perFORMative

Innovation Strategies for the built environment in research, practice & teaching

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Innovation Strategies for the built environment in research, practice & teaching

- Introduction and motivation
- Case studies in different scales
- Conclusions
- Q&A

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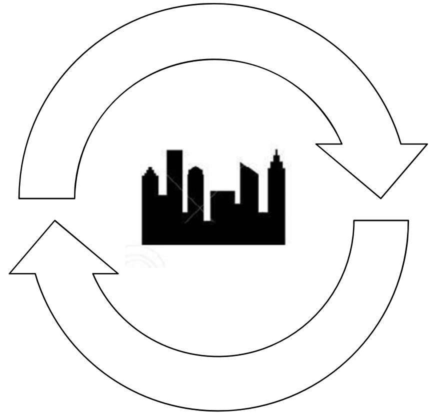
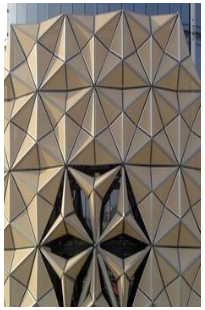
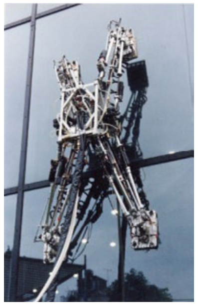
ARCHITECTURE
Qualitative
Conceptually driven

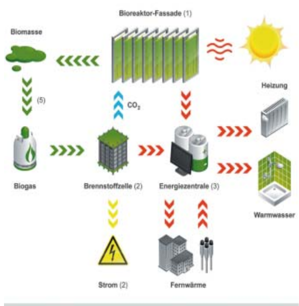


ENGINEERING
Quantitative
Science driven









Now				Next			New		

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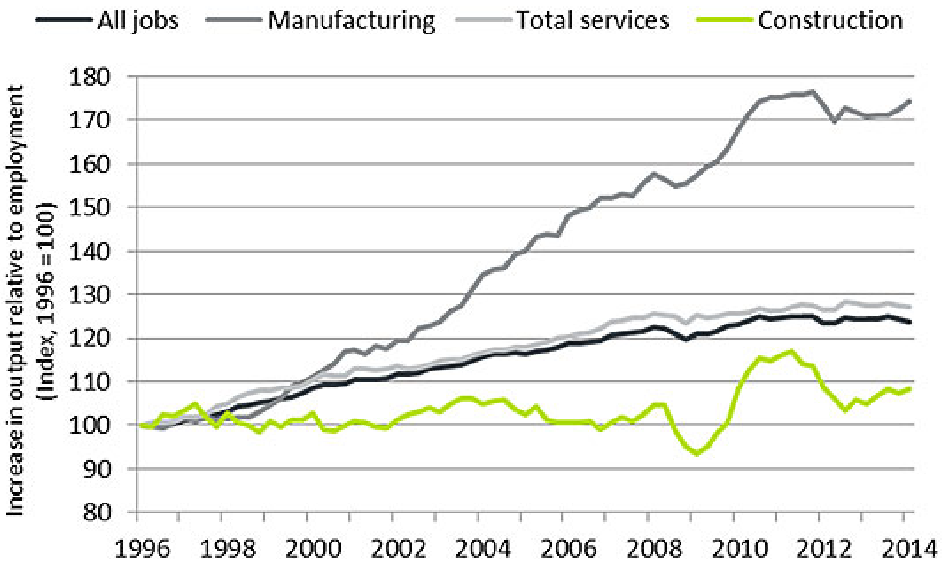
Drivers

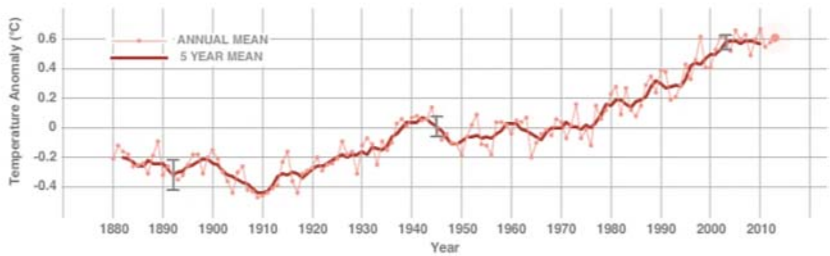
Productivity gap



Increase in output (E C Harris ONS 2014)

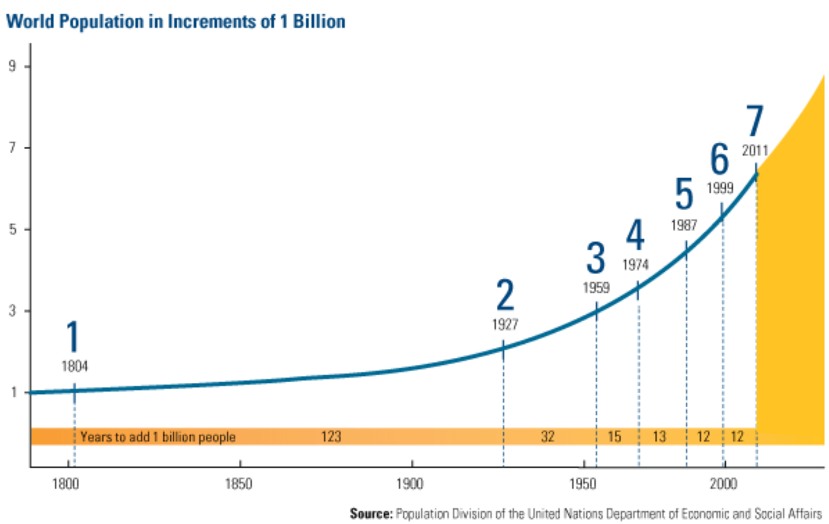
Drivers

Surface temperatures



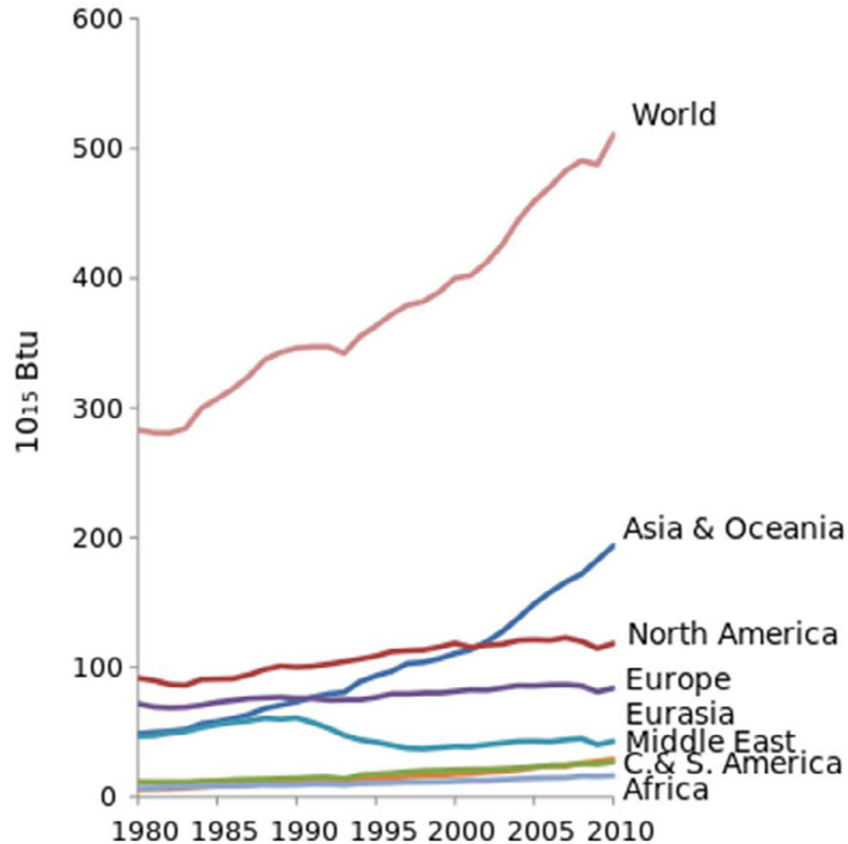
Source: NASA

Global population



Source: United Nations

Global energy demand (annual by region)



Source: US Energy Information Administration 2014.

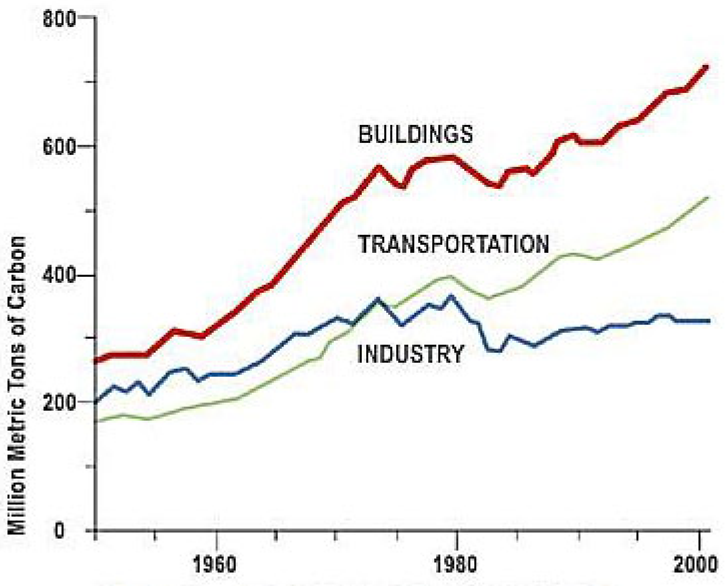
Drivers

Energy demand

- buildings largest consumers worldwide
- doubled between 1971 and 2010
- Under current policies global energy demand of buildings is projected to grow by an additional 30% by 2035 compared to 2010

Source: International Energy Agency 2017.

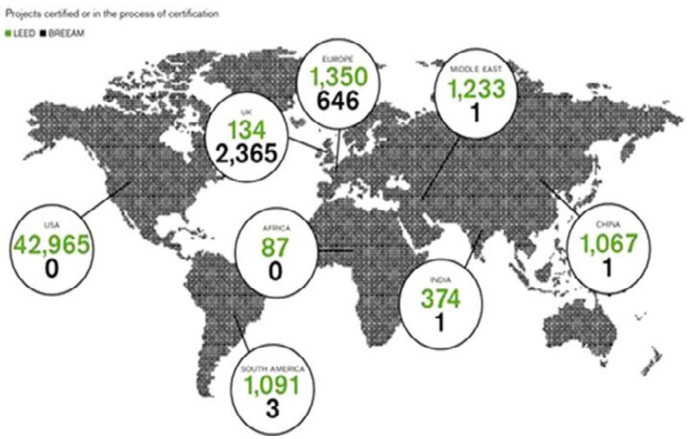
Co2 emissions by sector



Source: Architecture 2030

Drivers

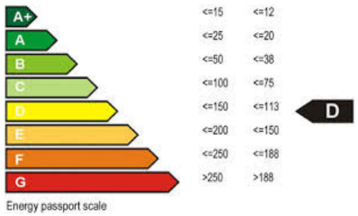
Performance rating systems



Impact of USGBC LEED & Building Research Establishment Environmental Assessment Method

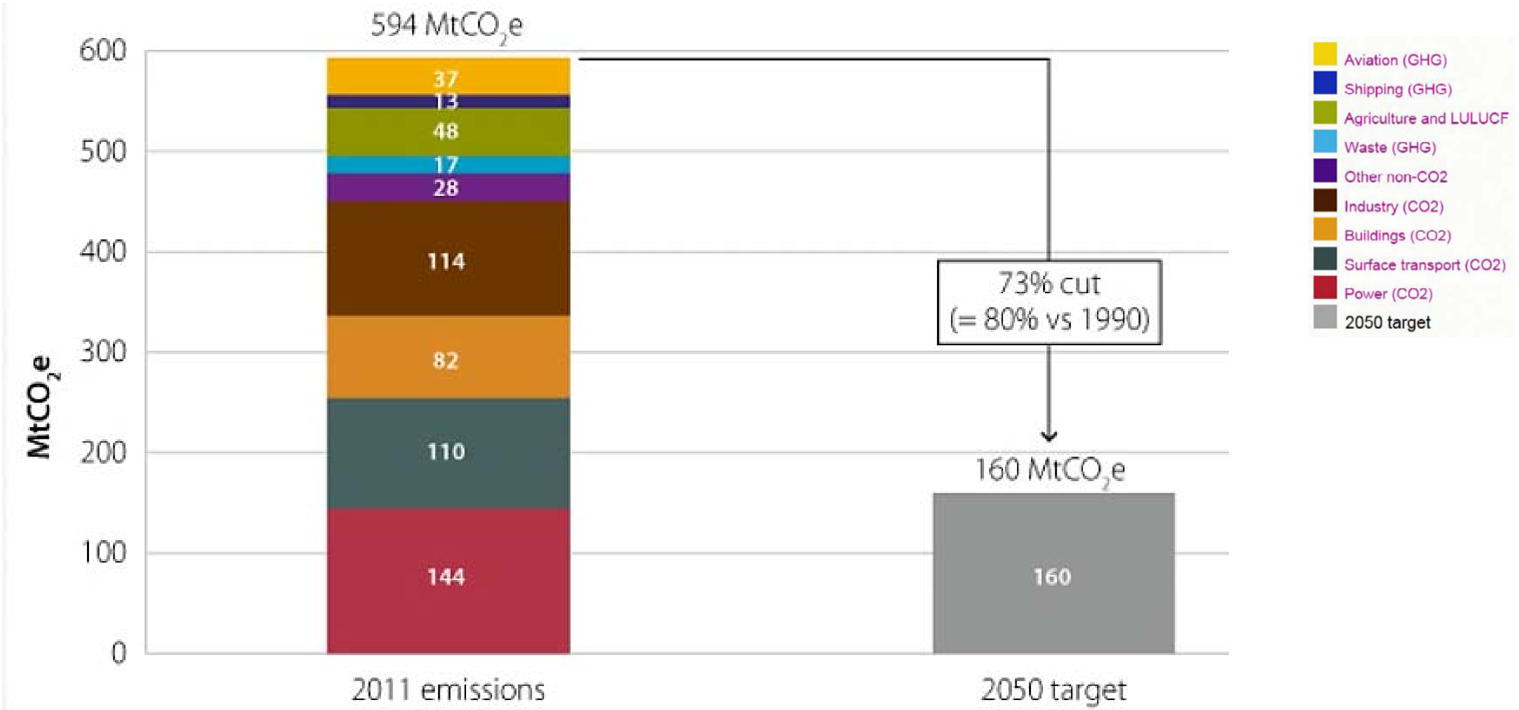
UK GREEN BUILDING COUNCIL Gold Leaf Founding Member

Home Quality Rating



Drivers

Reduction off UK [CO_2] Emissions by Sector

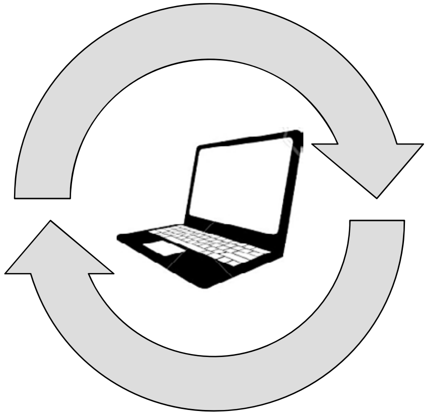


Source: UK Committee on Climate Change 2015.

DESIGN OPTIMISATION TOOL – VIRTUAL DESIGN STUDIO

SYRACUSE UNIVERSITY
US DEPARTMENT OF ENERGY

Architectural Design
Methodology focused
Interdisciplinary platform



Systems engineering
Following ADDAM structure
Qualitative and quantitative

Software scope 702.000 USD US Department of Energy	Development 2010- ongoing	Team P. Michael Pelken Dr. Jianshun Zhang Research Team

Virtual Design Studio

Development of a digital platform for integrated, **fully coordinated and optimized designs of buildings, energy and environmental systems** (BEES)
US Department of Energy funded project with an overall project value of $702.000 over 3 years

Dr. Jensen Zhang, Syracuse University LC Smith College of Engineering and Computer Science, Mechanical and Aerospace Engineering

Dan Rice, IT Specialist, Syracuse University LC Smith College of Engineering and Computer Science

Hugh Henderson, CDH Energy Corp. New York

Kelvin Feng*
Zhigao Li**
Shewangizawa Semahegn*
Yixing Chen*
Zhaozhou Meng*
MS** / PhD* candidates, Syracuse University LC Smith College of Engineering and Computer Science

Robbin Mocarski, Administrative Project Management, Syracuse University

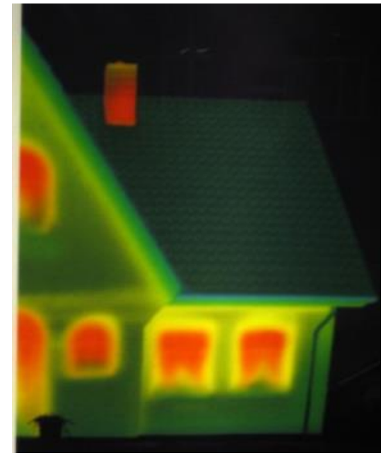
Trever Lee, DoE Project Management, National Energy Technology Laboratory

Lixing Gu,
Solar Energy Research Center, Florida

Paul Michael Pelken,
Syracuse University School of Architecture, Center of Excellence for Environmental and Energy Systems

Francesca Ling, Graduate RA, Syracuse University School of Architecture

“Architect”



“Engineer”

Dr. J. Zhang - Engineer

P.M. Pelken - Architect

VDS ADDAM structure

Design Stages	**Assess**	**Define**	**Design**	**Apply**	**Monitor**	Provide Data / Feedback
Design considerations						
Site and climate response						
Form and massing						
External enclosure incl. roof						
Internal configurations						
Environmental systems						
Energy and water						
Material use						
Other design factors						

VDS ADDAM structure

Design Stages	Assess	Define	Design	Apply	Monitor	Provide Data / Feedback
Design considerations						
Site and climate response	X					
Form and massing						
External enclosure incl. roof						
Internal configurations			X			
Environmental systems						
Energy and water					X	
Material use						
Other design factors						

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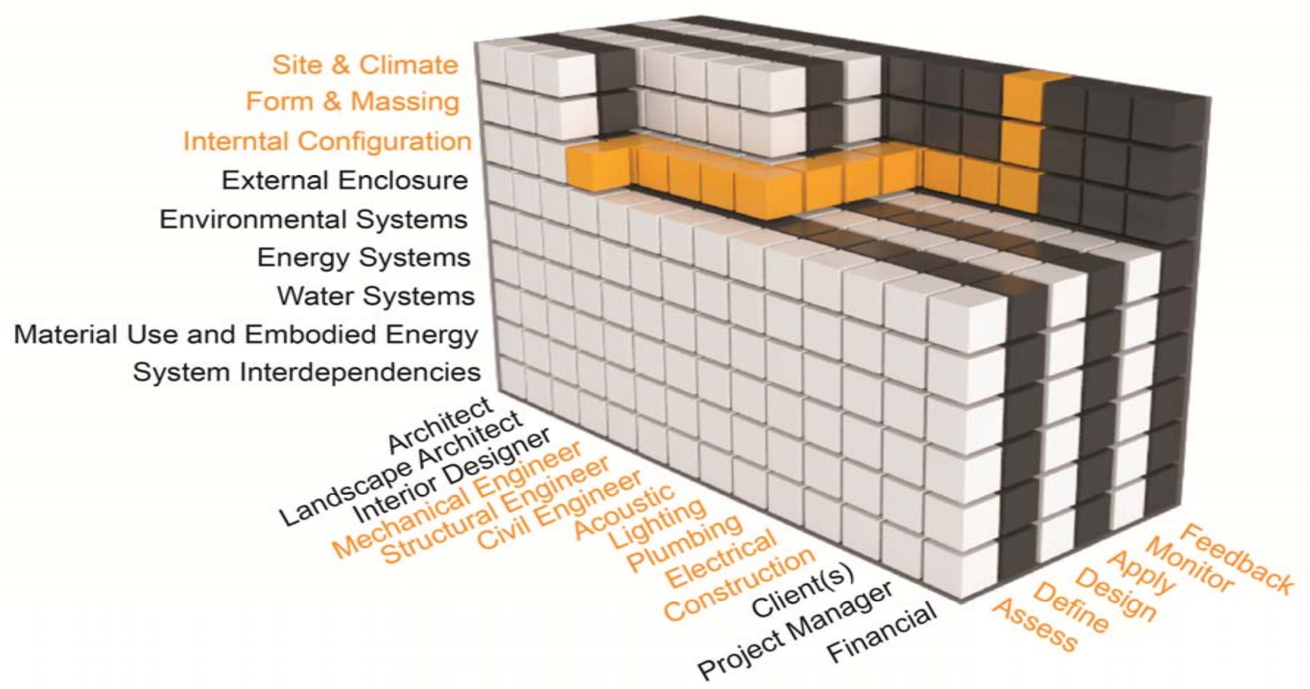
VDS ADDAM structure

