RENEWABLE AND SUSTAINABLE ASSETS

The Intelligent Workplace
The Building as Power Plant

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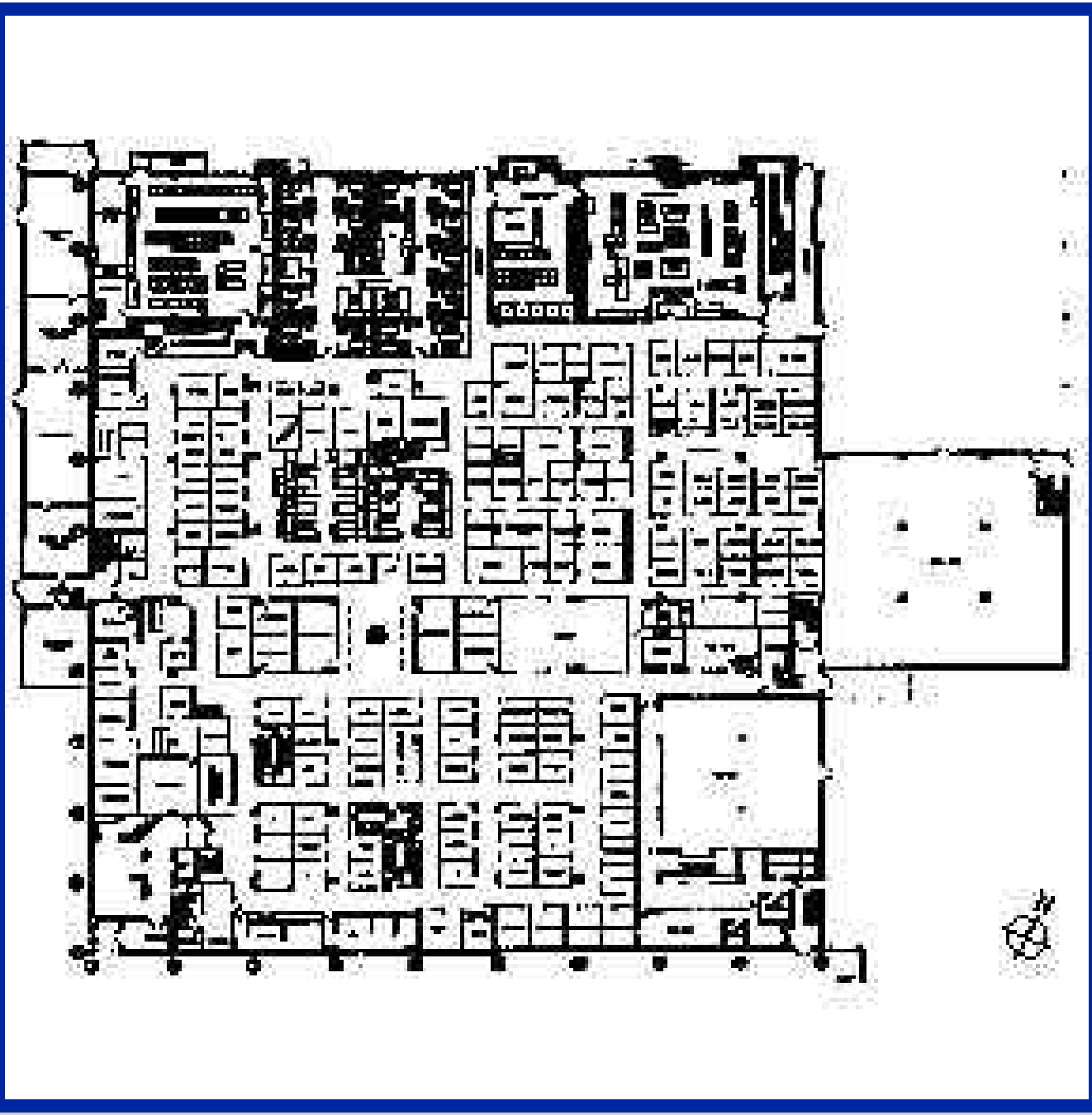
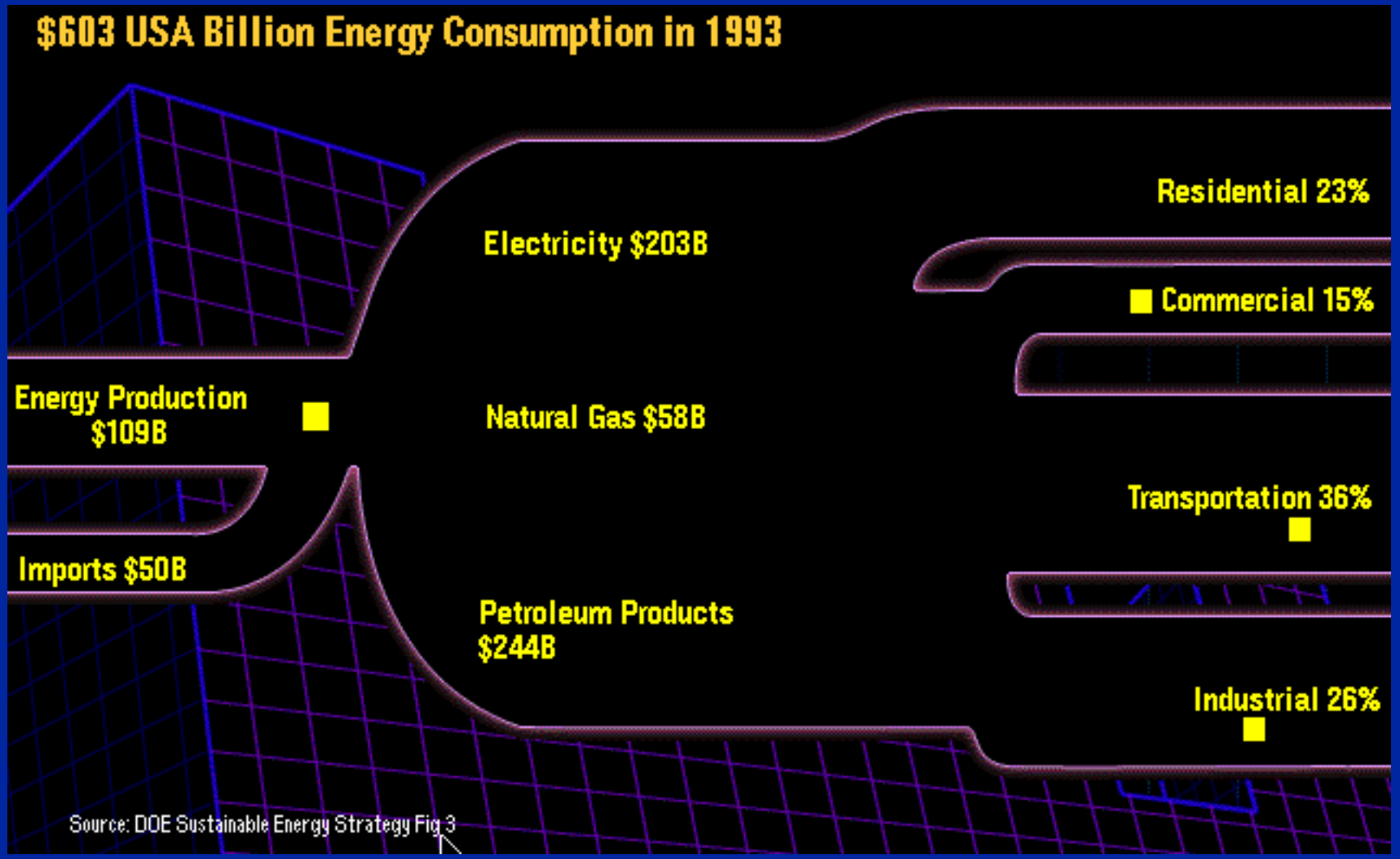
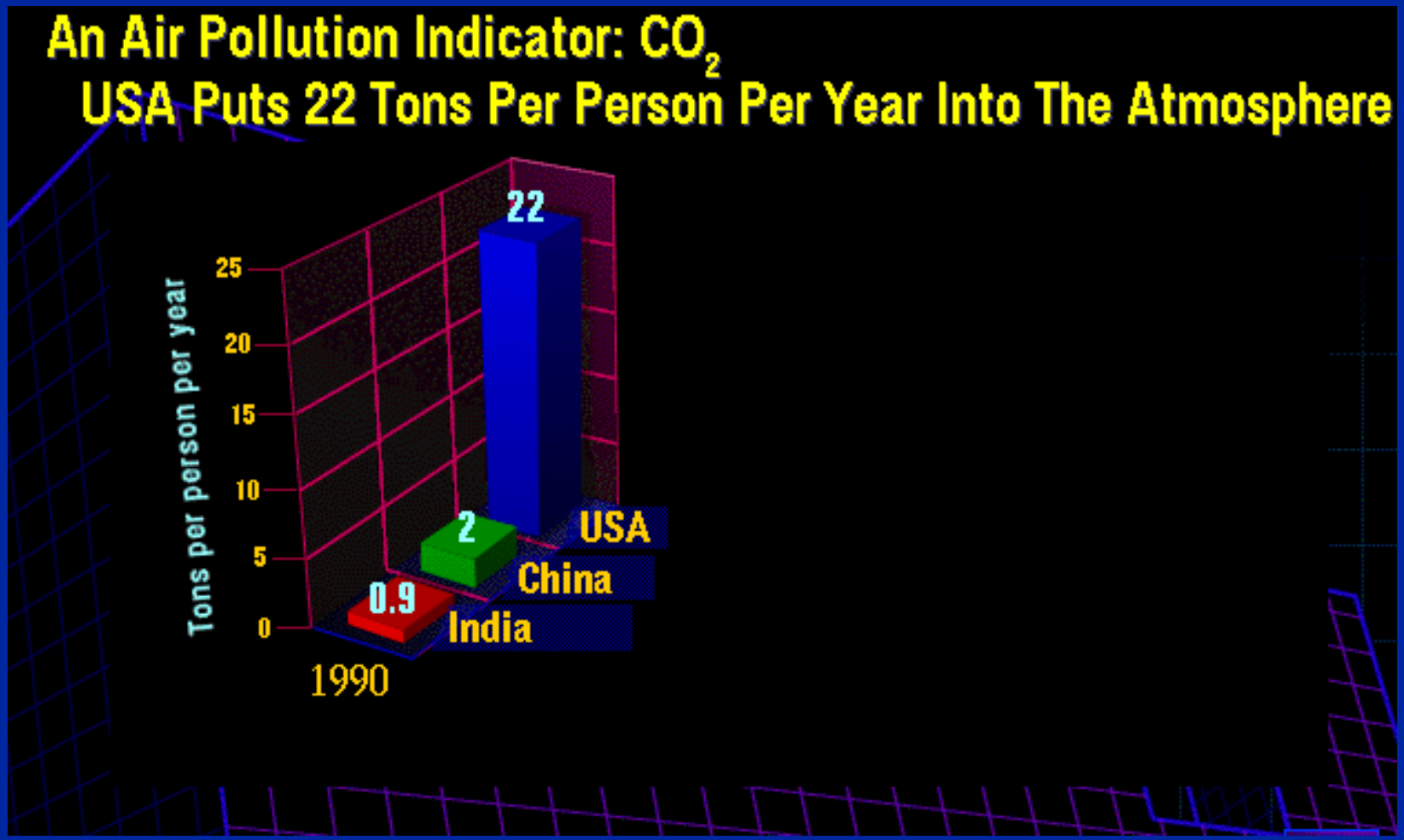
NATURAL GAS TECHNOLOGY
INVESTMENT IN A HEALTHY US ENERGY FUTURE
HOUSTON, TEXAS, MAY 2002

