Smart Building:
The Building that Learns

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DOWNLOAD slides:

http://ien.com.my/news.html#smartbuildings

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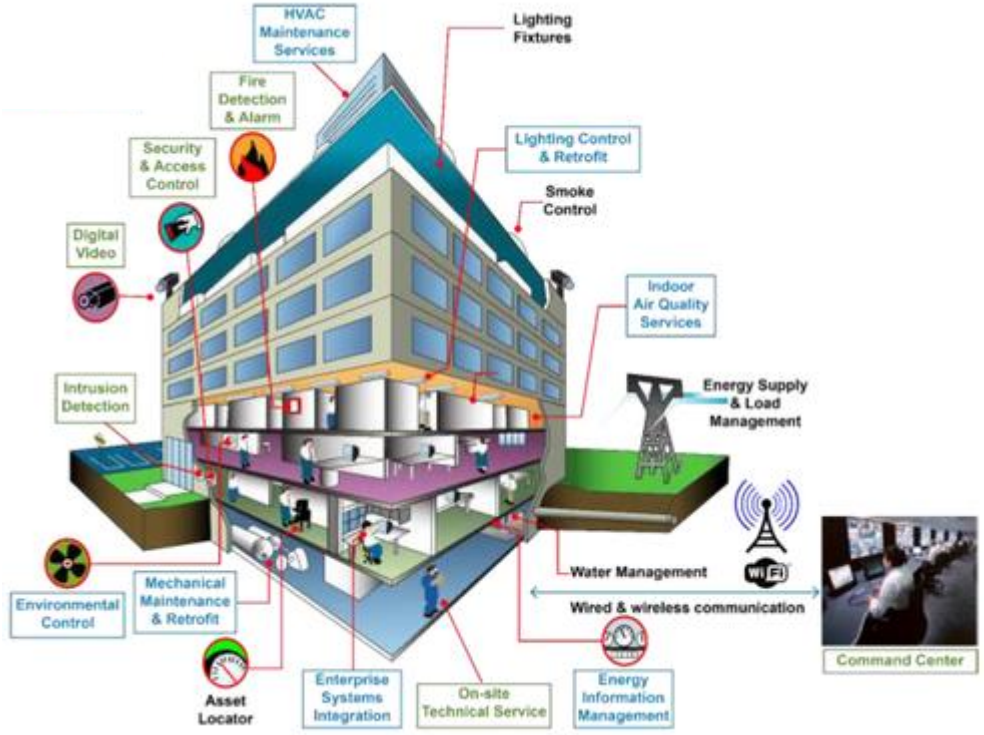
Smart Buildings: What is it?



Sophisticated operation

(needs continous maintenance)

OR

Natural air-conditioning

still works after no maintenance

500+ years, Fatehpur Sikri, India

Smart Buildings can be intimidating.....

Cartoon by: WULFF & MORGENTHALER

Smart Buildings can be intimidating.....

We want an easy solution.

A building that can operate itself!

Cartoon by: WULFF & MORGENTHALER

At least we can agree that we don't want a:
DUMB building

Building in Taiwan

Too hot inside, so the building occupants installed external shading

Surely not the original design intent of the architect!

Definitions

from Cambridge dictionary

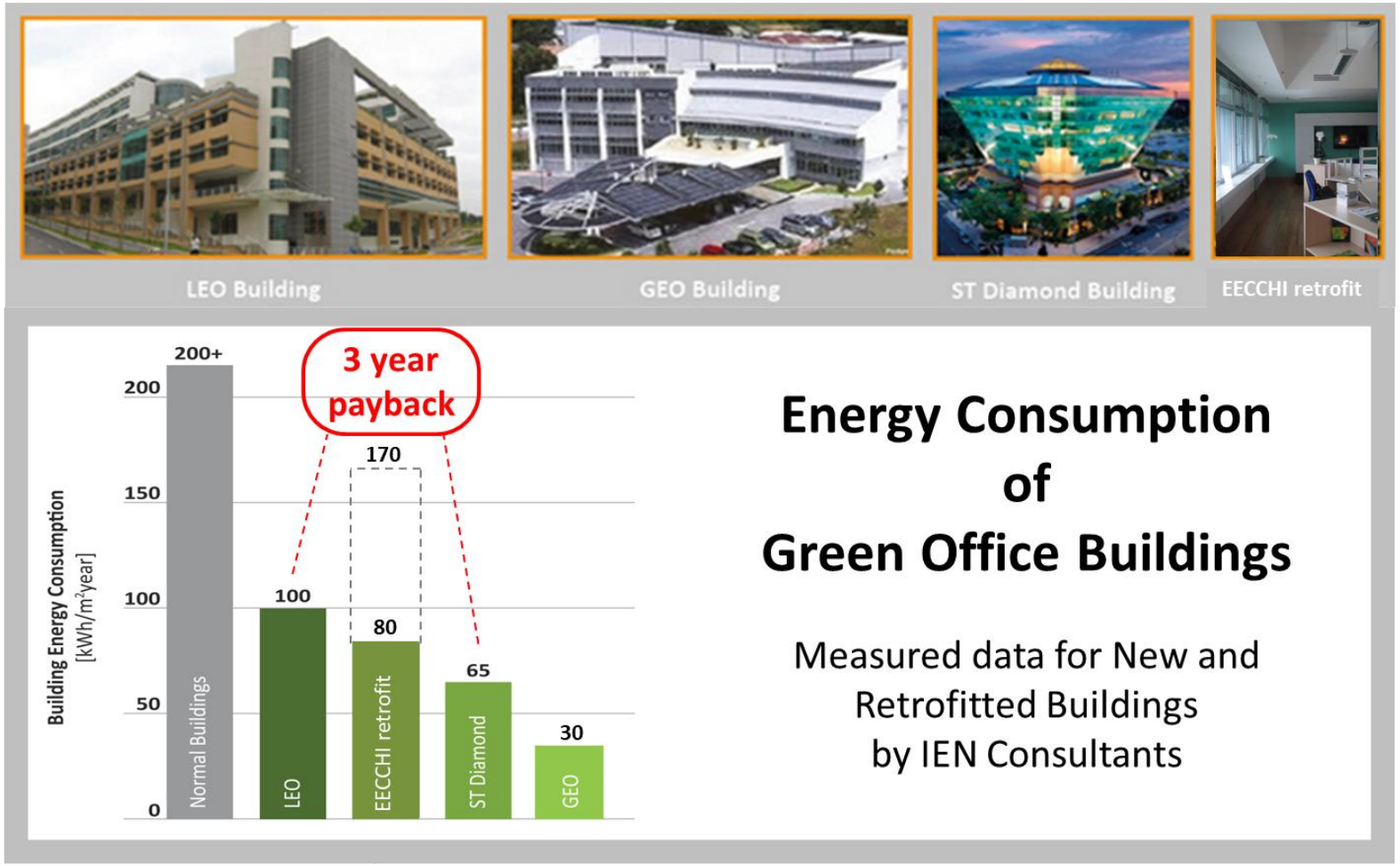
- **SMART**

  Intelligent, or able to think quickly or intelligently in difficult situations

- **LEARN**

  To get knowledge or skill in a new subject or activity

Are Energy Efficient buildings Smart?



