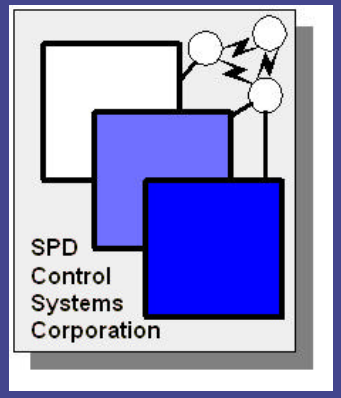
RESEARCH FRONTIERS INC.

SPD-SmartGlass™



Daylight Harvesting Using SPD-SmartGlass and Advanced Control Systems

Presented by:

Gregory M. Sottile, Ph.D.

Research Frontiers Inc.

John Petraglia

SPD Control Systems Corp.

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Part I:
The Need for Daylight Harvesting Using SPD-SmartGlass

US share of the world's total energy consumption in 2010

20.2%

Source: US DOE 2008 Buildings Energy Data Book

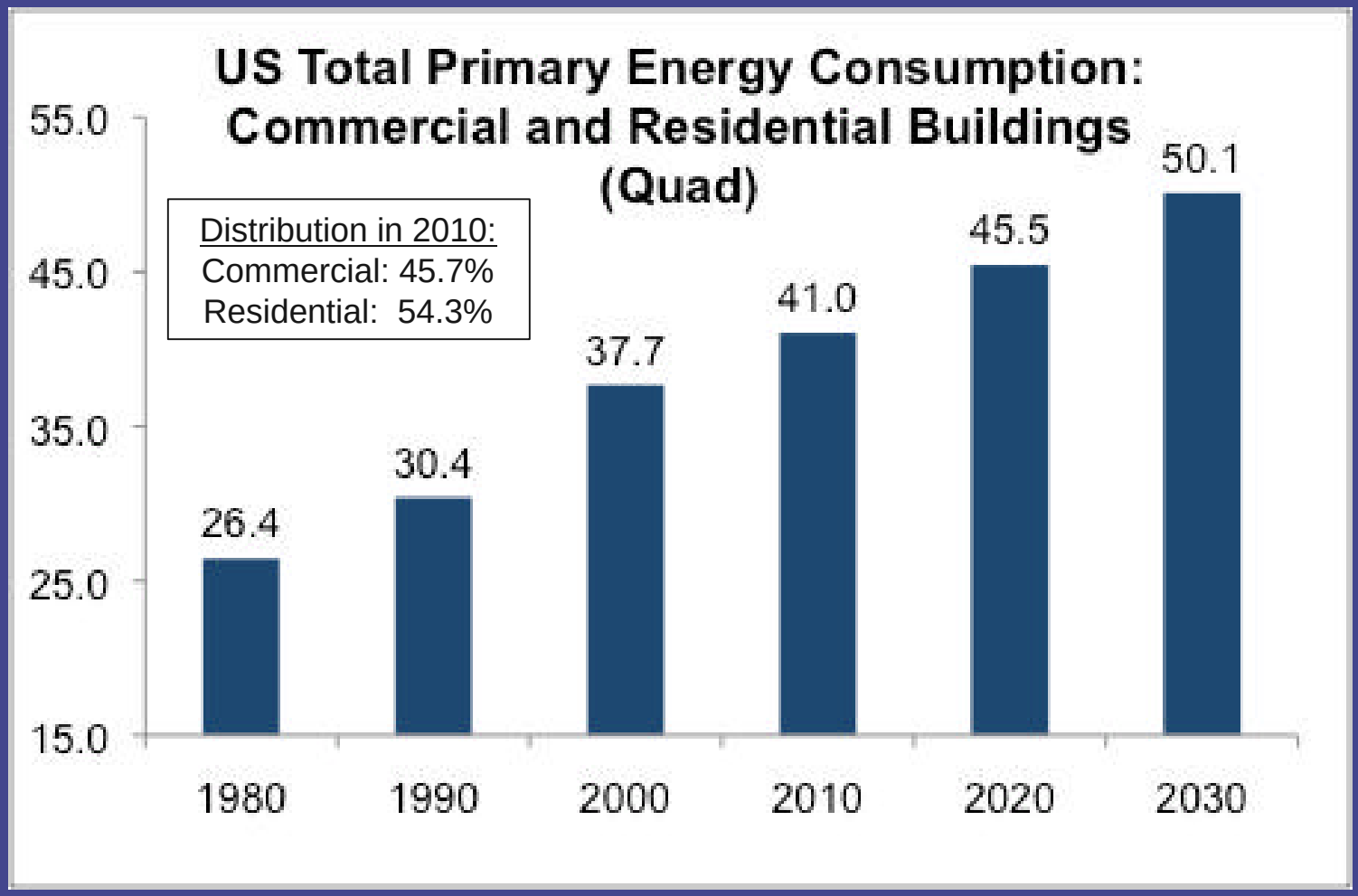
US Buildings Have a Major Impact on Energy Consumption