Design Stages	**Assess**	**Define**	**Design**	**Apply**	**Monitor**	Provide Data / Feedback

Design considerations

- Site and climate response
- Form and massing
- External enclosure incl. roof
- Internal configurations
- Environmental systems
- Energy and water
- Material use
- Other design factors



VDS ADDAM structure

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Form and massing						
External enclosure incl. roof						
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Environmental systems						
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Material use						
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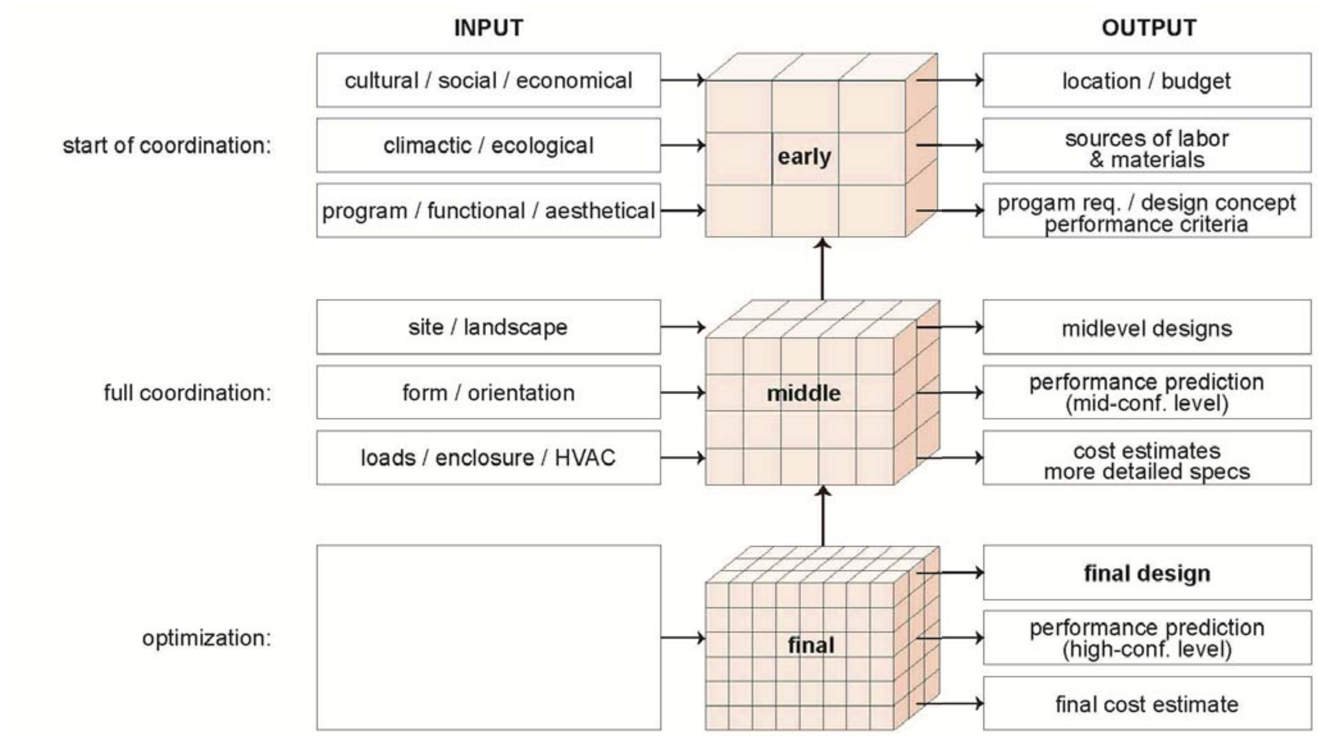

VDS ADDAM structure

Design Stages	Assess	Define	Design	Apply	Monitor	Provide Data / Feedback
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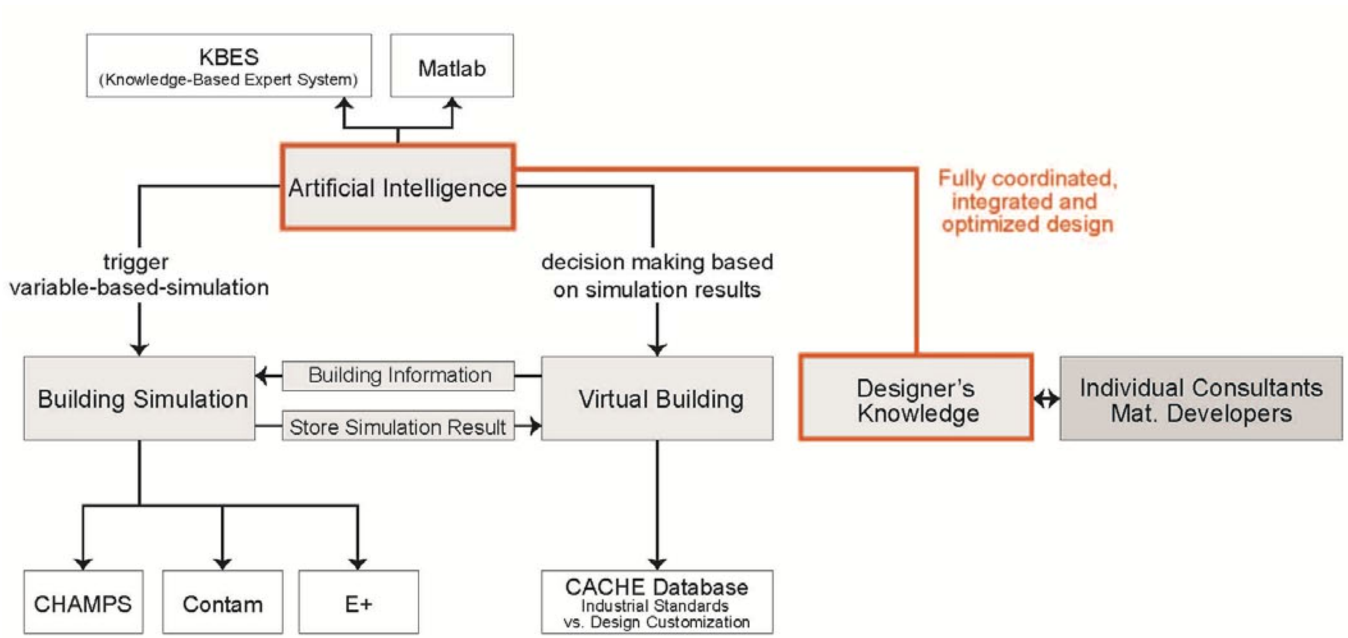

VDS ADDAM structure

Design Stages	**Assess**	**Define**	**Design**	**Apply**	**Monitor**	Provide Data / Feedback
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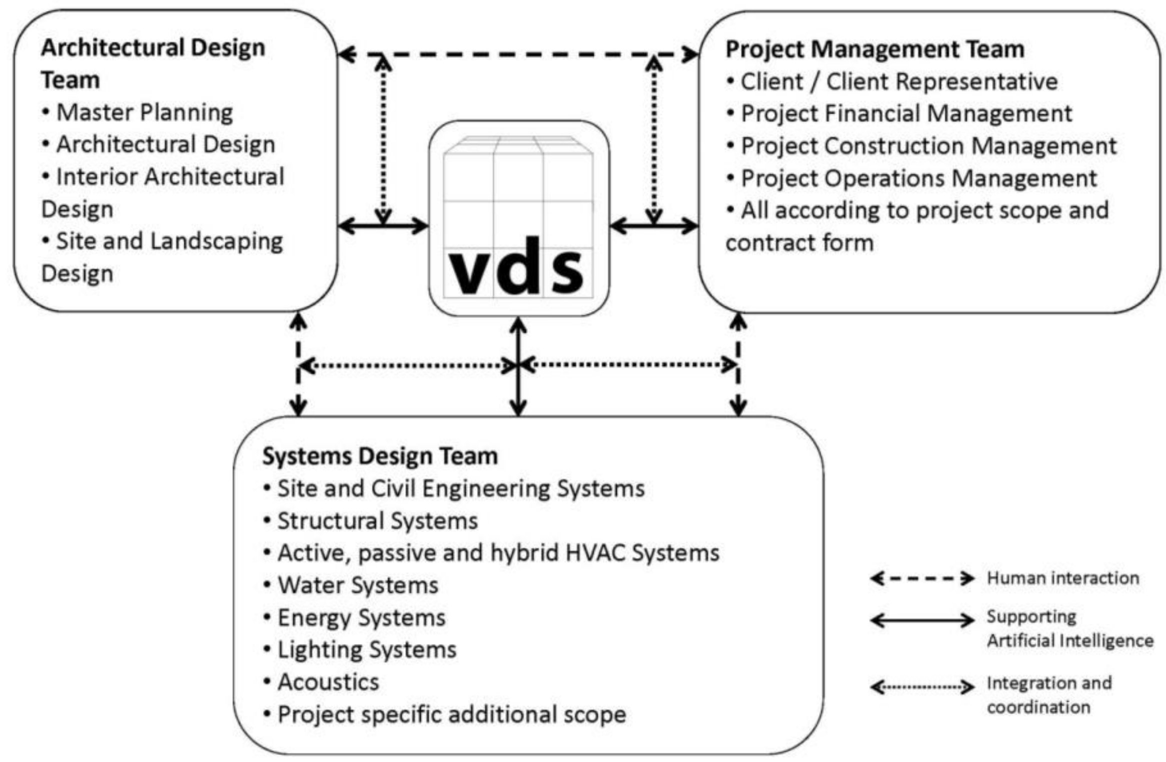

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VDS ADDAM structure

Design Stages	**Assess**	**Define**	**Design**	**Apply**	**Monitor**	Provide Data / Feedback
Design considerations						
Site and climate response						
Form and massing						
External enclosure incl. roof						
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Material use						
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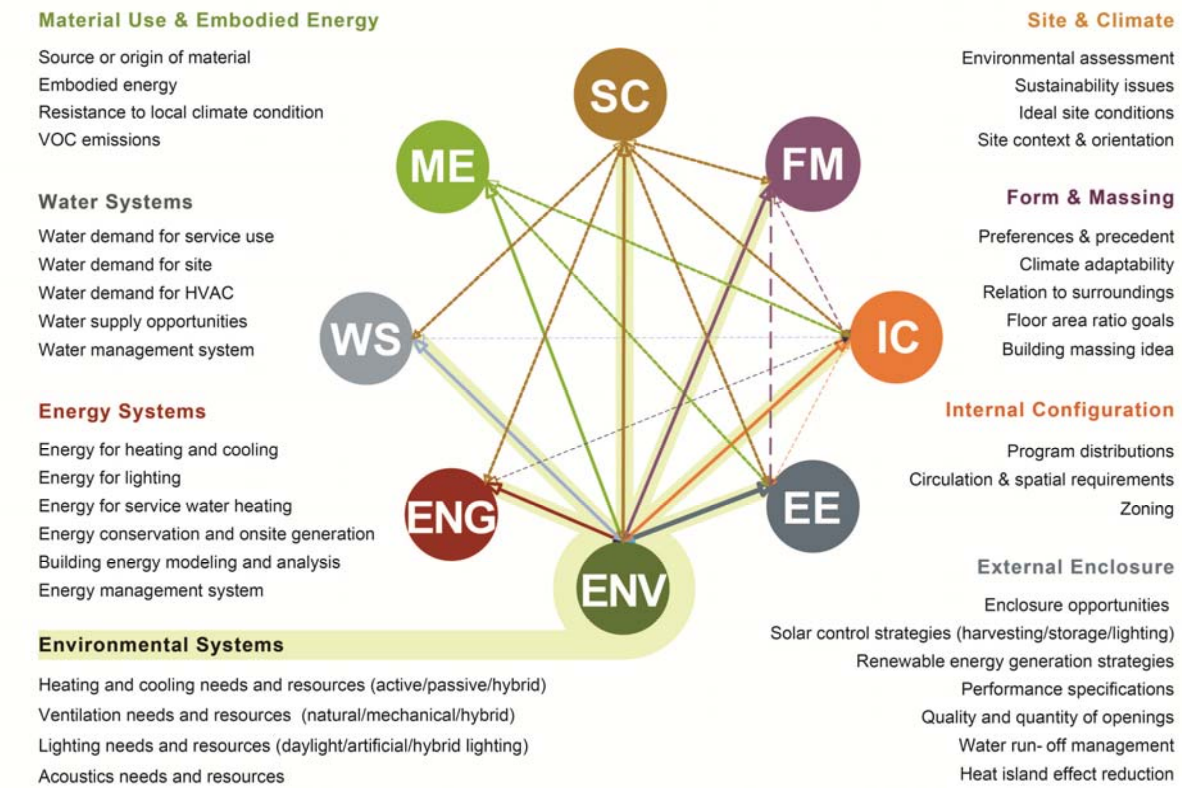

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VDS ADDAM structure

Design Stages	Assess	Re-Define	Design	Apply	Monitor	Provide Data / Feedback

Design considerations

- Site and climate response
- Form and massing
- External enclosure incl. roof
- Internal configurations
- Environmental systems
- Energy and water
- Material use
- Other design factors

Whole life cycle assessment and post occupancy data processing

Validation of

- early design assumptions
- supporting simulation results
- whole building and environmental control system performance

Creation of VDS case study and reference building data base

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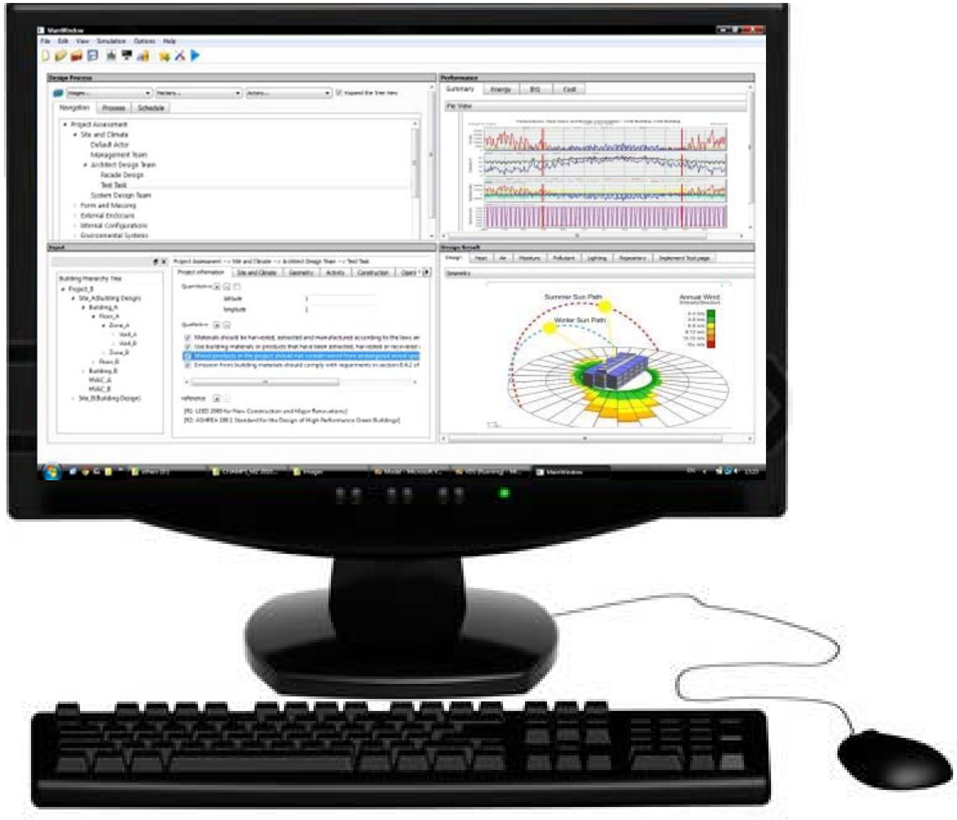
P+ Studio+Consulting

Project set up and evaluation procedures



Project set up and evaluation procedures

Qualitative and quantitative project input

Project set up and evaluation procedures

Qualitative and quantitative project input

Discipline dependent representation of design evaluation

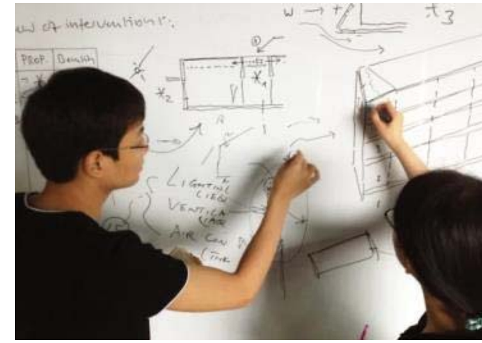
Project set up and evaluation procedures

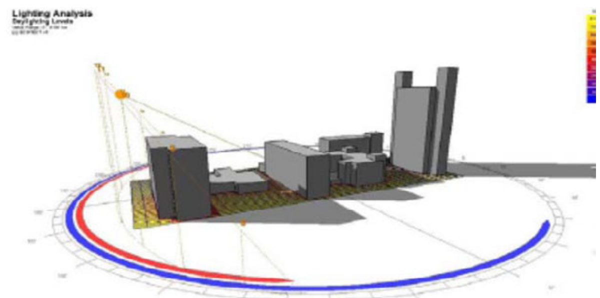
Qualitative and quantitative project input

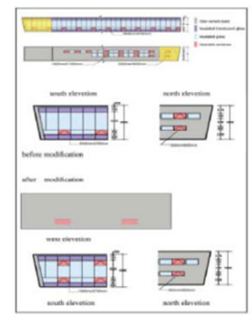
Discipline dependent representation of design evaluation

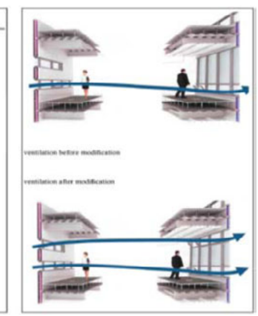
2D and 3D modeling and design viewer

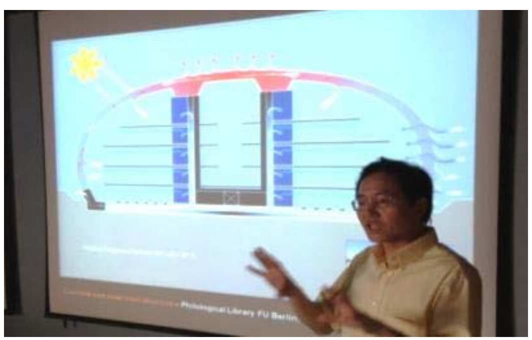
“Syracuse University (SU) - Nanjing University (NJU) International Center in Sustainability” – Interdisciplinary VDS course work and research