To some degree

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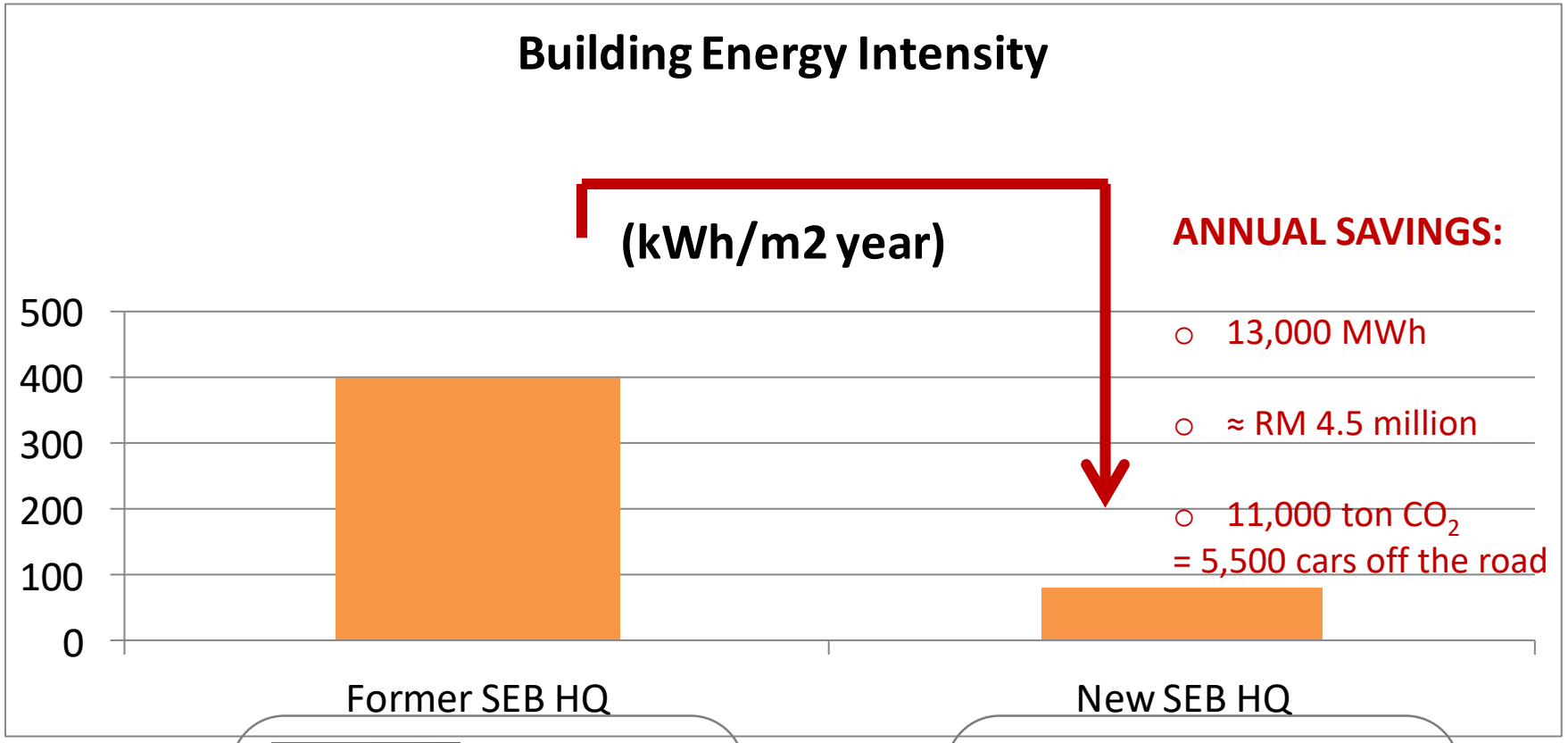
Energy Efficient building. It is smart, but does not learn.



NB. Approximate figure. Energy consumption of Scada subtracted (assumed to be 1/3 of the building's energy bill)

NB. As per measured data June – Dec 2012

Sarawak Energy Berhard building project page: http://ien.com.my/projects/seb.html

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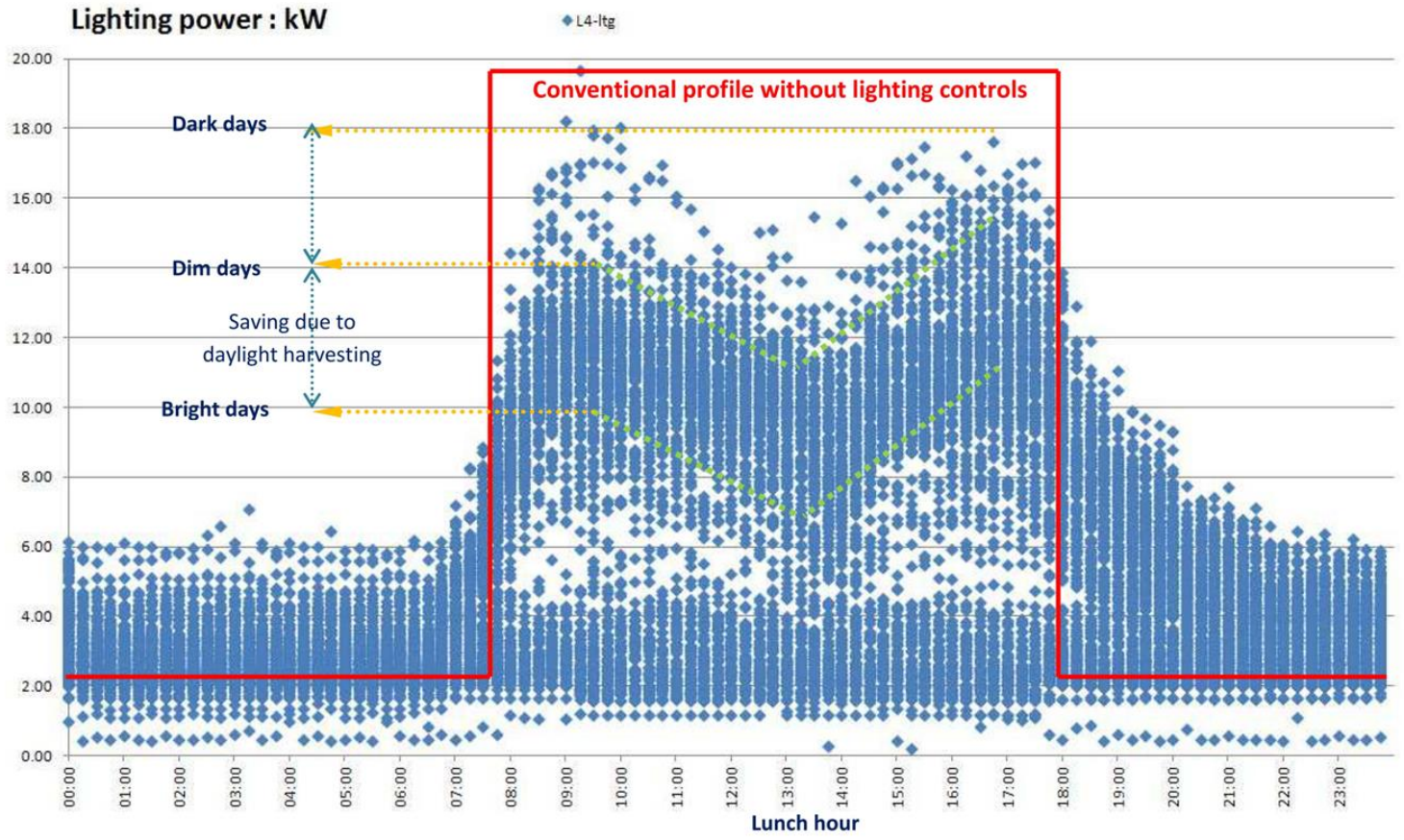
Energy Efficient building. It is smart, but does not learn.