- 40% of the nation's primary energy use
- 72% of electricity consumption

Similar data exist for the building's in other developed nations of the world.

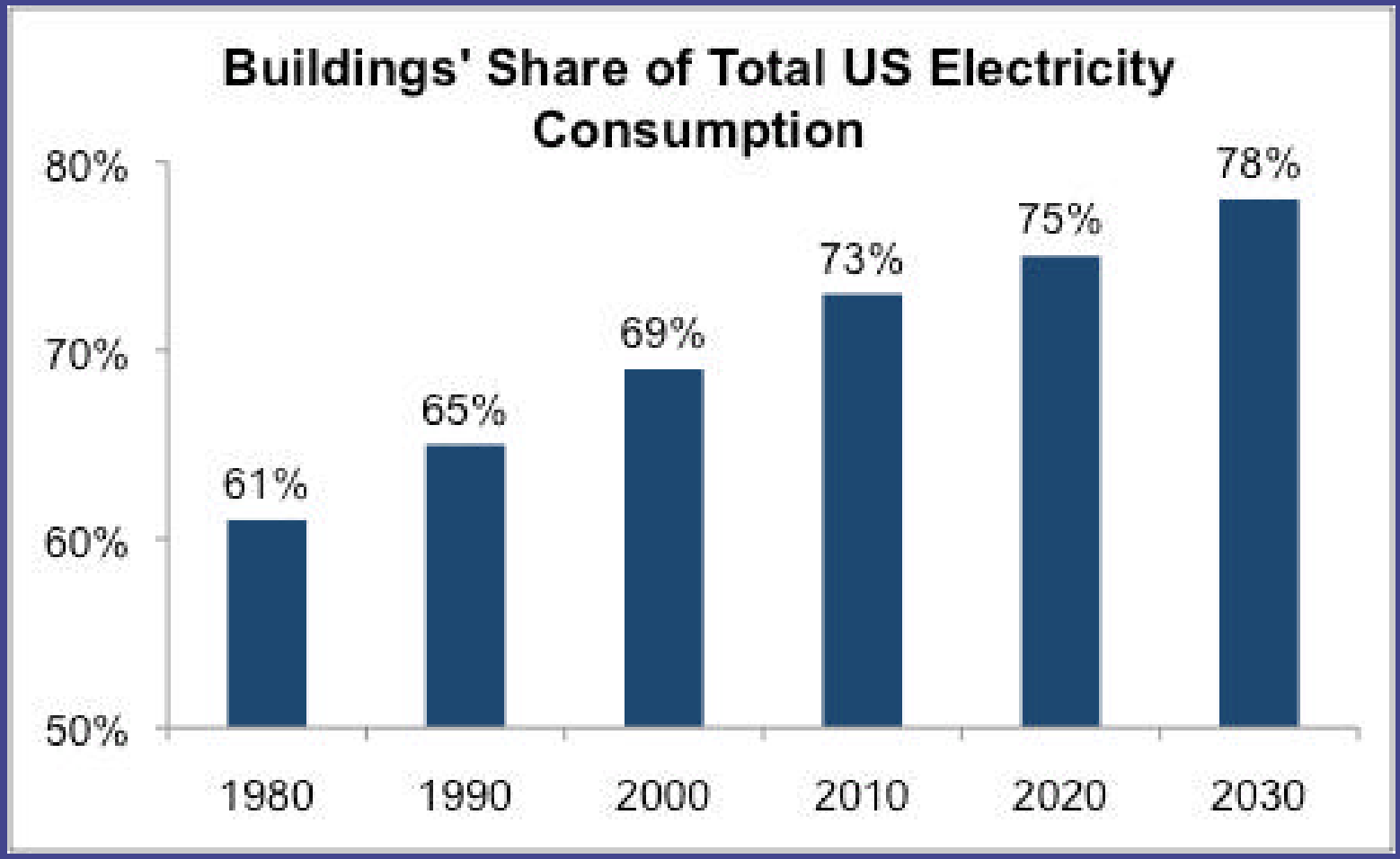
