Archer, Development of a Heat Transfer Model for the Integrated Façade Heating, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- A. Bharadwaj, D. H. Archer, E.S. Rubin; Modeling the Performance of a Tubular Solid Oxide Fuel Cell, Accepted for publication in the ASME International Journal of Fuel Cell Science and Technology, 2005
- A. Bharadwaj, D. H. Archer, E.S. Rubin; Modeling the Performance of a Flattened Tubular Solid Oxide Fuel Cell, Accepted for publication in the ASME International Journal of Fuel Cell Science and Technology, 2005
- Hartkopf, V, D. H. Archer, V. Loftness, A. Aziz, R. Brahme, V. Srivastava, H. Yin, and C. Zhai, (2005) "Building As Power Plant", Chapter 6 in Part 3 - merging Technologies and Tools, Smart and Sustainable Built Environment, Editors Yang, J., Brandon, P. S., and Sidwell A. C., Blackwell Publishing, UK
- Volker Hartkopf, D. H. Archer, and Hongxi Yin; International Building Energy Forum; "A Fuel Cell Based Supply System for a Multi Purpose Building"; Proceedings of 2003 Shanghai International Building Energy Forum; Shanghai, China; March 12, 2003
- National Research Council; "Integrated Design of Alternative Technologies for Bulk Only Chemical Agent Disposal Facilities"; National Academies Press; Washington, DC; May 2000. (D. H. Archer prepared the chapters on "Acquisition Design Package Processes and Modifications" and "Management of Process and Nonprocess Wastes".)
- • National Research Council; "Vision 21, Fossil Fuel Options for the Future"; National Academies Press; Washington, DC; May 2000. (D. H. Archer prepared the sections on fuel cells and on program management. He assisted in the preparation of sections on gasification and gas turbines.)
- Horazak, D. A. and D. H. Archer; "Performance Modeling as an Aid in the Preparation of a Test Code for IGCC Plants, PTC 47"; ASME Turbo Expo Land, Sea & Air; Indianapolis, IN; 7-10 June 1999.
- Shadle, L. J., D. H. Archer, et al; "Solids Mixing in a Spouted, Fluidized Bed, Cold Flow Model"; 15th International Conference on Fluidized Bed Combustion, ASME; Savannah, GA; 16-19 May 1999.

John W. Wiss,
Ph.D. 1976, North Carolina State University,
M. ME 1950, Rensselaer Polytechnic Institute,
B.S. 1946, United States Military Academy, West Point,
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John W. Wiss, a member of Sigma Xi, American Society of Mechanical Engineers, Society of Automotive Engineers, and American Institute of Aeronautics & Astronautics, graduated with a Ph.D. in Mechanical engineering from North Carolina State University. Dr. Wiss has over twenty years military service including engineering and engineering-management assignments as an Army Ordnance Officer and a three-year assignment as director of Army Tank-Automotive Laboratories.

Additionally, Wiss has thirty-six years prior engineering experience; twenty years as Army Ordnance Officer, in engineering & engineering-management assignments; three-year assignment was as director of Army Tank-Automotive Laboratories in Detroit, a 400-employee research & engineering organization with 1965 budget of $33,000,000. In his sixteen years commercial experience, including three years as Director of Technology for Rockwell.

More currently, Dr. Wiss continues as a consulting engineer, he is the President of Ohio Transportation Testing Corp. and the Chairman of Pittsburgh Electric Engines, Inc. He is a Registered Professional Engineer in PA, OH and MI who holds patents in diesel engines, dynamometers and fuel cells.

Selected Reviewed Publications:

- Wiss, Bryzik, Cheklich & Lux: "Controlling Diesel Exhaust Smoke with Combustion Chamber Surface Treatment" Seventh Intersociety Energy Conversion Engineering Conference, 1972. San Diego, 1972

• Hildebrand & Wiss: "Concept to Concrete - Development of a Truck Type Street Sweeper" Society of Automotive Engineers Paper 790879. Milwaukee, 1979

• Rychener, Subramanian, Wiss, & Lasky: "A Hybrid System for Helicopter Engine Troubleshooting" 2d International Conference on Applications of Artificial Intelligence... Old Woking, Surrey, UK, 1987

• Rychener, Subramanian, Wiss, & Lasky: "Diagnosis of a Complex Machine: Integration of Evidential Reasoning with Causal Reasoning and Quantitative Simulation." ASME Conference on Computers in Engineering, San Francisco, 1988.

Courses Taught:

24-227, Internal Combustion Engines
24-421, Internal Combustion Engines
24-266, Mechanical Engineering Design
24-999, Mechanics of Deformable Solids
24-271, -272 Mechanical Engineering Projects
24-795, Master of Engineering Projects
18-231, -331-612, -614, -615 Electrical & Computer Engineering Projects
Various CMU Post-College Professional Education program courses

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- Carnegie Mellon University, Center for Building Performance and Diagnostics, Research Associate, 2007 - Present
- L. D. Astorino & Associates, Director of Architecture and Engineering, China Market, 2006-2007
- Carnegie Mellon University, School of Architecture, Ph.D. in Building Performance and Diagnostics, 2000-2006
- Louisiana State University, School of Architecture, Master in Historic Preservation, 1999 – 2000
- SINOPEC Engineering Inc. (former Beijing Design Institute), Architect, Beijing, China, 1994 - 1999
- Xi'an Jiaotong University, China, Bachelor in Architecture, 1990 – 1994

Hongxi Yin is a research associate in the Center for Building Performance and Diagnostics at Carnegie Mellon University (CMU). Before Hongxi Yin joined the research team in CMU, he has been the Director of Architecture and Engineering for China Market in L. D. Astorino & Associates for one year. He has worked on research and consulting related to energy–efficient building component integration and architectural design, indoor and outdoor environment control.