Efficient Lighting Controls Measurements

Impact of daylight sensors and montion sensors clearly seen. Measured consumption (blue dots) clearly lower than red line (if all lights were operating)



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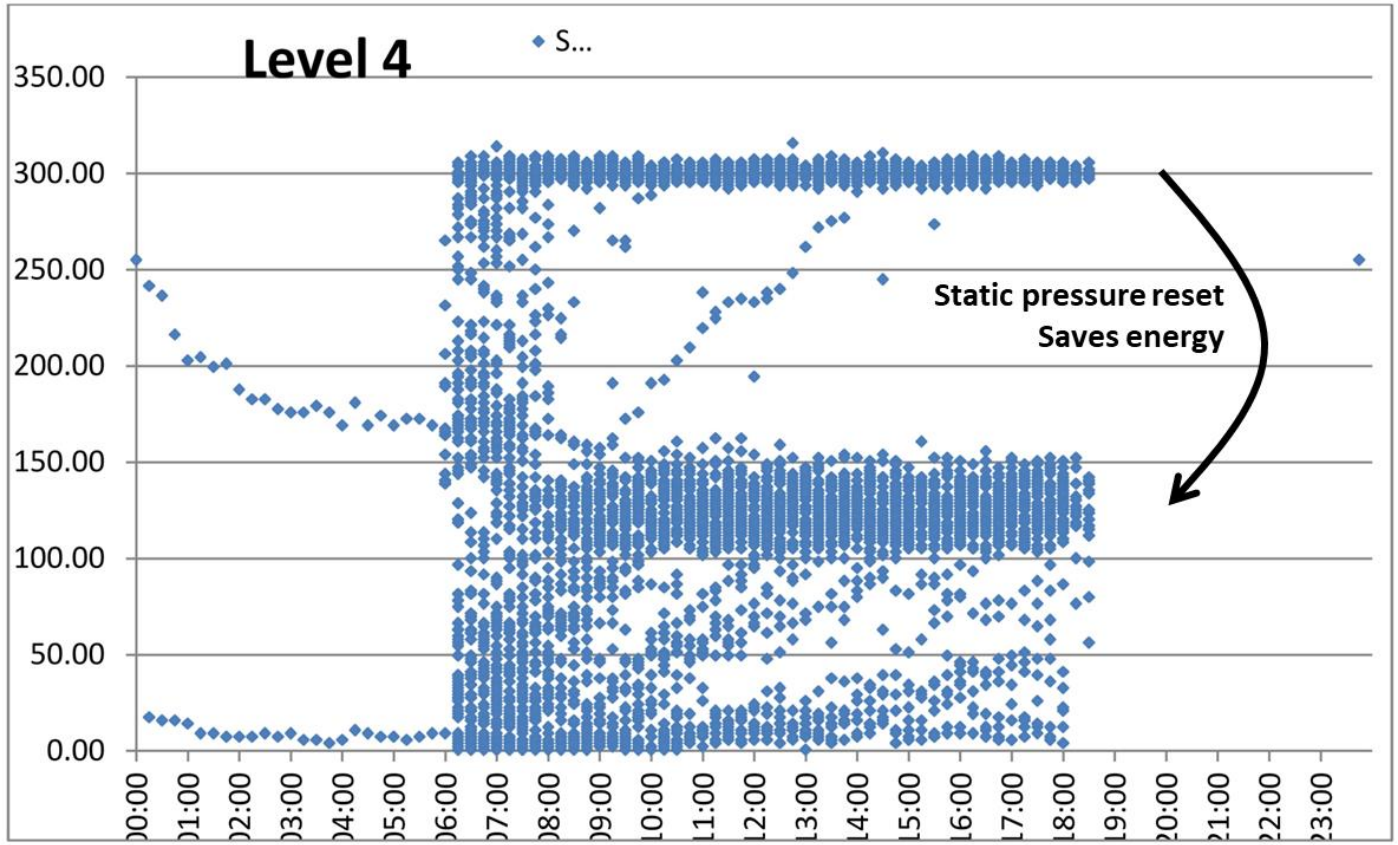
Energy Efficient building. It is smart, but does not learn.

Static Pressure Reset Measurements

Energy savings on fan power for days with low cooling load

"For Level 4, we can see two distinct set points of AHU static pressure (SP). Due to the perculiairy of the seating configuration, the set point is adjusted to 150 Pa during normal day. But it is adjusted to 300 Pa during hot day.



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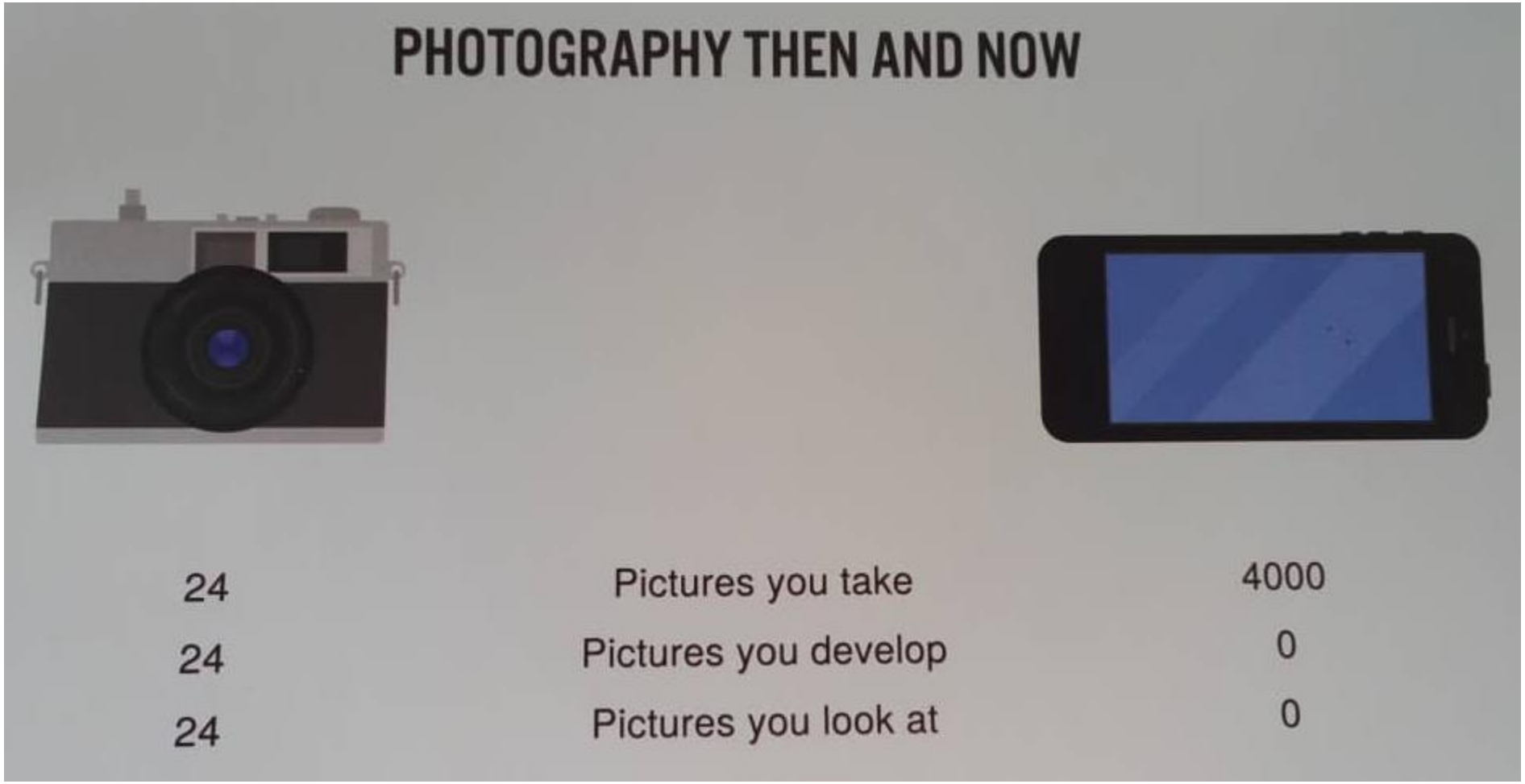
Building Automation for Ordinary Buildings