Source: U.S. Green Building Council

Buildings: Consuming Growing Amounts of Energy



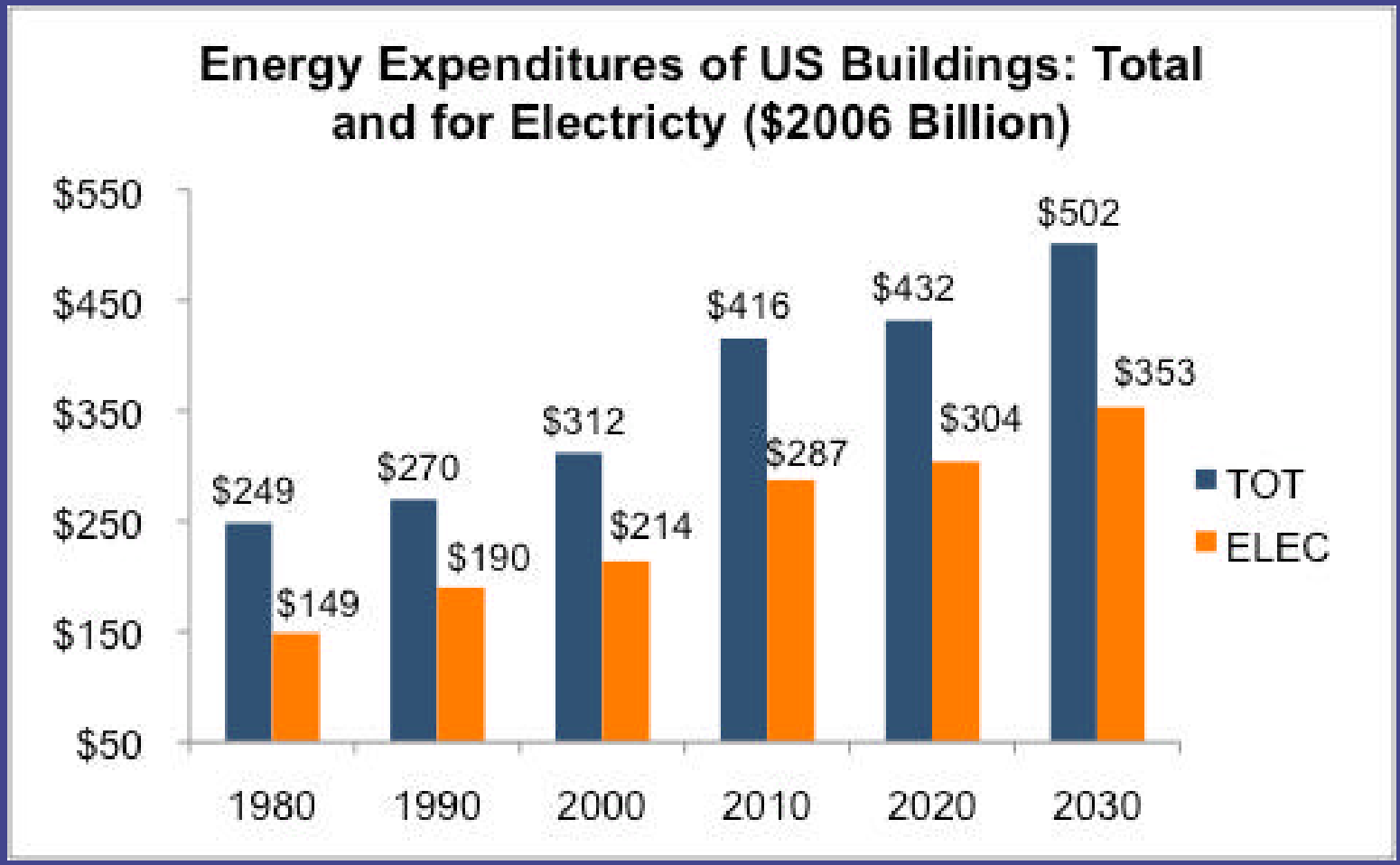
Source: US DOE 2008 Buildings Energy Data Book; Quad = Quadrillion BTUs