Hongxi Yin has in-depth knowledge of advanced building system design, analysis, and integration dedicated to sustainable and healthy built environments. He specializes in building energy system studies, controls, and ventilation and is seeking to improve the way in which buildings use the earth's resources. Working with his academic advisors Dr. Volker Hartkopf, Dr. David Archer, and Dr. David Claridge, Hongxi Yin carried out his Ph.D. study in absorption chiller, solid oxide fuel cell, and desiccant dehumidification ventilation systems at Carnegie Mellon University between 2000 and 2006. On the basis of the test and modeling of a micro-

scale absorption chiller, Hongxi Yin finished his outstanding dissertation at August 2006. He developed the mathematic model for absorption chiller which forms the basis for an integrated micro-scale cooling heating and power simulation tool.

In June 2004, Hongxi Yin worked with Dr. David Archer and Dr. Volker Hartkopf together obtained a joint $1,000,000 research grant with industrial partner, "Research, Development and Demonstration Micro CHP System for Residential Applications, U.S. Department of Energy Solicitation, DE-PS36-03GO93014". After the wining of this proposal, they started to build an innovative energy supply system for the Intelligent Workplace in the Center for Building Performance and Diagnostics from US governmental and industrial funds. Hongxi Yin took the lead in design at the initial stage of the project. This project has made great progress since then; 6 Ph.D. students have been working on different research topics in this.

Hongxi Yin has a unique background to be an architect and mechanical engineer practiced in China and the U.S., recently, he put forward an innovative design method which layout building energy plan and environment evaluation prior to the architectural design to reduce the resource (primary energy, material, and water) consumption in buildings. As a chief designer, he has practiced this integrated building design method in the first of a serious of energy-efficient demonstration buildings in China.

Currently, he is working in a CMU effort to develop integrated, energy-efficient, sustainable building technologies and compatible designs. This program is supported by U.S. Congress through DOE and carrying out research on natural ventilation of buildings, passive cooling, use of solar, bio-fuels, and large energy distribution networks, building designs to reduce energy use, and integration of energy-efficient measures with indoor environment and occupancy considerations.

Hongxi Yin's outstanding career began at the Sinopec Engineering Inc., Beijing, China (former SINOPEC Beijing Design Institute) with the design and construction of a petrochemical and oil refinery plant. He participated in and led various design projects on both the national and local scale from 1994 to 1999 in China. His research work on renewable energy utilization in Tibetan residential buildings knocked the door of his graduate study at Carnegie Mellon. As a graduate student, he received the Akram Midani Award from Carnegie Mellon University and Outstanding Contribution Award in preservation from Louisiana State University. He is a member of the American Society of Heating, Refrigerating, and Air conditioning Engineers.

Recent Publications and Designs

- The Performance of Broad BCT16 Steam Driven Absorption Chiller (Abstract), Hongxi Yin, David Archer, Volker Hartkopf, ASME International Mechanical Engineering Congress & Exposition, 2006

- Ph.D. Dissertation, Model Based Design and Performance Analysis of an Absorption Chiller in a Micro Building CHP System, Hongxi Yin, Carnegie Mellon University, 2006
- Ming Qu, David H. Archer and Hongxi Yin, A linear parabolic trough solar collector performance model, Proceedings of Energy Sustainability 2007, June 27-30, 2007, Long Beach, California
- Ming Qu, David H. Archer, Hongxi Yin, and Sophie Masson, Solar Absorption Cooling and Heating System in the Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Hongxi Yin interview, "Turning Office Buildings into Power Plants", Transforming Carnegie Mellon, the final report of the centennial campaign, through the eyes of students, Carnegie Mellon University, 2002
- D. H. Archer, Volker Hartkopf, and Hongxi Yin; 2004 19th World Energy Congress; "IWESS, a Micro-BCHP Prelude for the Building as Power Plant"; Sydney, Australia; September, 2004 (Abstract)
- Volker Hartkopf, D. H. Archer, and Hongxi Yin; International Building Energy Forum; "A Fuel Cell Based Supply System for a Multi Purpose Building"; Proceedings of 2003 Shanghai International Building Energy Forum; Shanghai, China; March 12, 2003
- Project Manager in Architecture and Engineering, Broad Sustainable Demonstration Center One, Broad Town, Hunan, Changsha, 2007
- Innovative Energy Supply System for the Intelligent Workplace, a micro absorption chiller with auxiliary steam system, Carnegie Mellon University, 2004
- Children's Hospital of Pittsburgh, clinical service building system simulation using DOE-2.1 for LEED rating documentation, 2003
- Siliang Mu, Liancheng, Shan, and Hongxi Yin; SINOPEC Beijing Design Institute; the shop design for the "The Co-generation Power Plant, and Transforming Plant for Dagang Oil Refinery Factory", 4,500 m2, Tianjing Dagang Oil Administration Bureau, China, 1996

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Education

- University of La Rochelle (France): Integration of Energy Efficiency and Renewable Energies in Building Design, MS, 2005
- Ecole des Mines (France): Energy Process Engineering, MS, 2004
- Ecole des Mines (France): Mechanical Engineering, BS, 2002

Working Experience

- Center for Building Performance and Diagnostics, Carnegie Mellon University, Research Associate, 2005 – present
- ELYO (France), Project Engineer, Summer 2004
- Raymond E.Moser SA (Switzerland), Consultant Engineer Assistant, Summer 2003

Research Interests

- Building performance and impact of advanced technologies on the physical and environmental settings in office buildings
- Design, performance modeling and optimization of passive and active conditioning systems to decrease the energy consumption and increase thermal

Selected Publications

- Sophie V. Masson, Ming Qu, David H. Archer, Performance modeling of a solar thermal system for cooling and heating in Carnegie Mellon University's Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Ming Qu, David H. Archer, Sophie Masson and Hongxi Yin, Solar Absorption Cooling and Heating System in the Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Ming Qu, Sophie V. Masson, David H. Archer, Performance modeling of a solar driven absorption cooling system for Carnegie Mellon University's Intelligent Workplace, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China

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- Ph.D. Candidate, Center for Building Performance and Diagnostics, Carnegie Mellon University, 2005
- Carnegie Mellon University: Graduate Teaching Assistant; Structure I & Structure II, 2004-2006
- SINOPEC Engineering Inc. (former Beijing Design Institute), Engineer, Beijing, China, 1994 - 1999
- Bachelor of Engineering, Department of Civil Engineering, Dalian University of Technology, P.R. China, 1995

Ming Qu is currently working on her PhD in Building Performance and Diagnostics at the Center for Building Performance and Diagnostics (CBPD) at Carnegie Mellon University. She earned her Bachelor of Engineering in Structural Engineering from the Dalian University of Technology in China. Ming Qu's outstanding career began at the Sinopec Engineering Inc., Beijing, China (former SINOPEC Beijing Design Institute) with the design and construction of a petrochemical and oil refinery plant. She participated in and led various design projects on both the national and local scale from 1994 to 1999 in China.