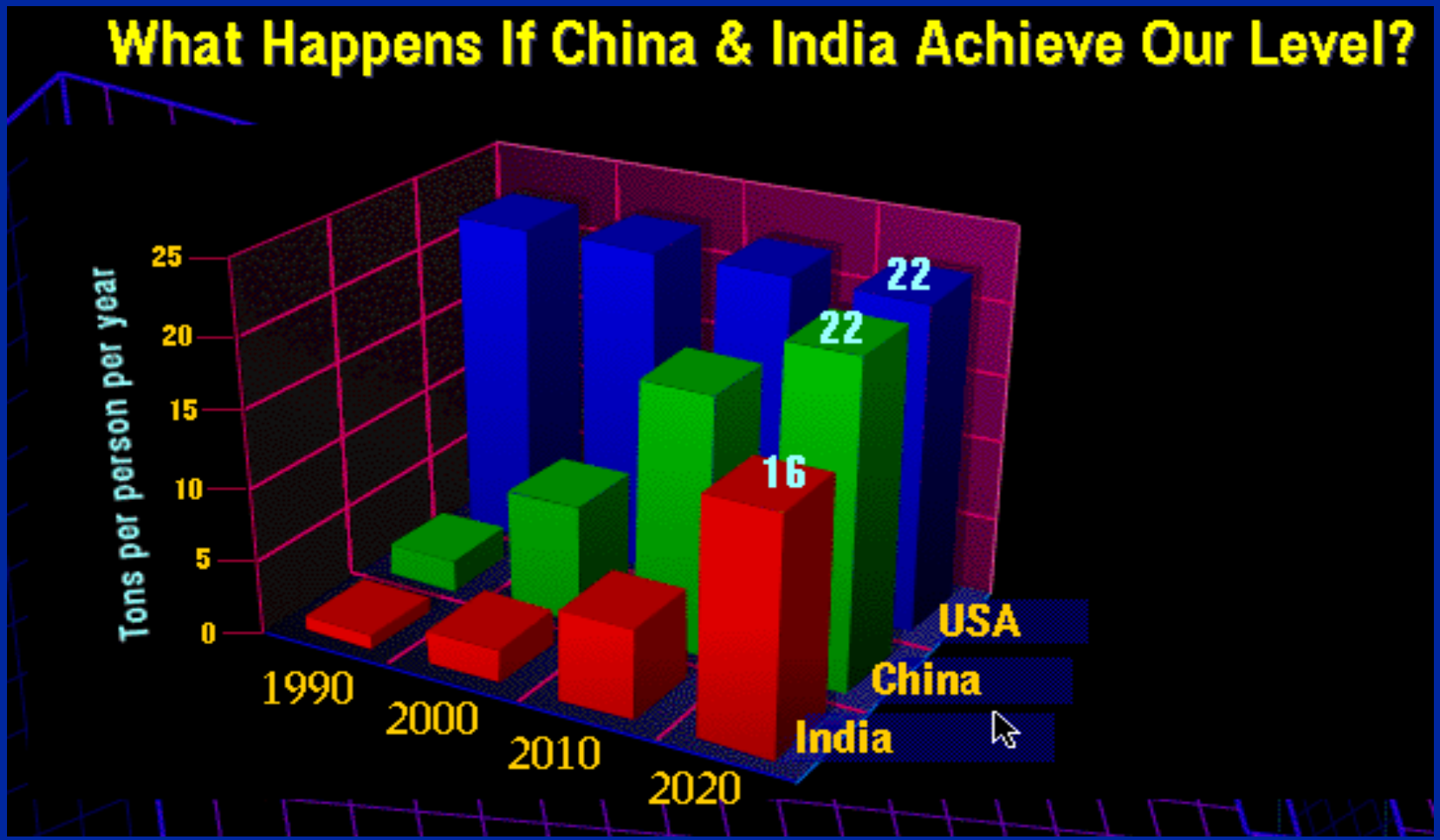
Source: Thomas Hylton

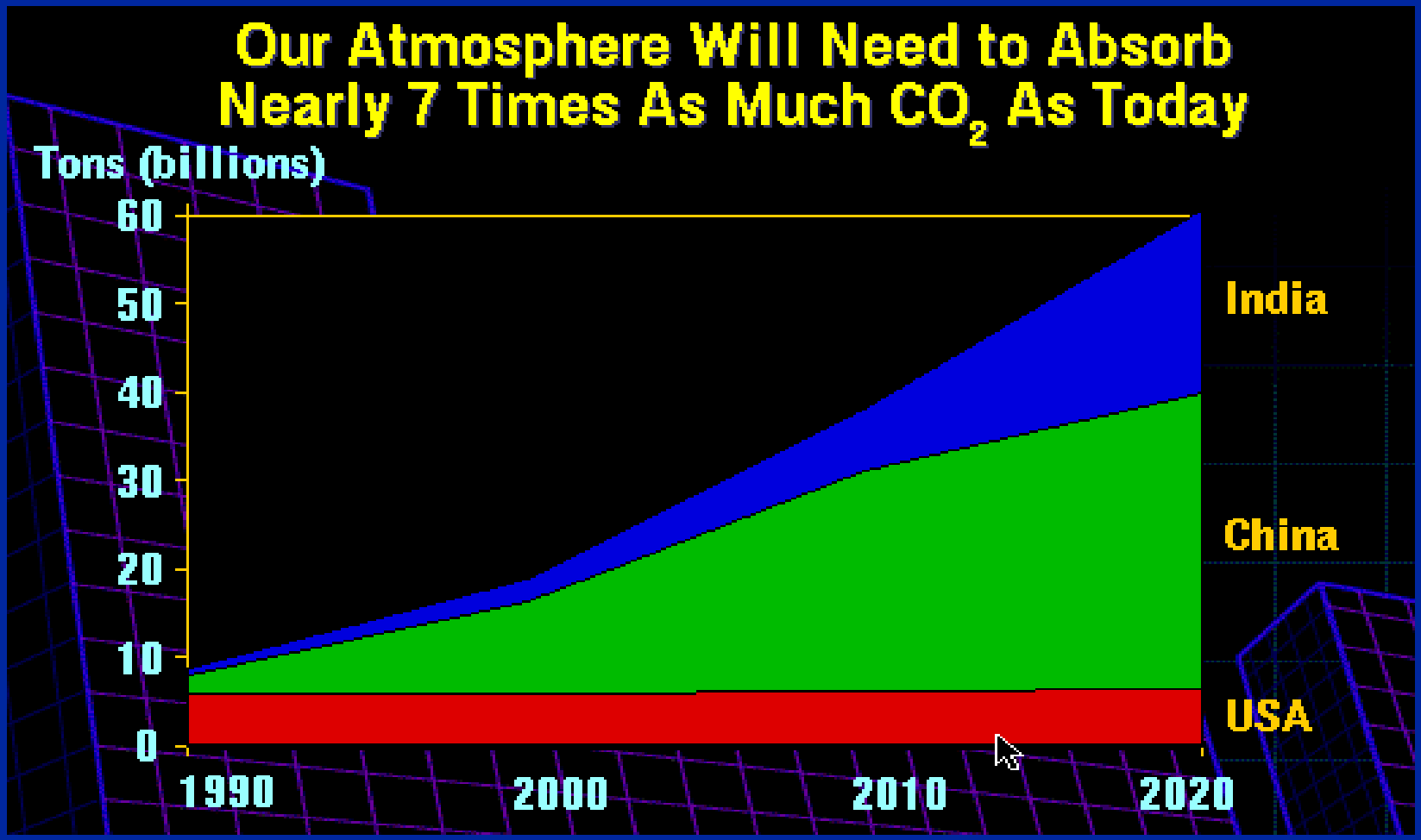
Source: Thomas Hylton

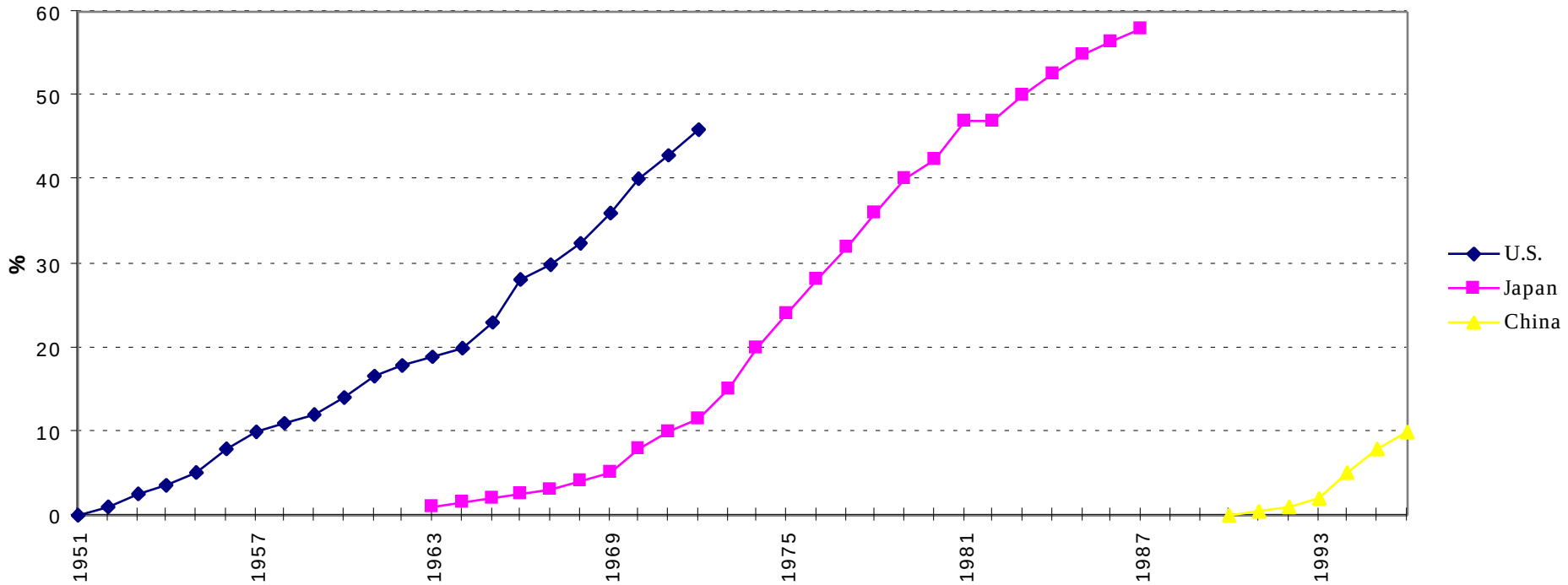



$603 USA Billion Energy Consumption in 1993
Energy Production $109B
Imports $50B
Electricity $203B
Natural Gas $58B
Petroleum Products $244B
Residential 23%
Commercial 15%
Transportation 36%
Industrial 26%
Source: DOE Sustainable Energy Strategy Fig 3


An Air Pollution Indicator: CO_2
USA Puts 22 Tons Per Person Per Year Into The Atmosphere
Tons per person per year
25
20
15
10
5
0
22
2
0.9
USA
China
India
1990


What Happens If China & India Achieve Our Level?
Tons per person per year
25
20
15
10
5
0
1990
2000
2010
2020
22
22
16
USA
China
India


Our Atmosphere Will Need to Absorb Nearly 7 Times As Much CO_2 As Today
Tons (billions)
60
50
40
30
20
10
0
1990
2000
2010
2020
India
China
USA



The Improvement of Popularization of Domestic AC in China, Japan, a the U.S.

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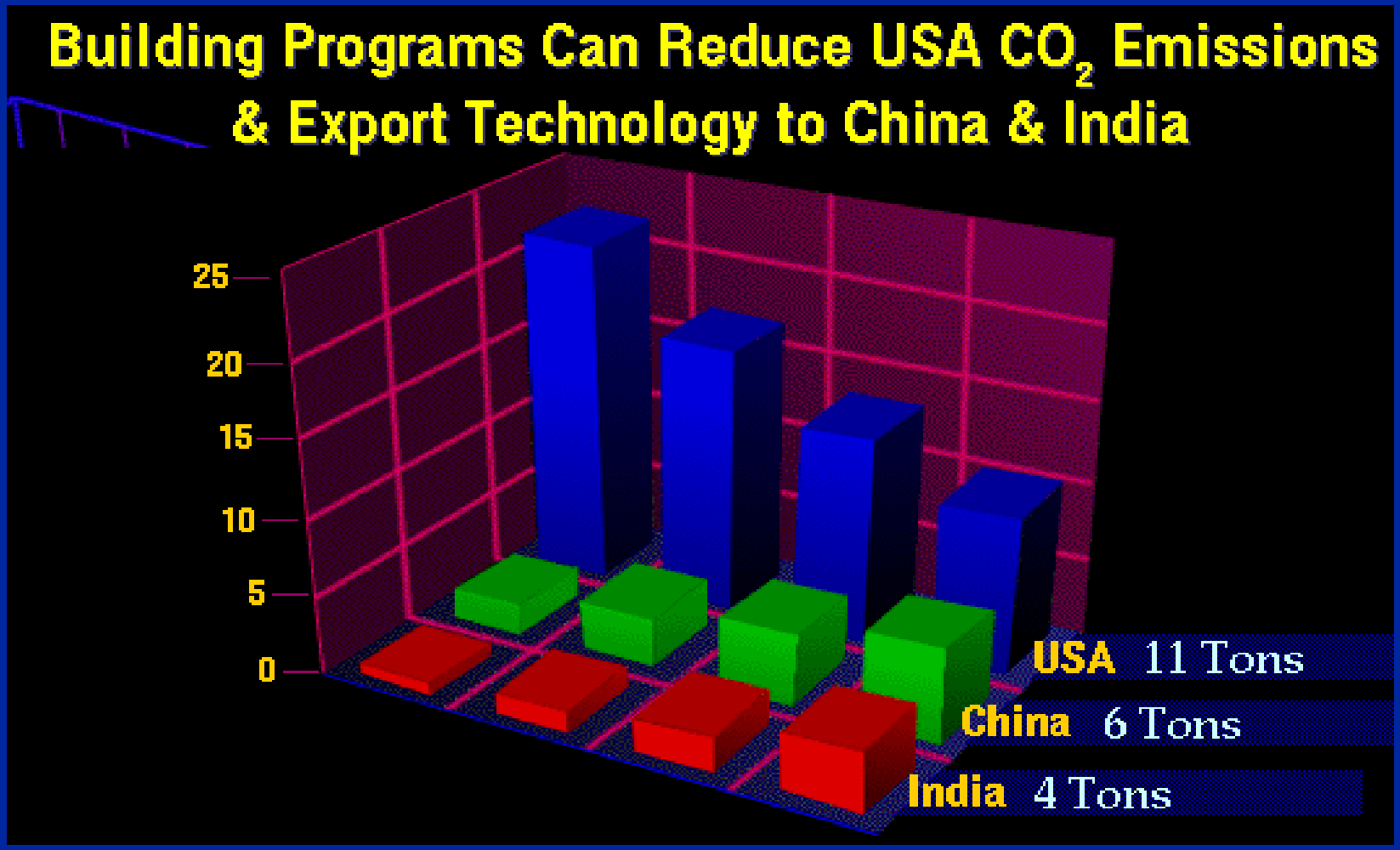
Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

Building Programs Can Reduce USA CO_2 Emissions & Export Technology to China & India