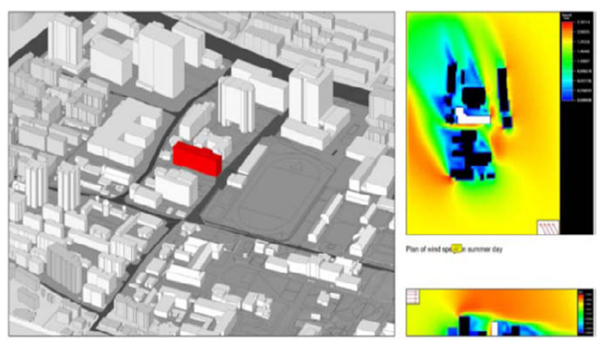


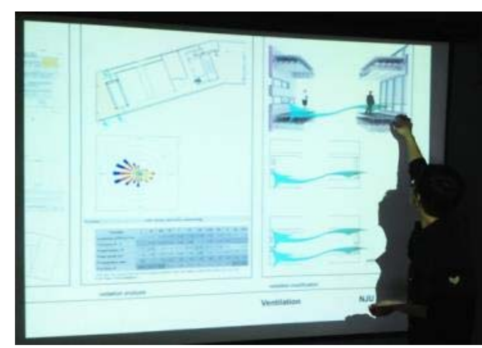


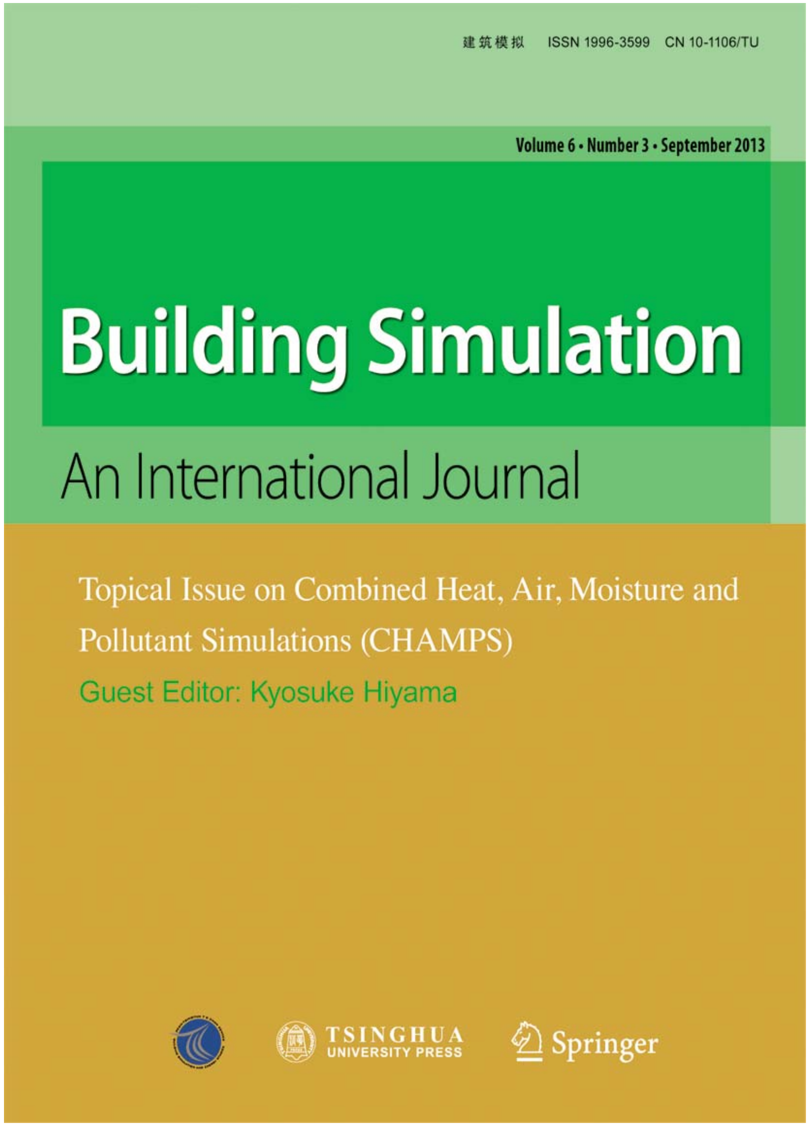












BUILD SIMUL
DOI 10.1007/s12273-013-0110-2

"Virtual Design Studio"—Part 1: Interdisciplinary design processes

P. Michael Pelken[2] (✉), Jianshun Zhang[1], Yixing Chen[1], Daniel J. Rice[1], Zhaozhou Meng[1], Shewangizaw Semahegn[1], Lixing Gu[3], Hugh Henderson[4], Wei Feng[1], Francesca Ling[2]

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Research Article

Abstract

The "Virtual Design Studio (VDS)" is a software platform currently under development in support of an integrated, coordinated and optimized design of buildings and their energy and environmental systems. It is intended to assist collaborating architects, engineers and project management team members throughout from the early phases to the detailed building design development. The platform helps to facilitate the workflow and the processing of information in combination with appropriate, task-based performance simulation tools as further analyzed in Part 2 of this study (DOI: 10.1007/s12273-013-0111-1). The present paper summarizes how VDS relates to the building design process and its typical project stages, performance-based design considerations and respective performance optimization strategies. It outlines the methodology and scope for the organization, implementation and respective requirements for the VDS platform development based on the interdisciplinary design needs. Part 2 will present the methodology for the systems integration and software implementation of VDS.

Keywords

integrated design,
design studio,
building simulations,
modeling,
green building design

Article History

Received: 3 October 2012
Revised: 21 December 2012
Accepted: 10 January 2013

1 Introduction

The Austrian philosopher *"Ivan Illich argued that the modern era of technology, characterized by tools, instrumentality, and function, gave way in the late twentieth century to the age of systems, characterized by complex configurations, self-organization, and emergence. This shift indicts the careful separation of design intention from means of construction codified in architectural contracts as well as the need-finding, problem-solving conventions of engineering practice. The shift from tools to systems heralds the emergence of complex performance problems—active glass walls and self-powered buildings—that demand hybrid responses. New practices are emerging from partnerships of architects, engineers, and others that blur disciplinary boundaries and advance new techniques in design and construction. […] Ecological, economic, and professional realities demand alternative models."*

This quote from the ACSA (Association of Collegiate Schools of Architecture) 2011 Conference on "Performative practices: Architecture and engineering in the twenty-first century" (ACSA 2011) describes objectives that are very similar to ours for the development of an integrated Computer Simulation Environment for Performance-Based Design of very low energy and high IEQ (indoor environmental quality) buildings. The development of an interdisciplinary design and simulation platform is hereby intended to address the above mentioned issues, the required flexibility and the application of a Holistic Systems Thinking.

Buildings designed and constructed using a performance-based energy and IEQ design process that optimizes the interaction between the building envelope and HVAC (heating, ventilation, and air conditioning) systems, among other design aspects, can save significant energy costs yet providing better indoor climate and air quality. These buildings can be constructed for the same or nearly the

Advances in Modeling and Simulation Tools

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Building Simulation

An International Journal

Topical Issue on Combined Heat, Air, Moisture and Pollutant Simulations (CHAMPS)

Guest Editor: Kyosuke Hiyama

TSINGHUA UNIVERSITY PRESS Springer

BUILD SIMUL
DOI 10.1007/s12273-013-0111-1

"Virtual Design Studio"—Part 2: Introduction to overall and software framework

Jianshun Zhang[1](✉), P. Michael Pelken[2], Yixing Chen[1], Daniel J. Rice[1], Zhaozhou Meng[1], Shewangizaw Semahegn[1], Lixing Gu[3], Hugh Henderson[4], Wei Feng[1], and Francesca Ling[2]

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2. School of Architecture, Syracuse University, 201 Slocum Hall, Syracuse, NY 13244, USA
3. Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922, USA
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Research Article

Abstract

The "Virtual Design Studio (VDS)" is a software platform for integrated, coordinated and optimized design of building energy and environmental systems. It is intended to assist management, architectural and systems design teams throughout the early to detailed building design stages as analyzed in Part 1 (DOI: 10.1007/s12273-013-0110-2). This paper presents an overview of the VDS design and method of software implementation, including system composition, architecture, graphical user interface (GUI), and simulation solver integration. A VDS user workflow is also illustrated with a simplified design example.

Keywords

integrated design,
design studio,
building simulations,
modeling,
green building design

Article History

Received: 2 October 2012
Revised: 21 December 2012
Accepted: 10 January 2013

Advances in Modeling and Simulation Tools

1 Introduction

Building system design is a multi-dimensional process involving multi-disciplinary design teams, multi-design stages, multi-design factors, and multi-performance objectives (Pelken et al. 2013). Designing a building is like solving a "magic cube" puzzle in which every step should be coordinated to reach the final solution efficiently. The design at a given stage needs to consider the primary parameters for the current stage, but also the parameters that are further considered in the more detailed subsequent design stages. These parameters represent multi-design factors including Site & Climate, Form & Massing, Internal Configuration, External Enclosure, Environmental System (HVAC), Energy Supply-System, Water Supply-System, Materials and their Interdependences. How these factors impact on building performance needs to be analyzed in the design process. The design results should be updated from one stage to next with more detailed specifications towards achieving the design goals. Sufficient and timely iterations are necessary among the different design factors in different design stages for trade-offs and optimization (Pelken et al. 2013).

Several software platforms have been developed to advance performance-based building design practices. DeST (Yan et al. 2008; Zhang et al. 2008) models and simulates both HVAC system and building energy consumption. It has a graphical user interface developed based on AutoCAD for data input, and the simulation results are given in Excel table formats. It has a ventilation module based on multi-zone network model, and an indoor air quality (IAQ) simulation module to predict multi-zone pollutant transport. However, it does not differentiate the needs of different design stages and also does not have the capacity to support the comparison of design performance versus actual monitored performance.

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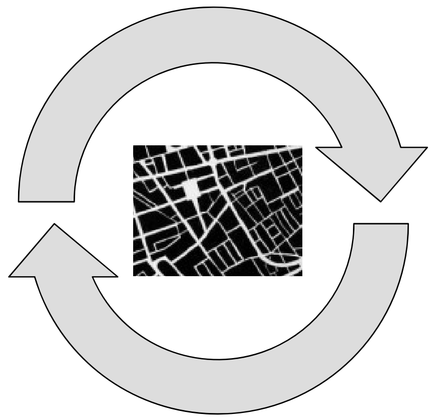
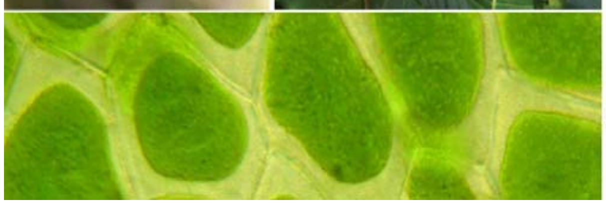
MIXED USE DEVELOPMENT– PEACH BLOSSOM BAY, FANGCHENGGANG
DEVELOPMENT COMPETITION AWARD WINNER, 2010

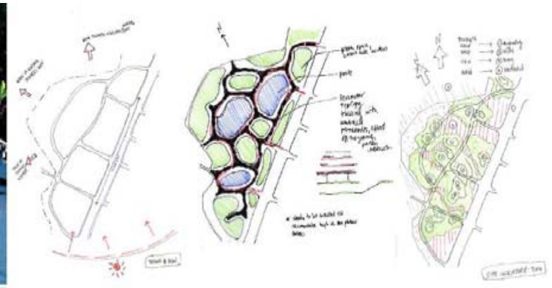
Design
4 mio. sqm in 4 weeks
2 time zones

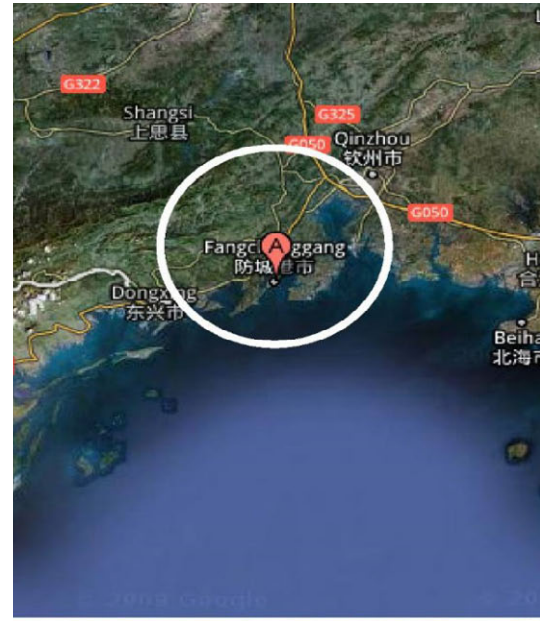


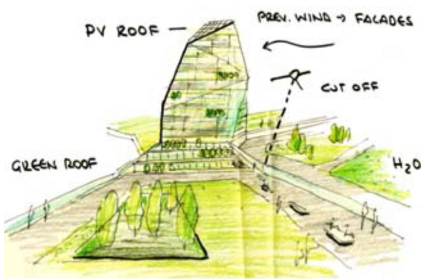
Construction
Response to local climate
Hybrid building operation

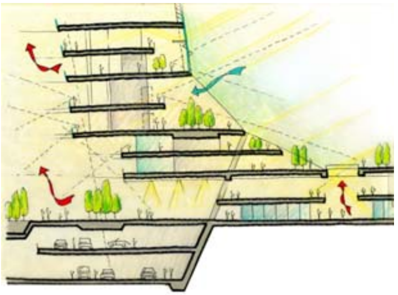
2nd place Wining entry International invited design competition	**Development** 4 mil sqm mixed use urban development	**Team** P. Michael Pelken (USA) Vasilena Vassilev (USA) Minq Deng (China) Climate Engineers (UTRC) Yi Jiang, Chang Xiaomin, Song Fangting; Tsinghua University Architectural Design and Research Institute