She has special knowledge in design and performance analysis of solar absorption cooling and heating system. Currently, she is taken charge of the design, installation and test an innovative solar driven heating and cooling system for the Intelligent Workplace at Carnegie Mellon.

Publications

- M. Qu, D.H.Archer and H.X. Yin, A LINEAR PARABOLIC TROUGH SOLAR COLLECTOR PERFORMANCE MODEL, Proceedings of ES2007 Energy Sustainability 2007 June 27-30, 2007, Long Beach, California

- M. Qu, D.H.Archer, S. Masson and H.X. Yin, SOLAR ABSORPTION COOLING AND HEATING SYSTEM IN THE INTELLIGENT WORKPLACE, Proceedings of ES2007 Energy Sustainability 2007 June 27-30, 2007, Long Beach, California

- Sophie V. Masson, Ming Qu, David H. Archer, Performance modeling of a solar thermal system for cooling and heating in Carnegie Mellon University's Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California

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Education

- Ph.D. in Building Performance and Diagnostics, Carnegie Mellon University, Thesis: Performance Modeling of Solid Desiccant Wheel Design and Operation, expected in November 2007
- B.Eng. in Air Conditioning Engineering, Tsinghua University, P. R. China, Thesis: Theoretical Validation of Building Thermal Simulation Program DeST Using Fourier Transform, July 1998

Research Experience

Center for Building Performance and Diagnostics, Carnegie Mellon University Aug., 2002 – present, Developed and implemented a numerical model to predict the operating performance of desiccant wheels; Conducted performance testing of an active desiccant integrated ventilation machine; Designed a liquid desiccant based ventilation system for the Intelligent Workplace; Evaluated the suitability of five representative energy modeling tools for the early phase of architectural design; Performed simulation investigation of the applicability and effectiveness of an energy recovery ventilator in different climatic context and building types; Conducted energy simulation analysis for offices, restaurants and big box retail buildings.

R&D Center of Tsinghua Tongfang Co. Ltd and HVAC Lab of Tsinghua University, Sep. 1998 – Mar. 2001, Investigated the energy efficiency of Chinese building industry, as part of a project funded by the World Bank; Conducted field measurement and analysis of HVAC systems in commercial buildings; Participated in the development, validation

and application of building energy simulation program DeST; Developed a business plan Consulting Office for the Physical Environment of Residential Buildings, which won the Excellent Innovation Award in the 3rd Business Plan Competition of Tsinghua University.

Internship

- United Technologies Research Center Mar. – Jun. 2006
- Developed energy efficiency concepts and conducted energy modeling for a supermarket; Formulated instrumentation plan for different building thermal and energy related problems.
- Center for Environmental Energy Engineering, University of Maryland Jul. – Aug. 2003
- Conducted energy simulation for the Center's CHP demonstration project.
- Parsons Brinckerhoff (Asia) Ltd Jul. – Aug. 1997
- Worked on energy audit and energy efficient retrofit of a hotel building in Beijing.

Technical Highlights

- Solid background in thermodynamics, heat and mass transfer, building science and technology
- Multiple research experience in areas of desiccant dehumidification, building ventilation system design and operation, combined heating and power system and building energy simulation
- Extensive hands-on experience in ventilation equipment testing, building energy audit, measurement and evaluation of indoor thermal conditions and indoor air quality
- Expertise in multiple building energy simulation programs: EnergyPlus, TRNSYS, eQUEST, Green Building Studio, DOE-2, Energy 10, Energy Scheming and Ecotect

Publications

- Chaoqin Zhai, David H. Archer and John C. Fischer, The Performance of an Energy Recovery Wheel in Ventilation of CMU's IW, Proceedings of IMECE2006: ASME International Mechanical Engineering Congress and Exposition, November 5-10, 2006, Chicago

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- Milwaukee School of Engineering: Mechanical Engineering; BS, 2003
- Milwaukee School of Engineering: Engineering; MS, 2005
- Milwaukee School of Engineering: Graduate Research Assistant; Installation and Analysis of a 60 kW Microturbine Combined Heat and Power facility, 2002 – 2004
- Milwaukee School of Engineering and Carnegie Mellon University: Graduate Research Assistant; Installation and Analysis of a 25 kW Biodiesel Fueled Combined Heat and Power facility, 2004 – present
- Carnegie Mellon University: Graduate Research Assistant; Installation and Analysis of a CO2 sensing based occupancy detection system, part of the Information Technology Enabled Sustainability Test-bed (ITEST), 2005 - present

Fred Betz is currently working on his PhD in Building Performance and Diagnostics at the Center for Building Performance and Diagnostics (CBPD) at Carnegie Mellon University. He earned his Bachelors of Science in Mechanical Engineering as well as a Master of Science in Engineering from the Milwaukee School of Engineering. During this time he focused on energy systems with a particular interest in energy efficiency, combined heat and power (CHP), and biofuels. Fred's masters thesis was titled, "A Theoretical Model of the Processing and Economics of a Biodiesel Refinery".

Before coming to CMU, Fred worked with a team of faculty and students from MSOE on a natural gas fueled 60 kW microturbine with heat recovery for the department of Public Works in the City of Milwaukee, WI. This work included thermodynamic modeling as well as specifying the necessary instrumentation to validate this model. Finally, emissions were tested to verify that the installation met EPA's non-attainment standards for NOx for the Milwaukee area.

Currently, Fred is leading the installation of a 25 kW biodiesel fueled CHP system, which recovers heat from the engine exhaust to generate steam for a 16 kW double effect absorption chiller and heat from the coolant to regenerate a solid desiccant dehumidification ventilation

system during summer. This energy can also be used for space heating in the winter. Finally, he is working with faculty and students from CMU and MSOE to develop thermodynamic models of this system, install instrumentation, and monitor emissions.