Buildings: Using a Growing Share of All Electricity



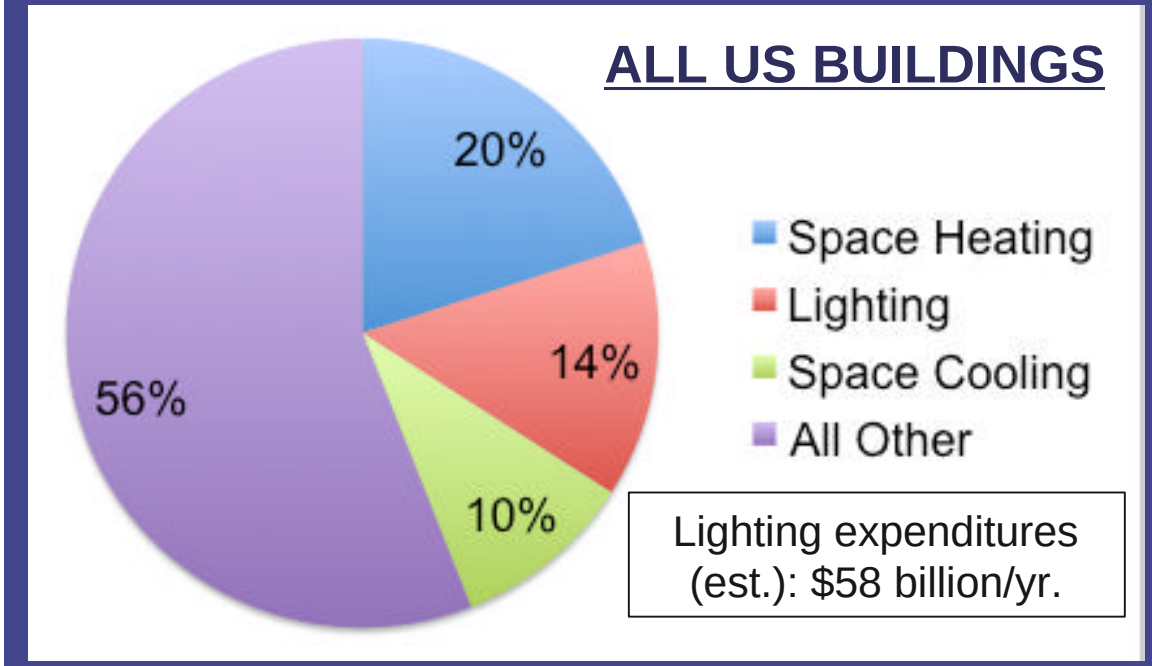
Source: US DOE 2008 Buildings Energy Data Book

Buildings: Rising Energy Expenditures



Source: US DOE 2008 Buildings Energy Data Book

How Energy in Buildings Is Used



USE	COMM	RES
SPACE HEATING	11.0%	27.6%
LIGHTING	18.8%	10.1%
SPACE COOLING	8.4%	11.1%
ALL OTHER	61.8%	51.2%
TOTAL	100.0%	100.0%

1/10th to almost 1/5th of all energy used in US buildings is for lighting.