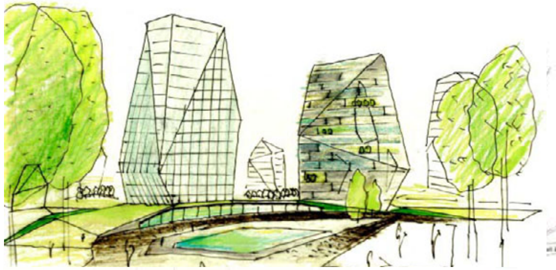


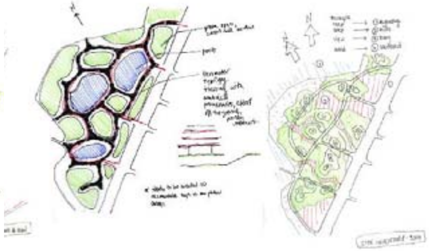


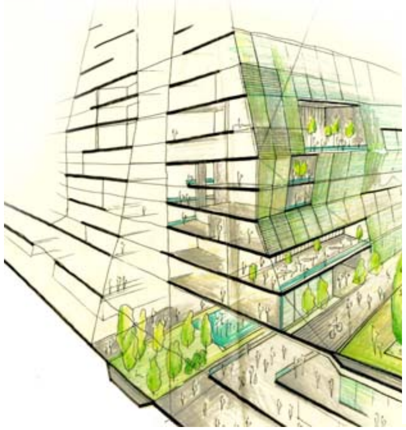

G322
Shangsi
上思县
G325
Qinzhou
钦州市
G050
Beihai
北海市

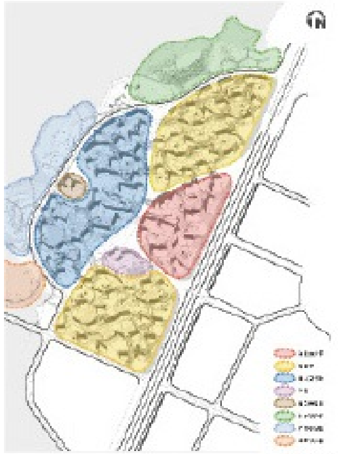

PV ROOF
PREV. WIND → FACADES
CUT OFF
GREEN ROOF
H_2O





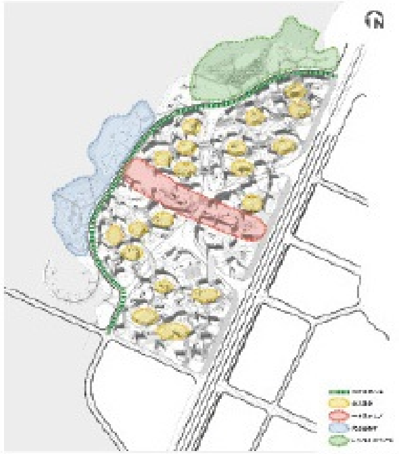




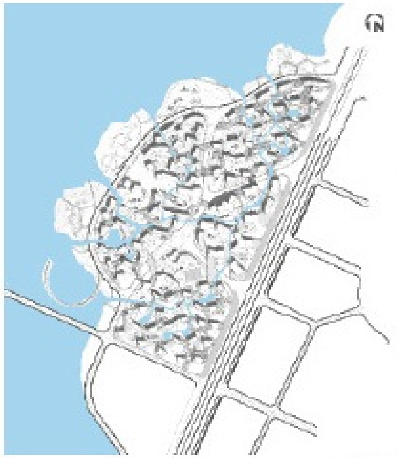


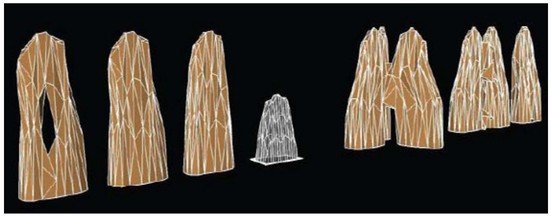
功能分区图

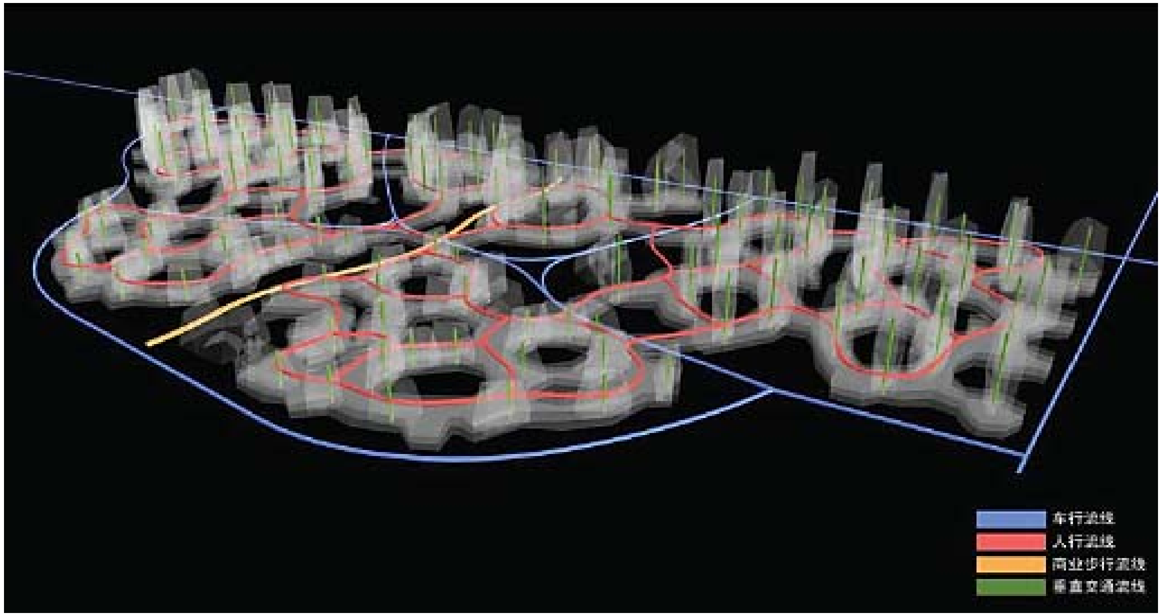
首層交通分析图



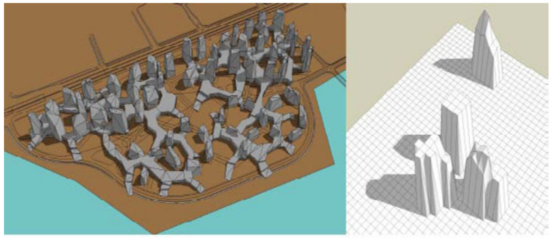
景观分析图

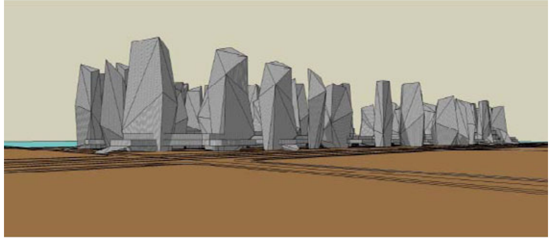






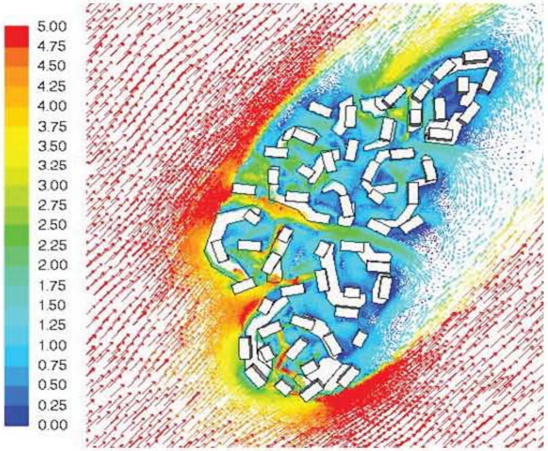
车行流线
人行流线
商业步行流线
垂直交通流线



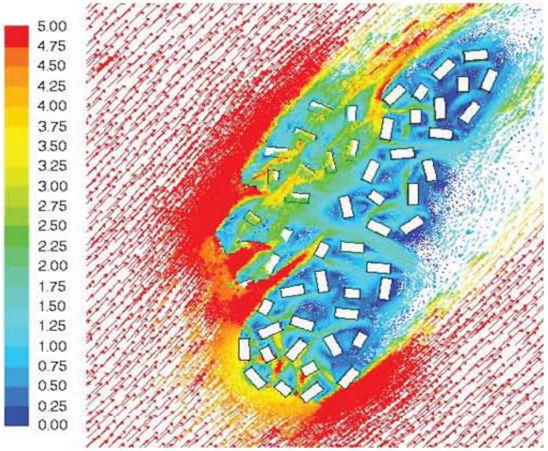


Plan 01

Wind Direction	Avg. Wind Velocity m/s	Height
SW	4.86	1.5m

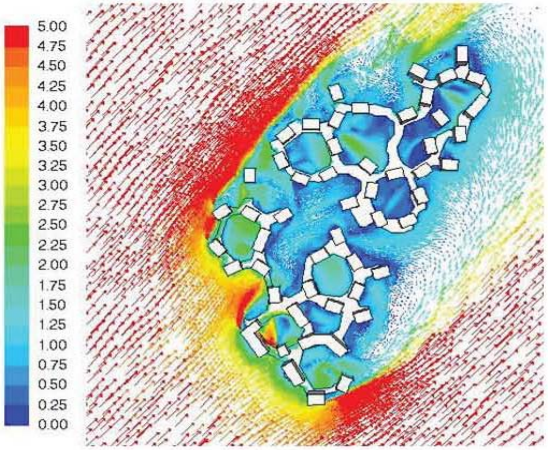


Wind Direction	Avg. Wind Velocity m/s	Height
SW	4.86	36m

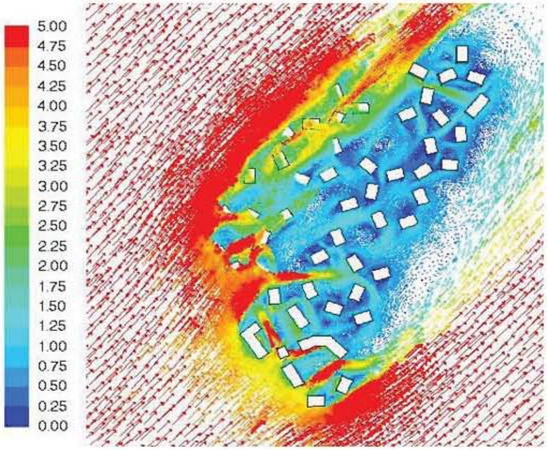


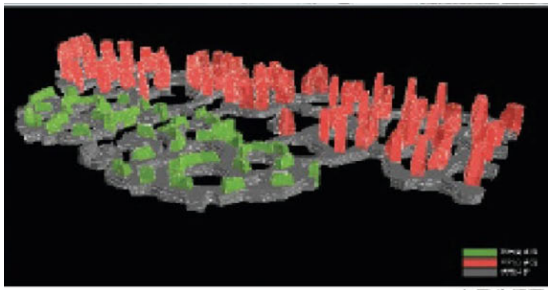
Plan 02

Wind Direction	Avg. Wind Velocity m/s	Height
SW	4.86	1.5 m

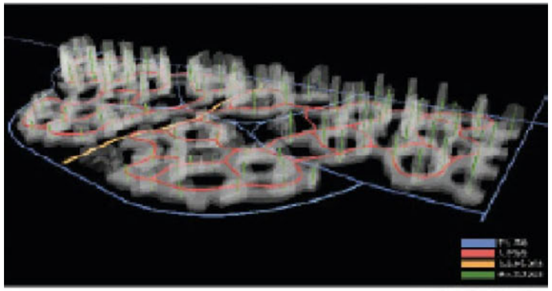


Wind Direction	Avg. Wind Velocity m/s	Height
SW	4.86	36m

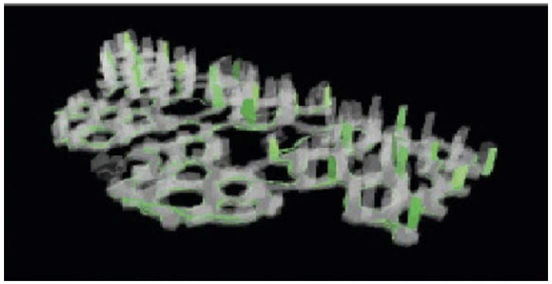




高层分析图

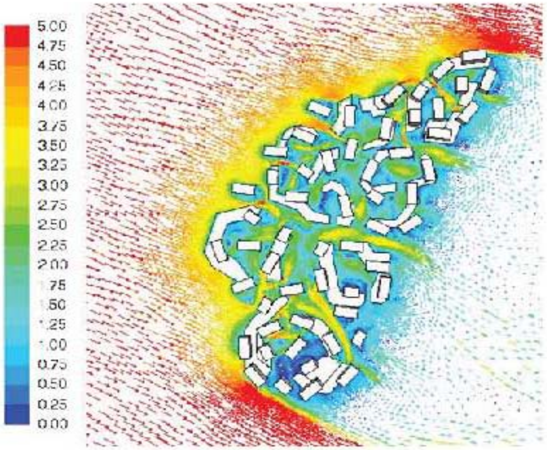


立体交通分析图

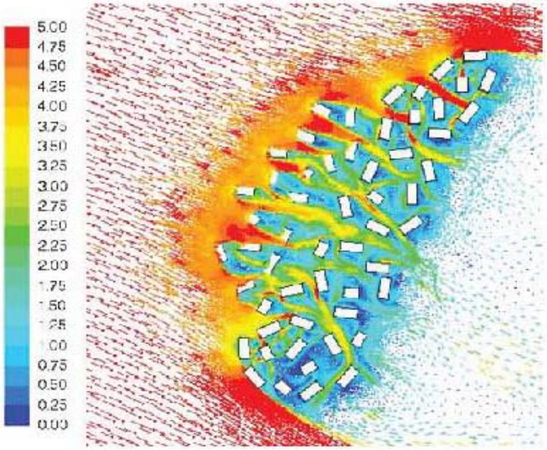


Plan 01

Wind Direction	Avg. Wind Velocity m/s	Height
NNW	4.86	1.5m

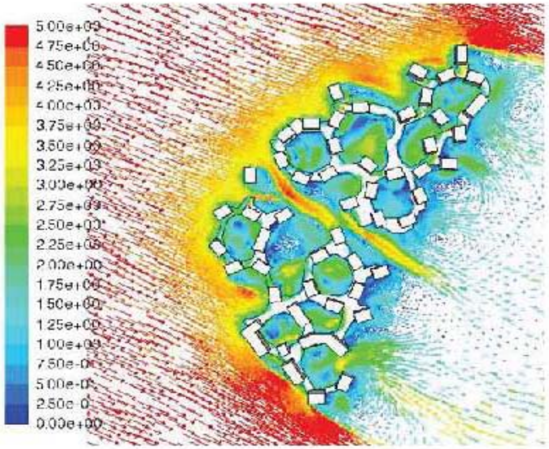


Wind Direction	Avg. Wind Velocity m/s	Height
NNW	4.86	36m

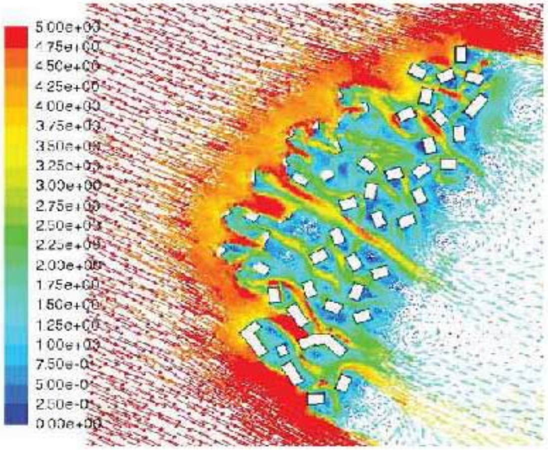


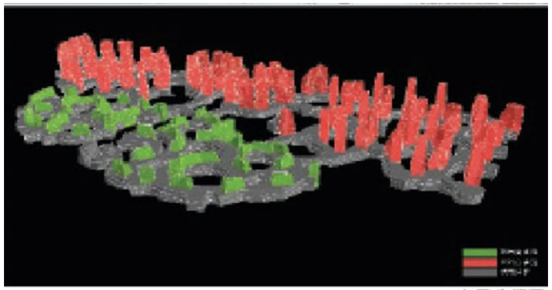
Plan 02

Wind Direction	Avg. Wind Velocity m/s	Height
NNW	4.86	1.5 m

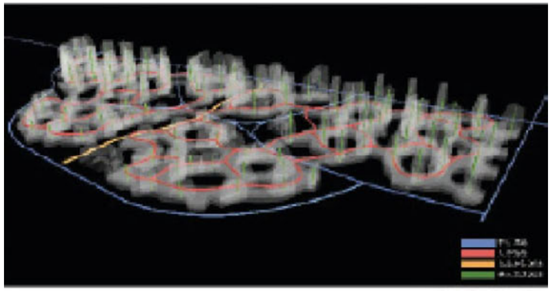


Wind Direction	Avg. Wind Velocity m/s	Height
NNW	4.86	36m

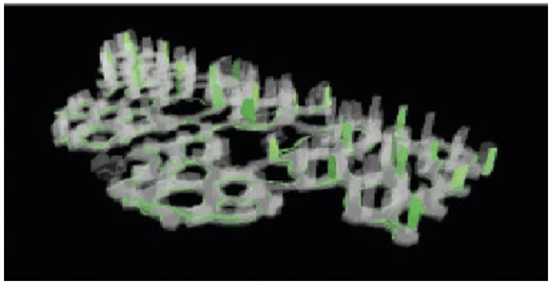


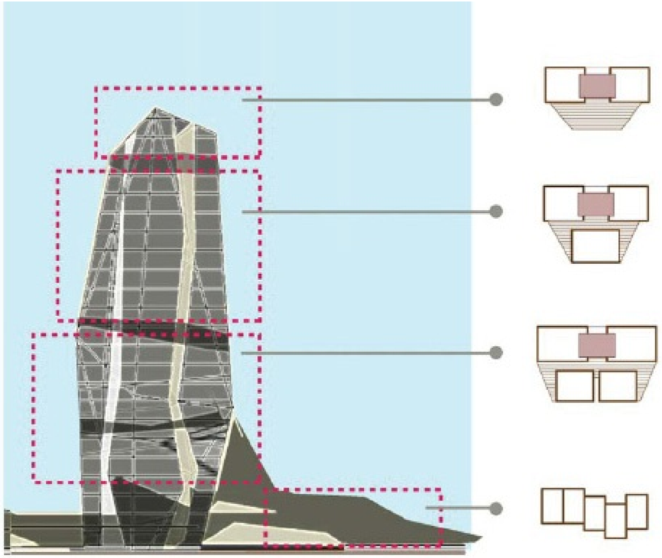


高层分析图

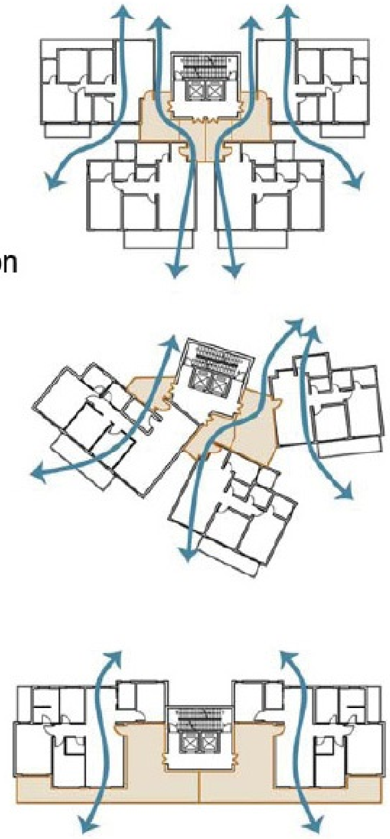


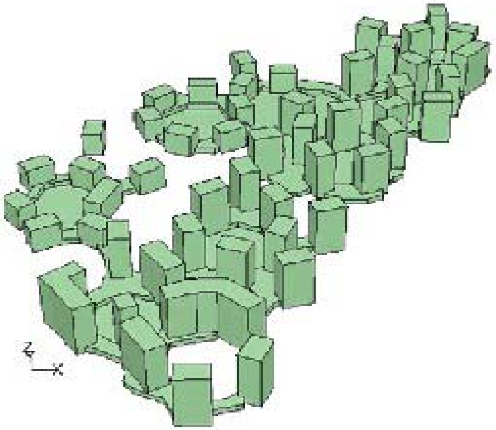
立体交通分析图

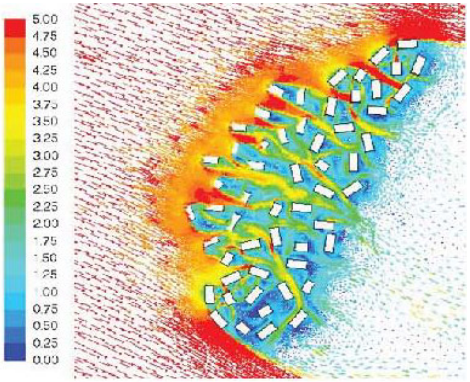




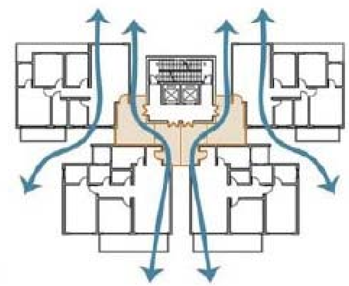
Natural Ventilation

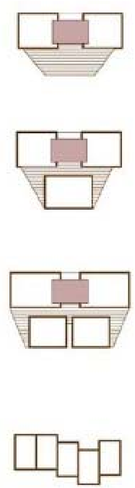


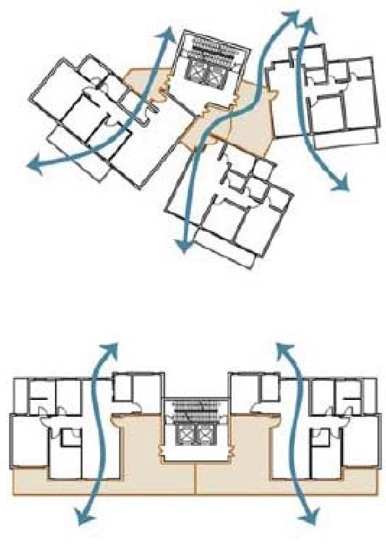


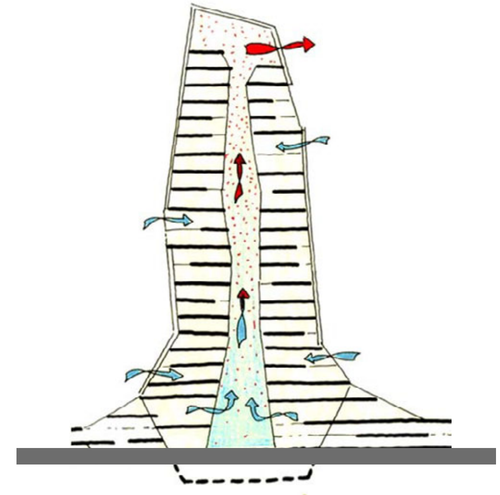


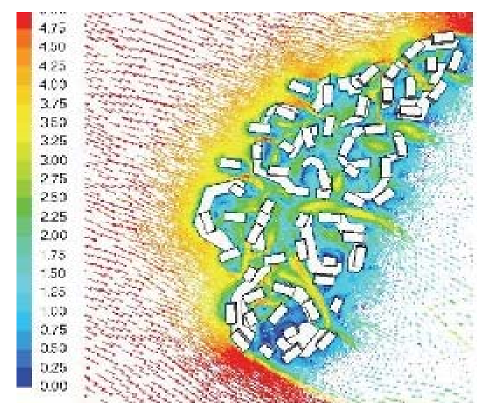
Natural Ventilation

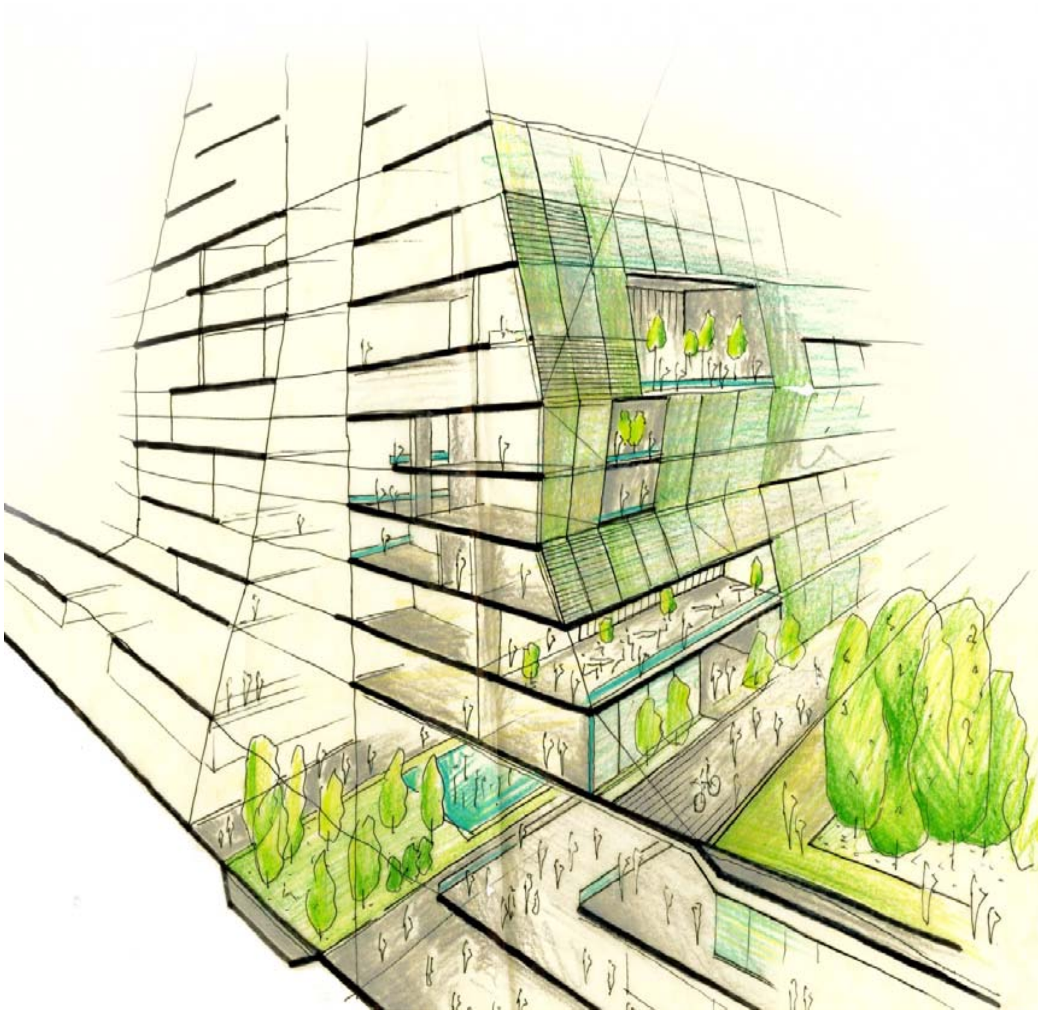
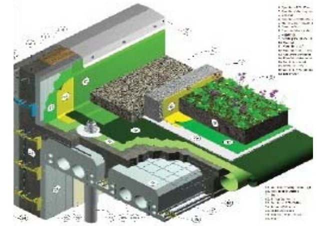


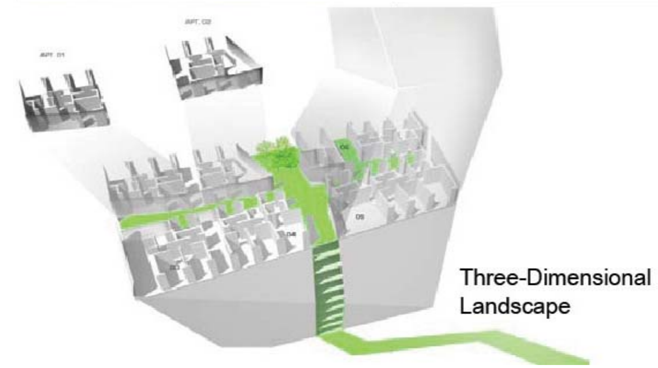


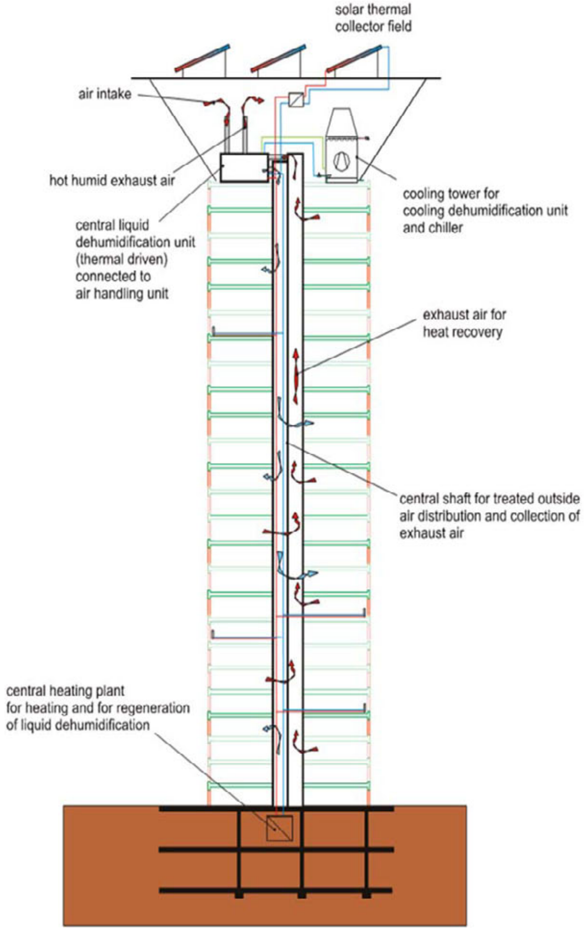


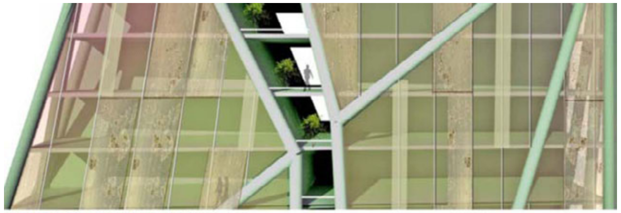





Three-Dimensional
Landscape





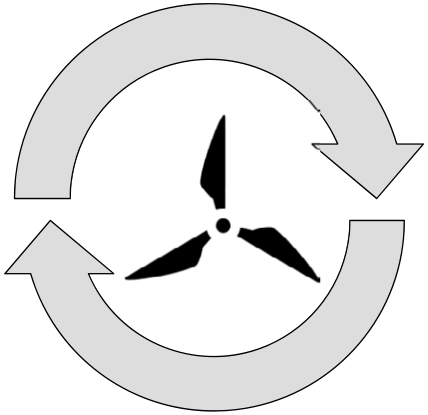
Green Systems

Vertical gardens are beautiful additions to any typology and allow for nature to penetrate the entirety of the structure, both at ground level and beyond. This living, breathing intervention creates a natural cooling effect in the summer and provides a more comfortable environment at balconies and around windows.