Publications

- Glenn Wrate, Michael Swedish, Frederik Betz, Justin Reese, Chad Weis, and Lee Greguske. Design, Construction, and Commissioning of a 60 kW Microturbine Demonstration Facility. Proceedings of American Society of Engineering Education 2003. June 22-25 2003, Nashville, Tennessee.
- Michael Swedish, Glenn Wrate, Frederik Betz, Emily Blakemore, Lee Greguske, and Joe Jacobsen. A 60 kW Microturbine Demonstration Facility. Phase II: Instrumentation, Website Development, and Evaluation. Proceedings of American Society of Engineering Education 2004. June 20-23 2004, Salt Lake City, Utah.

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- Ph.D. Candidate, Center for Building Performance and Diagnostics, Carnegie Mellon University, Pittsburgh, PA, 2006
- B.Arch in Architecture, School of Planning and Architecture, New Delhi, India, 2001

Viraj's primary area of research is in Adaptive Control of Indoor Thermal Environments using Sensor Networks. This includes research in Sensor Based Modeling of Indoor Thermal Environments. Viraj has also worked extensively in data gathering and analysis from sensor networks.

Viraj research includes integration of sensor instrumentation for the National Environmental Assessment Tool (NEAT) instrument cart. This has been developed with GSA support to measure temperature at three heights, relative humidity, CO2 and CO, total particulates, and VOC. Attached to this cart are hand-held instruments for light levels, radiant temperature, and air velocity, as well as an equipment data logger, a PDA, and a digital camera.

Viraj is currently a Carnegie Mellon Graduate Student Mentor. He was the Graduate Student Representative for the School of Architecture from 2004-2006. He has been a Teaching Assistant for Building Controls and Diagnostics 2003-2006, Paradigms and Methods of Research 2004, Ethics and Decision Making in Architecture 2003.

Selected Publications

- Lam.K.P., Srivastava.V., Living in the Intelligent Workplace - Structuring and Managing Building Operation Information, Insights of Smart Environments, CAAD TALKS 5, Archidata, Taiwan, (2005), pp 297-314.
- Park.K., Srivastava.V., Krishnamurti.R., Integrated Progression of Building Information Model and Building Technology, ACAADIA 2005.

- Kim.S.H., Srivastava.V., Aziz.A., EnviroDB: Applied Database Systems Design For the National Environment Assessment Toolkit (NEAT), ICEBO 2005

- Loftness.V., Aziz.A., Srivastava.V., WorkPlace2020-Toolkit for Physical Measurement, PBS Research Program Annual Report, US General Services Administration

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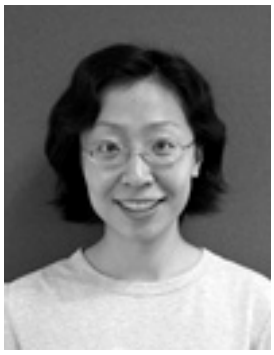


- 2002 – Present, Carnegie Mellon University, Pittsburgh PA, Ph.D Candidate of Building Performance and Diagnostics
- June 2000, Tongji University, Shanghai, China, Bachelor in Building Facilities Engineering and Management, Honored University Graduator

Yun Gu is interested in improving performance of user side heating, cooling and ventilation delivery system which directly provides comfort, health and productivity for occupant, meanwhile, minimizing energy consumption with passive design and control strategies as well as system integrations.

Research Project

Intelligent Workplace Energy Supply System
Focus on user side thermal comfort and ventilation delivery to provide comfort, healthy and productive environment for occupant with minimized energy consumption and improved building system integration and control optimization.

Building Investment Decision Support
Collect case studies for developing life-cycle analysis for office and hospital buildings that demonstrate the cost-benefits of advanced and innovative building.

Productivity Protocol Development, Workplace 20·20
Build evaluation protocols linking environmental, technical and spatial quality to individual and organizational effectiveness.

Greening the Operation and Maintenance of the Children's Hospital of Pittsburgh

Build benchmarks and opportunities for innovation of utility and material flows for hospital operation

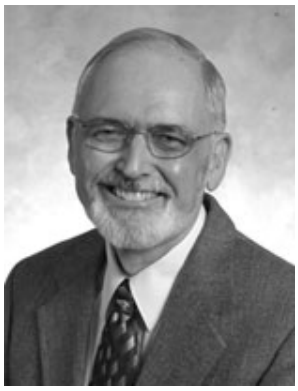
Teaching Experience

Advanced Building System, Teaching Assistant
The course explore the relationships, opportunities, and conflicts of the performance mandates, and the integration of building systems necessary to achieve total building performance. It highlights the state-of-the-art and major innovations in building technologies for structure, enclosure, mechanical, telecommunications, lighting, and interior systems.

Publications

Vivian Loftness, FAIA; Volker Hartkopf, PhD; Lam Khee Poh, PhD; PhD students: Megan Snyder, Ying Hua, Yun Gu, Joonho Choi, Xiaodi Yang; "Sustainability and Health are Integral Goals for the Built Environment", Healthy Buildings 2006, Lisbon, Portugal, June 4-8, 2006

David E. Claridge



Ph.D. 1976, Stanford University,
Leland Jordan Professor and
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- B.S., Walla Walla College, 1964
- M.S., Stanford University, 1966
- Ph.D., Stanford University, 1976
- 1991 - Professional Engineer (Mechanical), State of Texas #69305
- U.S. Congress Office of Technology Assessment, 1976–1980
- Solar Energy Research Institute, 1980–1982
- University of Colorado, Boulder, 1982–1986
- Canterbury University, Visiting Erskine Fellow, 2000

Dr. Claridge is internationally known for his work over the last 15 years directing the development and participating in the implementation of the Continuous Commissioning(R) process for improving the comfort and energy efficiency of buildings. It has been applied in well over 300 large buildings that include higher education facilities, military facilities, medical facilities, and office buildings. He has made major contributions to the analysis of heat transfer between buildings and ground and to the analysis of air leakage in buildings. He is also a world leader in development and application of measurement and verification techniques to determine savings from efficiency projects.