The Robert L. Preger

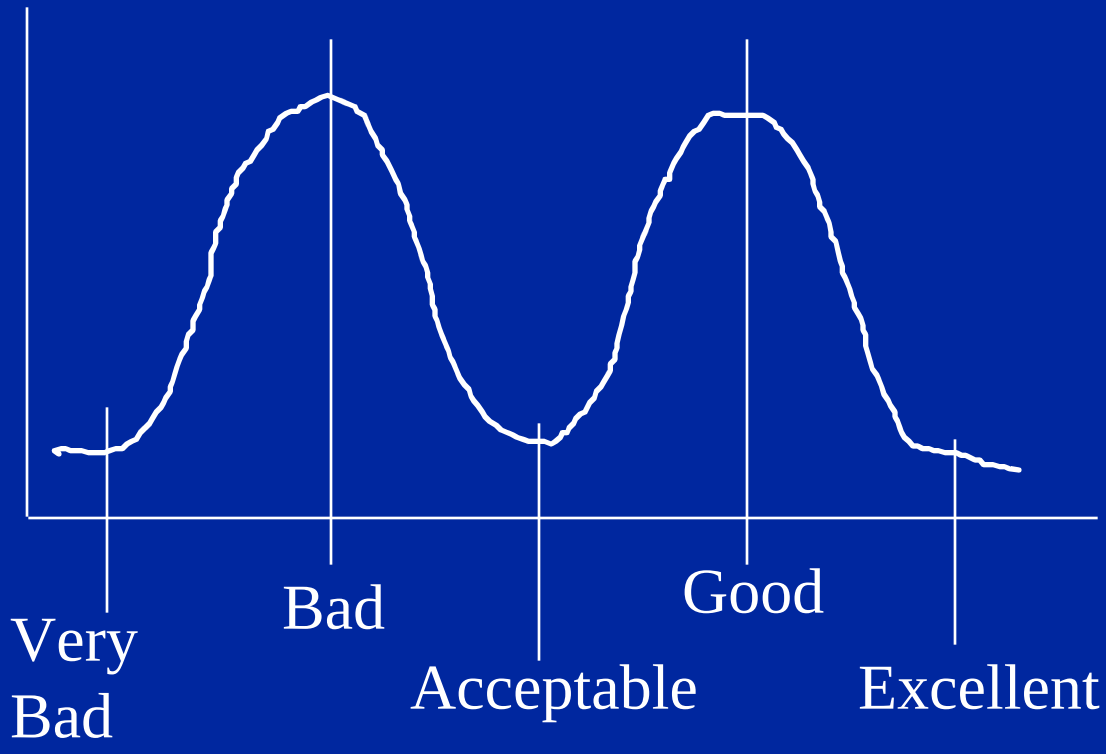
Intelligent Workplace

The Advanced Building Systems Integration Consortium

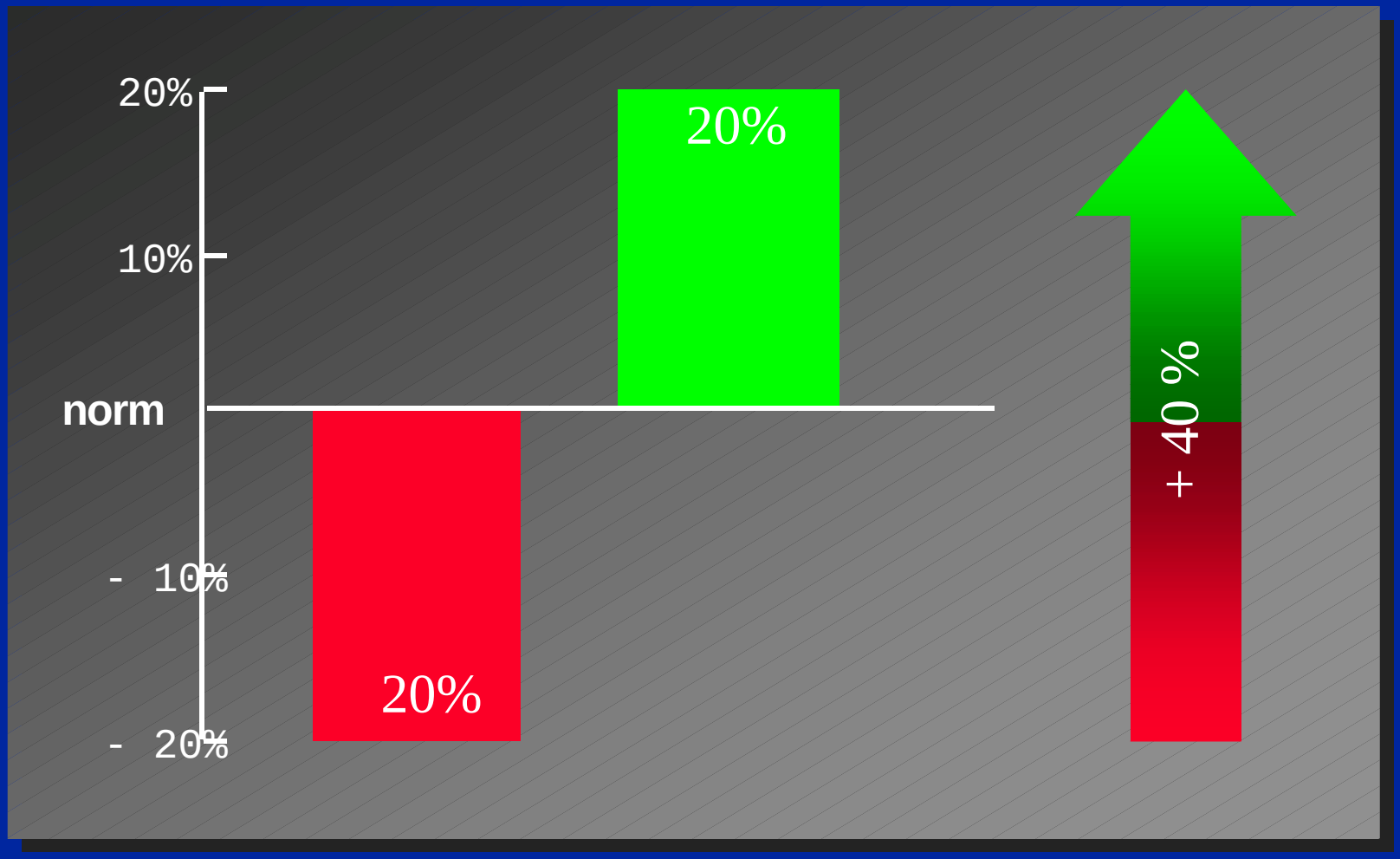
Mission

- Fundamental improvement of the work environment in commercial buildings with a simultaneous reduction of energy consumption and environmental impact
- Goal: Two times FACTOR FOUR :
- Four-fold improvement in quality of life (measured by occupants' satisfaction)
- With a simultaneous four-fold reduction of nonrenewable energy consumption and environmental burden

Improving User Satisfaction



Worker Productivity Improvement



Advanced Building Systems Consortium

- Armstrong World Industries
- AMP Incorporated
- Bricsnet
- BP Solar
- Con Edison
- Electricite de France
- Johnson Controls, Inc.
- LTG Lufttechnische GmbH
- Siemens Energy & Automation, Inc.
- Steelcase, Inc.
- Thyssen Krupp
- Technion
- UTC/Carrier/Otis
- Zumtobel Staff Lighting, Inc.

- National Science Foundation
- US Department of Defense
- US Department of Energy
- US Department of State
- US Environmental Protection Agency
- US General Services Administration

- Dutch Building Ministry
- Public Works and Government Services Canada
- Carnegie Mellon University

The successful interaction of

People
Process
Technology, and
Place

enable the execution of business strategies

(after Kenneth Alvares, VP HR SunMicrosystems during National Summit on Building Performance, Wahington DC, 1996)

Four Categories of Performance

1 Thermal, visual, acoustic, spatial/ergonomic, and air quality for each occupant

PERSONAL MOTIVATIONAL ENVIRONMENT

2 Organizational flexibility to enable teaming for different group sizes and individual thinking work

ORGANIZATIONAL CHANGE ON DEMAND

Four Categories of Performance, cont.

3 Technological adaptability for rapidly evolving multi media communication and decision support systems for global connectivity

TECHNOLOGICAL CHANGE ON DEMAND

4 Energy and environmental effectiveness to minimize energy investment and environmental degradation during construction, operation, maintenance and physical change to respond to organizational and technological requirements

BUILDING AS RENEWABLE AND SUSTAINABLE ASSET

Four Plug and Play Systems

1 PLUG AND PLAY BUILDING INFRASTRUCTURES

Floor or Ceiling Based “Migrating” HVAC, Lighting, Electrical, Communication, Computation Systems With One-Per-Person Terminal Units & Individual Control

2 PLUG AND PLAY INTERIOR SYSTEMS

Furniture, Partitions, Walls and Their Interfaces With the Infrastructures

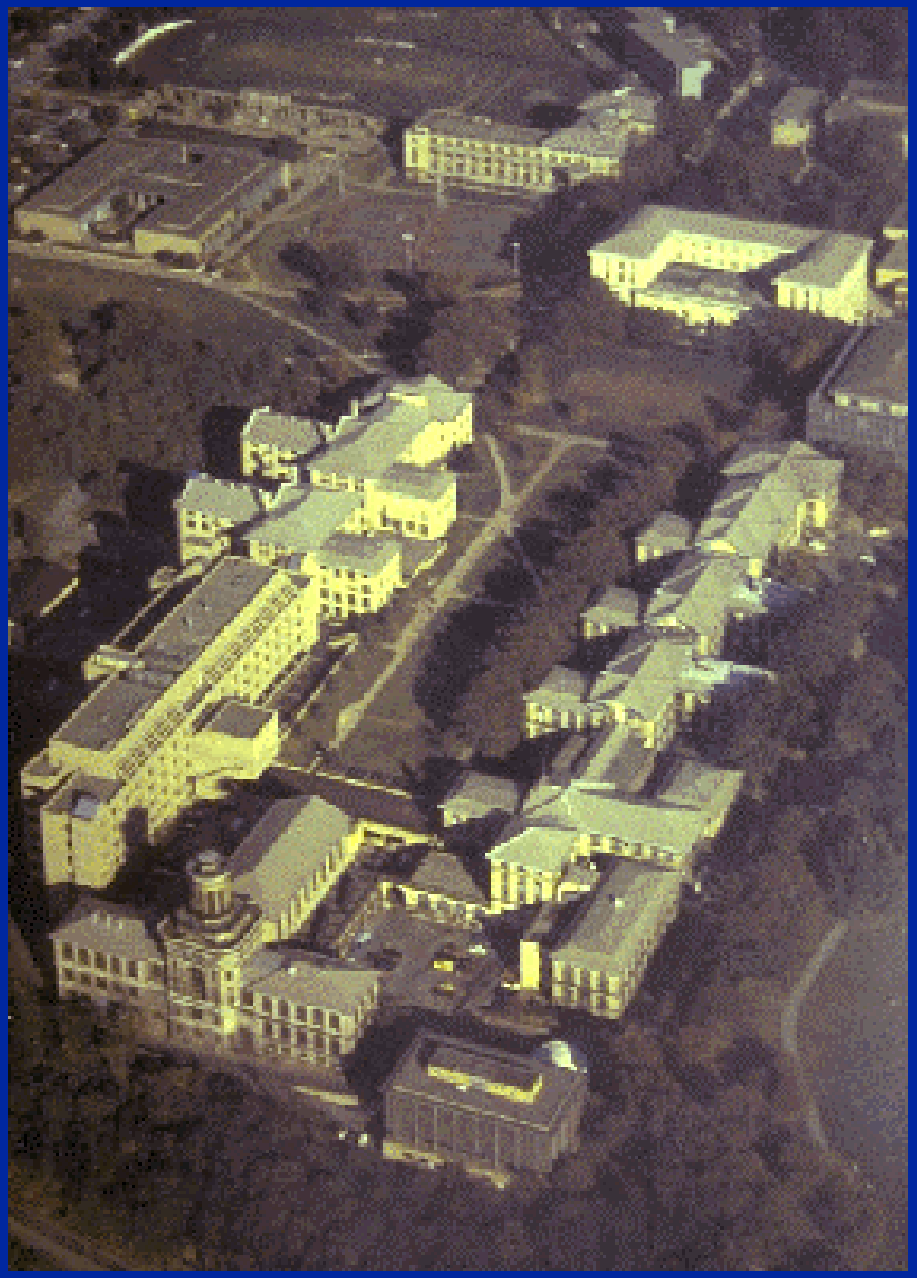
Four Plug and Play Systems, contd.