Purifying the air and creating a pleasant atmosphere for offices and residential buildings alike, green facade systems extend the beauty of nature into the interior space of the tower.

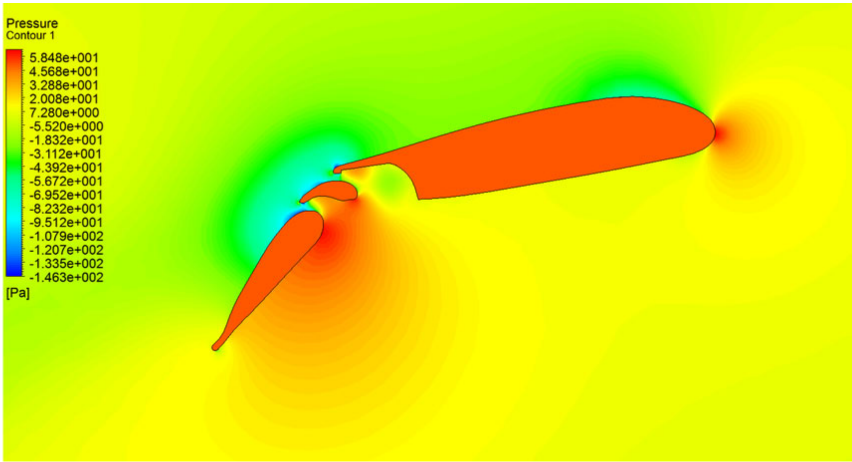
AIR CONTROL - INTEGRATED WIND TURBINES FOR ENVIRONMENTAL CONTROL AND ENERGY GENERATION

Design
Manipulating air flow
Hybrid building operation

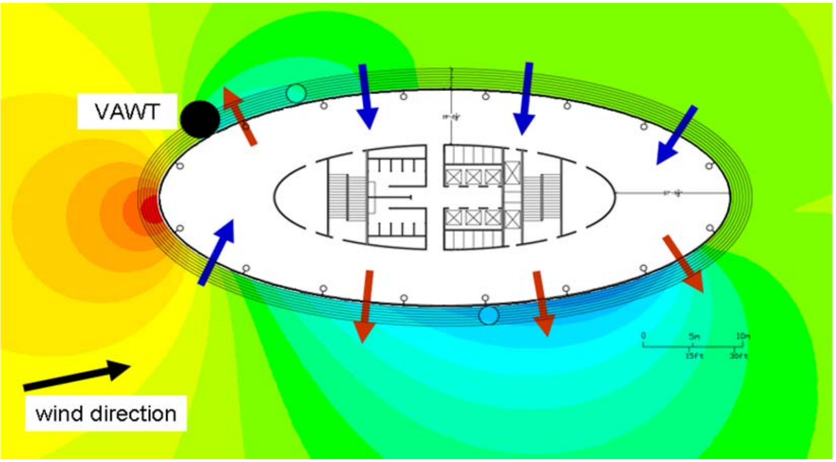


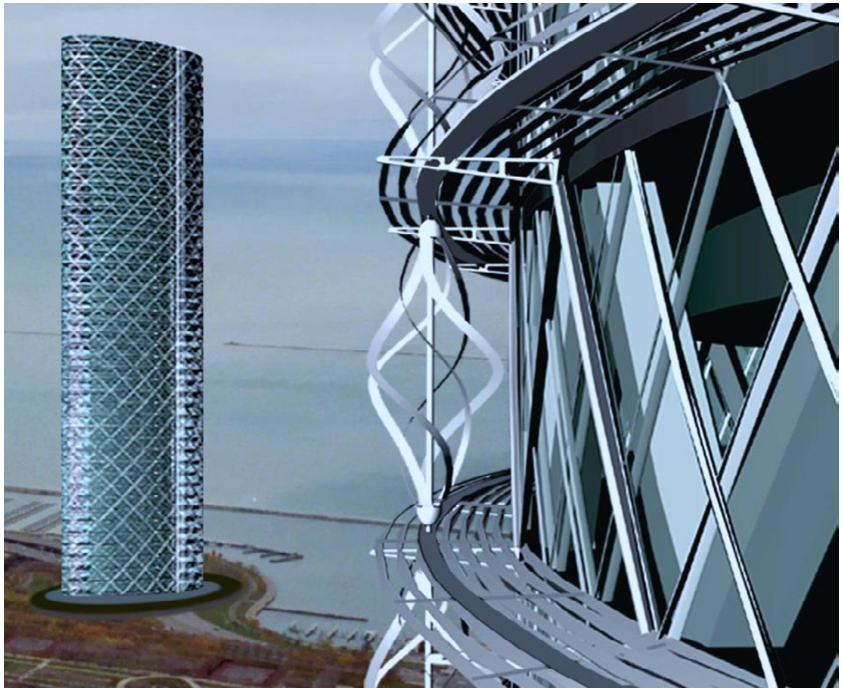
Construction
Reduced wind loads
Novel façade interfaces

Project scope Proof of concept	Development NYSERDA and CoE funded	Team P.M. Pelken Dr. Thong Dang Research team SU Technology Transfer Department



School of Engineering, Warwick University





Zhaozhou Chen
PhD candidate, Syracuse University LC Smith College of Engineering and Computer Science

Dr. Thong Dang,
Syracuse University LC Smith College of Engineering and Computer Science, Mechanical and Aerospace Engineering

Harish J Palanthandalam-Madapusi, (CO-PI) Syracuse University LC Smith College of Engineering and Computer Science

Victor Nieto
Columbia University GSAPP Department of Real Estate Development Sustainability Forum

Air Control

Synergistic Integration of Flow Resistance Devices (VAWT"S) and Architectural Arrangements and **Control Methodologies for a Novel Natural Ventilation** Scheme to manage IAQ and other wind load specific requirements

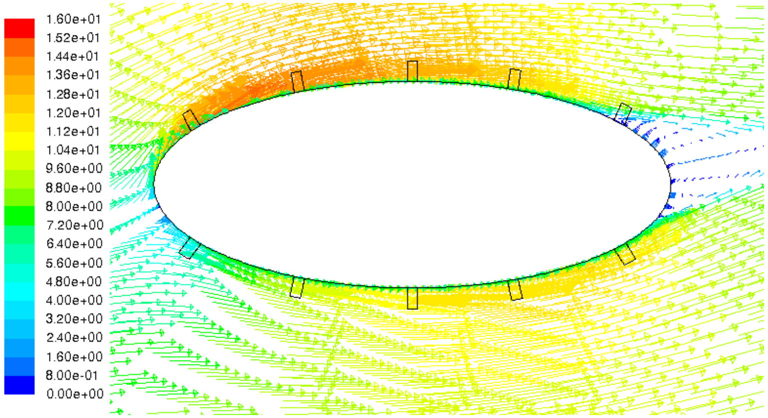
Dr. Ez Khalifa
(CO-PI) , Syracuse University LC Smith College of Engineering and Computer Science

Paul Michael Pelken,
Syracuse University School of Architecture, Center of Excellence for Environmental and Energy Systems

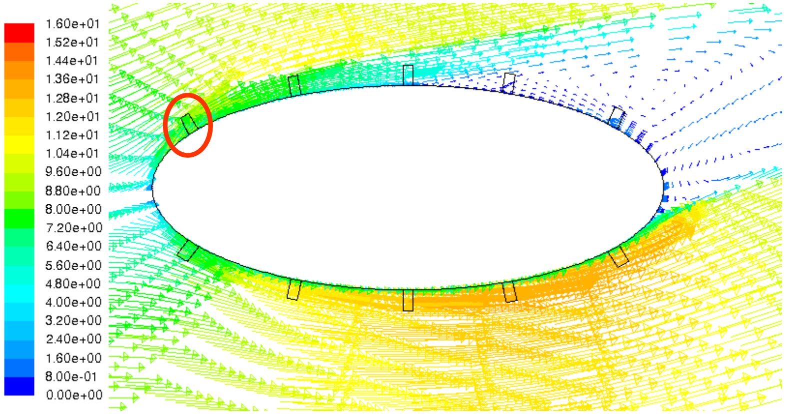
John Santoro,
RA, Syracuse University School of Architecture

Velocity Vectors

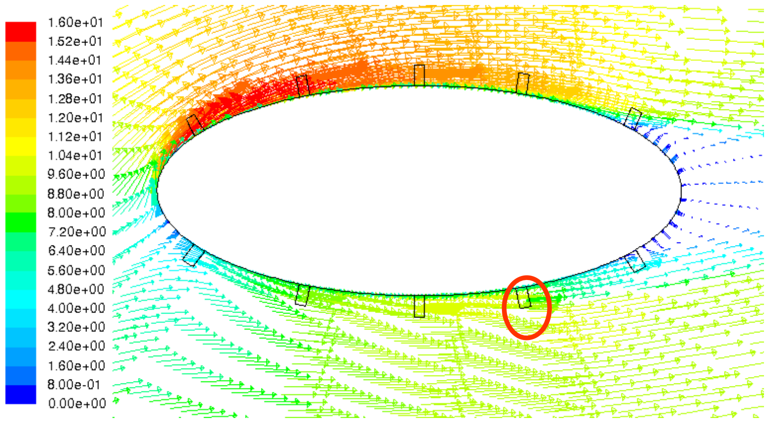
Allocated flow resistance device (Vertical Axis Wind Turbine or similar): o



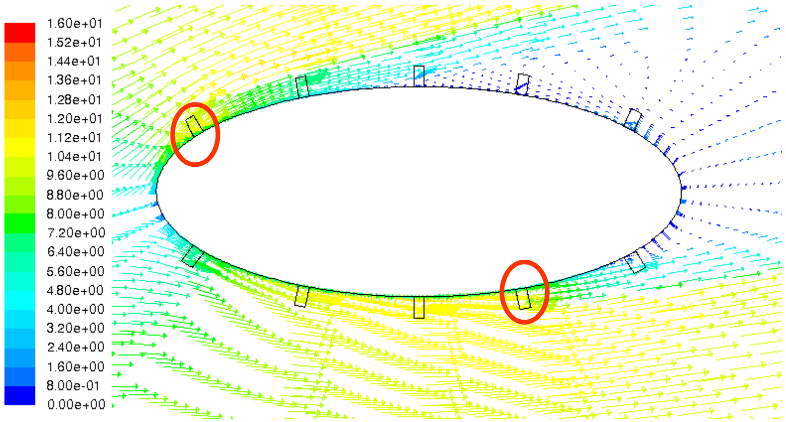
C2=0



C2=0.5 (Upper on)



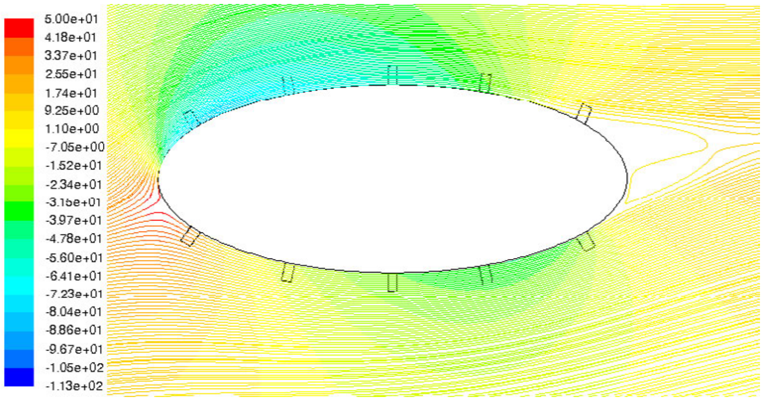
C2=0.5 (Lower on)



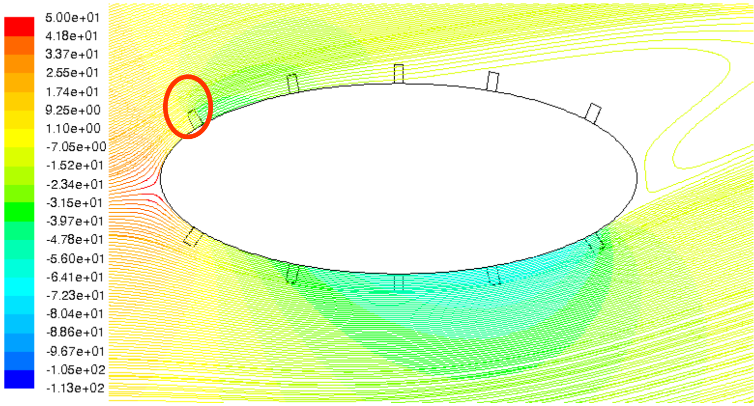
C2=0.5 (Both on)

Streamlines by pressure

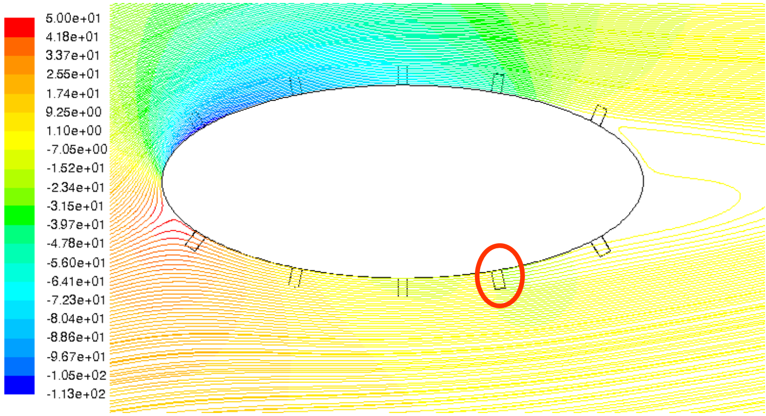
Allocated flow resistance device (Vertical Axis Wind Turbine or similar): o



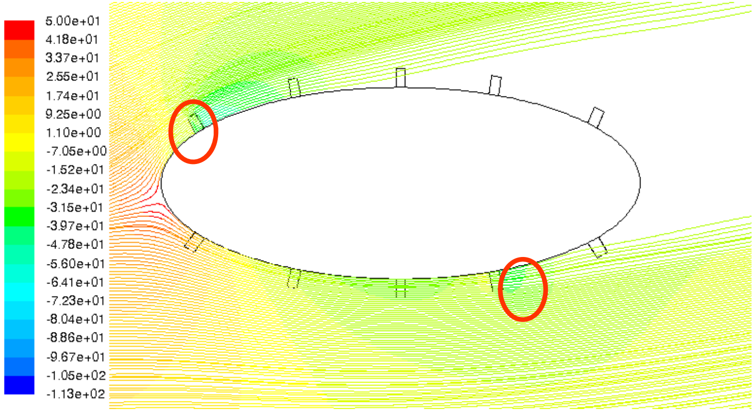
C2=0



C2=0.5 (Upper on)

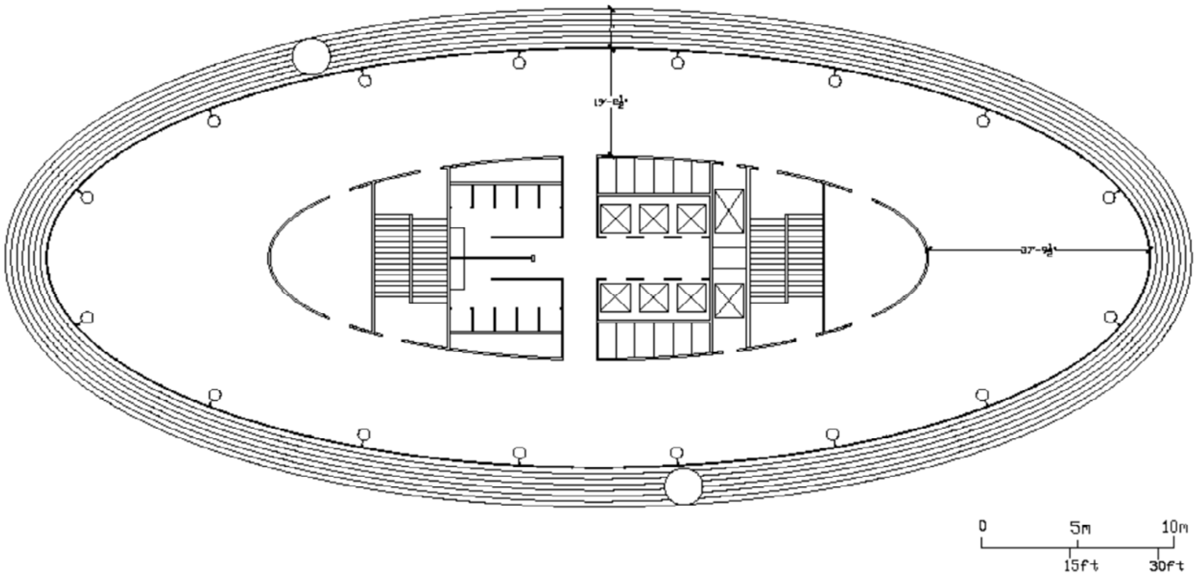


C2=0.5 (Lower on)