He has taught numerous commissioning workshops and is the author of over 300 journal and conference papers. He had 10 years of experience in the HVAC field, prior to coming to Texas A&M in 1986. He frequently gives presentations at national and international conferences and is a Fellow of the American Society of Mechanical Engineers. Prof. Claridge is active nationally in the American Society of Heating, Refrigerating and Air Conditioning Engineers and the American Society of Mechanical Engineers.

Research

- Dallas/Fort Worth Airport Assessment, U.S. Department of Energy, PI's: W.D. Turner, B. Yazdani, C.H. Culp, S. Deng, M. Verdict, and D.E. Claridge.
- Western Power Grid Peak Demand and Energy Reduction Phase II - Navy, Intuitive Research and Technology, PIs: D.L. Schneider, W.H. Mills, D. Claridge, and W.D. Turner.
- Western Power Grid Peak Demand and Energy Reduction Phase II–Marines, Intuitive Research and Technology, PIs: D.L. Schneider, W.H. Mills, D. Claridge, and W.D. Turner.
- Support for International Energy Agency Annex 40 on Commissioning of Building HVAC Systems, Lawrence Berkeley National Laboratory.
- Physical Plant Engineering Services Agreement, Texas A&M University, PIs: S. Deng, D. E. Claridge, W.D. Turner, and J. Haberl.
- The Brazos Valley Energy Conservation Coalition, U.S. Department of Energy, PIs: D. Claridge, W.D. Turner, N. Saman, T.A. Reddy.
- Energy Management Baseline Measurement and Monitoring Agreement, Dallas County Commissioners' Court, PIs: W. Dan Turner, D. Claridge, and Jeff Haberl.
- Integrated Commissioning and Diagnostics, Lawrence Berkeley National Laboratory, PIs: David E. Claridge, W. D. Turner, and C. Culp.
- Campus-Wide Energy Management Program Rebuild America Initiative, Alamo Community College District, PIs: W. Dan Turner, David E. Claridge, Bahman Yazdani, Jeff Haberl, and Malcolm Verdict.
- Technical Assistance for Texas Department of Mental Health and Mental Retardation for Commissioning Services, Texas Mental Health and Mental Retardation, PIs: W. D. Turner and David Claridge.
- Texas A&M University Support for International Energy Agency Annex 40 on Commissioning of Building HVAC Systems for Improved Energy Performance, National Institute of Standards and Technology.
- Extended Services to Terrell State Hospital, Terrell State Hospital, PIs: G. Wei, D. Claridge, W.D. Turner.

Patents

- "System and Method for Remote Monitoring and Controlling of Facility Energy Consumption," with C. Culp, D. Turner, and J. Haberl, TAMUS 1549.
- "System and Method for Remote Identification of Energy Consumption Systems and Components," with C. Culp, W. Turner, and J. Haberl, TAMUS 1550
- "System and Method for Diagnostically Evaluating Energy Consumption System and Components of a Facility," with C. Culp, M. Liu, W. Turner, J. Haberl, TAMUS 1561

- "System and Method for Remote Retrofit Identification of Energy Consumption Systems and Components," with C. Culp, W. Turner, J. Haberl, TAMUS 1555.

Recent Publications

- Gong, X. and Claridge, D.E., "Investigation of a Radiantly Heated and Cooled Office with an Integrated Desiccant Ventilation Unit," Journal of Harbin Institute of Technology, Volume 13, Sup., Oct. 2006. ISSN 1005-9113.
- Gong, Xiangyang and Claridge, David E., "Impact of the Position of the Radiators on Energy Consumption and Thermal Comfort in a Mixed Radiant and Convective Heating System," ASHRAE Trans., Vol. 113, Pt. 1, pp. 494-503.
- Xiangyang Gong, David E. Claridge, David Archer, Infiltration Investigation of a Radiantly Heated and Cooled Office, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- Xiangyang Gong, David E. Claridge, David Archer, Development of a Heat Transfer Model for the Integrated Façade Heating, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- 75. Baltazar, J.C. and Claridge, D.E., "Study of Cubic Splines and Fourier Series as Interpolation Techniques for Filling in Short Periods of Missing Building Energy Use and Weather Data, ASME Journal of Solar Energy Engineering, Vol. 128, pp. 226-230, May 2006.
- 76. Claridge, David E. and Chen, Hui, "Missing Data Estimation for 1-6h Gaps in Energy Use and Weather Data Using Different Statistical Methods," Int. Journal of Energy Research, Vol. 30, pp. 1075 – 1091, 2006.
- 77. Shao, X. and Claridge, D.E., "Use of First Law Energy Balance as a Screening Tool for Building Energy Data, Part I – Methodology," ASHRAE Transactions - Research, Vol. 112, Part 2, QC-06-068, 2006.
- 78. Claridge, D.E., "Methodologies for Determining Persistence of Commissioning Benefits," Journal of Harbin Institute of Technology, Volume 13, Sup., Oct. 2006. ISSN 1005-9113.
- Liu, M., Claridge, D.E. and Deng, S., "Air-Filter-Associated Fan Energy Consumption in Variable Air Volume Systems," ASHRAE Transactions-Research, Vol. 109, Part 1, pp. 45–51, 2003.
- Liu, M., Claridge, D.E. and Deng, S., "An Air Filter Pressure Loss Model for Fan Energy Calculation in Air Handling Units," International Journal of Energy Research, Vol. 27, No. 6, pp. 589–600, 2003.
- Kissock, J.K., Haberl, J., and Claridge, D., "Inverse Modeling Toolkit–Numerical Algorithms," ASHRAE Transactions-Research, Vol. 109, Part 2, pp. 425–434, 2003.
- Haberl, J., Sreshthaputra, A., Claridge, D., and Kissock, J.K., "Inverse Modeling Toolkit–Application and Testing," ASHRAE Transactions-Research, Vol. 109, Part 2, pp. 435–448,

2003.
Yoon, J., Lee, E.J., and Claridge, D.E., "Calibration Procedure for Energy Performance Simulation of a Commercial Building," ASME Journal of Solar Energy Engineering, Vol. 125, pp. 251–257, 2003.