3 ***PLUG AND PLAY MULTI MEDIA HARDWARE, SOFTWARE COMPUTER SUPPORTED CO-OPERATIVE WORK SYSTEMS (CSCW)***

4 ***PLUG AND PLAY STRUCTURE, FACADE, HVAC, INTERIOR, CSCW, COGENERATION SYSTEMS***

The Intelligent Workplace
as an enabling instrument for

Individual Comfort and Productivity
Organizational Flexibility
Technological Adaptability
Energy and Environmental Effectiveness



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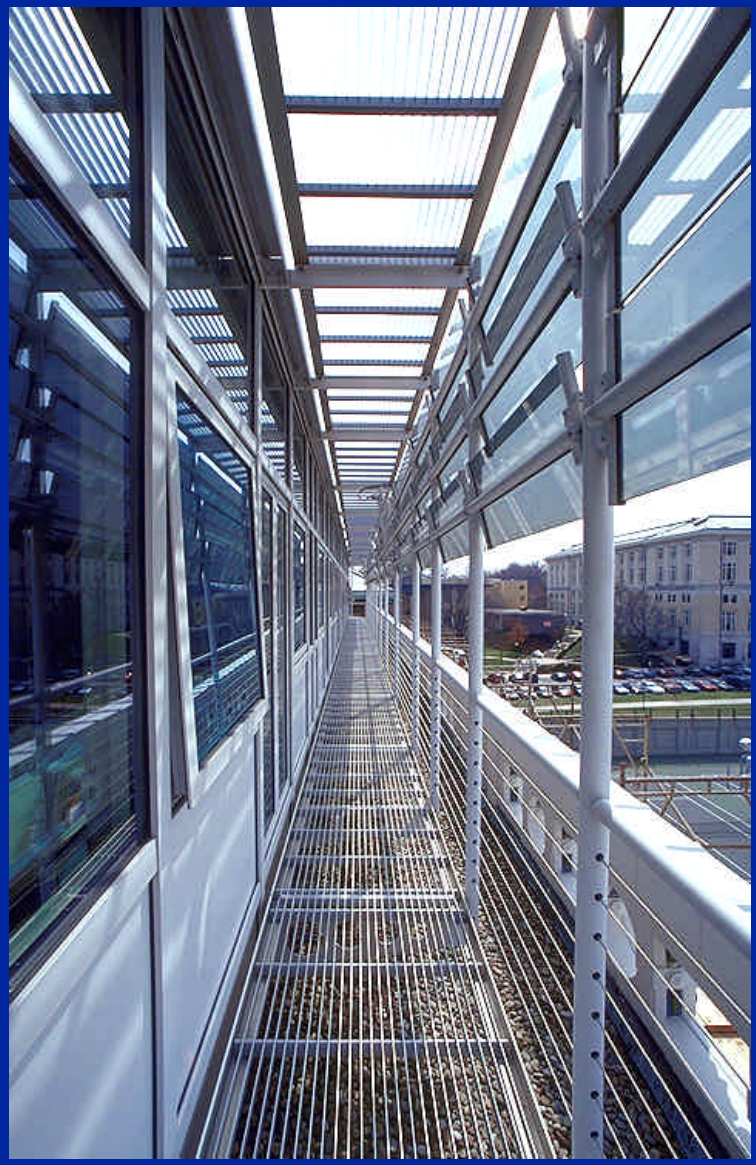

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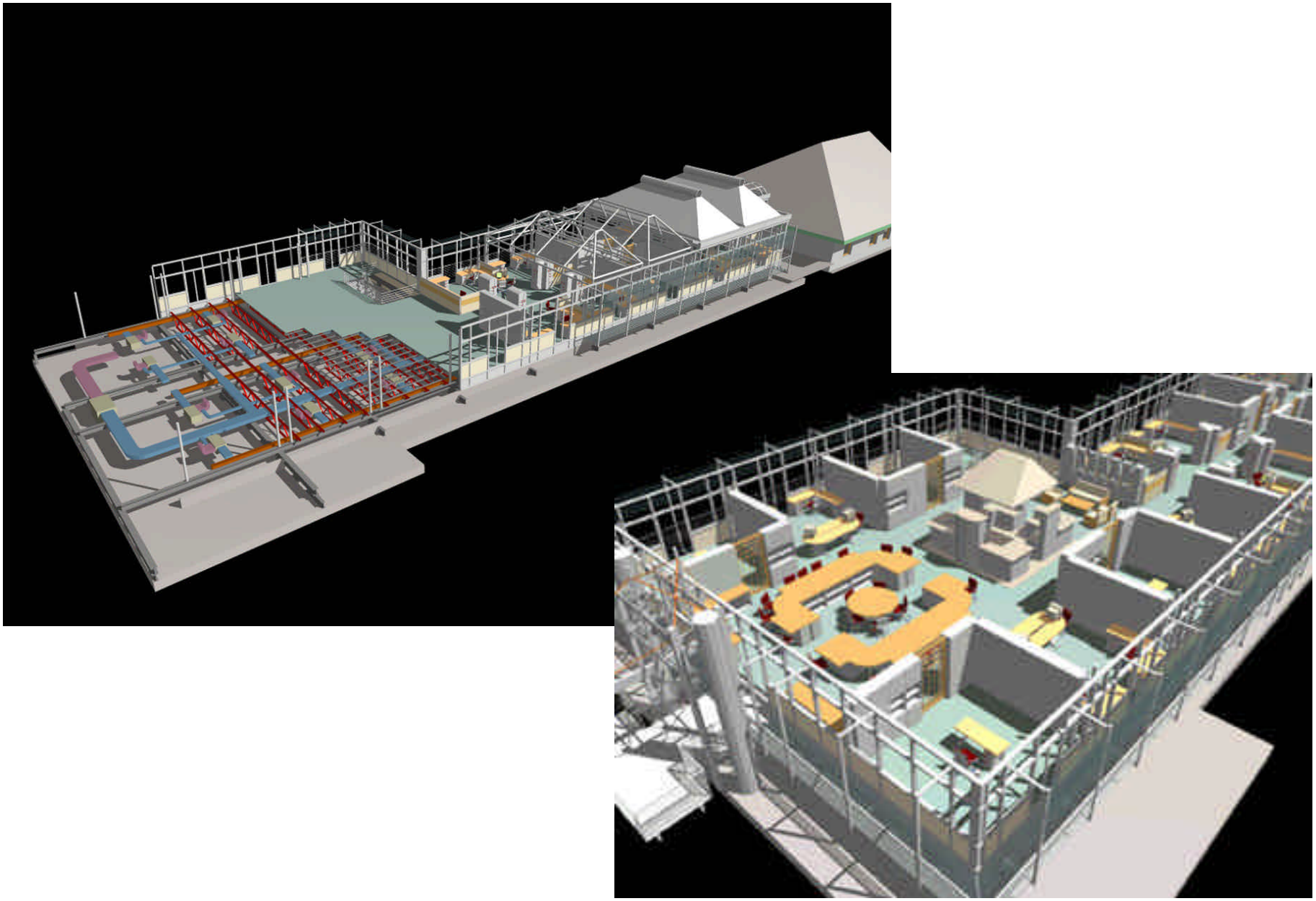
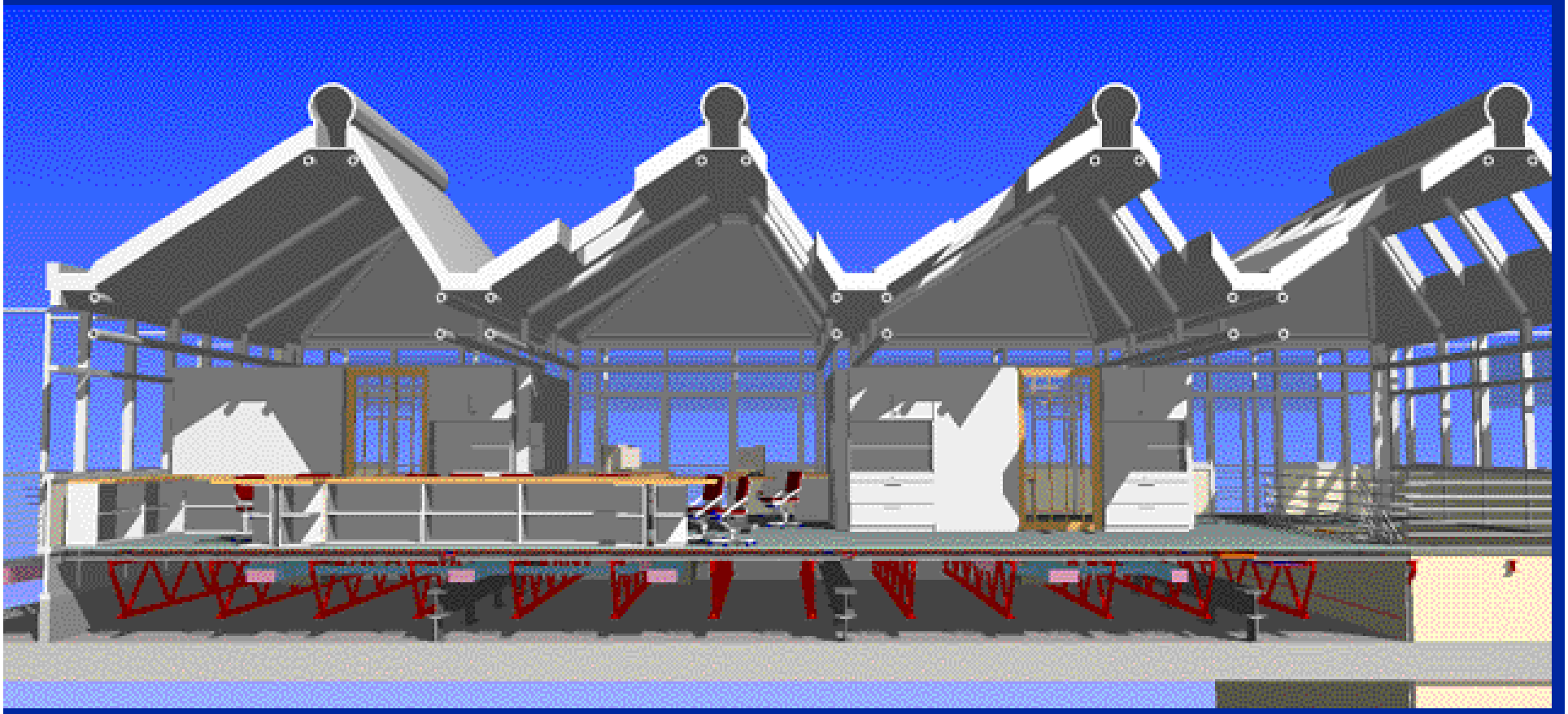
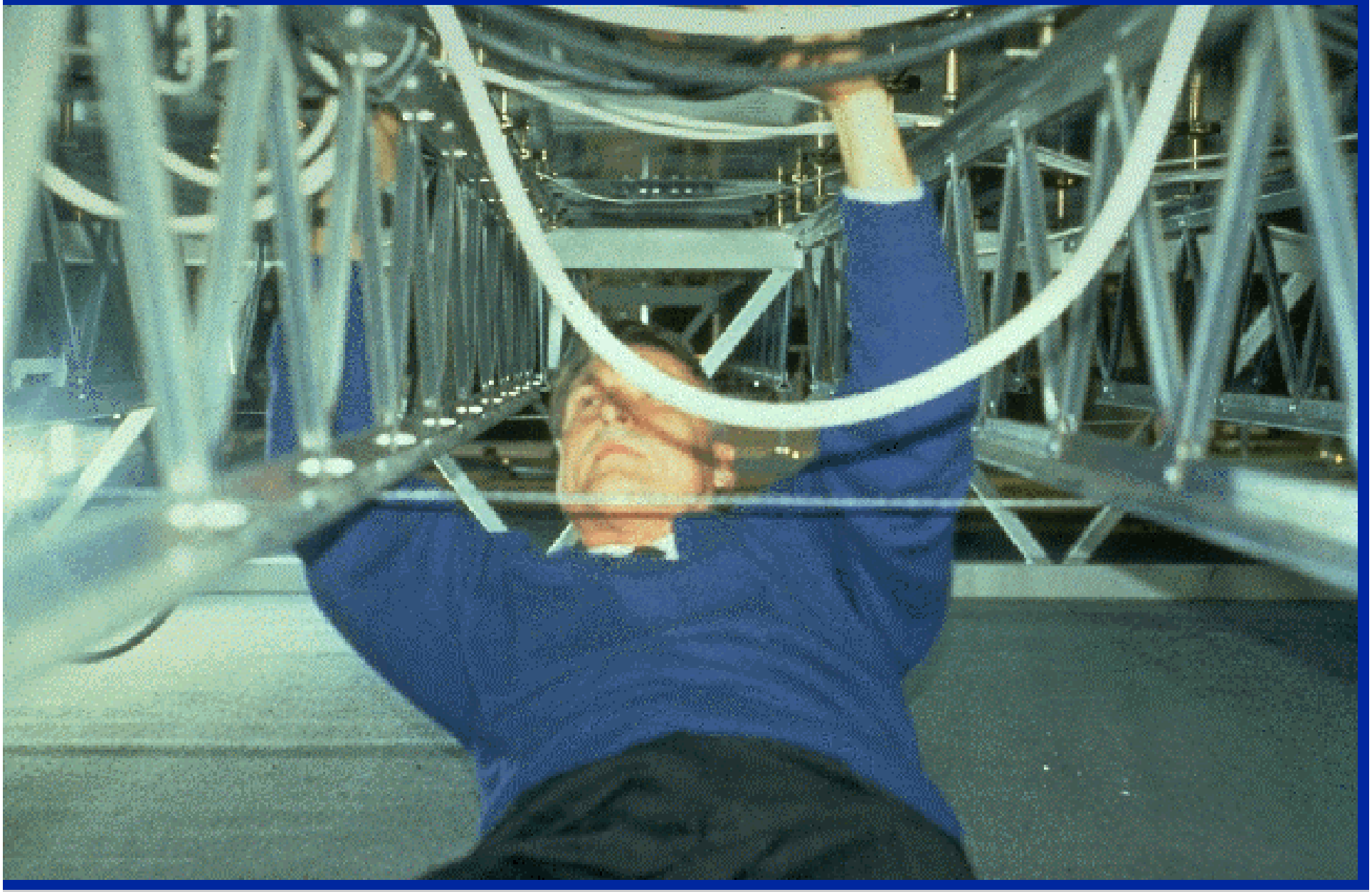
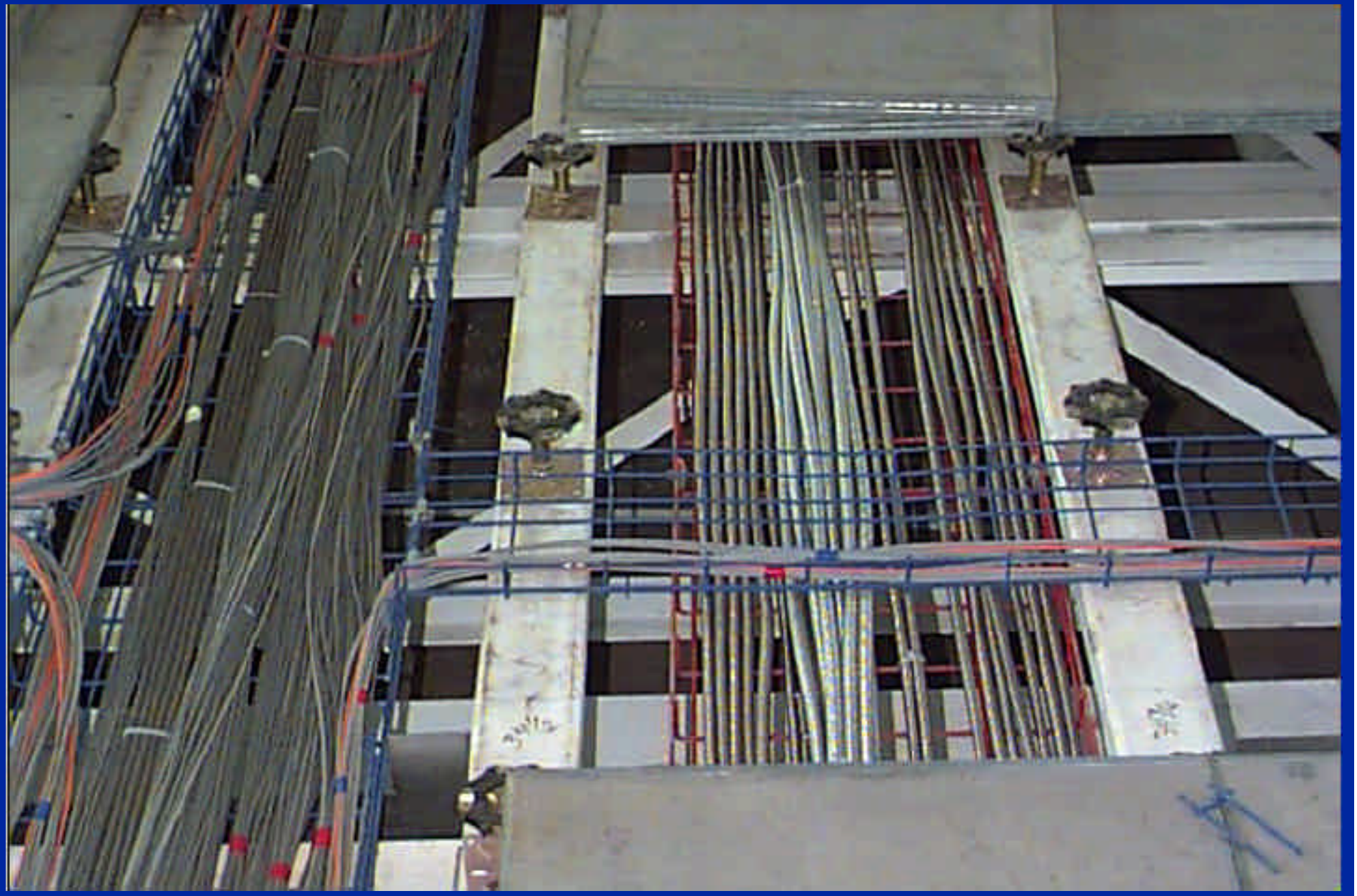
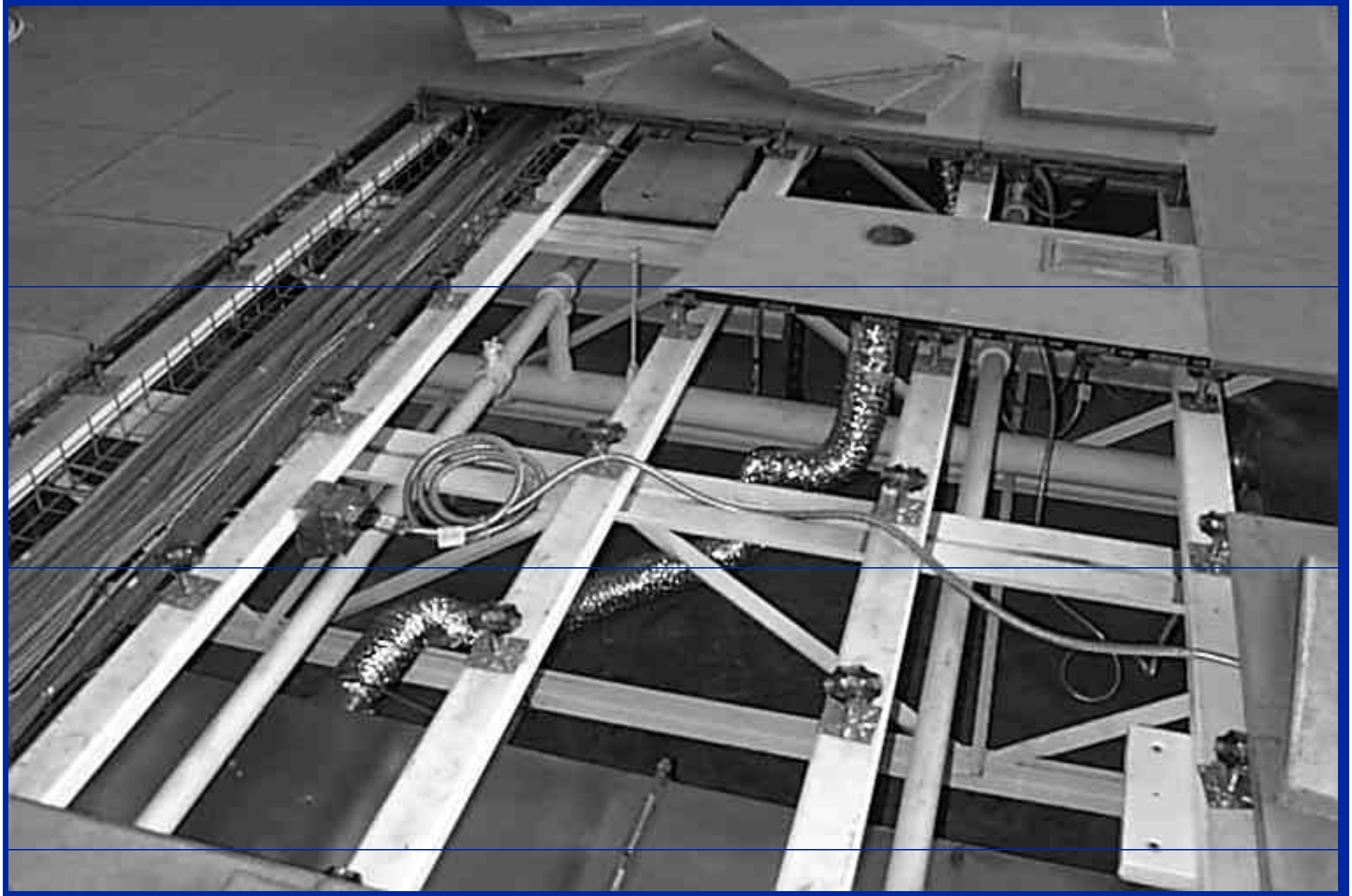








Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon



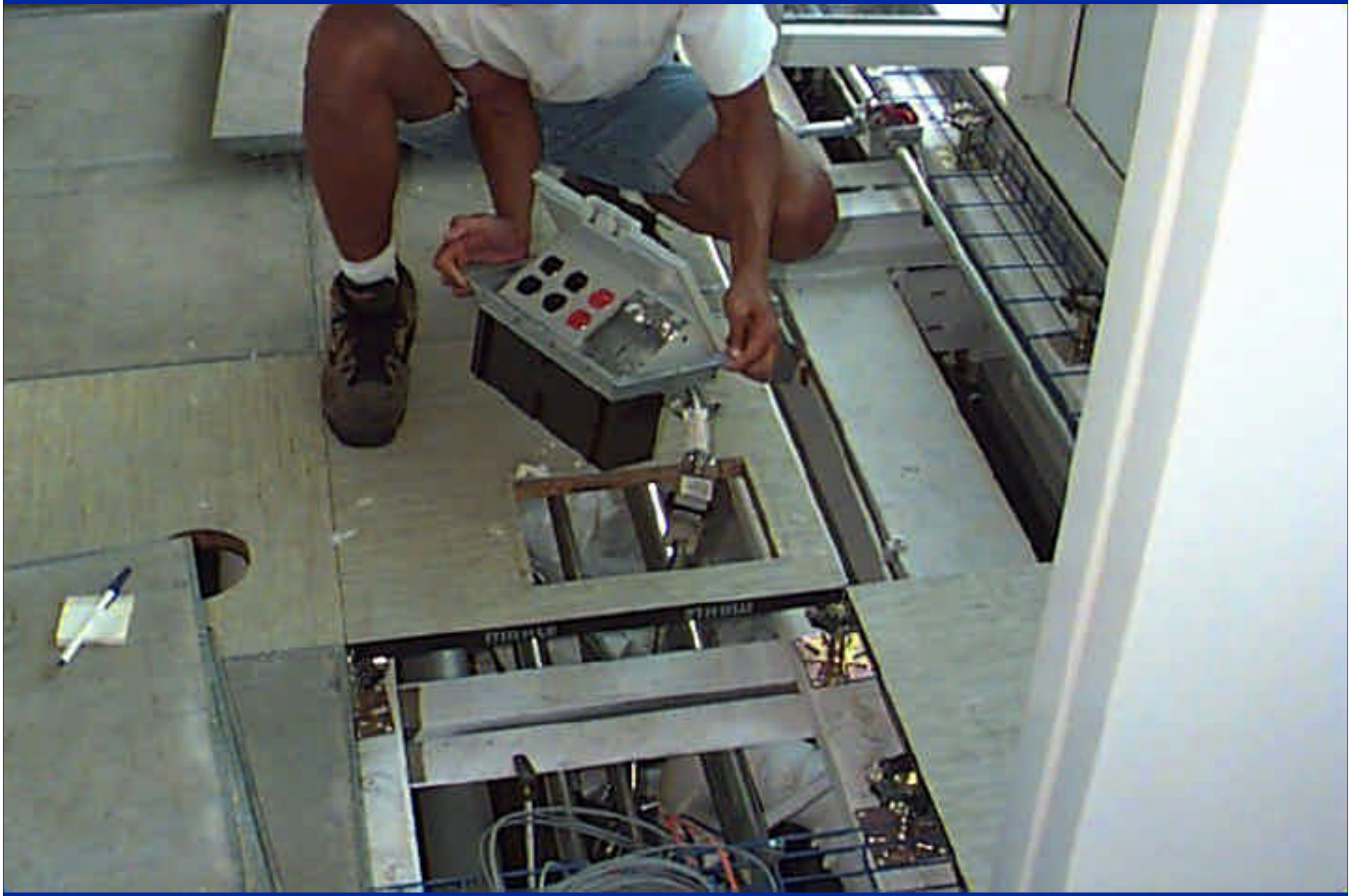
Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

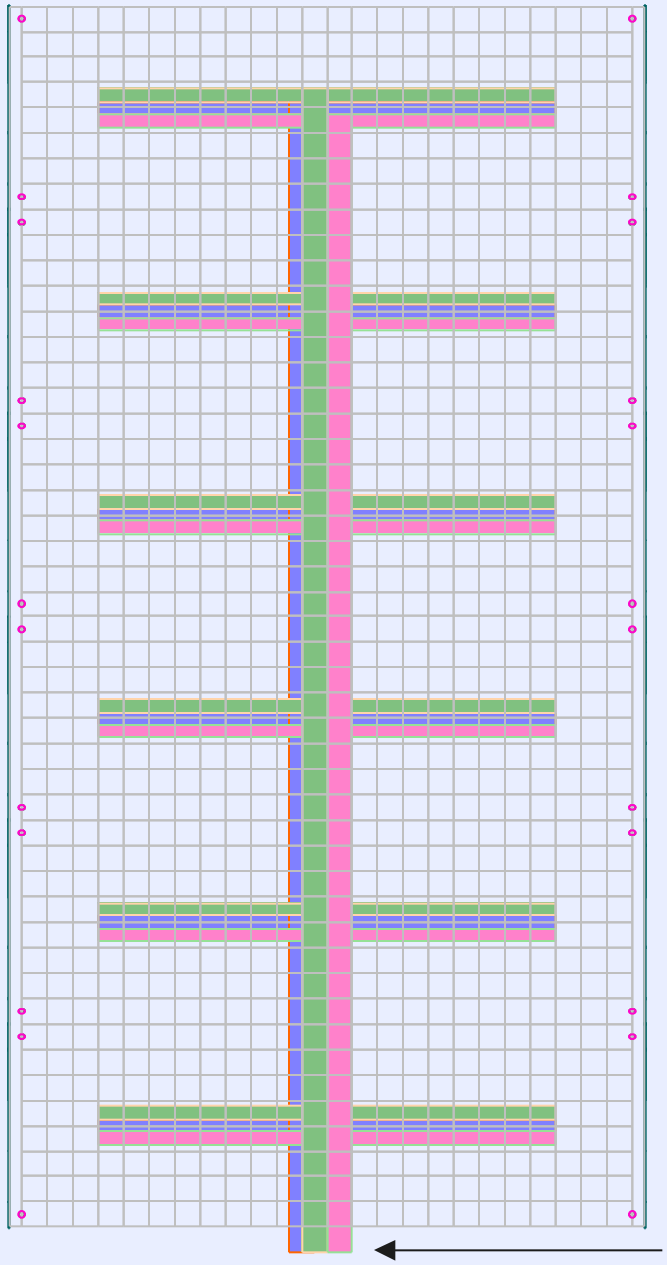
Courtesy: Johnson Controls

Johnson Controls Personal Environment Module [PEM™]

Courtesy: Johnson Controls

Johnson Control's Personal Environment Module [PEM™] supports user based outside air and temperature settings by introducing individual mixing boxes in the furniture. Users can set their own demands on the amount of conditioned outside air through ventilation speed and temperature control.