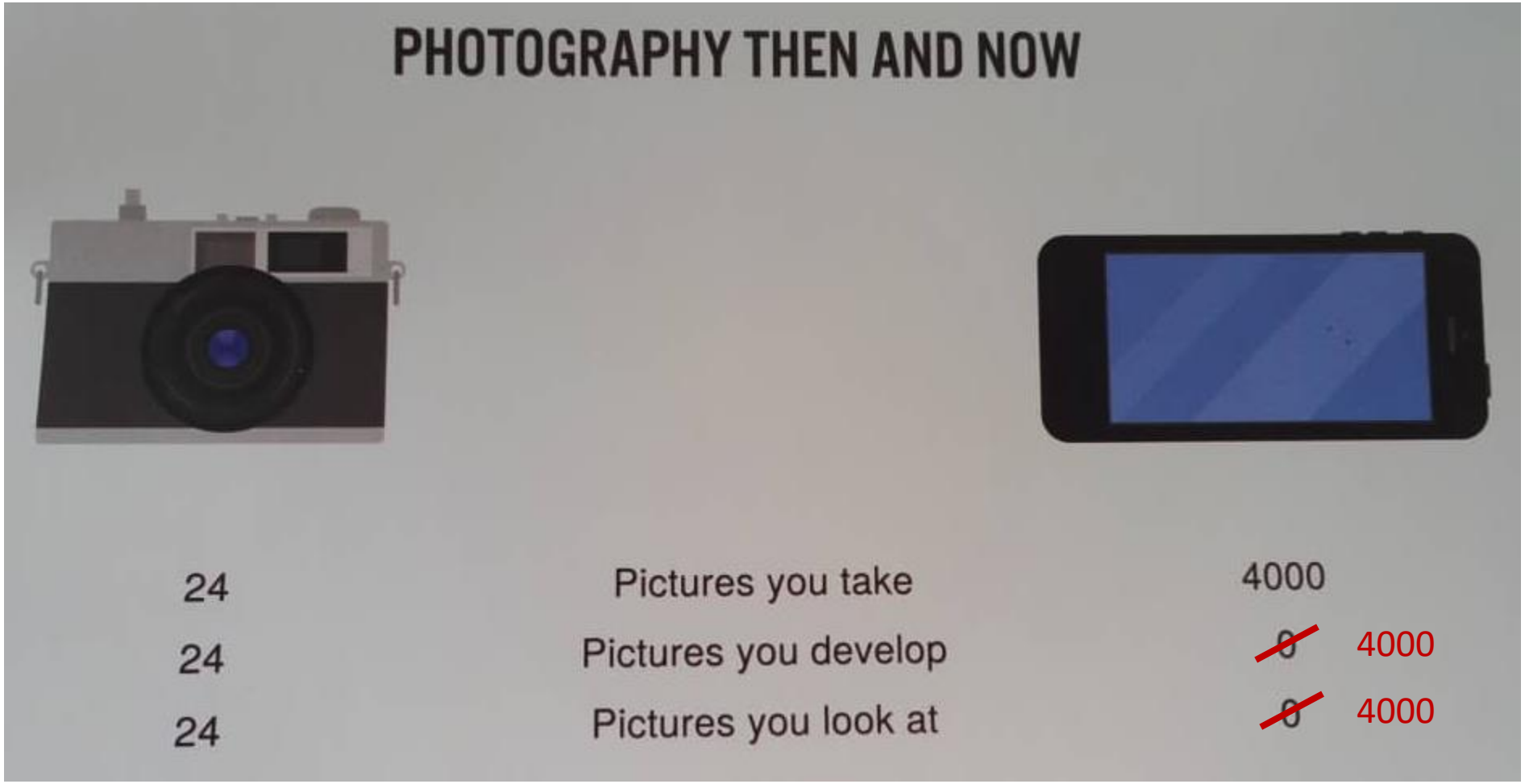


Current situation for many buildings.

Nobody looks at the building management system data. Data is collected and not used!

Cartoon by: WULFF & MORGENTHALER

Building Automation for Smart Buildings



Smart Buildings look at the data for you and respond accordingly.

But do they also learn?

Cartoon by: WULFF & MORGENTHALER

Are Building Occupants Smart?

Not always

Cartoon of a real conversation
I had when explaining my job as Energy Efficiency Consultant

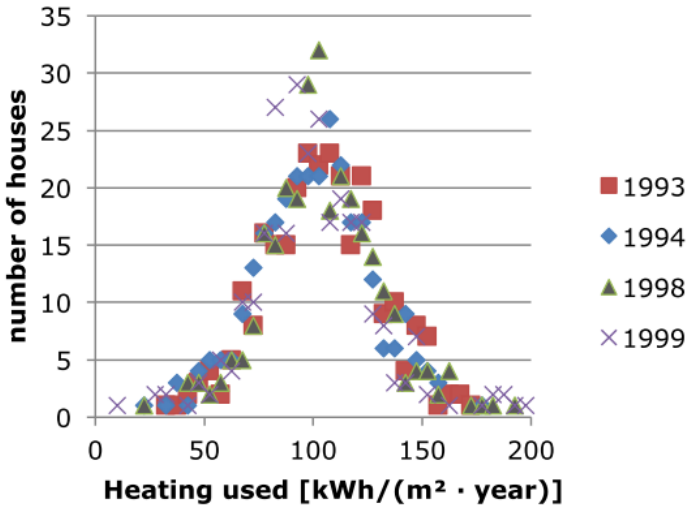
Courtesy of Gregers Reimann/IEN Consultants Sdn Bhd / Illustration by Rachel Chen Ruiqi

The Star newspaper, Malaysia, 16 August 2013

Are Building Occupants Learning?

Energy consumption comparison of 290 identical houses in Denmark

- Factor 20 difference in energy consumption
- No change over time



Slide credit: Bjarne W. Olesen | 2017-2018 ASHRAE President

What motivate people to change habits?

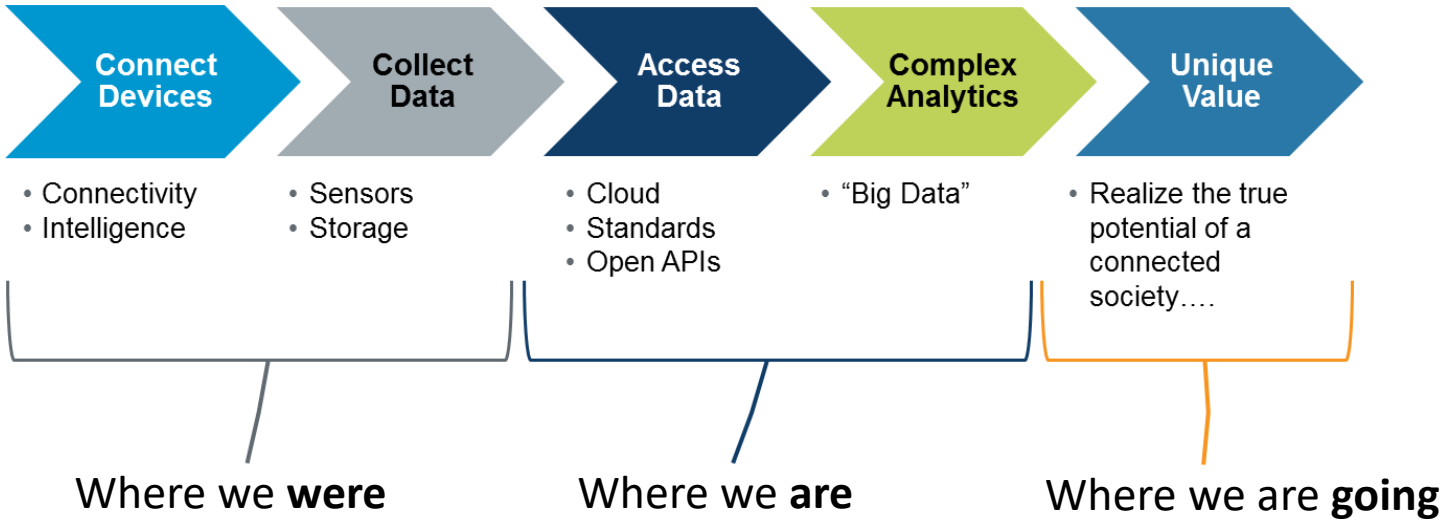
Alex Laskey: How behavioral science can lower your energy bill

96,575 views 1.5K 45 SHARE SAVE ...