- Liu, M., Claridge, D.E. and Turner, W.D., "Continuous CommissioningSM of Building Energy Systems," ASME Journal of Solar Energy Engineering, Vol. 125, pp. 275–281, 2003.
- Liu, M., Song, L., Wei, G., and Claridge, D. E., 2003, "Simplified Building and Air Handling Unit Model Calibration and Applications," Proceedings of ASME Solar Energy Conference, ISEC 2003–44023, Hawaii Island, Hawaii, March 2003, CD.
- Song, L., Liu, M., Claridge, D. E., and Haves, P., 2003, "Study of On-Line Simulation for Whole Building Level Energy Consumption Fault Detection and Optimization," Proceedings of Building Integration Solutions, Architectural Engineering 2003 Conference, Austin, Texas, September 2003.
- Liu, M., Claridge, D. E., and Turner, W. D., 2003, "Introduction to the DOE Continuous Commissioning Guidebook-Maximizing Building Energy Performance and Efficiency," Proceedings of Building Integration Solutions, Architectural Engineering 2003 Conference, Austin, Texas, September 2003.
- Wei, G., Turner, W. D., Claridge, D. E., and Liu, M., 2003, "Single-Duct Constant Air Volume System Supply Air Temperature Reset: Using Return Air Temperature or Outside Air Temperature," Proceedings of Building Integration Solutions, Architectural Engineering 2003 Conference, Austin, Texas, September 2003.
- Liu, C., Deng, S., Claridge, D., Turner, D. and Bruner, H., "Room Temperature Control during Season Switchover with Single Duct Variable Air Volume System Without Reheat," Proceedings of International Conference on Enhanced Building Operation, Berkeley, CA, October 2003, CD.

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PhD ('81), MS ('77), BS ('75) - Physics
Munich Institute of Technology (Muenchen, Germany)

Research Interests

- Advanced Energy Conversion Systems
- Cooling, Heating and Power (CHP) Systems
- Optimization of Thermal Systems
- Vapor Compression Heat Pump and Refrigeration Cycles: Design, Testing and Simulation
- Sorption Heat Pumps: Design, Testing and Simulation
- Energy and Environment
- Working Fluid Mixtures

Dr. Radermacher has almost 30 years of experience in research and development of energy conversion systems in general and CHP (Cooling Heating and Power) Systems and air-conditioning/heat pumping devices in particular. He is an internationally recognized expert in the use of working fluid mixtures. His research grew to range from environmentally safe refrigerants in residential air-conditioners and heat pumps to combined heating, cooling and power systems for buildings and campuses. His work has resulted in over one hundred fifty publications, as well as numerous invention records and nine patents, and he co-authored three books.

Dr. Radermacher founded the Energy Laboratory in 1983 and is the director and co-founder of the Center for Environmental Energy Engineering (CEEE) at the University of Maryland. The

Center is taking the lead in developing energy conversion systems that meet environmental and economic concerns. Research is organized in consortia that are sponsored by industry, government and research institutions. Varieties of short courses are offered for industry and research sponsors. CEEE has also introduced four new courses in the area of Energy and Environment and Integrated Cooling, Heating and Power Systems.

His service includes international activities such as US representative of the International Energy Agency Annex 13, past vice president of Commission B1 and President of Commission B2 of the International Institute of Refrigeration (IIR), as well as invited lecture tours to Europe, China, Japan, Korea, and South America. He also serves as the coordinator of the German Exchange Program for the University of Maryland College of Engineering. Nationally, he is an active member of the American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE) and the American Society of Mechanical Engineers (ASME). He serves as the editor of the ASHRAE HVAC&R Research Journal starting in July 2002.

Publications

- Heat Conversion Systems, Georg Alefeld and Reinhard Radermacher (CRC Press, 1994)
- Absorption Chillers and Heat Pumps, Keith E. Herold, Reinhard Radermacher and Sandy A. Klein (CRC Press, 1995)
- Vapor Compression Systems with Refrigerant Mixtures, Reinhard Radermacher, Yunho Hwang, 2000
- more than 100 articles and conference proceedings
- 9 patents

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2006-	Director, Mid-Atlantic CHP Application Center
2002 -	President, Platinum Energy, Incorporated
1983-2002	President GKCO, Incorporated
1978-1983	Vice President, GKCO Consultants
1973-1978	Director, Mathtech, Inc.
1972-1973	Director, Decisions Sciences Corporation
1969-1972	Research Associate, Drexel University
1964-1969	Engineer, General Electric Company

As Director of the Mid-Atlantic CHP Application Center, Dr. Orlando is responsible for promoting applications of Combined Heat and Power technologies in the multistate regions consisting of Pennsylvania, Maryland, New Jersey, Delaware, West Virginia, Virginia and the District of Columbia. His responsibilities include technical assistance to potential CHP developers and/or owners, support of state energy offices, documentation of CHP applications, and a variety of educational activities.

As President of Platinum Energy (formerly known as GKCO, Incorporated) Dr. Orlando has been responsible for a variety of energy and central plant assignments both in the United States and abroad. His assignments have included:

- Evaluation of steam, gas and electric rates
- Evaluation of campus electric master plans, including evaluation of service voltage levels, substation ownership and redundant service issues.
- Electric utility negotiations including line relocations, joint construction of duct banks, redundant services, interruptible rates and special contracts.
- Facility energy management planning

- Central Heating and Chilled Water plant management;
- Expert witness services in natural gas, electricity, steam and chilled water regulatory proceedings;
- Engineering services including on-site power conceptual designs, engineering management and project development;
- Due diligence and owners agent services including independent reviews of engineering feasibility analyses and designs, system performance projections and evaluation of business, legal and regulatory issues;

Dr, Orlando has completed a number of assignments throughout the United States over the past twenty five years and has interacted with utilities and energy suppliers throughout the nation. He has testified in a number of proceedings before state regulatory bodies. His assignments include the evaluation of a third party proposal for steam and power supplies to Jeanes Hospital in Pennsylvania, the evaluation of the electric master plan for Eastern Michigan University and development of a revised plan that includes upgraded service voltages, a new University owned substation and an upgrade of the campus distribution system from 480 v to 13.2 kV, and an evaluation of the 2,400 volt system at Episcopal Hospital in Philadelphia, Pennsylvania. He has negotiated performance contracts for energy management technologies and acted as the owner's representative on several energy projects. ..