Source: US DOE 2008 Buildings Energy Data Book (for year 2010)

The Broadening Scope of Green Building

- Energy efficiency
- Occupant well-being
- Environmental stewardship
- Buildings as “smart” systems

Daylighting Plays a Key Role

Photo courtesy of NASA

Daylighting: The Purposeful Introduction of Natural Light

✓	**Energy Savings** • Reduces need for artificial lighting
✓ ✓	**Natural Light in Interior Spaces** • Improves learning rates in schools • Generates higher sales in retail settings
✓ ✓ ✓	**Glare Control** • Increases productivity
✓ ✓ ✓ ✓	**Window View Preservation** • Improves performance of workers

Sample of selected sources for above: a.) California Energy Commission, Daylighting in Schools: Reanalysis Report, 2003, b.) California Energy Commission, Daylight and Retail Sales, 2003, c.) California Energy Commission, Windows and Offices: A Study of Office Worker Performance and the Indoor Environment, 2003.

Features of A Typical Daylight Harvesting System

- **Sensors**
  - Measure a room's illumination, the presence of occupants, and other items
- **Algorithms**
  - Adjust artificial lighting intensity in response to the amount of natural light available to harvest

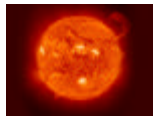
Economic Incentive

Daylight Harvesting
Potential annual savings of 35% to 60% on lighting energy.*

Energy Savings for US Buildings:
An estimated $20-$35 bil/year on lighting energy

* Source: New Buildings Institute as cited by Archi-Tech Magazine, 2008

Consider An Office With These Typical Conditions

CONDITIONS	8A	10A	12N	2P	4P
Availability of Natural Light	Low	↗	**Peak** 	↘	Low
Office Illumination Need	High	High	High	High	High

Comparison of Two Approaches For This Office

1: Conventional

- Windows with static (i.e. non-tunable) dark/reflective tint
- Manually controlled interior blinds

2: SPD-Smart Daylight Harvesting System

- SPD-Smart windows
- Sensor-based advanced control system

Photo courtesy of NASA

Energy Efficiency

1: CONVENTIONAL

	8A	12N	4P
STATUS	Window tinted, blind open	Window tinted, blind status varies	Window tinted, blind open
DAYLIGHT HARVESTED	Low	May be adequate	Low
ARTFICIAL LIGHTING ENERGY NEEDED	High	Moderate	High

2: SPD-SMART DAYLIGHT HARVESTING SYSTEM

✓ ADVANTAGE SPD

	8A	12N	4P
STATUS	Clear	Tinted as needed	Clear
DAYLIGHT HARVESTED	Higher	Higher	Higher
ARTFICIAL LIGHTING ENERGY NEEDED	Lower	Lower	Lower

The SPD-Smart System Also Supports Occupant Well-Being

✓	More natural light in the office space
✓ ✓	Shading with views preserved
✓ ✓ ✓	Glare control with views preserved

✓ ADVANTAGE SPD

Benefits to the SPD-Smart Office

- Energy Savings
  - Lower use of energy for artificial lighting
  - Reduced heat build-up
    - SPD-Smart windows (instant-responding) and artificial lighting can go dark when occupants leave the room or other conditions are met
  - Exceptional management of solar heat gain
    - Reduces heating and and cooling loads
- Occupant Well-Being
- UV Protection: 99%+
- Innovative Designs

SPD Control Systems Corporation (SCSC)

Control Systems and Controllers for Optimum Energy Efficiency

Part II

Advanced Control Systems

Smart Building Window Management Systems

John Petraglia, CEO & President

The Systems Behind the Glass©

Topics

- **Benefits** — SPD-SmartGlass in Buildings
- **Concept to Reality** — Smart Building Window Management System Overview
- **Balancing Act** — Implementing a Smart Building Window Management System
- **NYSERDA Contract** — Prototype Smart Building Window Management System

Glass in Modern Construction

Solar Energy Bombardment Equals Huge Lighting and HVAC Electrical Power Consumption

Imagine

- Energy Conservation
- Daylighting
- Glare Control

The U.S. Energy Department has estimated that rooms with windows that control tint could reduce lighting energy use by up to 60 percent.