Play video: https://youtu.be/4cJ08wOqloc

Understanding behavioral science

The next step for buildings



"The **next leap forward** in the effort to achieve **high performance environmentally friendly buildings** is to **engaging the users** in the operation of the building through **informed decision making**"

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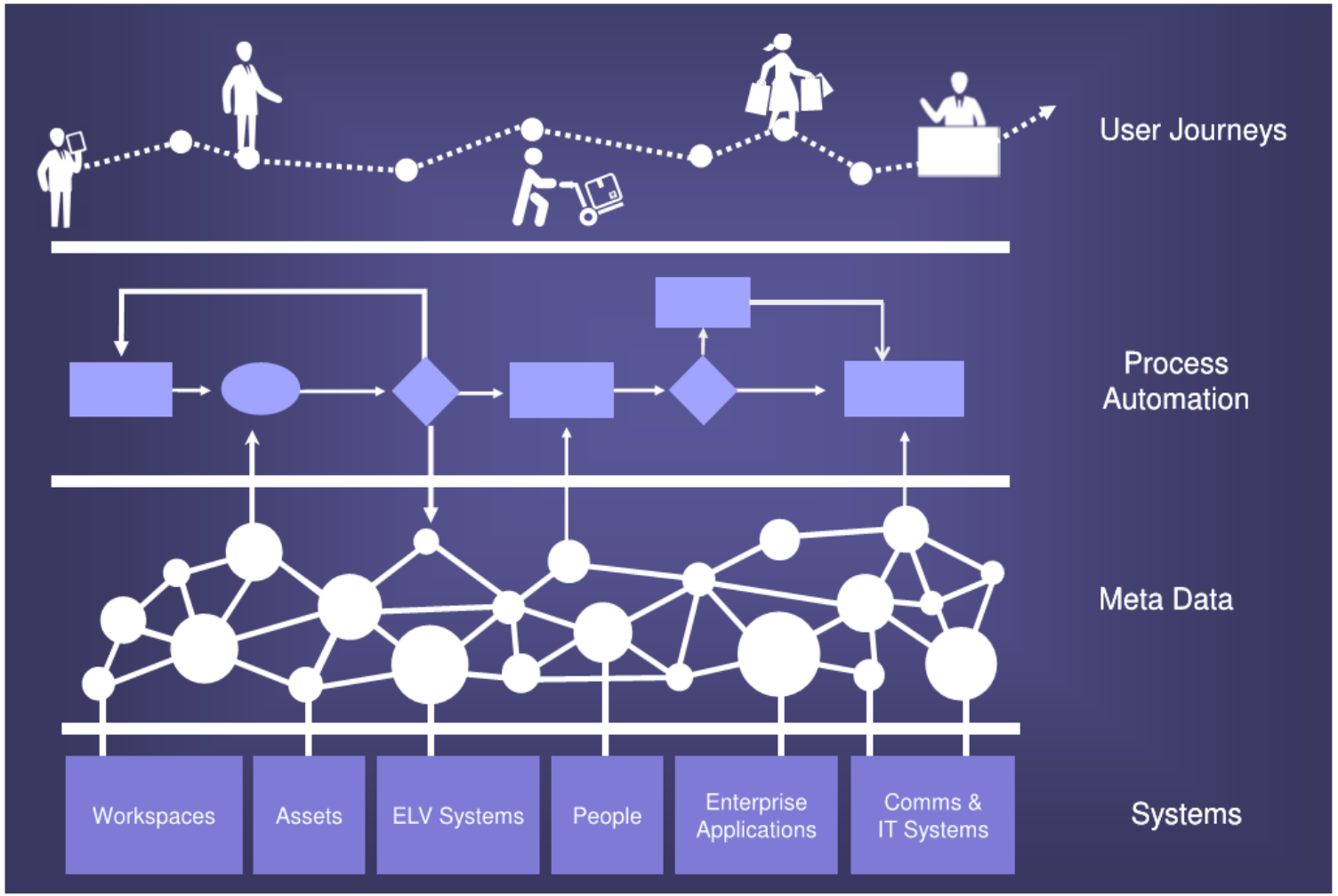
The Vision for Smart Buildings that Learn

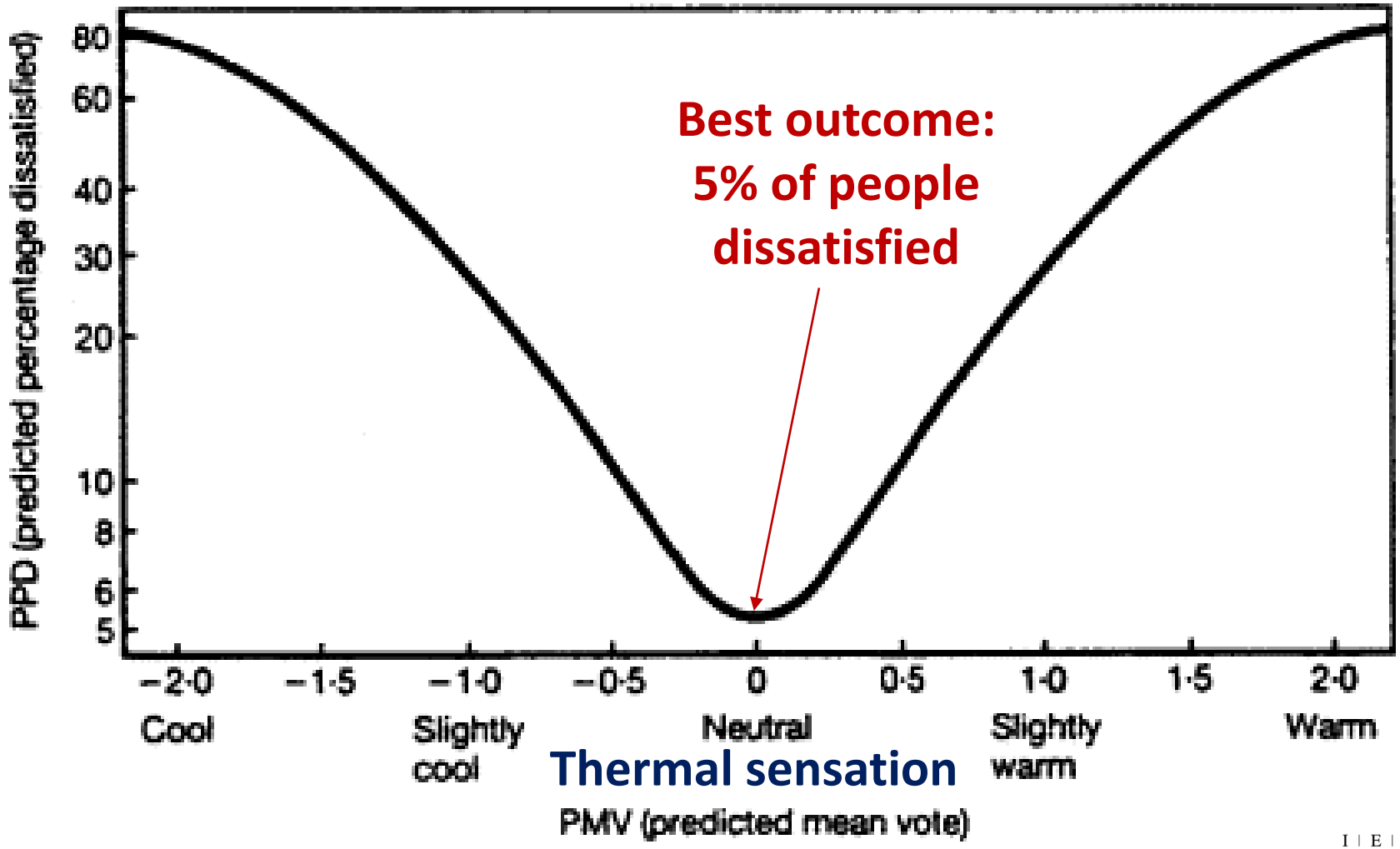


”To develop efficient processes and systems to achieve **satisfying, convenient and seamless** building user journeys throughout the lifecycle of the facility and at the **lowest lifecycle cost**”