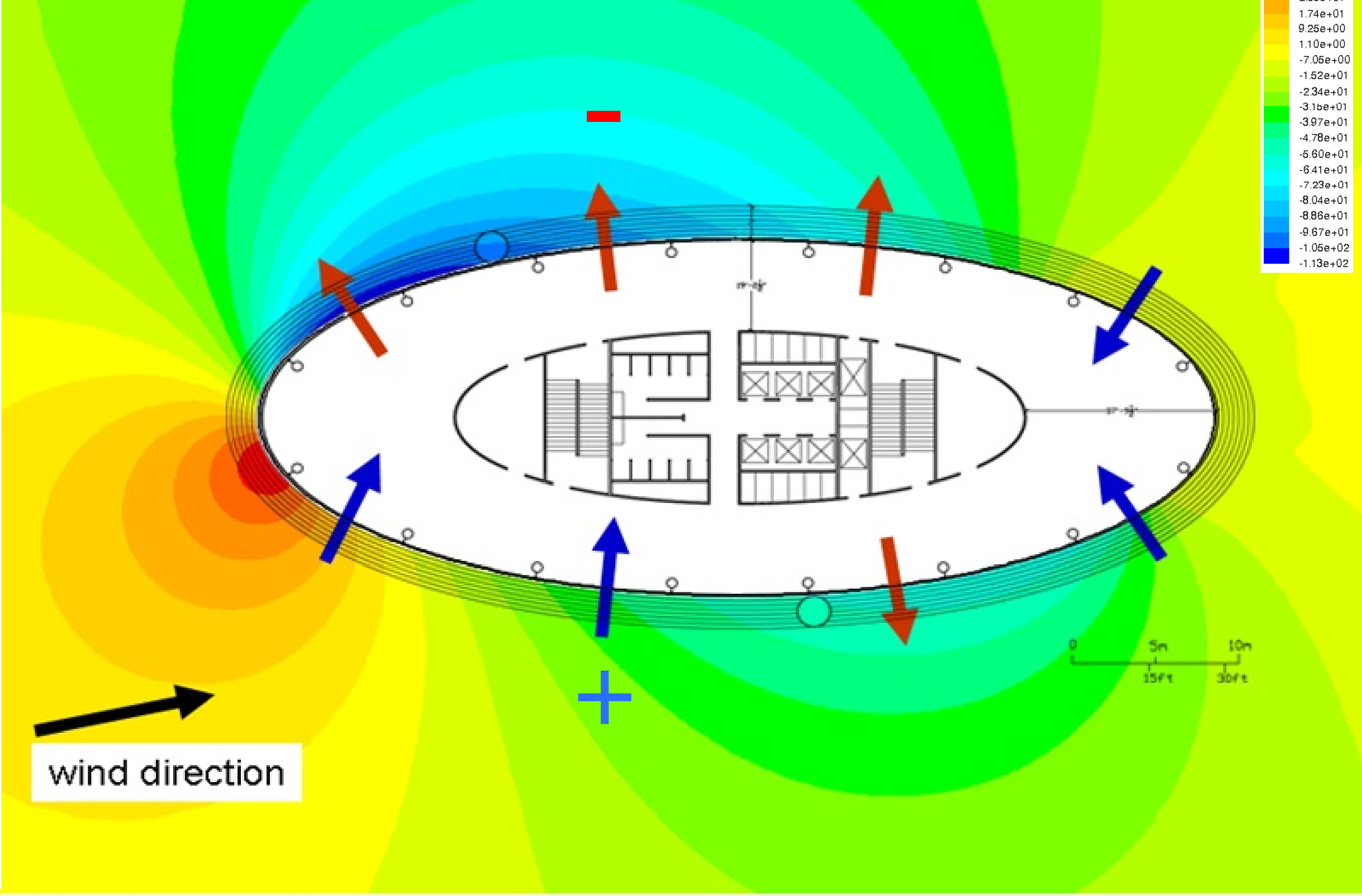


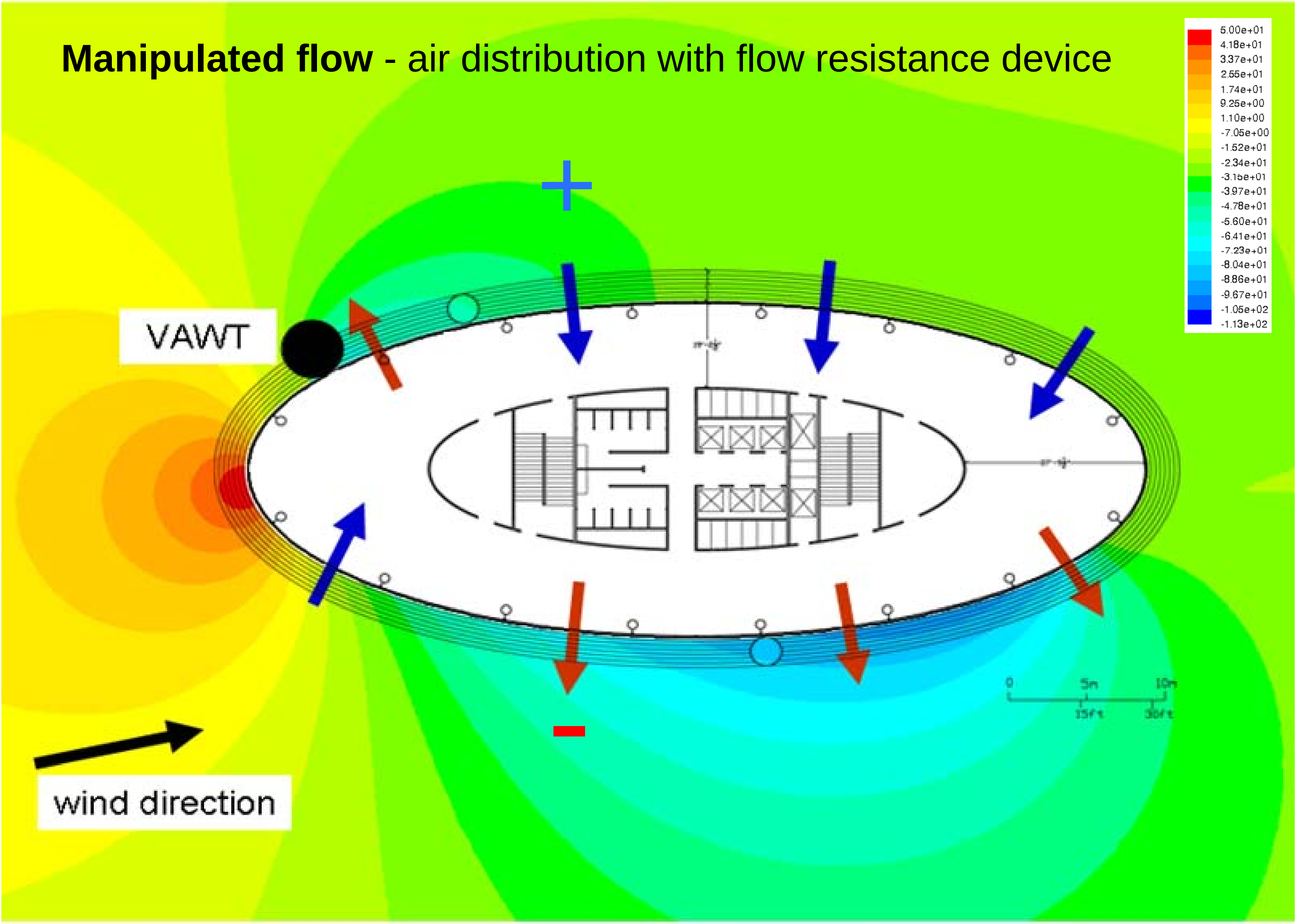
C2=0.5 (Both on)

Typical Plan

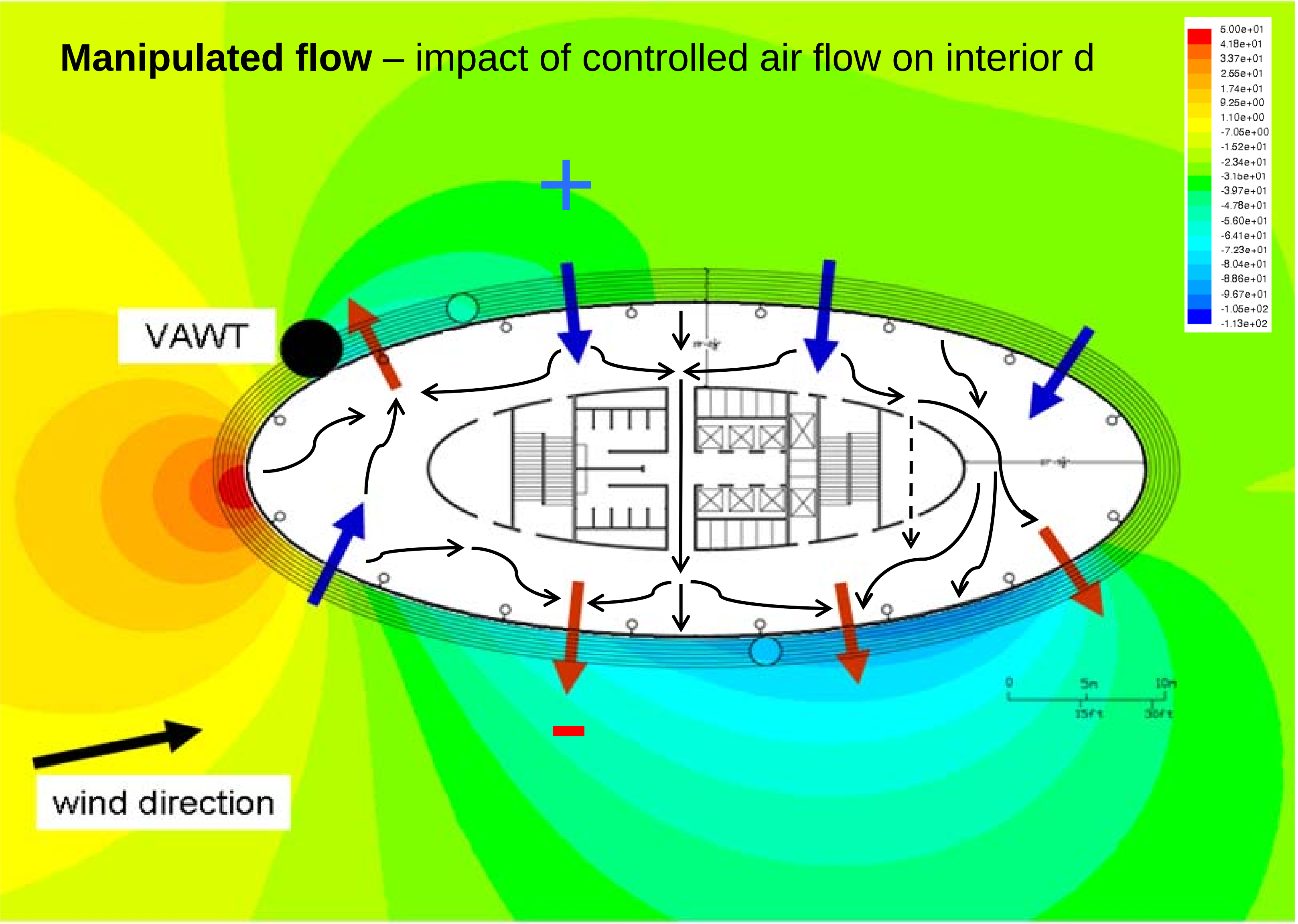


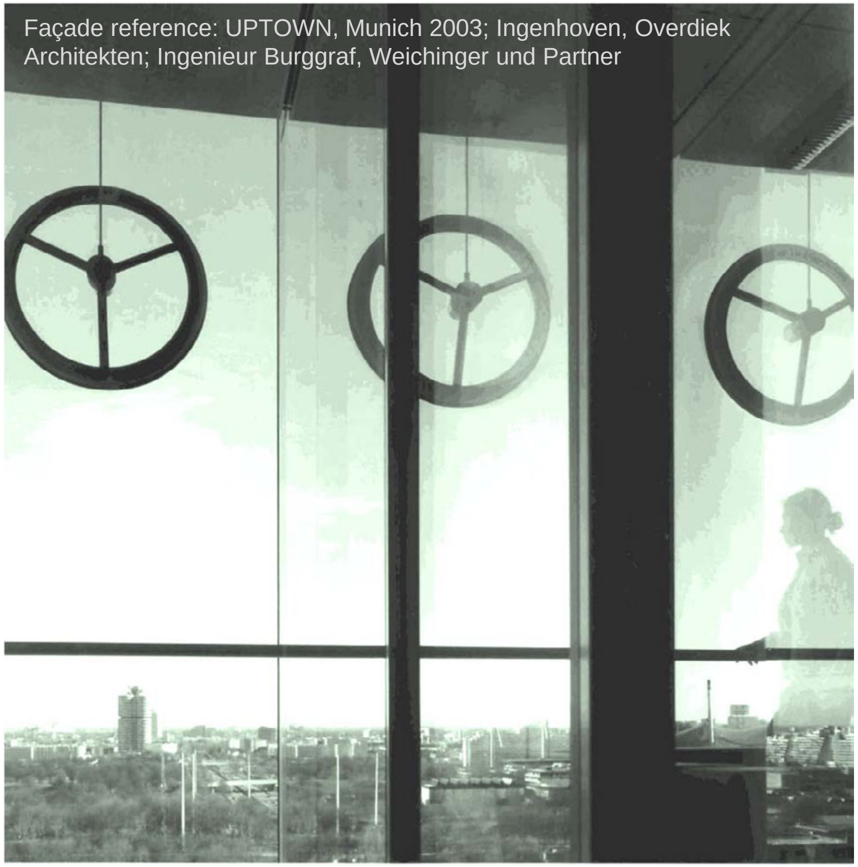
Base condition - air distribution without flow resistance device



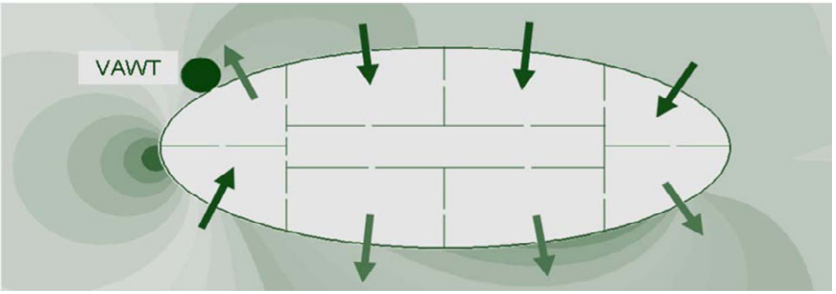

Manipulated flow - air distribution with flow resistance device
5.00e+01
4.18e+01
3.37e+01
2.55e+01
1.74e+01
9.25e+00
1.10e+00
-7.05e+00
-1.52e+01
-2.34e+01
-3.15e+01
-3.97e+01
-4.78e+01
-5.60e+01
-6.41e+01
-7.23e+01
-8.04e+01
-8.86e+01
-9.67e+01
-1.05e+02
-1.13e+02
+
VAWT
-
wind direction

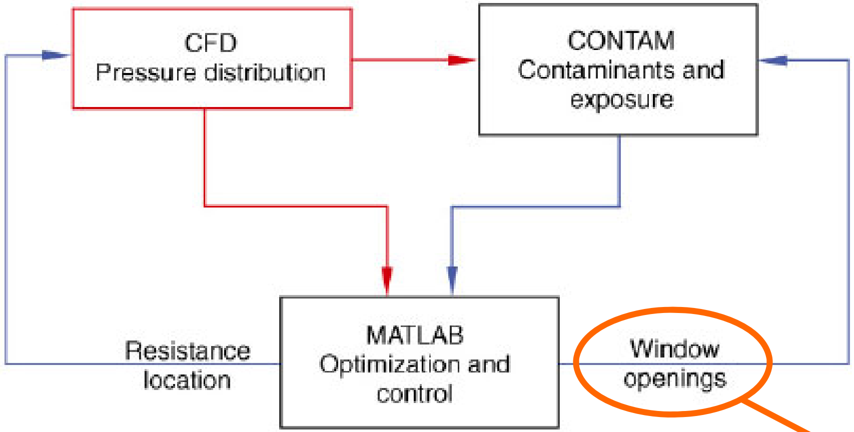
Manipulated flow – impact of controlled air flow on interior d

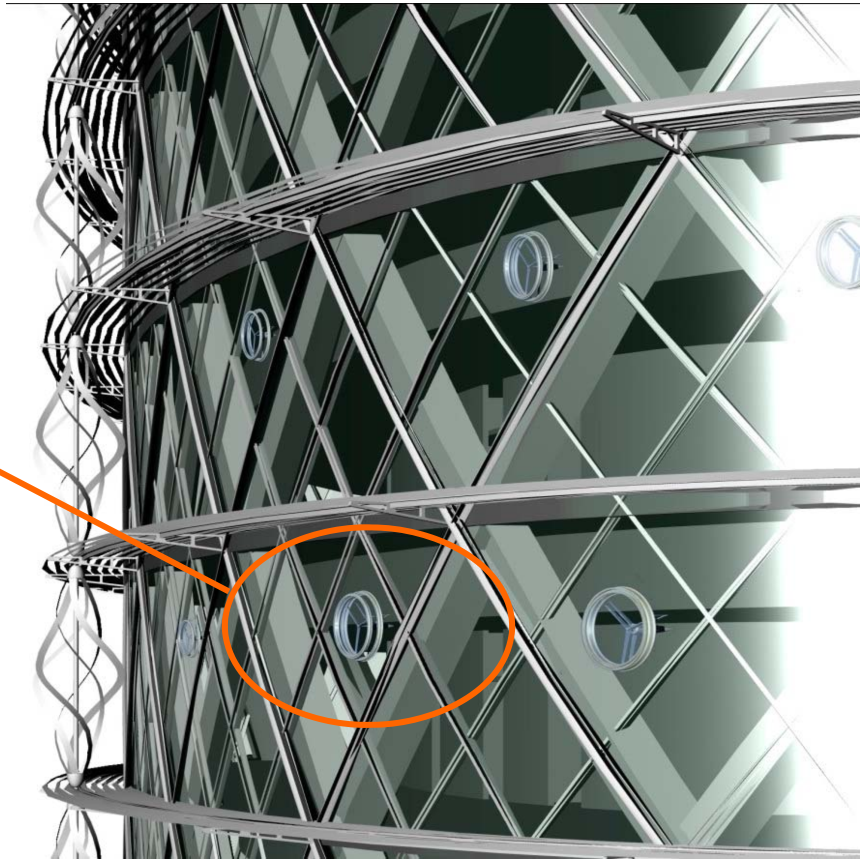


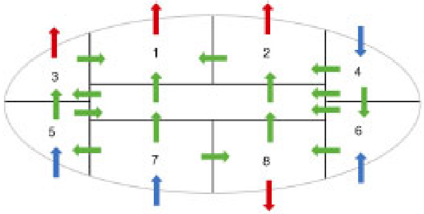


Façade reference: UPTOWN, Munich 2003; Ingenhoven, Overdiek Architekten; Ingenieur Burggraf, Weichinger und Partner

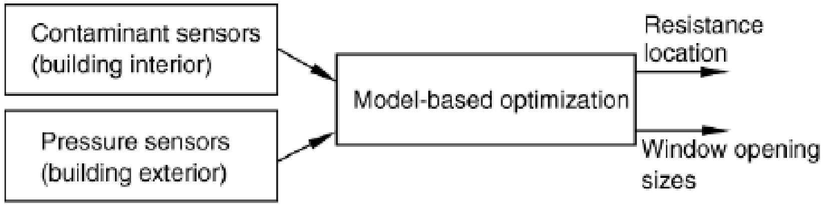








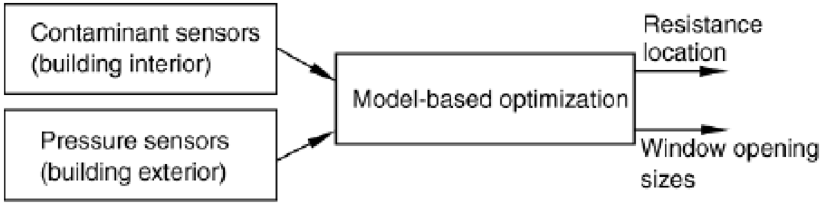
Development strategies for interactive and hybrid HVAC control mechanisms



R&D opportunities:

- IAQ+ via enhanced natural ventilation
- responsive single layered façades
- Impact on conventional occupancy related room zone modeling
- Impact of reduced wind loads on building structure - material savings
- Interactive HVAC control and sensing
- Real Estate and FM Finance Models

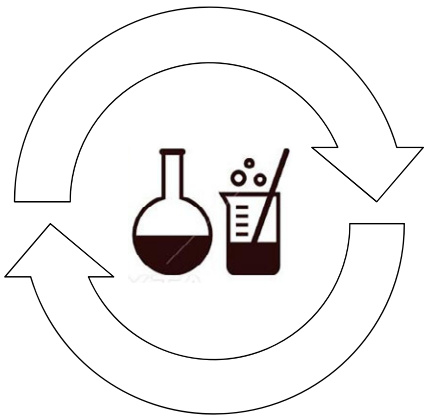
Development strategies for interactive and hybrid HVAC control mechanisms