Imagine

- Occupant Comfort
- Aesthetics
- Security
- Privacy

Berkley Labs Estimate -
20% Energy Savings
by
Absorbing or Reflecting
Solar Energy

Smart Building Window Management

Small Number of Rooms

Off-the-Shelf Controls

Larger Buildings to Skyscrapers

Smart Building Window Management System for Optimum Energy Efficiency

Examples

- Optimize Daylighting to Reduce Lighting Costs
- Building Façade Tint Control
- Automatic Tint Control
- Room Occupant Manual Control to Override Automatic Operation
- Allow Building Management to Determine Balance of Energy Efficiency, Daylighting and Occupant Comfort
- Use Current Energy Cost to Determine Optimum Energy Efficiency
- iPhones and other handheld devices to control tint

Opportunity Awaits

The real benefit and cost effectiveness of Smart Windows is when multiple goals can be satisfied together:

- Energy Savings
- Security
- Privacy
- Aesthetics
- Daylighting
- Glare Control
- Occupant Comfort

Intelligent Control Systems by SCSC can integrate all of these goals.

Smart Windows are Smarter with Intelligent Control Systems

Concept to Reality

- There are constant dynamic decisions to make that balance energy efficiency, daylighting and occupant comfort. The algorithms are complex to balance these conditions.

- Our Smart Building Management System satisfies a wide range of building energy efficiency and control requirements while providing optimum creature comfort.

Monitor Environmental Conditions

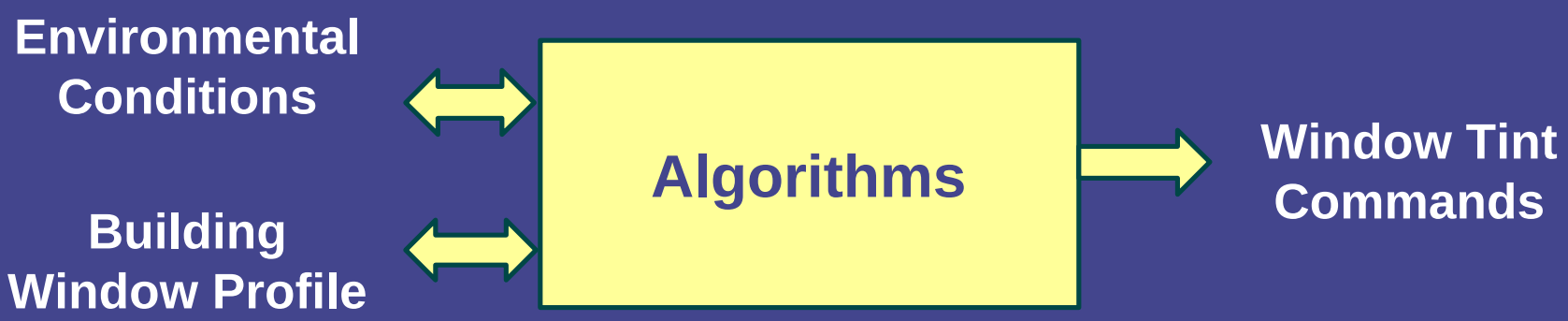
Condition	Source
▪ Light levels	▪ Light Sensors
▪ Room Occupancy	▪ Occupancy Sensor
▪ Time of Day Tint Level	▪ User Defined Tables
▪ Real-time Energy Cost	▪ Energy Company Interface
▪ Sun Position	▪ Sun Transit Calculation

Building Window Profiles

- Building Window Profiles are the requirements for a specific building to balance energy efficiency, occupant comfort, daylighting, glare control, …