Lessons from thermal comfort:

Impossible to make everyone happy with static settings

Thermal discomfort
(% of people)



Lessons from thermal comfort:

Possible to make everyone happy with user adjustable settings

Thermal comfort experiment in Singapore (2018):

79% thermally comfortable
Without control of temperature
Without control of ceiling fan speed

94% thermally comfortable
Without control of temperature
With control of ceiling fan speed

100% thermally comfortable
With control of temperature
With control of ceiling fan speed

Lessons from thermal comfort:

Possible to make everyone happy with user adjustable settings

Wall mounted

Hand held

thermostat control

Next level

Automatic personalized

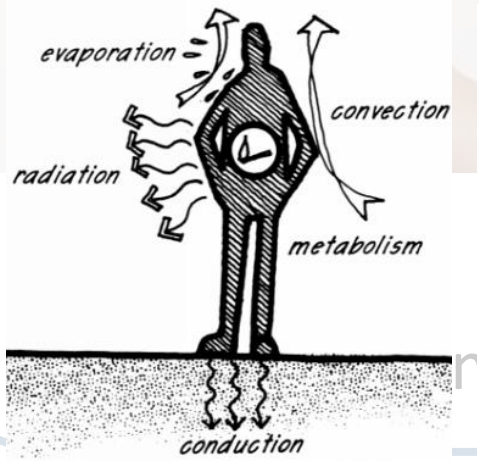
comfort control

Why are real-time body monitoring devices bringing us to the next level of Smart Building?

Buildings that learn

- Smart watches ”know how you feel thermally”, i.e. they already can monitor your metabolic rate (heart rate) your body temperature (from skin temperature) your prespiration level (skin moisture) and how well you slept last night

- Pairing the above information with how you adjust your office environment (thermostat, light dimming, window blinds etc.) enables the building to learn your preferred settings.



Fanger Comfort Equation

$$M - W = (C + R + E_{sk}) + (C_{res} + E_{res})$$

“skin” “breathing”

M = metabolic rate
W = Work
C = Heat transfer by convection from clothing surface
R = Heat transfer by radiation from clothing surface
E_{sk} = Evaporative convective heat exchange
C_{res} = Respiratory convective heat exchange
E_{res} = Respiratory evaporative heat exchange

Next level

Automatic personalized

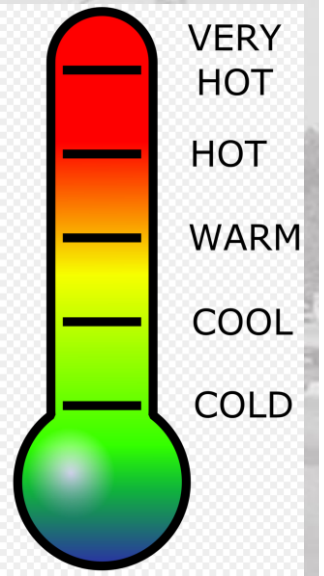
comfort control

Imagine if your Smart Watch connected to the environment around you……

Imagine if your Smart Watch connected to the environment around you……

Thermal comfort

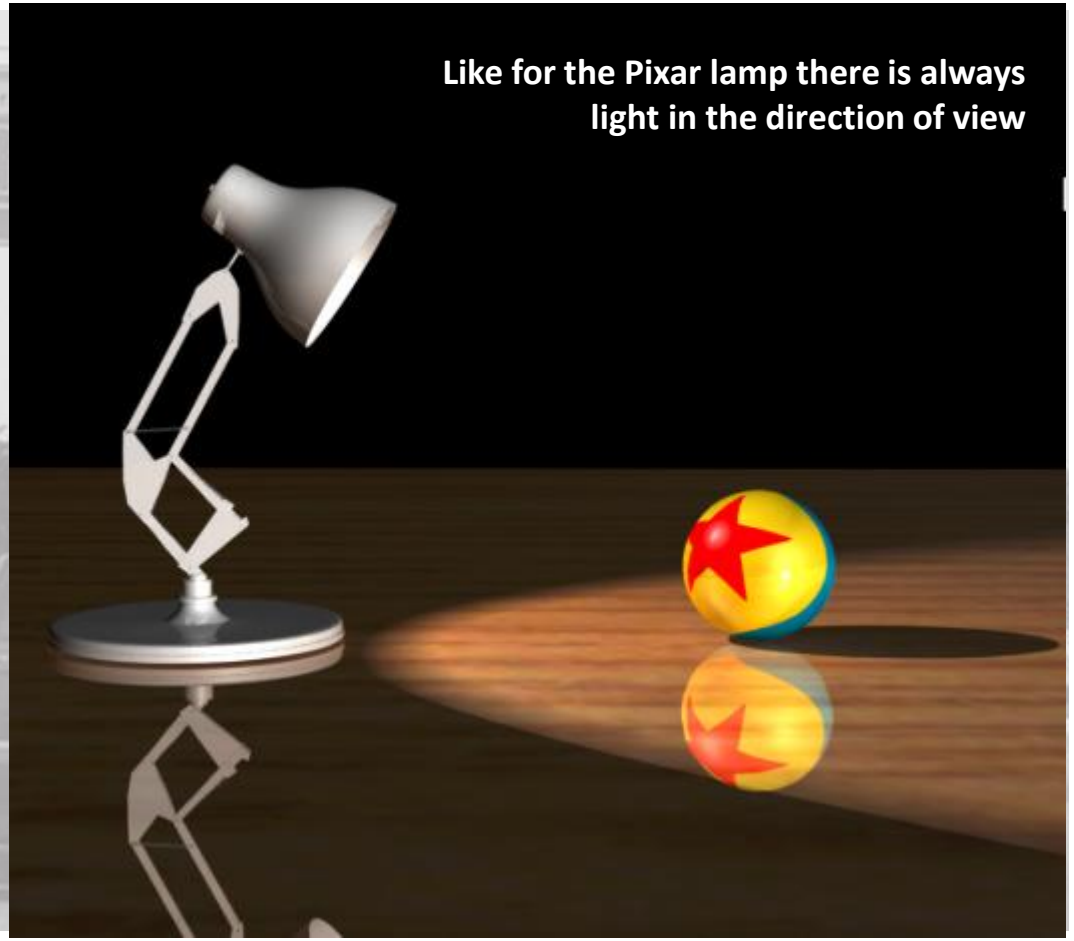
- Your office building knows that you are driving today, not taking public transport, hence, your metabolism will be lower and the temperature at your desk is adjusted accordingly
- Smart lift awaits your arrival, so minimal waiting time in lift lobby
- Final adjustment to your office temperature once in lift based on your metabolic rate, skin temperature and skin moisture readings.
- Outdoor sensor measures sun light intensity and adjust your office blind to your preferred position
- Gradual adjustment to your office temperature as your metabolic rate drops from sedentary office work
- The office meeting room powers up 10 minutes before the scheduled meeting in your online calendar



Imagine if your Smart Watch connected to the environment around you……

Seamless responses by building

- Upon entering the underground car park, the building knows your preferred parking spots and will direct you to your preferred lot that is still available.
- The building can detect your position with an accuracy of 1 meter and will hence be able to swith on lights / ceiling fans shortly before you arrive, say, at the toilet.
- The shared printer will print your document, so it is ready just before you arrive to collect it



Imagine if your Smart Watch connected to the environment around you……

Meals

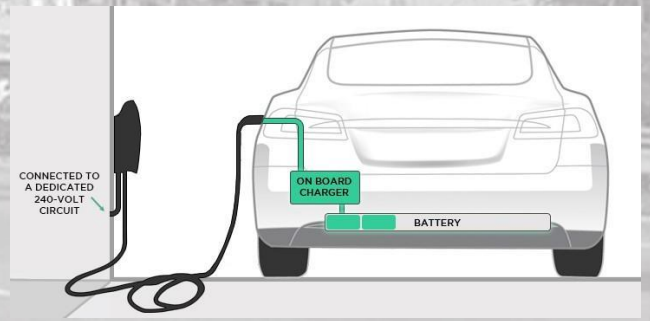
- Based on your vital signs and your habits, your smart watch proposes your preferred choice of drink (say, cafe latte) and when to serve it (e.g. upon arrival of your office). You confirm the order with a touch of a button. Or easily change the order, also via your smart watch
- Same goes for lunch. Once confirmed, a booking will be made at the restaurant, if applicable.
- Toilet sensor will perform health check and alert you if any sickness is detected. And will recommend dinner choice to ensure balanced diet.