Underfloor Infrastructure distribution diagram

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Prizes

Regional: Three Rivers Environmental Prize, 1998

State: Green Building Prize, 1998

National: Honor Award, American Institute of Architects, 1999

International: Business Week/Architectural Record Awards, 1999

Applications

Kangnam Tower, Seoul, Korea

OC Headquarter, Toledo, Ohio

Soffer Organization Tech Offices, Pittsburgh,PA

Adaptable Workplace Laboratory,GSA, Wash.,DC

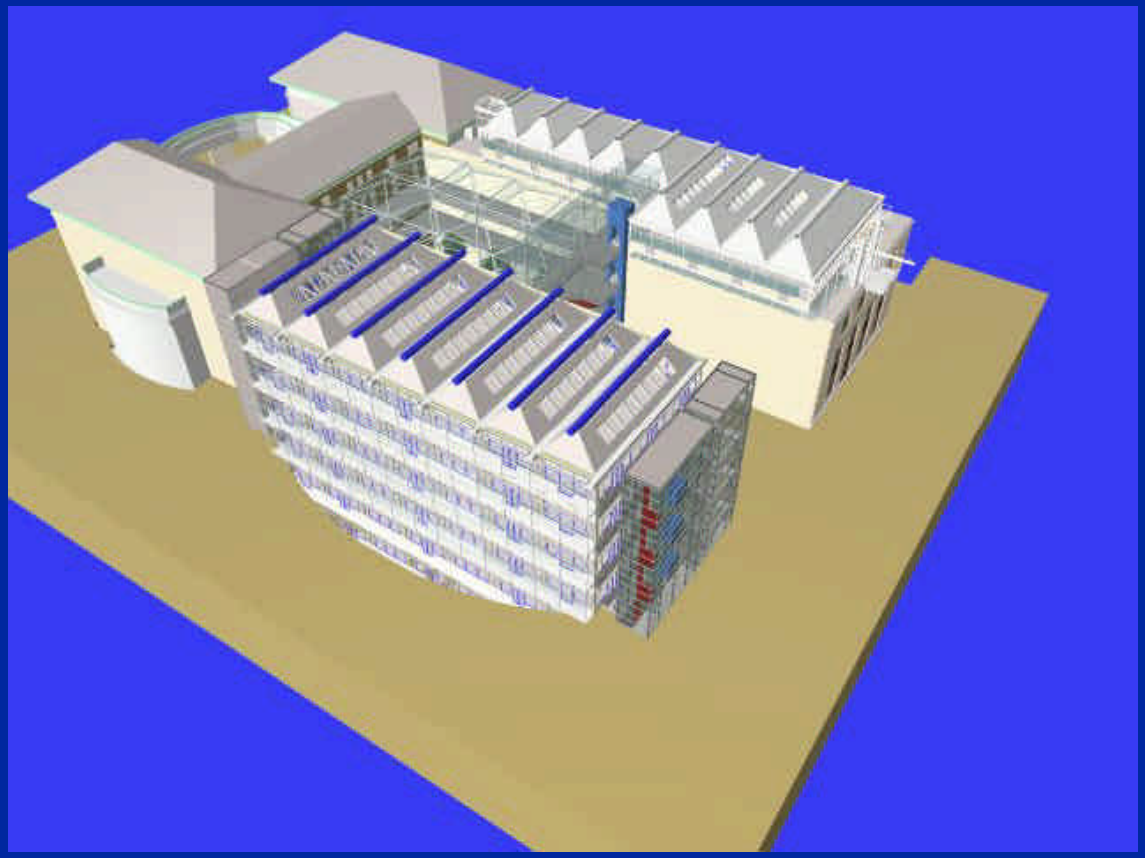
Region 3 Headquarter, DEP, Harrisburg, PA

Laboratory for the Design of Cognition, EDF, Paris

Beijing Energy Efficient Office Building, Beijing

Building as Power Plant (BAPP) -Intelligent Workplace Energy Systems

Volker Hartkopf (PI), David Archer (Co-PI)
Azizan Aziz, Rohini Brahme
Colbi Cannon, Claudia Otto, Hongxi Yin

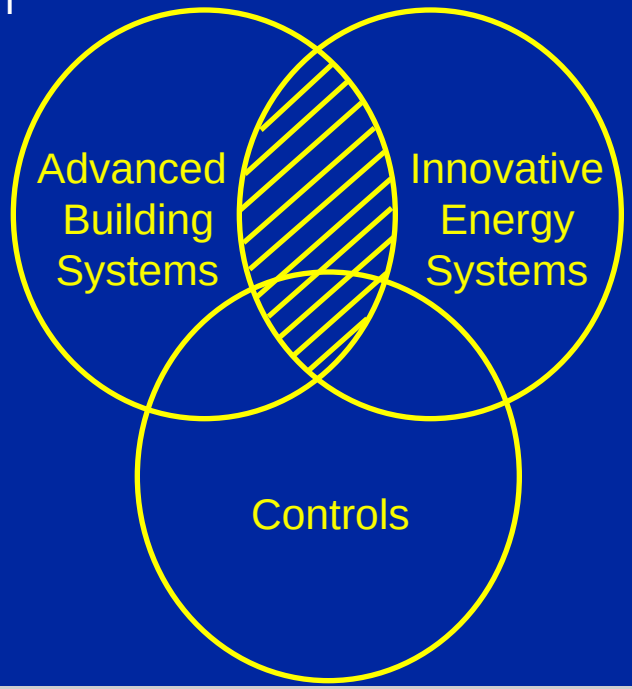


Concept

Buildings Can be Net Exporters of Energy

Systems Integration for:

- First, life cycle, environmental cost reduction
- Increased energy effectiveness
- Improved performance for user comfort
- Reliable and effective control technology
- Reliable energy supply
- Increased Return on Investment



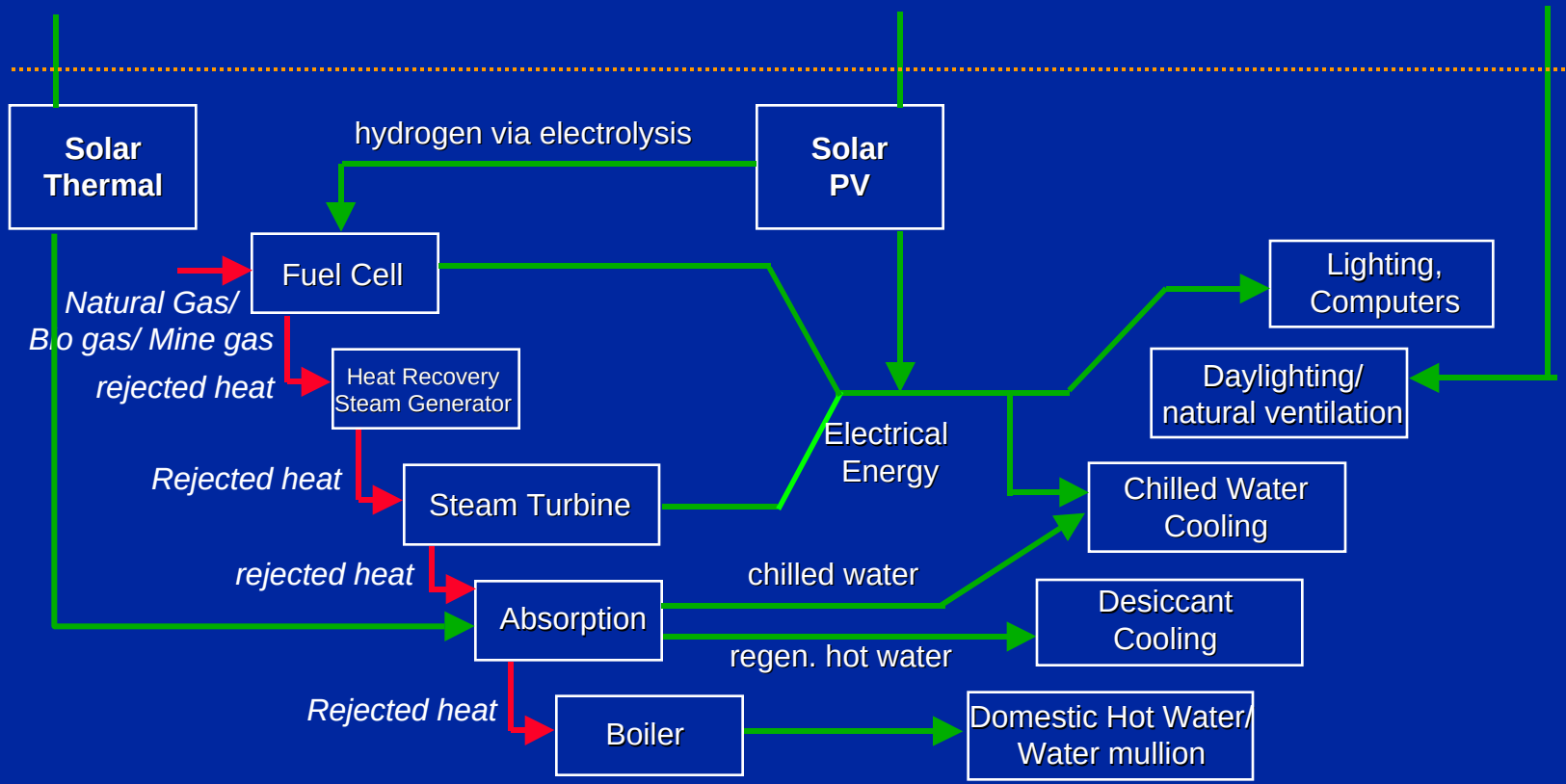
Advanced Building Systems

- Daylight
- Natural Ventilation
- Passive Solar Heating and Cooling
- Multi-mode Thermal Conditioning including Active Solar Systems
- User-based Controls and Conditioning

Innovative Energy Systems

Multi-modal Conditioning

- Ascending-Descending Strategy



Geothermal Energy

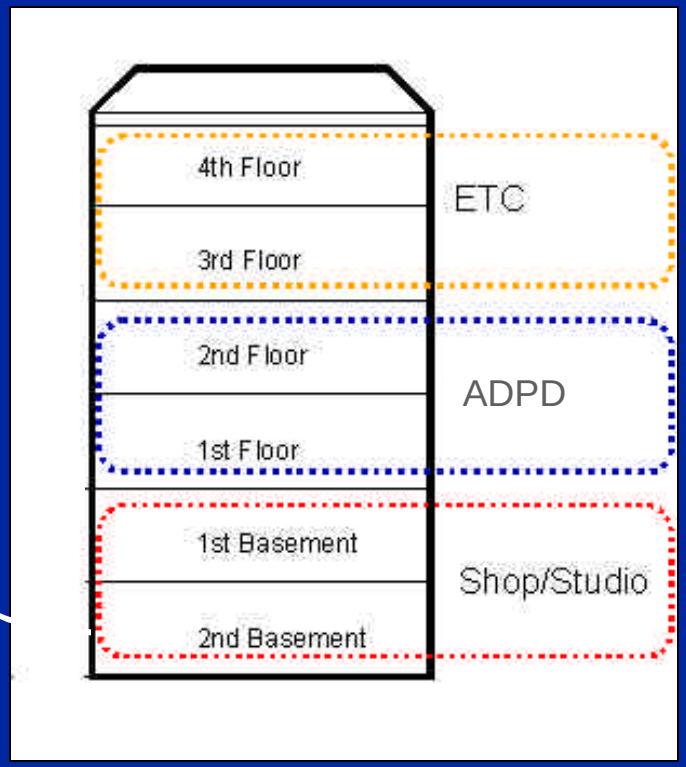
250-kW SOFC Specification

- Net AC power: 226 kW
- Electric efficiency (Net AC/LHV): 46%
- Fuel flow: 100lb/hr
- Air flow: 1.6lb/sec
- Exhaust gas flow rate: 2340 kg/h
- Exhaust gas heat capacity (@300^{o}C): 1104.8J/kg-^{o}C
- Exhaust temperature of SOFC: 755^{o}C
- Inlet temperature of air to SOFC: 500~550^{o}C

Source: Christian A Forbes, Siemens Westinghouse Stationary Fuel Cells (SWSFC)

Expected Energy Demand of BAPP

Internal Energy of Each Space

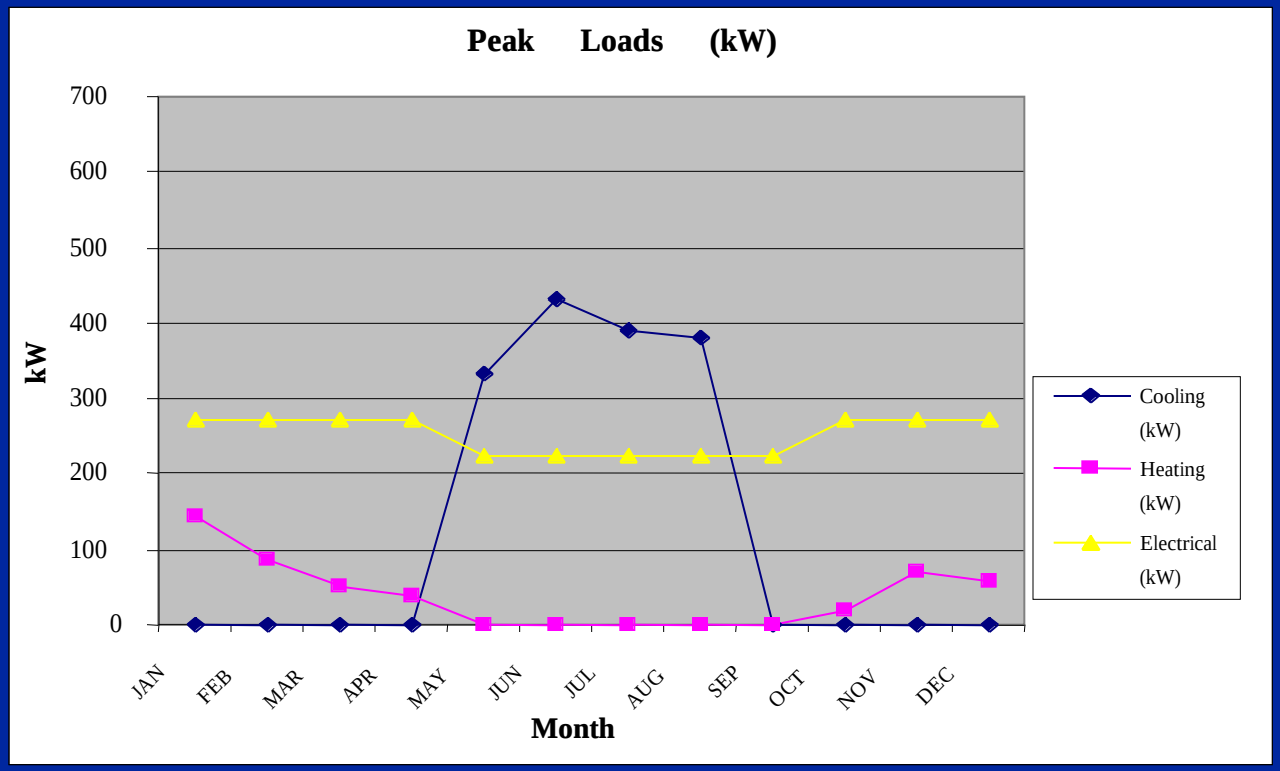


	Equip. Loads	Lighting Loads
ETC	6 w/ft^2	1.3 w/ft^2
ADPD	2 w/ft^2	1.3 w/ft^2
Shop/Studio	7 w/ft^2	1.2 w/ft^2