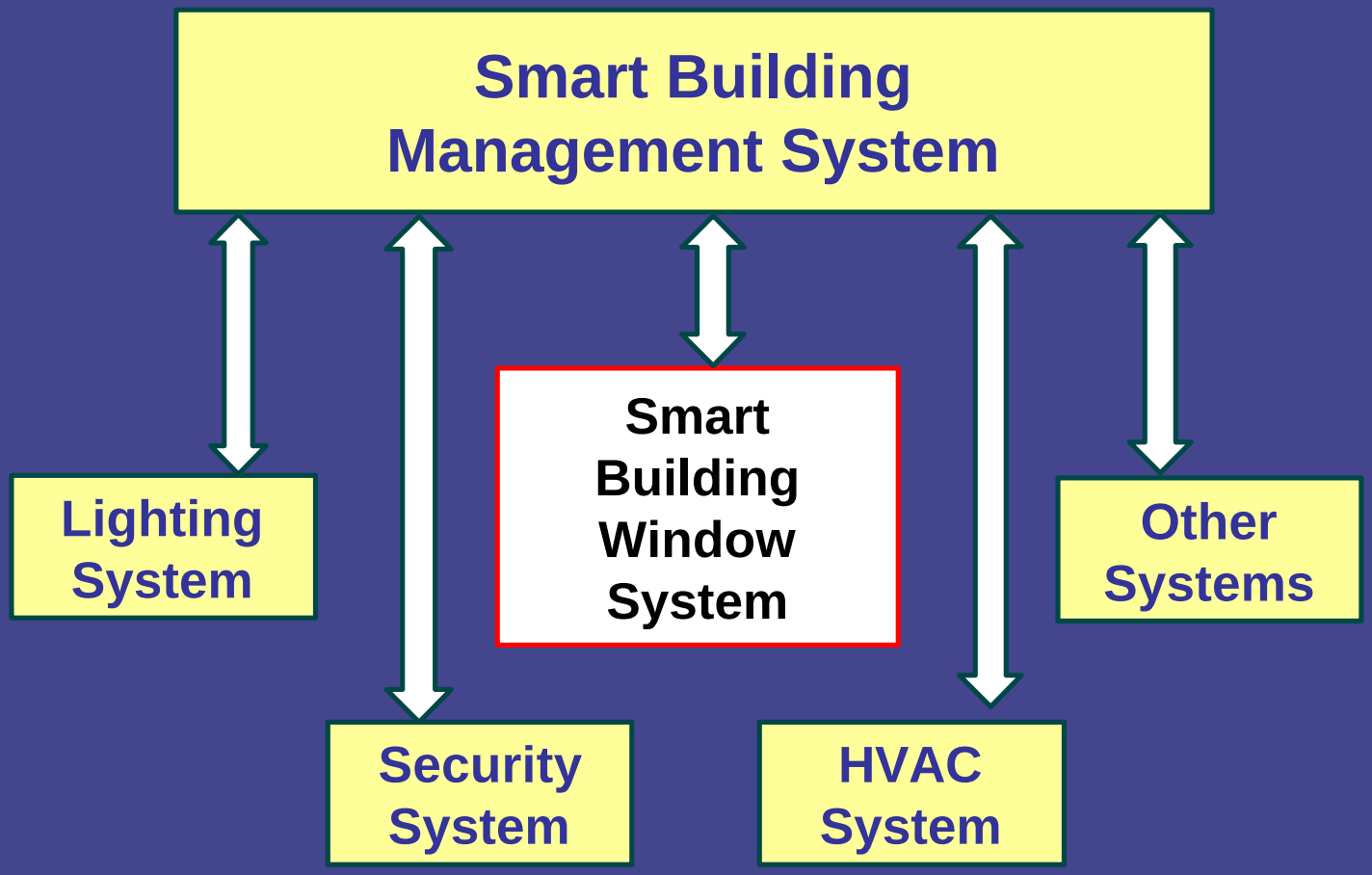
- Energy saving will be different as every Building Management Organization has its own set of requirements (their Building Window Profile) affecting the overall savings.