Automated room service robot

Imagine if your Smart Watch connected to the environment around you……

Others

- Preventive facilities management
- Automated facade shading system for individual glare control
- Building flushing with outside air depending on weather forecast and air quality forecast
- Energy storage/export/production depending on current and forecasted electric grid pricing / penalties.
- Hot-desk assignment and optimization
-



Electric car charging cost optimization

Dynamic Facades in a Smart Building

1. Electrochromic Glazing

2. Real-time Glare Measurements for Dynamic Facades

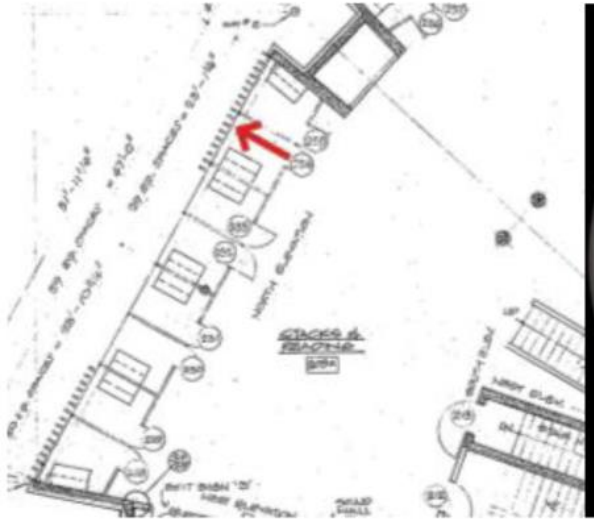
3. Real-time Thermal comfort in facade perimeter zone

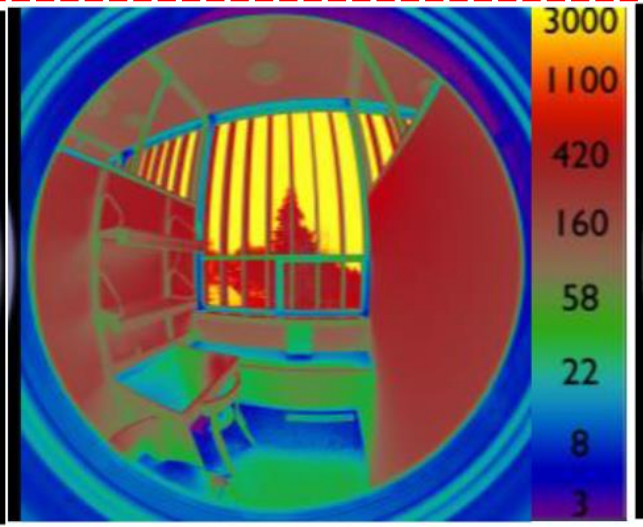
Dynamic Facades to Control What?

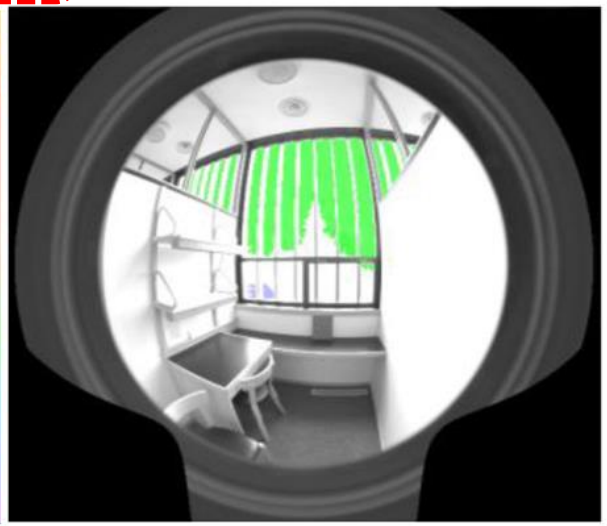
The key to daylighting is avoiding glare

Control what?	Using what sensor?	State of technology
HEAT	Irradiance (W/m^2)	Established
DAYLIGHT	Light (lux)	Established
GLARE	HDR camera	**NEW**

HDR
camera



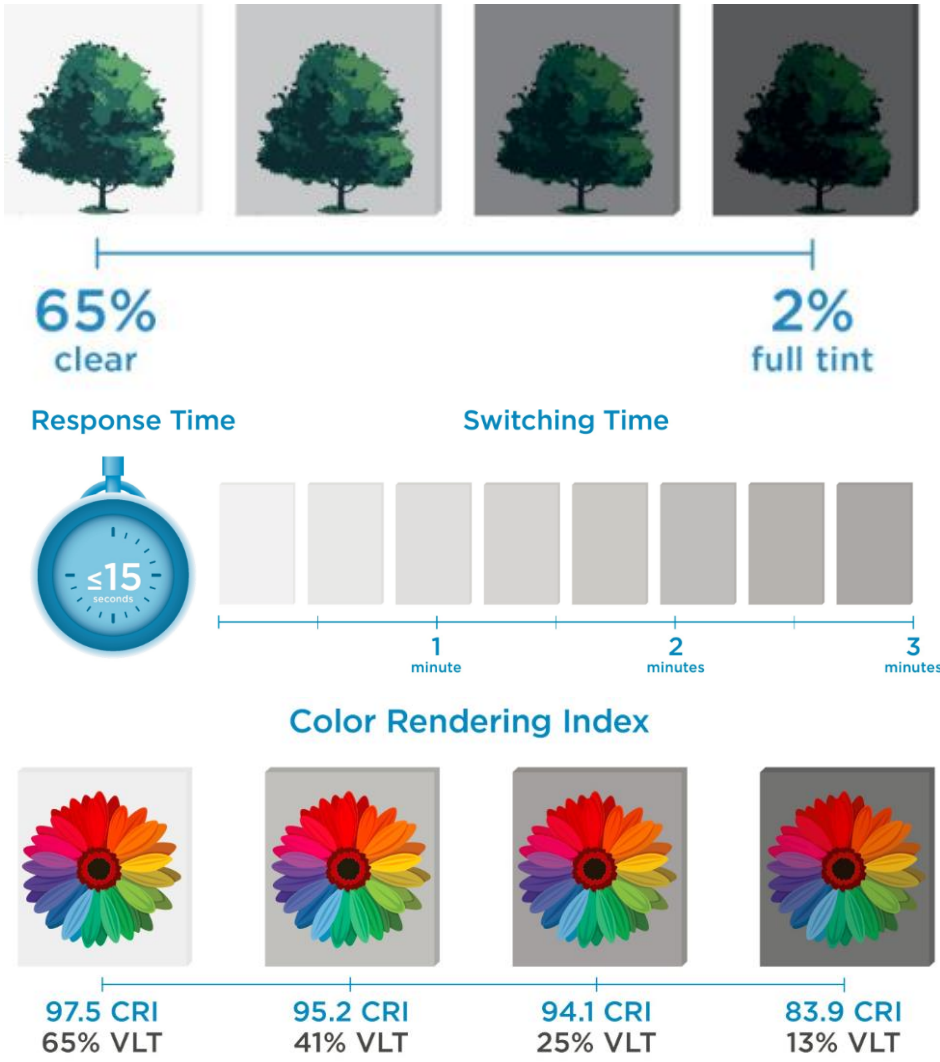




Controlling daylight and glare

without annoying the building occupants, i.e. should not be noticable

Technology	How?	Noticable to Occupants?
Automated shading (venetian blinds)	• Rotate slats • Blind moves up/down	• No • Yes
Automated shading (roller blinds)	• Blind moves up/down	• Yes
Electrochromic Glazing	• Tint varies	• No