He has a broad understanding of public and private energy issues having provided consulting services to industrial facilities, health care providers, utility companies, financial institutions, equipment manufacturers, independent power producers, and numerous energy end users. He is a nationally recognized expert on power and central plant topics having been appointed as an officer and Board Member of the Cogeneration and Independent Power Coalition of America. He also served as Chairman of the ASHRAE Cogeneration Technical Committee (three years) where he was responsible for revising the ASHRAE Handbook chapters on Cogeneration and on Prime Movers and is the sole author of the ASHRAE Cogeneration Design Guide.

Dr. Orlando is a registered engineer in a number of states and has completed energy cost management assignments for applications at universities, hotels, industrial plants, nursing homes, hospitals, and office buildings.

EDUCATION:

1972	Ph. D.	Drexel University, Environmental Engineering
1967	M.S.	University of Pennsylvania, Electrical Engineering
1964	B.S.	Drexel Institute of Technology, Electrical Engineering

REGISTRATIONS:

Illinois	Iowa
Maryland	Ohio
Pennsylvania	Michigan
Virginia	Minnesota
Wisconsin	

PROFESSIONAL ACTIVITIES:

Board Member	Cogeneration & Competitive Power Institute of the Association of Energy Engineers (1998 to 2002).
Founder	Cogeneration and Independent Power Research Institute (1988)
Board Member	Cogeneration and Independent Power Coalition of America, Inc., 1985-1990; served as Treasurer, Secretary and member of the Executive Committee and Policy Committee
Member	American Consulting Engineers Council, Cogeneration Committee
Member	ASHRAE TC 9.5, Cogeneration Systems; Chairman, 1981-84; International Ambassador, 1982
Member	ASHRAE TC 9.6, Energy Systems; Chairman of Research Subcommittee
Member	American Society of Mechanical Engineers, Cogeneration Committee Chairman, 1987
Member	North American District Heating and Cooling Institute, 1984
Member	International Cogeneration Society, 1978-80
Chairman	Mayor's Science and Technology Advisory Committee, Environmental Division, Philadelphia 1974-76
Chairman	Environmental Advisory Board, Marple Township, 1972-75

Christopher J. Damm,
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- Assistant Professor, Department of Mechanical Engineering, Milwaukee School of Engineering (since 2004)
- Consultant, Skogen Engineering Group, Madison, Wisconsin (since 2004)
- Ph.D. University of California, Berkeley, Department of Mechanical Engineering, Combustion/Thermodynamics; Minor fields: Applied Mechanics, Spectroscopy, Air Quality, 2001
- M.S., Brown University, Department of Physics,1995
- M.S., University of Minnesota, Department of Mechanical Engineering, 1993
- B.S., University of Minnesota, Department of Mechanical Engineering1991

Research Interests
Energy conversion and pollutants associated with energy conversion, solar photovoltaic optimization, use of bio-fuels for power generation, combined heat and power systems for advanced commercial buildings, emission factors from on-road motor vehicles, the development of laser diagnostic techniques for characterizing reacting flows, and the design and implementation of advanced energy technologies.

Professional Associations and Activities
- Member of the Governing Board of the Society of Automotive Engineers (Milwaukee Section)
- Faculty Advisor for Society of Automotive Engineers student chapter at the Milwaukee School of Engineering
- Reviewer for Applied Spectroscopy
- Reviewer for CLEAN AIR - International Journal on Energy for a Clean Environment

- Reviewer for 114th Annual American Society of Engineering Education Conference and Exhibition
- Society of Automotive Engineers (SAE)
- American Society for Engineering Education (ASEE)

Professional/Research Experience

- 9/01 – 5/04 Assistant Professor, Environmental Engineering, Science and Policy, Sierra Nevada College
- 3/03 – 5/04 Co-Director, Honors Program, Sierra Nevada College
- Summer '04 Visiting Professor, Center for Building Performance and Diagnostics, Carnegie Mellon University
- Summer '05 Visiting Professor, Center for Building Performance and Diagnostics, Carnegie Mellon University
- 5/03 – 7/04 Visiting Scientist, Division of Atmospheric Sciences, Desert Research Institute
- Summer '02 Visiting Scientist, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory
- 9/97 – 6/01 Graduate Researcher, Combustion Chemistry and Laser Diagnostics Laboratory, Lawrence Berkeley National Laboratory
- 6/90 – 5/92 Energy Engineer, Center for Energy and Environment, Minneapolis, MN

Selected Recent Publications

- McMillen, G. Wrate, C. Damm, and C. Diggelman, "Optimizing the Performance of a Photovoltaic Array by Evaluating Site-Specific Parameters," Center for Alternative Energy and Technology 2007 Alternative Energy Symposium, Chicago, IL, August 9-10, 2007.
- Egan, S. Dechant, and C. Damm, "Building as a Power Plant: Modeling and Selection of a Combined Heat and Power System for an Advanced Commercial Building," 114th ASEE Annual Conference and Exhibition, Honolulu, Hawaii, June 24-27, 2007.
- A.W. Gertler, H.D. Kuhns, M. Abu-Allaban, C.J. Damm, J. Gillies, V. Etyemezian, R. Clayton, and D. Proffitt, "A Case Study of the Impact of Winter Road Sand/Salt and Street Sweeping on Road Dust Re-Entrainment," Atmospheric Environment v. 40, pp. 5976-5985 (2006).
- J. Choi, C. Damm, N. O'Donovan, R. Sawyer, C. Koshland and D. Lucas, "Detection of Lead in Soil with Excimer Laser Fragmentation Fluorescence Spectroscopy" Applied Spectroscopy, v. 59, n. 2, pp. 258-261 (2005).
- C.J. Damm, H.D. Kuhns and A.W. Gertler, "An Assessment of Motor Vehicle Particulate Matter Emissions Measurements," 13th International Scientific Symposium on Transport and Air Pollution, Boulder, Colorado, September 13-15, 2004.