Algorithms



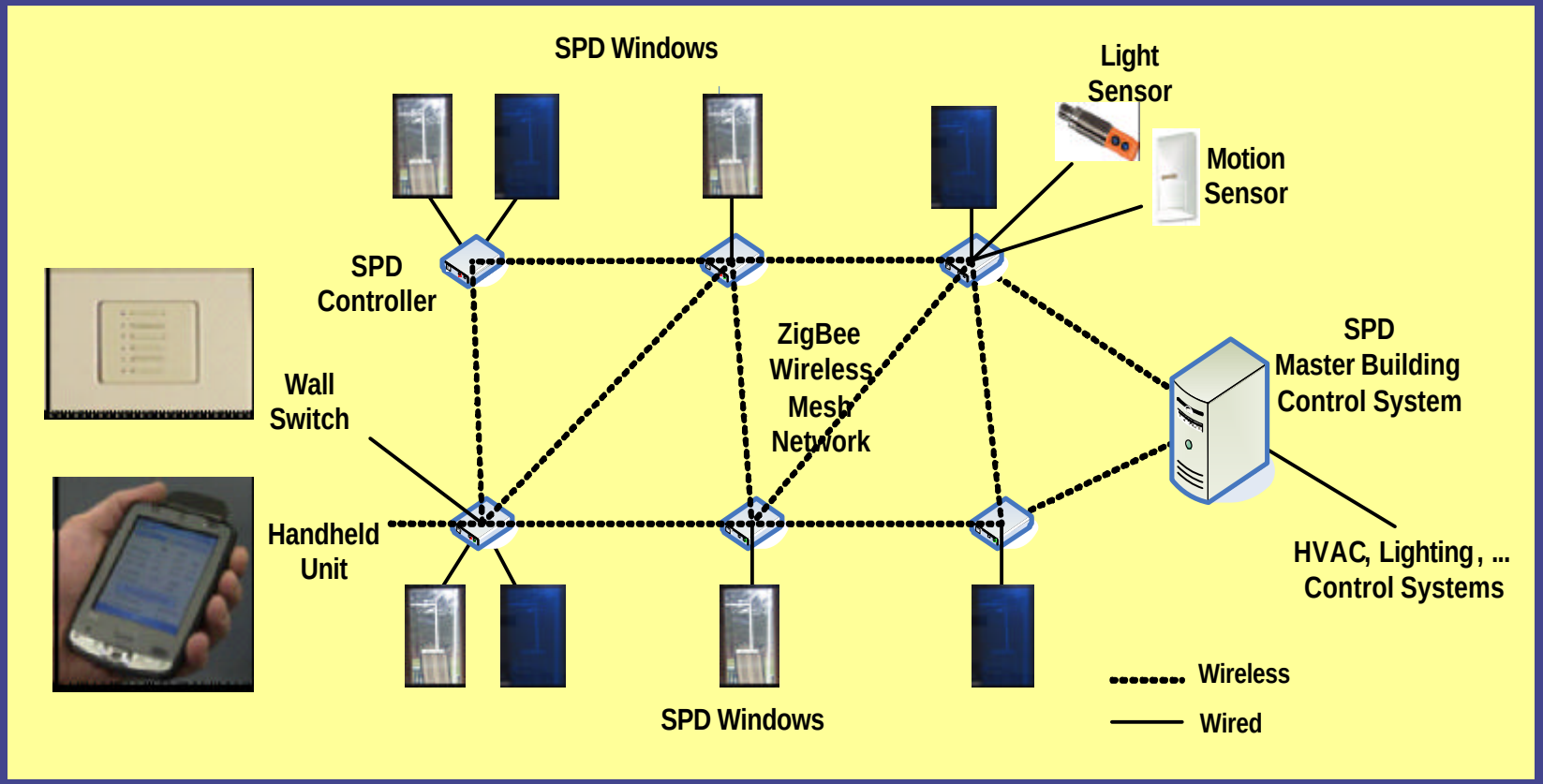
- Determine the combination of SPD-Smart window tint levels that will provide optimal energy performance.
- Our System provides multiple algorithms to optimize energy efficiency based on the building profile.

Smart Building Management System



NYSERDA Contract

Smart Building Window System



Develop and demonstrate a building control system for dynamically controlling the electronically variable tinting of Suspended Particle Device (SPD) SmartGlass windows.

Key Points

- A few rooms may not require a Smart Building Window System. Simple off-the-shelf switches are satisfactory.
- Large scale use of dynamic shading in a building does require an intelligent Building Energy Management System.
- An intelligent Smart Building Window System is needed to effectively balance the diverse energy efficiency requirements of a building.
- Our System provides a platform for developing algorithms to optimize and balance energy efficiency and occupant well-being for different building profiles.

Contact Information

Changing the way you view windows©

SPD Control Systems Corporation (SCSC)
25 Health Sciences Drive
Suite 212B
Stony Brook, NY 11790
631-776-8500 telephone
631-776-8501 fax

Web Site www.spdControlSystems.com
Information information@spdControlSystems.com