P+ DEMONSTRATION BUILDING – COMPONENT TESTING

WUJIN, CHANGZHOU, CHINA
P+ DESIGN GROUP

Design
‘Living Lab’
Three programs for testing



Construction
Adoptable for building and component optimisation

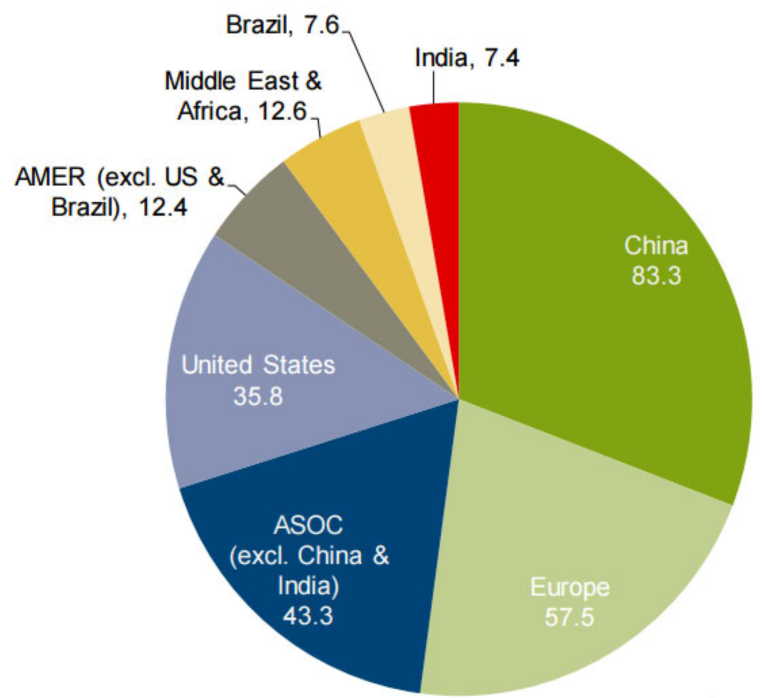
Building scope	Development	Team
600 m² governmental project	Completed November 2015	P+ Design Group Institute of Architecture Design & Planning Co. Ltd., Nanjing University Wujin Green Building Industry Development Zone

WUJIN GREEN BUILDING EXPO – P+ DEMONSTRATION BUILDING

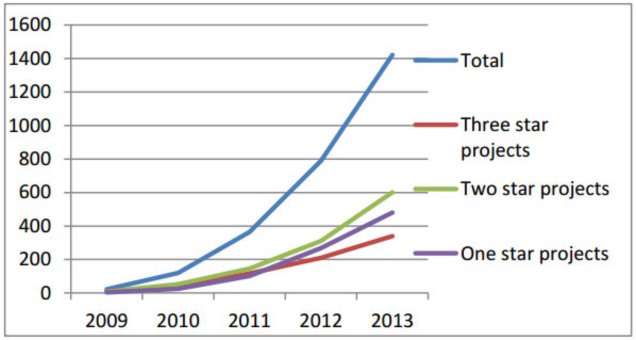
WUJIN, CHANGZHOU, CHINA
P+ DESIGN GROUP

GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2014 ($BN)

Frankfurt School
UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

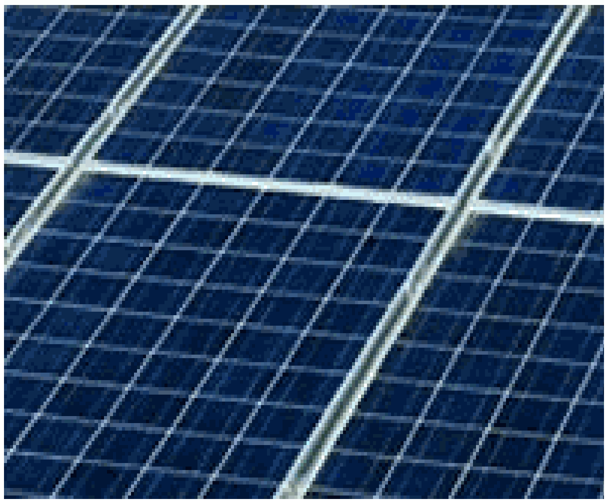


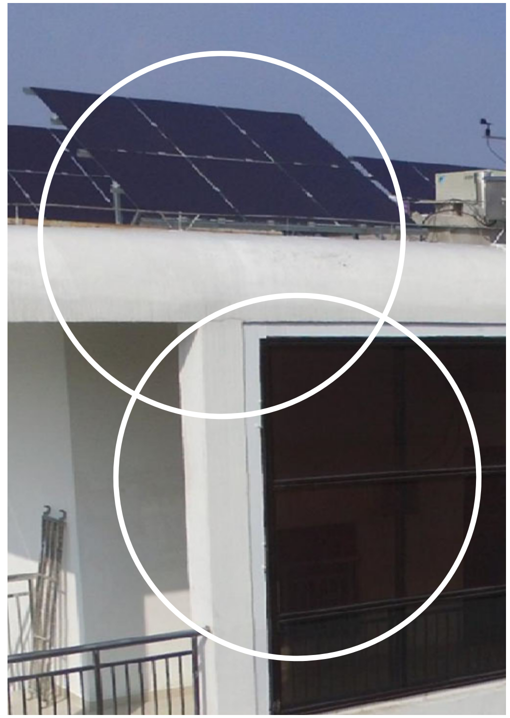
Source: Bloomberg New Energy Finance; UNEP



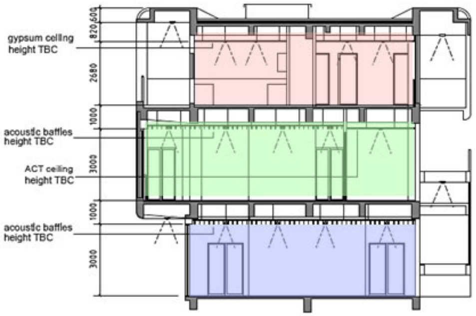

• A living lab - configuration changes
• Industry collaboration
• Academic research
• Testing of range of standards
• Component optimisation
• Building performance monitoring

Trinasolar





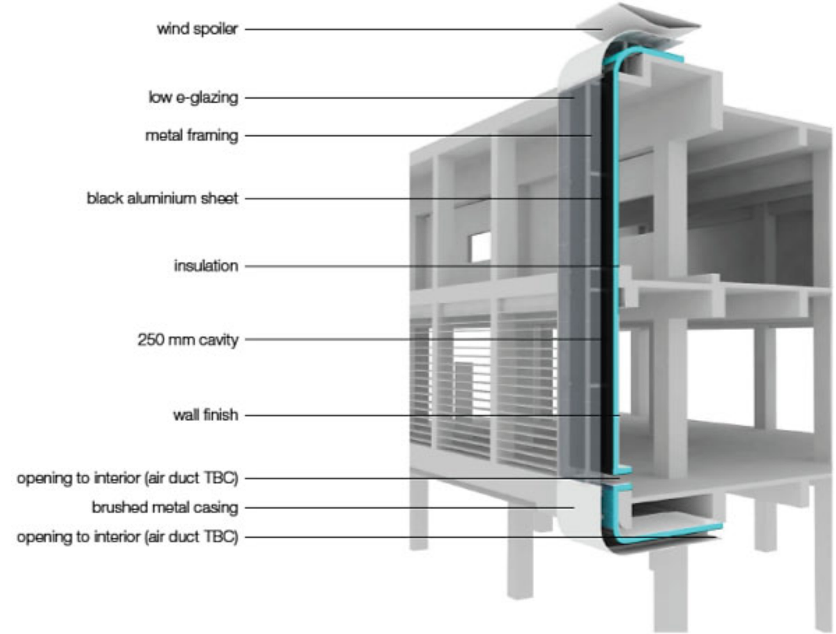
Provide renewable energy and measure building performance



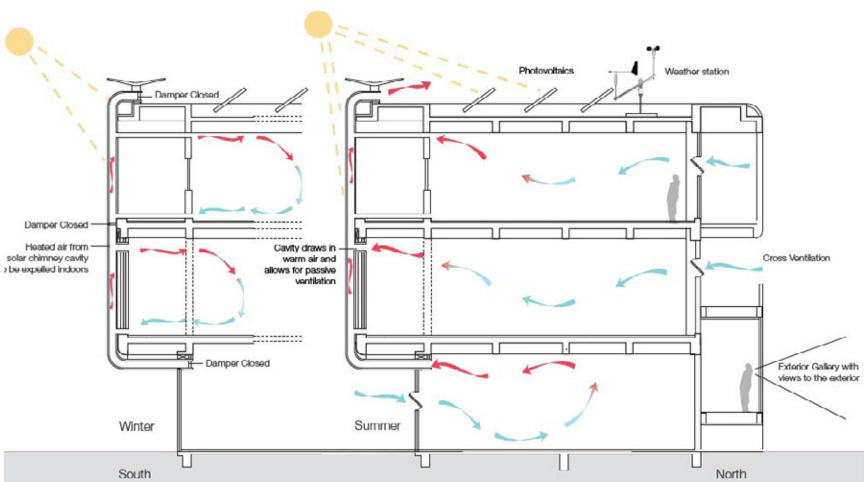
- Expo Park’s only weather station and used for regional climate monitoring
- Measuring IEQ and energy consumption in relation to outdoor climate

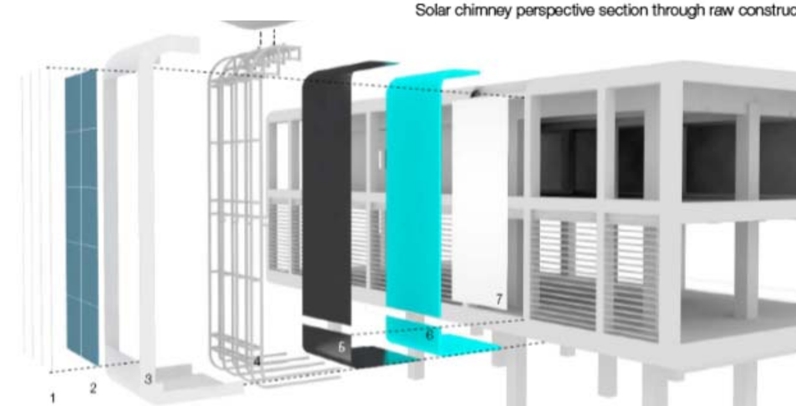
Programmatic and environmental zoning
Opportunities for testing of different IEQ standards and building systems

- residential standards
- office environments
- auditorium / exhibition / public space



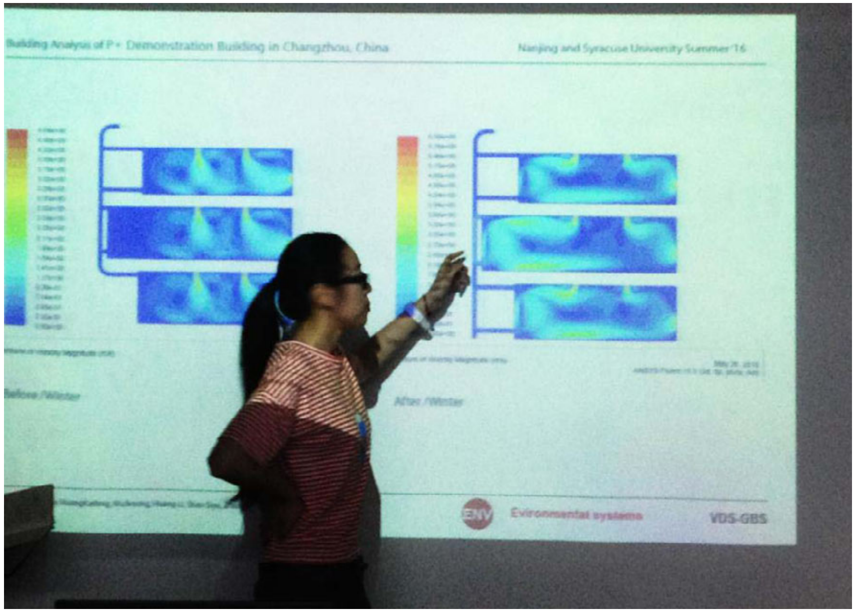
Solar chimney perspective section through raw construction

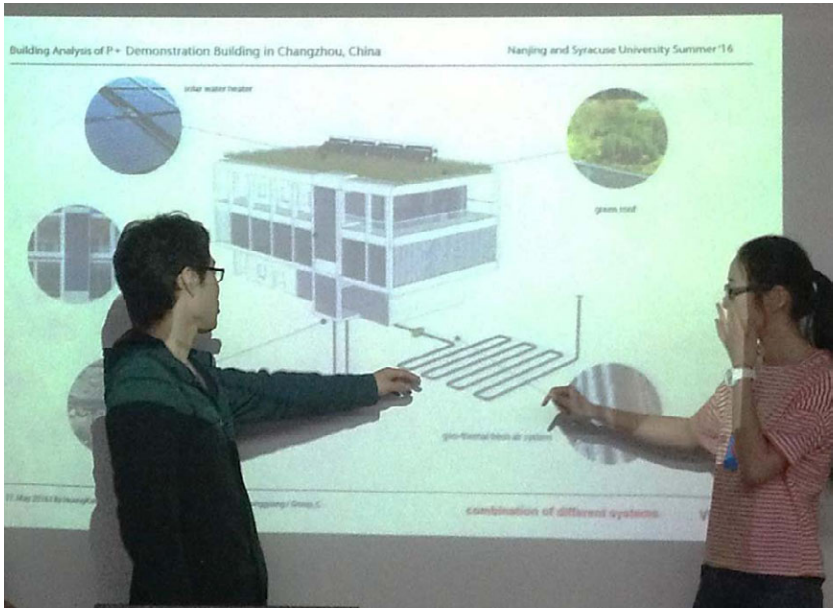


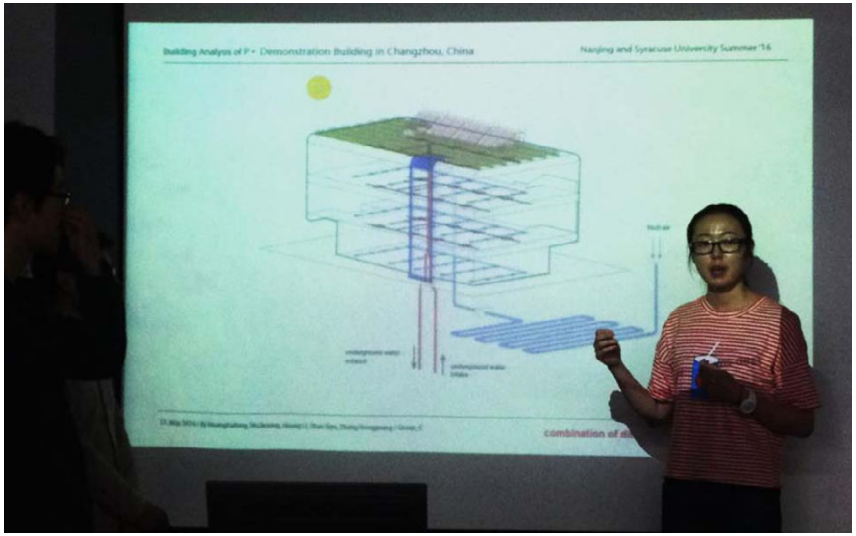


1. mullions
2. glazing
3. powder coated metal casing
4. metal framing
5. black painted aluminium
6. insulation
7. interior finish board

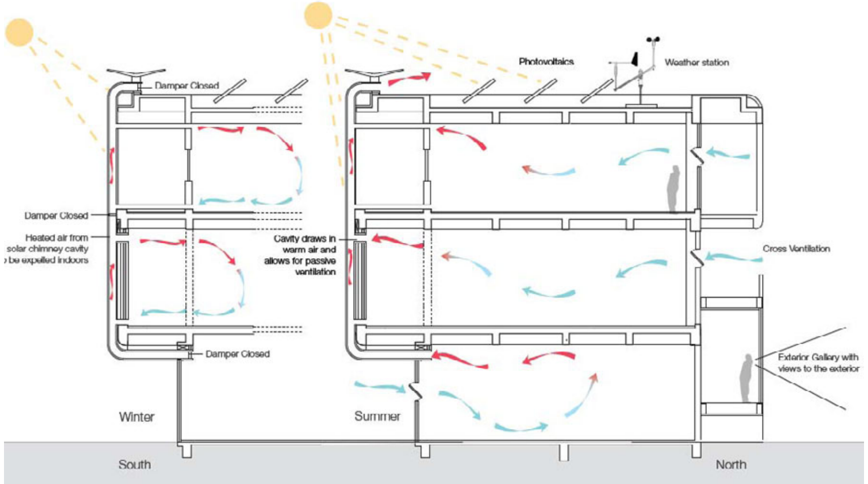
Solar chimney exploded axonometric diagram





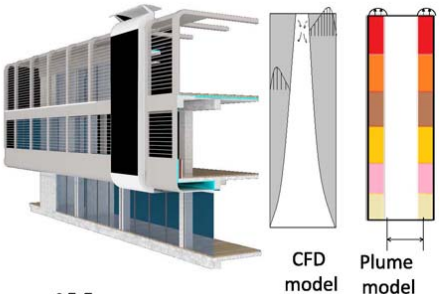


Interdisciplinary Graduate Level Research



SOLAR CHIMNEY MODEL VALIDATION & PERFORMANCE ENHANCEMENT

Guoqing He, Zhejiang University, guoqinghe@.zju.edu.cn



Plume model

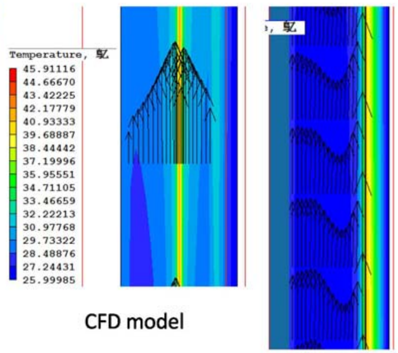
$$\boxtimes_i \boxtimes \frac{2\boxtimes_0\boxtimes_{i,H}}{\boxtimes_0 \boxtimes \boxtimes_{i,H}}$$

$$\boxtimes_{i,b} \boxtimes \frac{P_{0,a}/R}{T_{o,a} \boxtimes \dot{q}wh/(C\dot{m})} x \boxtimes \boxtimes_0 (1 \boxtimes x)$$

$$\boxtimes \frac{M_b}{\boxtimes_{i,b}} \boxtimes \frac{M_a}{\boxtimes_{o,a}} \boxtimes \frac{M_c}{\boxtimes_i} \boxtimes \dot{m}^2 \boxtimes \frac{P_o g}{R\dot{q}w} C\dot{m}x \ln(1 \boxtimes \frac{\dot{q}wH}{T_{0,a}C\dot{m}}) \boxtimes \boxtimes_o gHx \boxtimes 0$$

OBJECTIVE

Validation of a plume model and a CFD model for predicting flow rates generated by a solar chimney under the solar radiation.