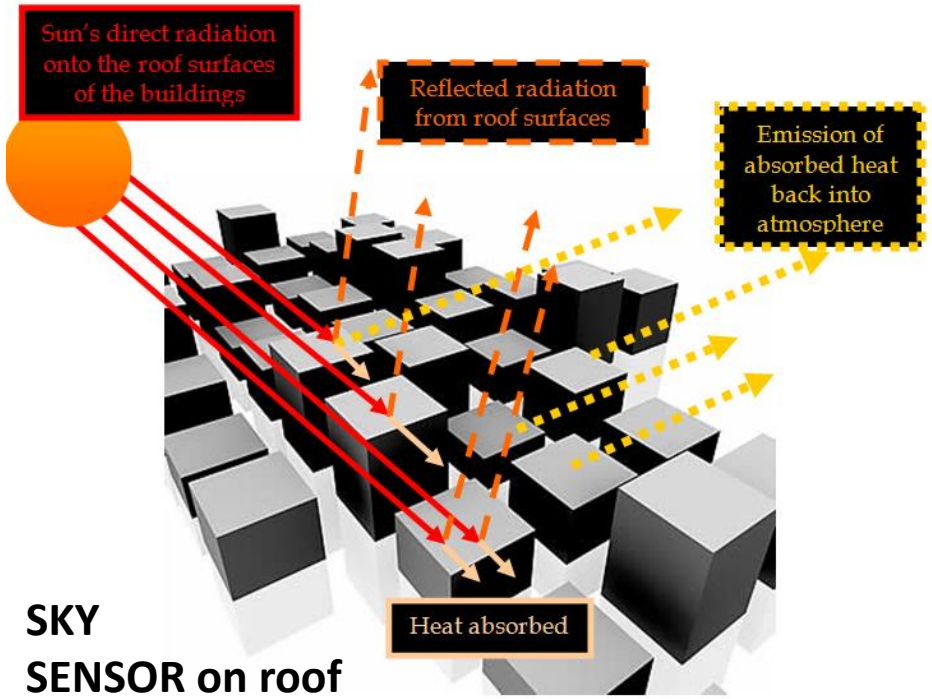


Controlling daylight and glare

without annoying the building occupants, who don't like cameras everywhere

HDR
camera

vs.



SKY
SENSOR on roof

PREFERRED

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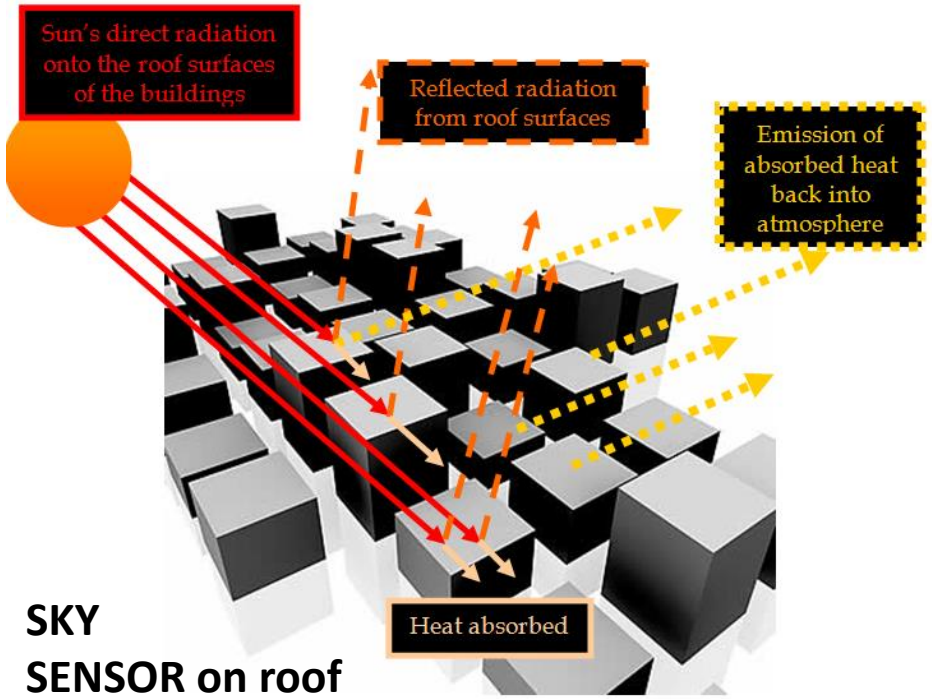
Controlling daylight and glare

without annoying the building occupants, who don't like cameras everywhere

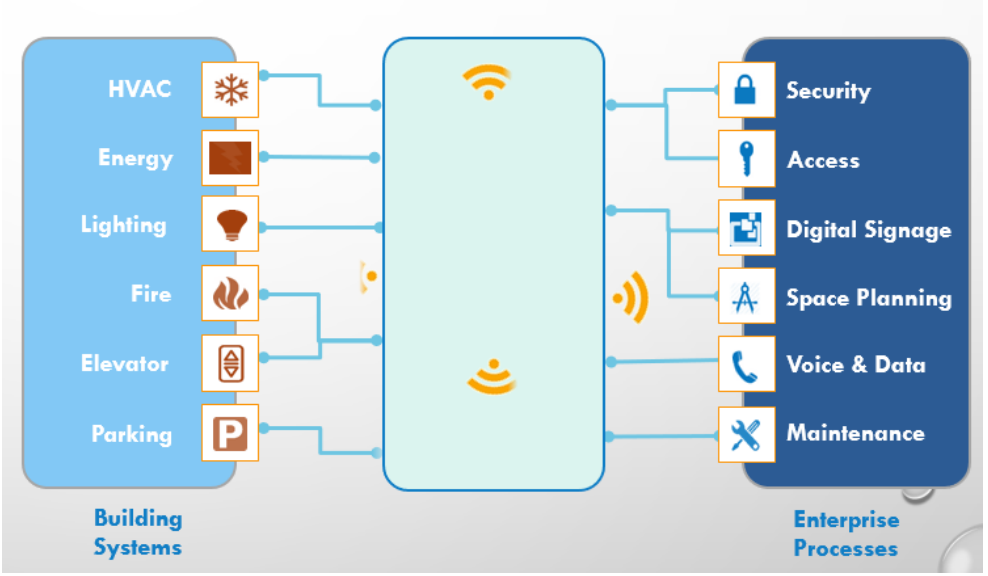
Real time computer simulation of glare

- Window blinds are adjusted in accordance with individual glare tresholds for all the occupants.
- If users override the blind setting, the system takes note and **learns** for next time around.



In conclusion for Smart Buildings that Learn

1. They collect / simulate / forecast operational data
2. They automatically adjust to occupant preferences, who might even wear biometric devices (like smart watches)
3. When users override the building settings, the building takes note (aka learns)
4. Manual override always possible, but as the building learns, it becomes more and more seamless in its operation to achieve the operational objectives (comfort, low operating cost etc.)



Interconnecting all building systems

Slide credit: Optergy Sdn Bhd

The future for smart buildings that learn:

Like a self-driving car!

THANK YOU

Any questions?