Building Load Simulation

- Simulation tools – DOE 2, Energy Plus
- Hourly-based data through a whole year
  - Electrical Loads
    - Lighting and equipment
    - Pumps & fans
  - Cooling Loads
  - Heating Loads

Simulation Results

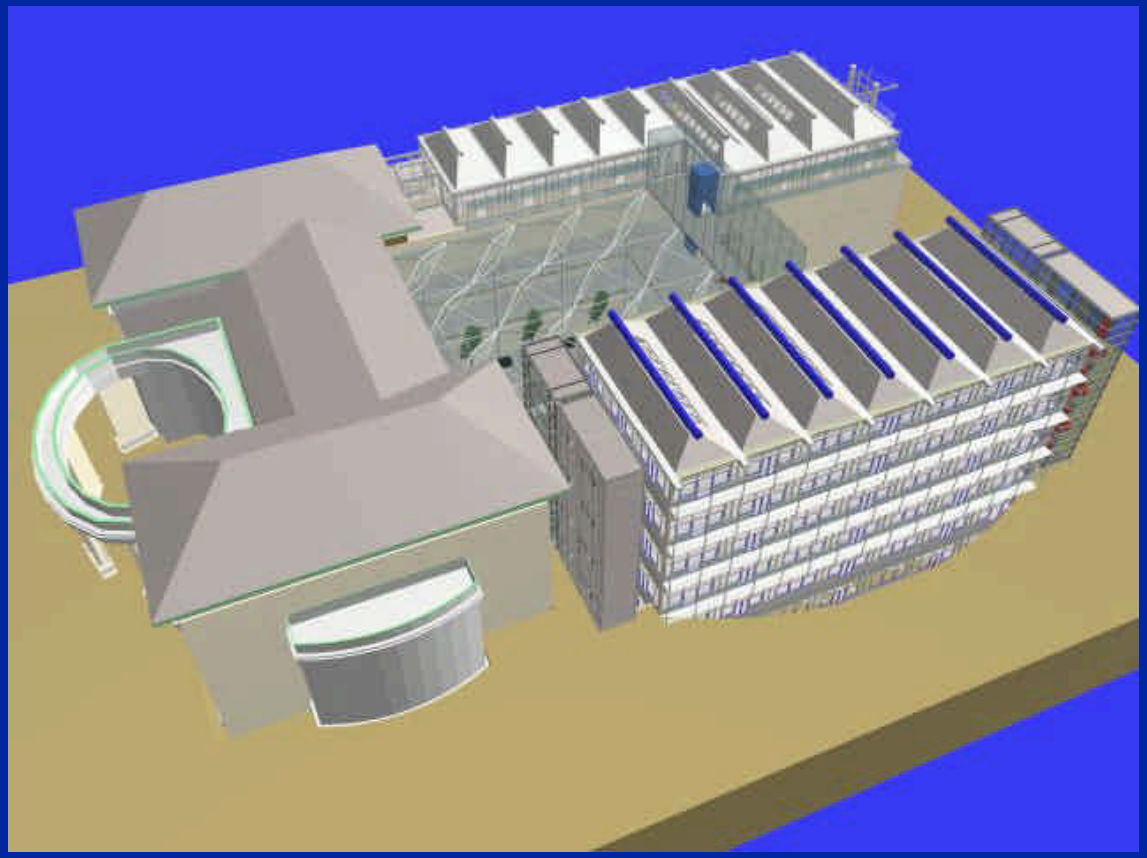


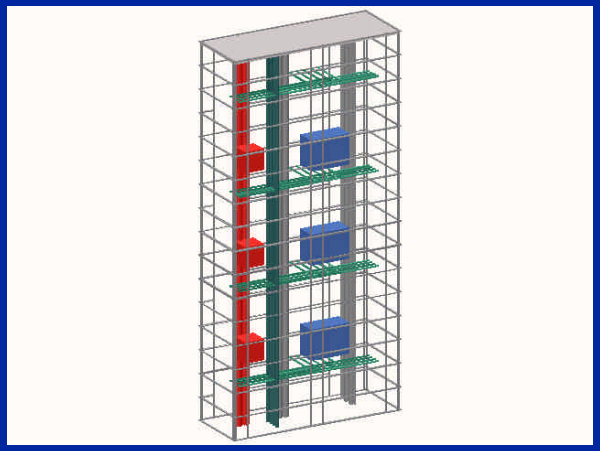
Note: Data taken from Dr. Rohini Brahme

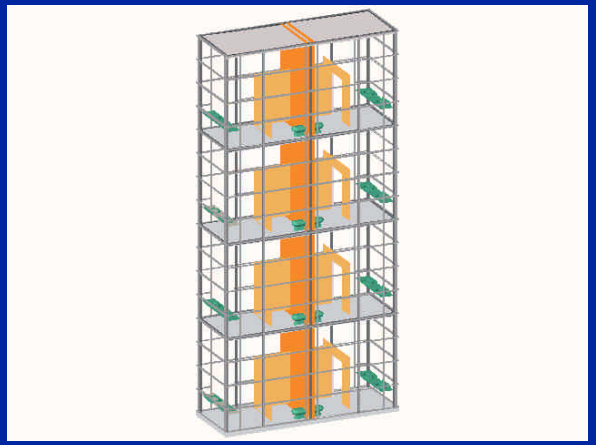
Scenario 1 - Configuration

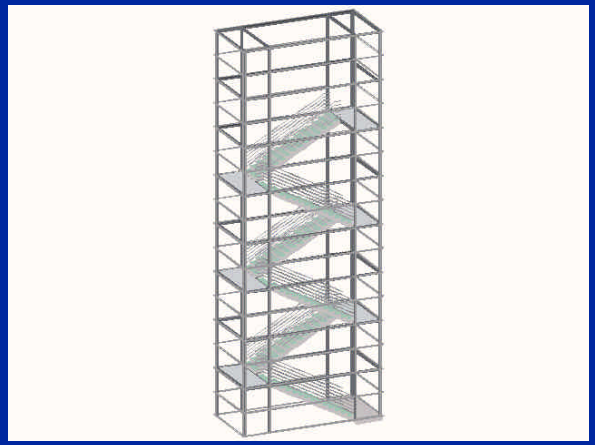
- Solid oxide fuel cell
- Heat recovery steam generator
- Steam-water exchanger
- Absorption chiller
- Electrical chiller
- Water heater

Preliminary Architectural Design









The Vision

- Creating enabling environments
  - Data, Information, knowledge, wisdom
  - Learning, teaching, practicing
- Confluence of advanced electronic tools with the total environment
- Strategic advantage - effective conservation of key resources
  - Human attention & creativity
  - Organizational responsiveness
  - Nonrenewable Resources

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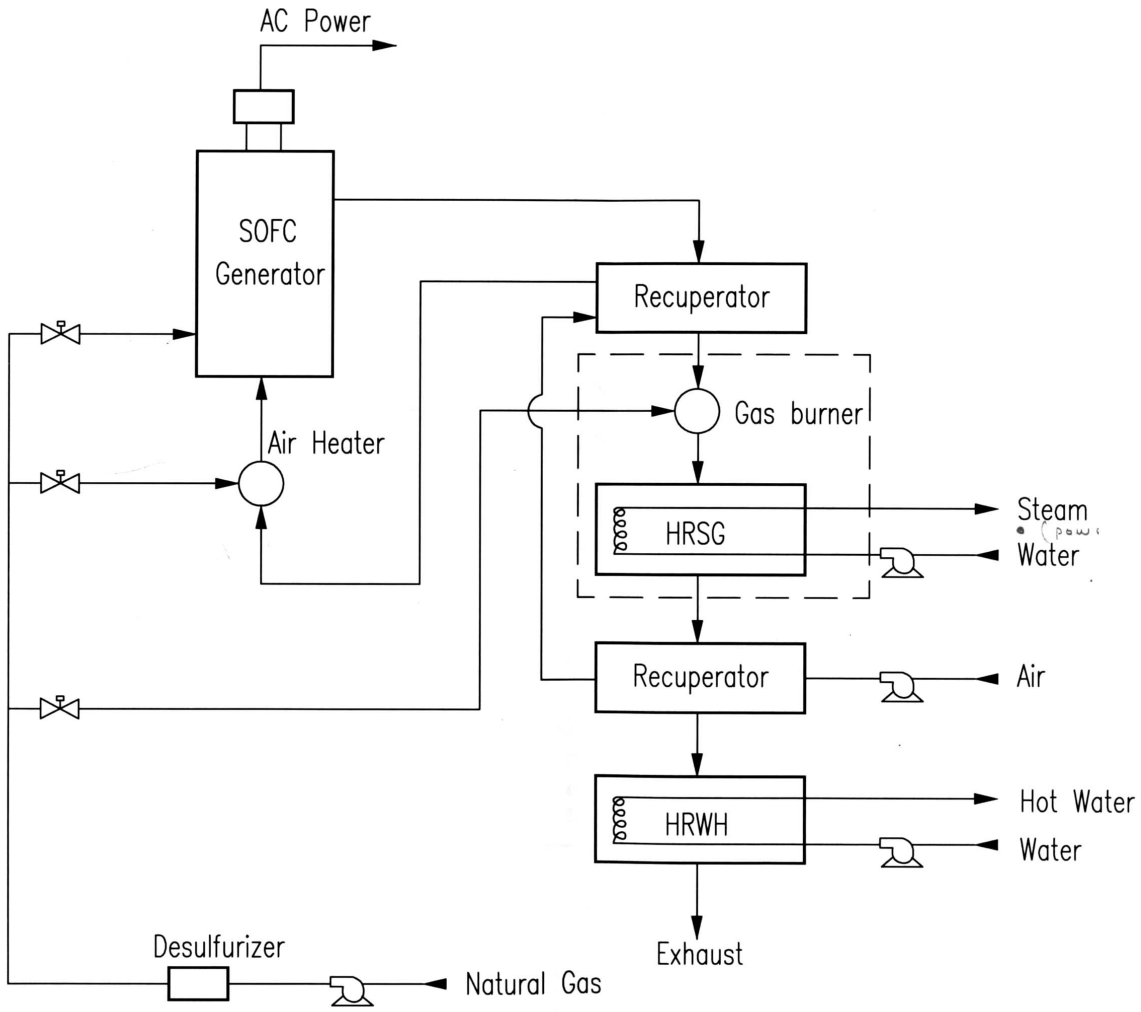
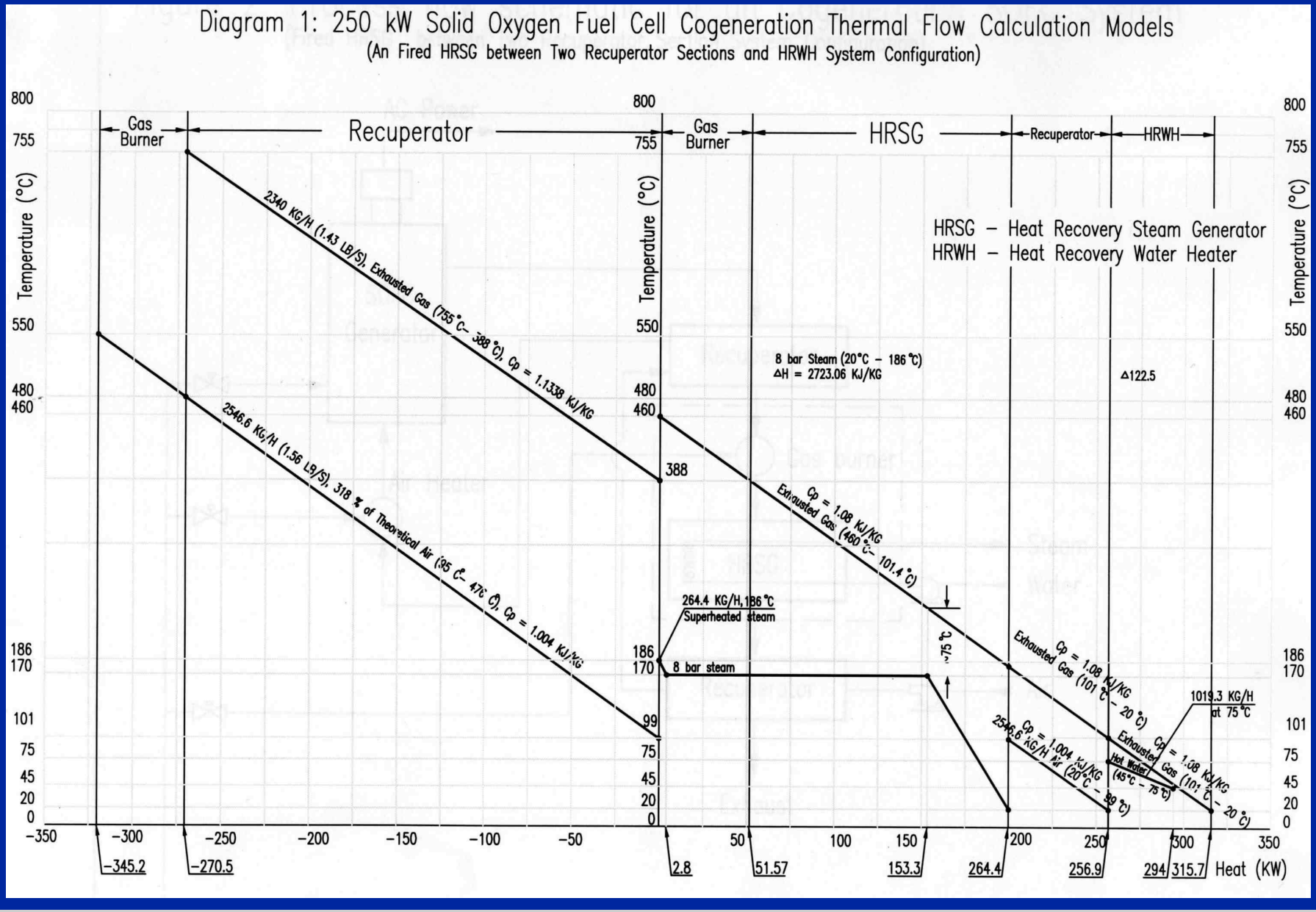
SOFC Thermal Flow Diagram