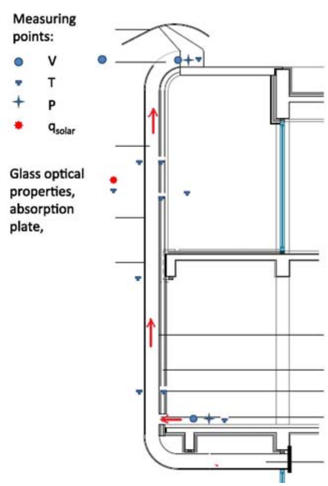


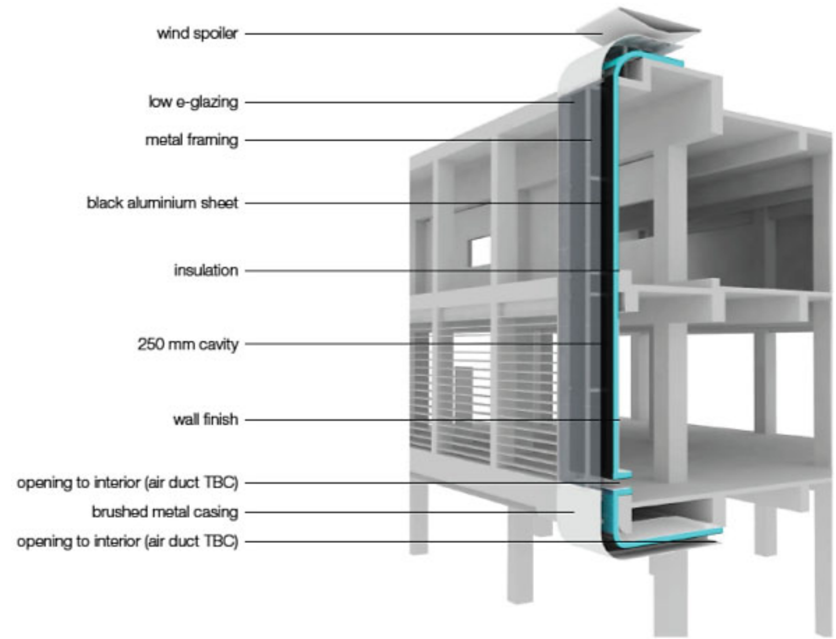
CFD model

METHOD

Choose a sunny and windless day;
1. Measureflow rate in the solar chimney:
Thermal anemometers; Tracer gas; Atmospheric pressure ;
2. Measure temperature in and outside the chimney, temperature of the walls and the glass, T of inlet and outlet:
3.Measure of solar irradiation on the vertical surface, q_{solar}
4. Measure of the wind velocity at the inlet and the outlet.
5. Test of performance with variations:
Change positions of the absorption plate or add extra absorption plate

Percentile	solar irradiation (vertical)	Tamb, oC	Expected heat gain, W/m2	CFM by Plume model
75%	220	18	196	375
50%	138	18	123	334
25%	55	18	49	266





Solar chimney perspective section through raw construction

PhD Level Research

IEA-EBC Annex 68

Indoor Air Quality Design and Control in Low Energy Residential Buildings

EBC
Energy in Buildings and Communities Programme

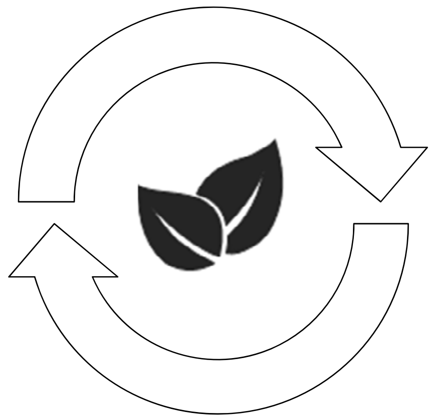
ABOUT ANNEX 68 | ABOUT IEA-EBC | EVENTS | SUBTASKS | CONTACT

P+ demonstration building in Changzhou, China

GREEN WALL – AIR PURIFICATION SYSTEM (2 WEEK SEMINAR)

SYRACUSE UNIVERSITY
WITH LC SMITH COLLEGE OF ENGINEERING

Design
New green wall typology
Interdisciplinary systems design

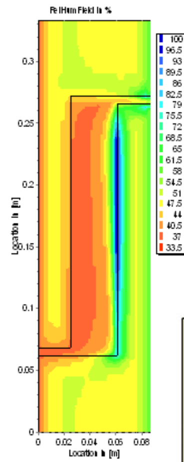


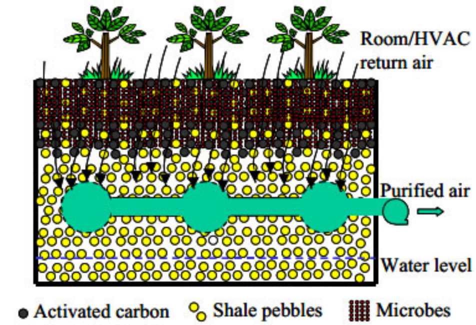
Construction
Living system
Modular assembly

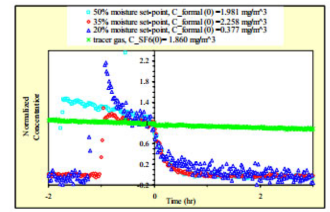
Building scope Based on the Wolverton System, a NASA spinoff technology	Development Construction of Prototype	Team P+ Studio Prof. Dr. Jensen Zhang Master's level mechanical engineering students Undergraduate + graduate architecture students

NASA SYRACUSE coe center of excellence

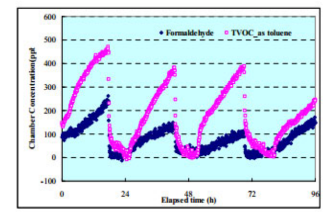
BEESL Building Energy and Environmental Systems Laboratory





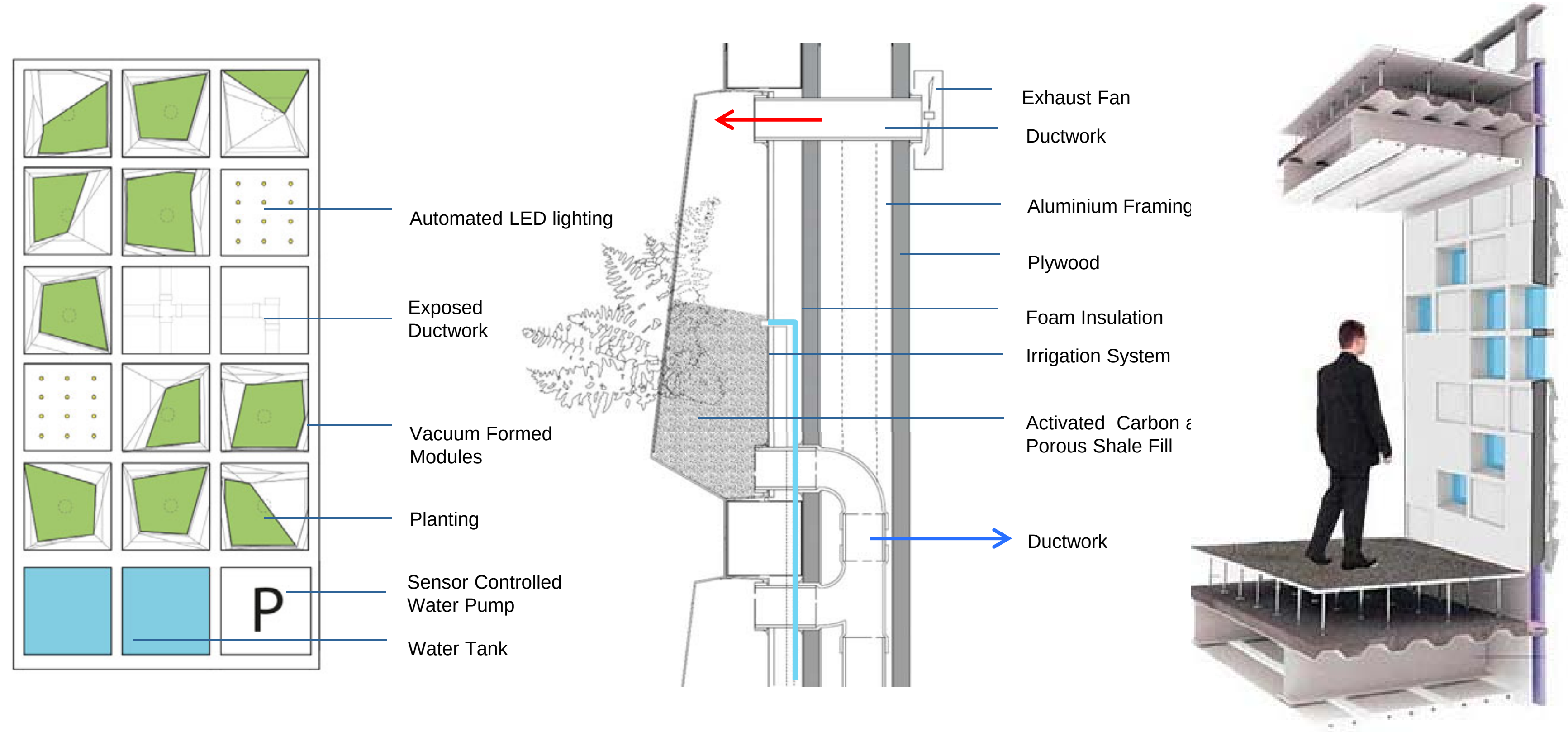


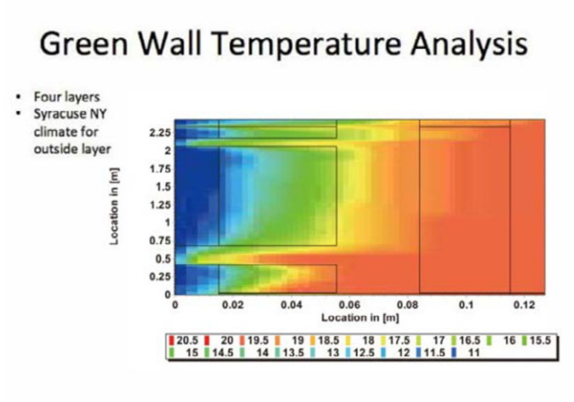
“Pull-down” test result

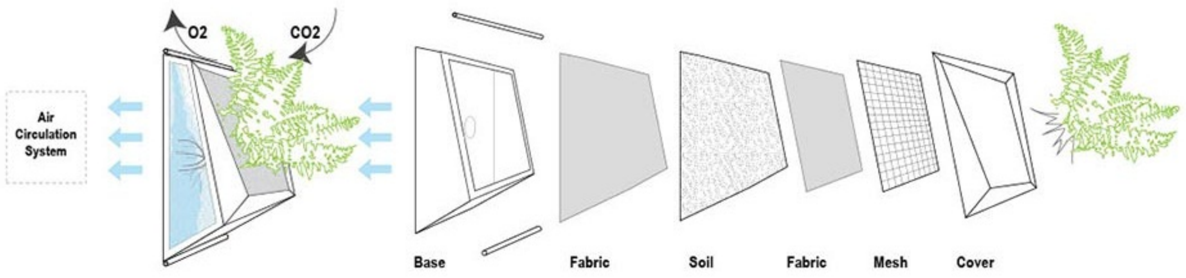


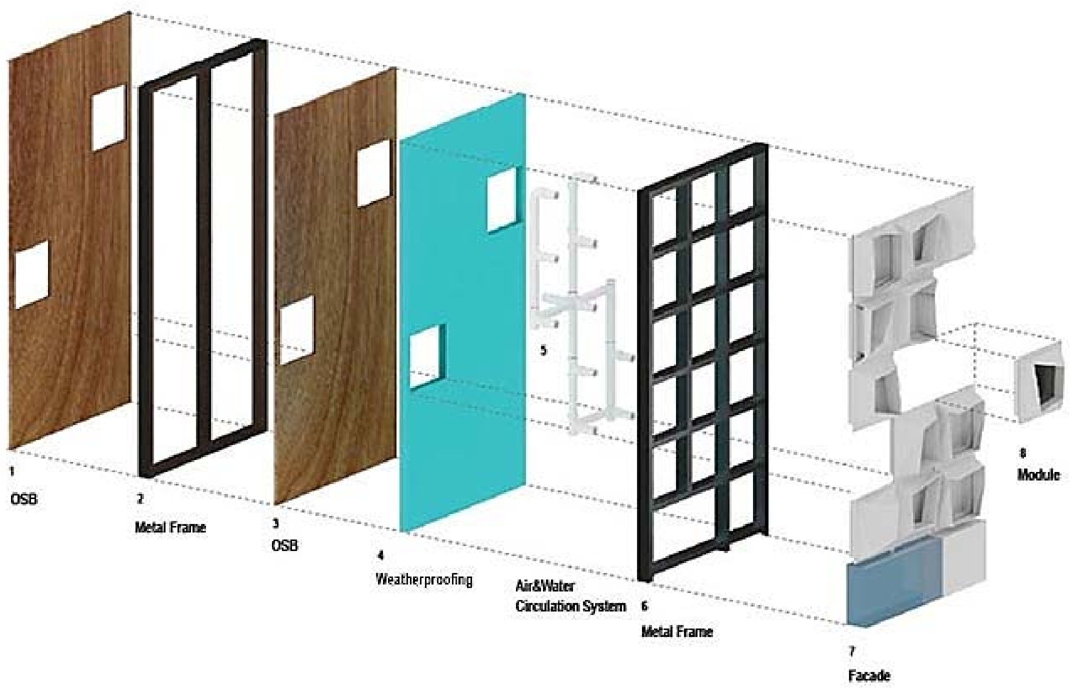
Running for 8 h per day

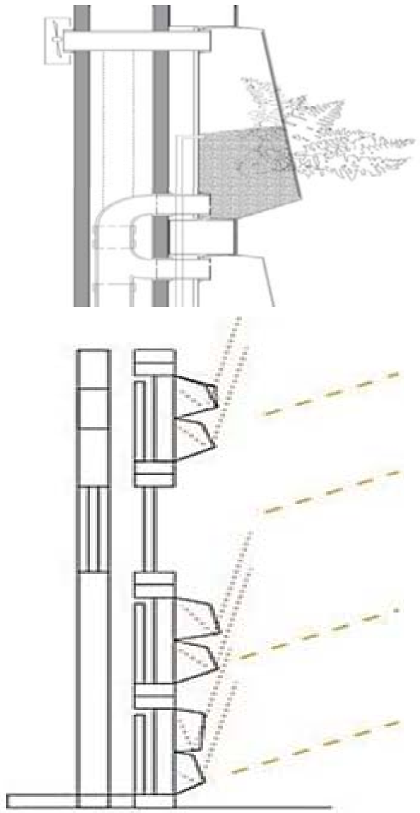
Research: Z.Wang, J.S. Zhang, M. Mittelmark, and B. C. Wolverton, *Air Cleaning Technology for Indoor Air Quality: How To “Grow” Fresh Air?* Syracuse University, Mechanical and Aerospace Engineering http://beesl.syr.edu

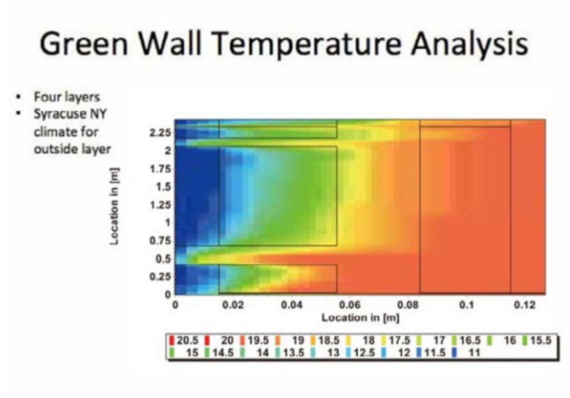

Automated LED lighting
Exposed Ductwork
Vacuum Formed Modules
Planting
Sensor Controlled Water Pump
Water Tank
P
Exhaust Fan
Ductwork
Aluminium Framing
Plywood
Foam Insulation
Irrigation System
Activated Carbon a
Porous Shale Fill
Ductwork

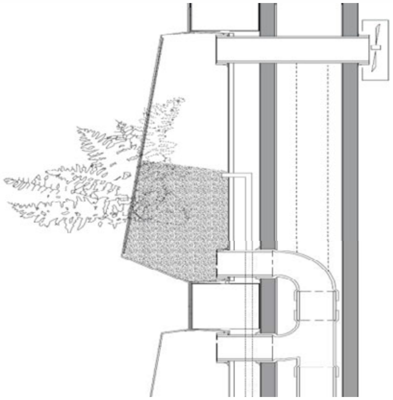

Green Wall Temperature Analysis
Four layers
Syracuse NY climate for outside layer
Location in [m]
Location in [m]


O2
CO2
Air Circulation System
Base
Fabric
Soil
Fabric
Mesh
Cover

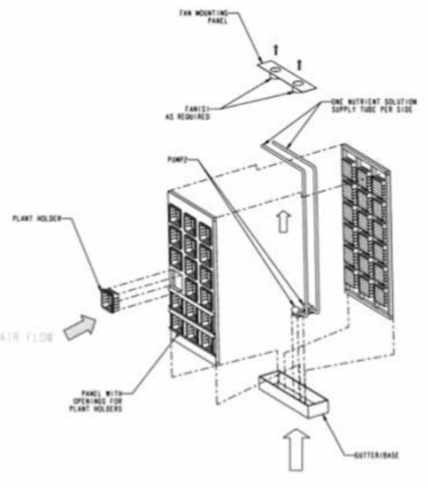

1
OSB
2
Metal Frame
3
OSB
4
Weatherproofing
5
Air&Water Circulation System
6
Metal Frame
7
Facade
8
Module

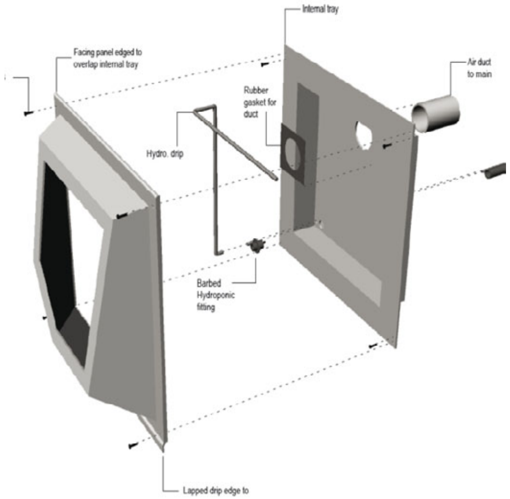



Green Wall Temperature Analysis
• Four layers
• Syracuse NY climate for outside layer
Location in [m]
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
0
0.02
0.04
0.06
0.08
0.1
0.12
Location in [m]
20.5 20 19.5 19 18.5 18 17.5 17 16.5 16 15.5
15 14.5 14 13.5 13 12.5 12 11.5 11

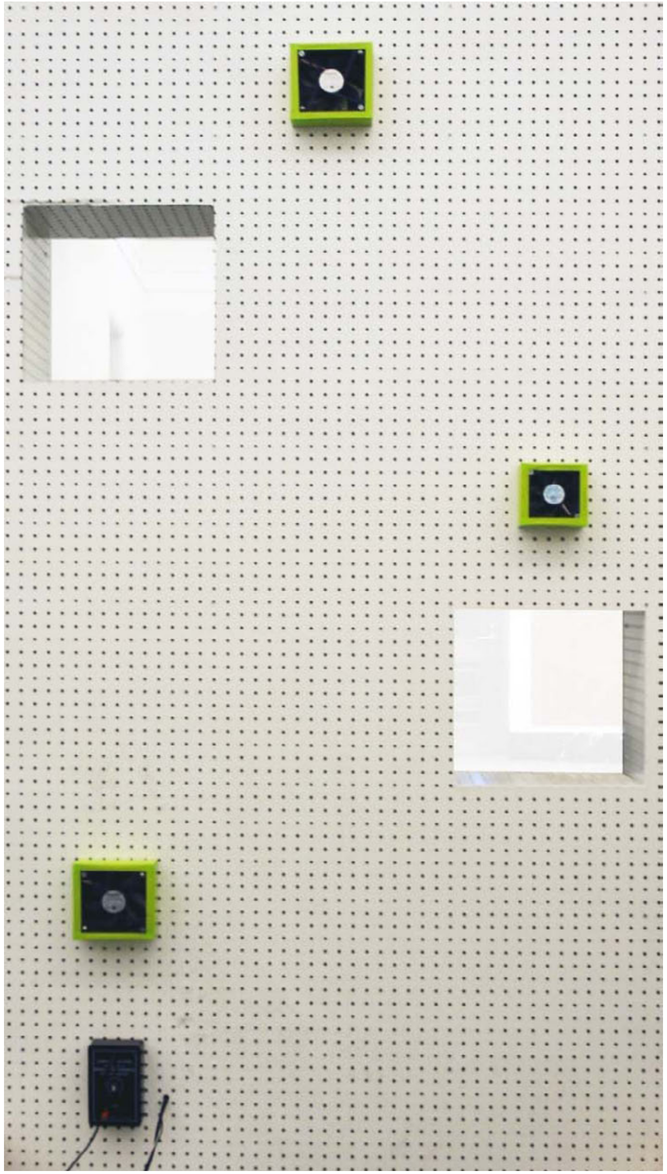


Air Flow Diagram



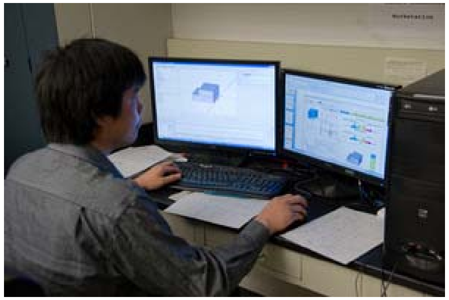


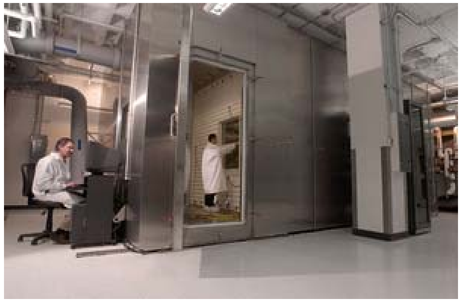
P. Michael Pelken
P+ Studio+Consulting



Design Build Research – Botanical Air Purification Wall System

P. Michael Pelken
P+ Studio+Consulting





Design Build Research – Botanical Air Purification Wall System

P. Michael Pelken
P+ Studio+Consulting

perFRMance based design

Innovation Strategies for the built environment in research, practice & teaching

Thank you for your attention!

P. Michael Pelken
P+ Studio+Consulting