- H.D. Kuhns, C.J. Damm, John Gillies, Mahmoud Abu-Allaban, Russ Clayton, David Proffitt, and A.W. Gertler, "The Impact of Winter Road Sand/Salt and Street Sweeping on Road Dust Re-Entrainment," 13th International Scientific Symposium on Transport and Air Pollution, Boulder, Colorado, September 13-15, 2004.
- C.J. Damm, A. S. (Ed) Cheng, R. W. Dibble, D. Lucas, R.F. Sawyer, and C.P. Koshland, "The Effect of Low Sulfur Diesel, Oxygenate-in-Diesel Blends, and Fischer-Tropsch Diesel on Particulate Matter Emissions from a Compression-Ignition Engine," presented at the 8th International Congress on Toxic Combustion Byproducts, Umea, Sweden, June 17-19, 2003.
- J. Damm, D. Lucas, R. F. Sawyer, and C. P. Koshland, "Characterization Of Diesel Particulate Matter With Excimer Laser Fragmentation Fluorescence Spectroscopy," Proceedings of the Combustion Institute 29, 2767-2774 (2002).
- C.J. Damm, D. Lucas, R.F. Sawyer, and C.P. Koshland, "Real-time Measurement of Combustion Generated Particles with Photofragmentation-Fluorescence," Applied Spectroscopy, v. 55, n. 11, pp. 1478-1482 (2001).
- C.J. Damm, D. Lucas, R.F. Sawyer, and C.P. Koshland, "Excimer Laser Fragmentation Fluorescence Spectroscopy as a Method for Monitoring Ammonium Nitrate and Ammonium Sulfate Particles," Chemosphere, v. 42, n. 5, pp. 655-661 (2001).
- C.J. Damm, H.D. Kuhns and A.W. Gertler, "Towards Reconciling Motor Vehicle Particulate Matter Emissions Measurements, Emission Factors, and Emissions Models," (in preparation)
- Recent Invited Talks
- Keynote Address at the Society of Automotive Engineer's Emissions: The Engineering Challenge Technical Lecture Series, "Well-to-Wheel Emissions from Motor Vehicles: A Discussion of the Performance of Alternative Propulsion Systems," Discovery World Digital Theater, Milwaukee, WI, January 24, 2007. Webcast can be viewed at http://www.saemilwaukee.org
- 4th Annual Green Vehicle Workshop, "Carbon Dioxide Emissions from Passenger Motor Vehicles with Alternative Powertrain Systems," Milwaukee, WI, March 30, 2007.
- 6th Annual Green Colleges Workshop, "MSOE's (Solar Electric) PV System," Milwaukee, WI, April 20, 2007.
- 16th Annual Keep Greater Milwaukee Beautiful Environmental Business Seminar—Global Warming: Strategies for Wisconsin, "Plug-in Hybrids Using Renewable Energy—A Primer," Milwaukee, WI, May 11, 2007.

8 ABET/IWESS Publications in 2006 and 2007

Ph.D. Thesis

- Xiangyang Gong, Investigation of a Radiantly Heated and Cooled Office with an Integrated Desiccant Ventilation Unit, Thesis Report, Texas A&M University, 2007
- Hongxi X. Yin, An Absorption Chiller in a Micro BCHP Application: Model based Design and Performance Analysis, Thesis report, Carnegie Mellon University, September 2006 (Appendix 1A, 2A, 2B, 3A, 4A)

Conference Proceeding, Journal, and Web Site

Solar Heating and Cooling

- Ming Qu, David H. Archer and Hongxi X. Yin, A linear parabolic trough solar collector performance model, Proceedings of Energy Sustainability 2007, June 27-30, 2007, Long Beach, California
- Ming Qu, David H. Archer, Sophie Masson and Hongxi X. Yin, Solar Absorption Cooling and Heating System in the Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California
- Sophie V. Masson, Ming Qu, David H. Archer, Performance modeling of a solar driven absorption cooling system for Carnegie Mellon University's Intelligent Workplace, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- Sophie V. Masson, Ming Qu, David H. Archer, Performance modeling of a solar thermal system for cooling and heating in Carnegie Mellon University's Intelligent Workplace, Proceedings of Energy Sustainability 2007, June 27-30 2007, Long Beach, California

Steam absorption chiller

- Hongxi Yin, David Archer, Broad BCT 16 Absorption Chiller Performance: Steam Driven, Double Effect, 16 kW (4.5) Ton, Applied Research, Whole Building Design Guide, 2007, (www.wbdg.org/research/chillers.php)

Radiant systems

- Xiangyang Gong, David E. Claridge, Impact of the Position of the Radiators on Energy Consumption and Thermal Comfort in a Mixed Radiant and Convective Heating System, ASHRAE Transactions, V 113, part 1, 2007

- Xiangyang Gong, David E. Claridge, Indoor Humidity analysis of an Integrated Radiant Cooling and Desiccant Ventilation System, Proceedings of International Conference of Enhanced Building Operation, Nov 6-9, 2006, Shenzhen, China.
- Xiangyang Gong, David E. Claridge, Impact of the Position of the Radiators on Energy Consumption and Thermal Comfort in a Mixed Radiant and Convective Heating System, Proceedings of International Conference of Enhanced Building Operation, Oct 11-13, 2005, Pittsburgh
- Xiangyang Gong, David E. Claridge, David Archer, Infiltration Investigation of a Radiantly Heated and Cooled Office, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China
- Xiangyang Gong, David E. Claridge, David Archer, Development of a Heat Transfer Model for the Integrated Façade Heating, Proceedings of International Conference of Enhanced Building Operation, 2006, Shenzhen, China

Ventilation unit

- Chaoqin Zhai, David H. Archer and John C. Fischer, The Performance of an Energy Recovery Wheel in Ventilation of CMU's IW, Proceedings of IMECE2006: ASME International Mechanical Engineering Congress and Exposition, November 5-10, 2006, Chicago