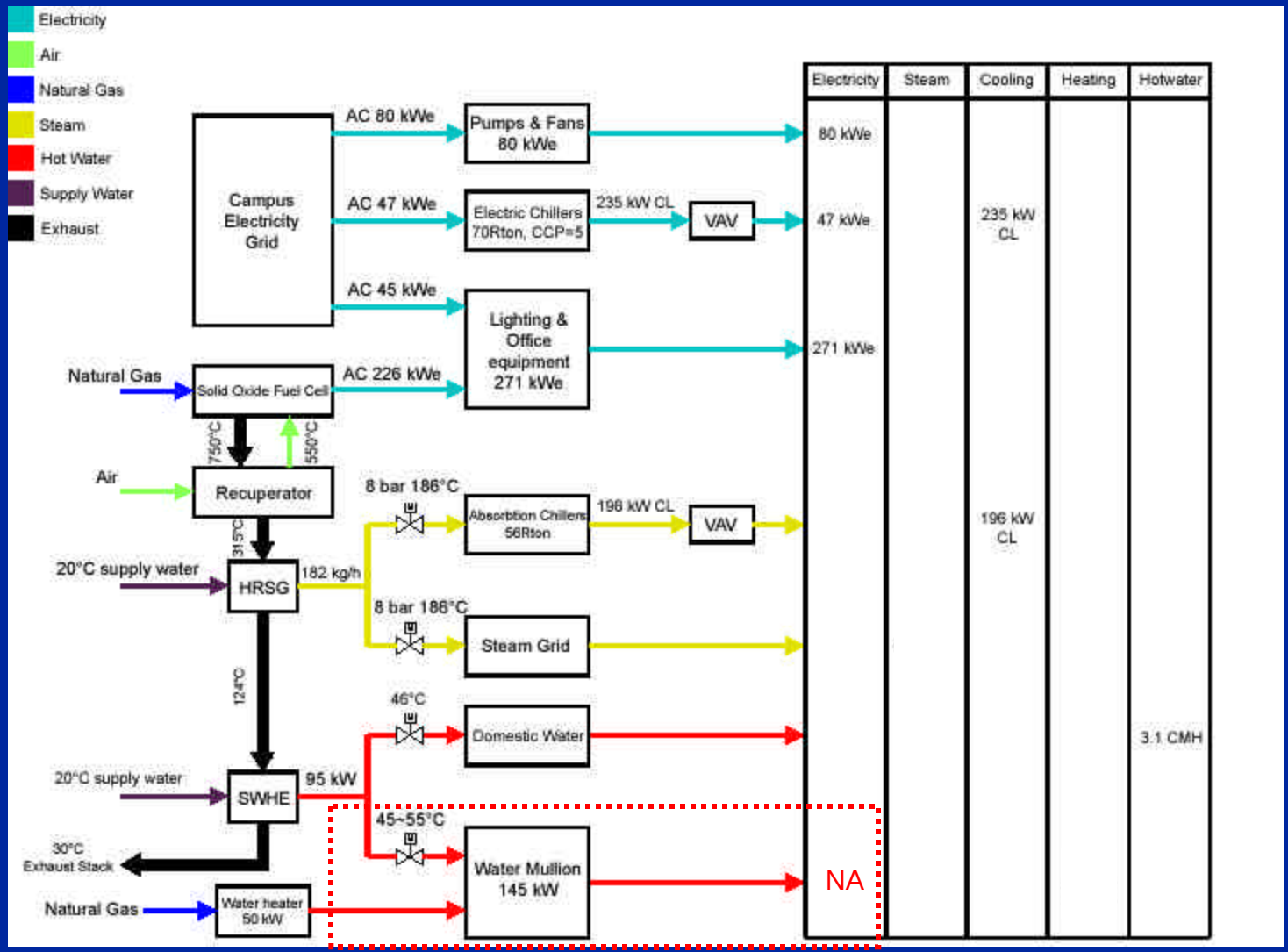
Figure 1: Process flow schematic for an Cogeneration SOFC System
(Fired HRSG between Two Recuperator Section System Configuration)



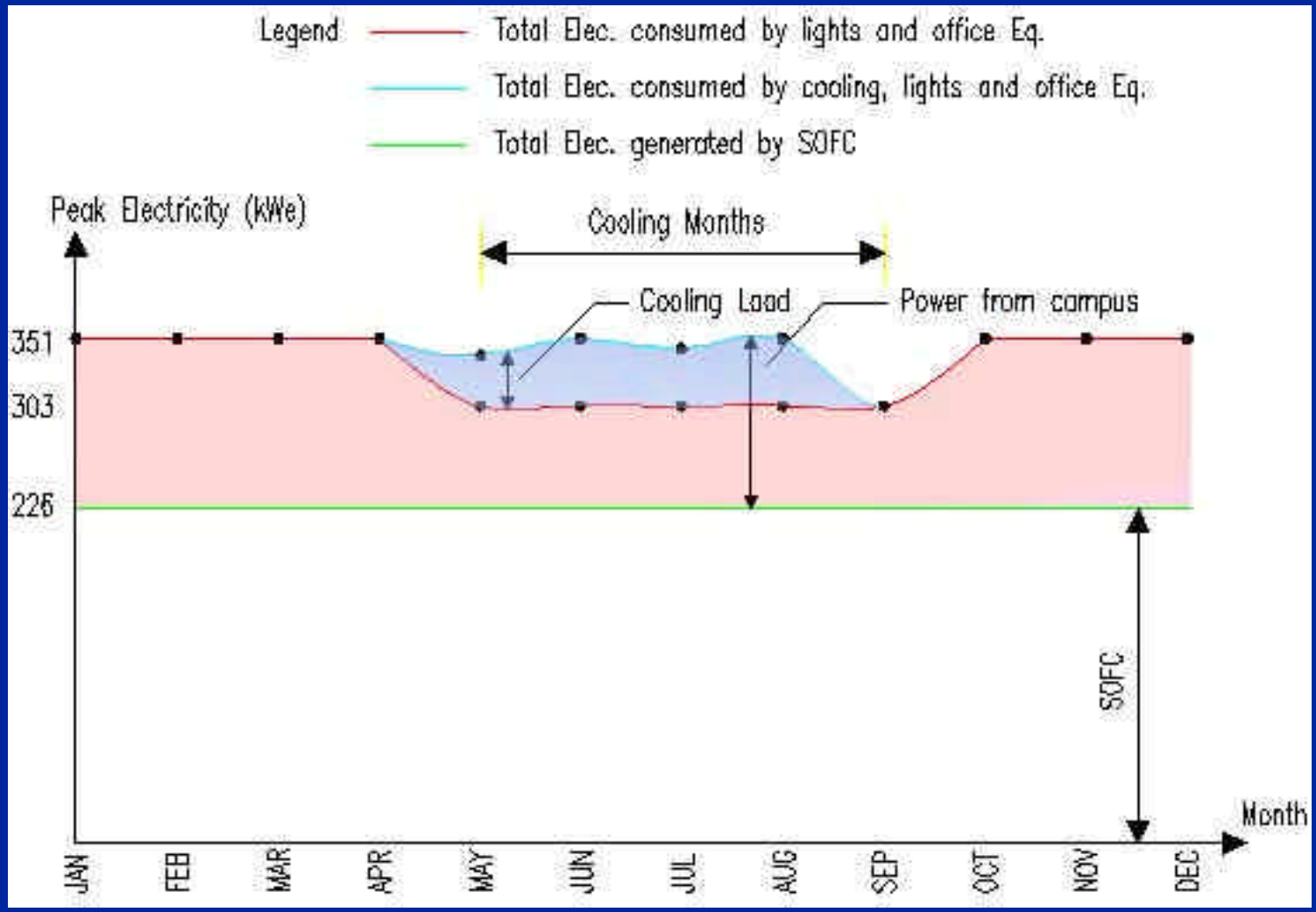
SOFC Thermal Flow Calculation Model



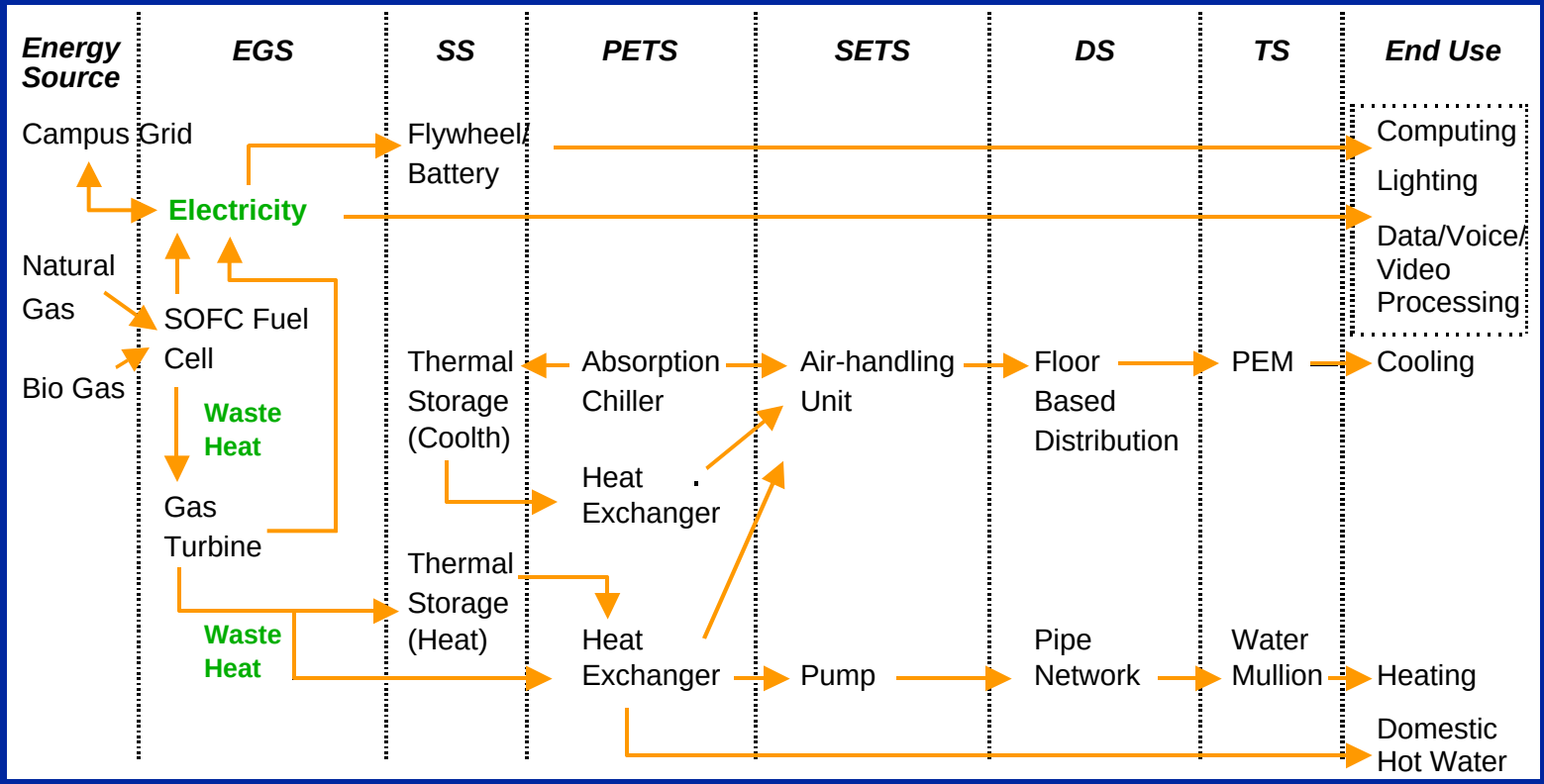
Scenario 1 – Summer



Scenario 1 – Electricity Curve



Strawman Scenario



EGS: Energy Generation System
SS: Storage System
PETS: Primary Energy Transfer System
SETS: Secondary Energy Transfer System
DS: Distribution System
TS: Terminal System