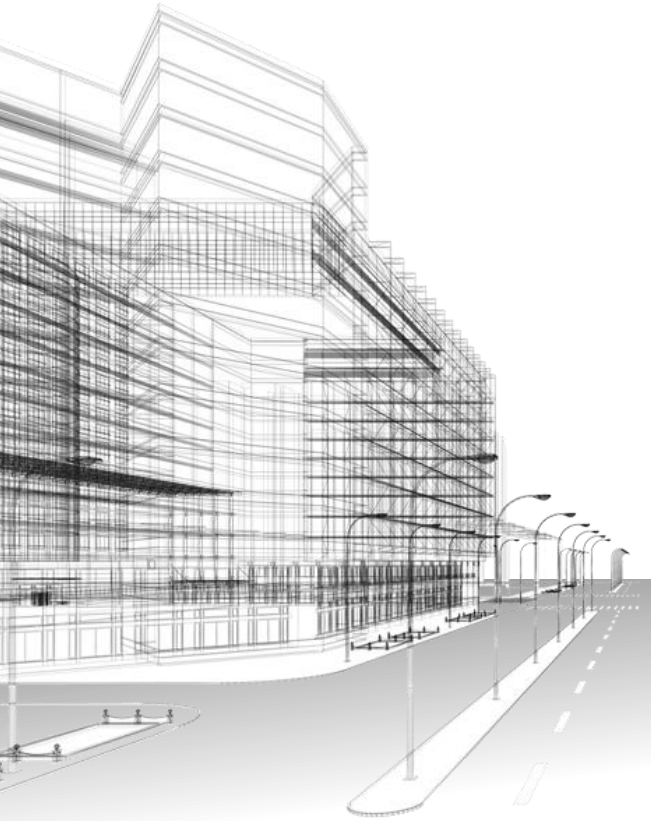

Interdisciplinary approach for energy management in office buildings: Energy Optimisation Model.

Maciej Czajka
Sr Technical Manager

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PhD, Faculty of Economic Sciences

Anglet (F), June 29-July 01, 2016

SUSTAINABLE PLACES 2016 June 29-July 1, 2016 Anglet, France

Abstract

Trend (UK) is a leader of networked building controls focused on energy savings (BeMS). Beginning from simple solutions as self-reseting setpoints through optimized start-stop algorithms up to model based energy optimizer Trend tries to keep the comfort conditions and human's satisfaction on high levels decreasing energy use in a background. The latest solution that is still in beta phase gives absolutely positive feedback and helps to reduce cost, energy or CO2 emission in new buildings and old ones. The more points of installations are monitored/controlled the more energy can be saved. The model collects data about ambient and installation parameters, checks energy demands and estimates the best adjustments for main "energy consumers" in a building, e.g. chillers, boilers, AHUs. The positive action of the optimizer can be seen through a simple day-after-day switching strategy that changes user's adjustments to calculated ones and vice-versa.

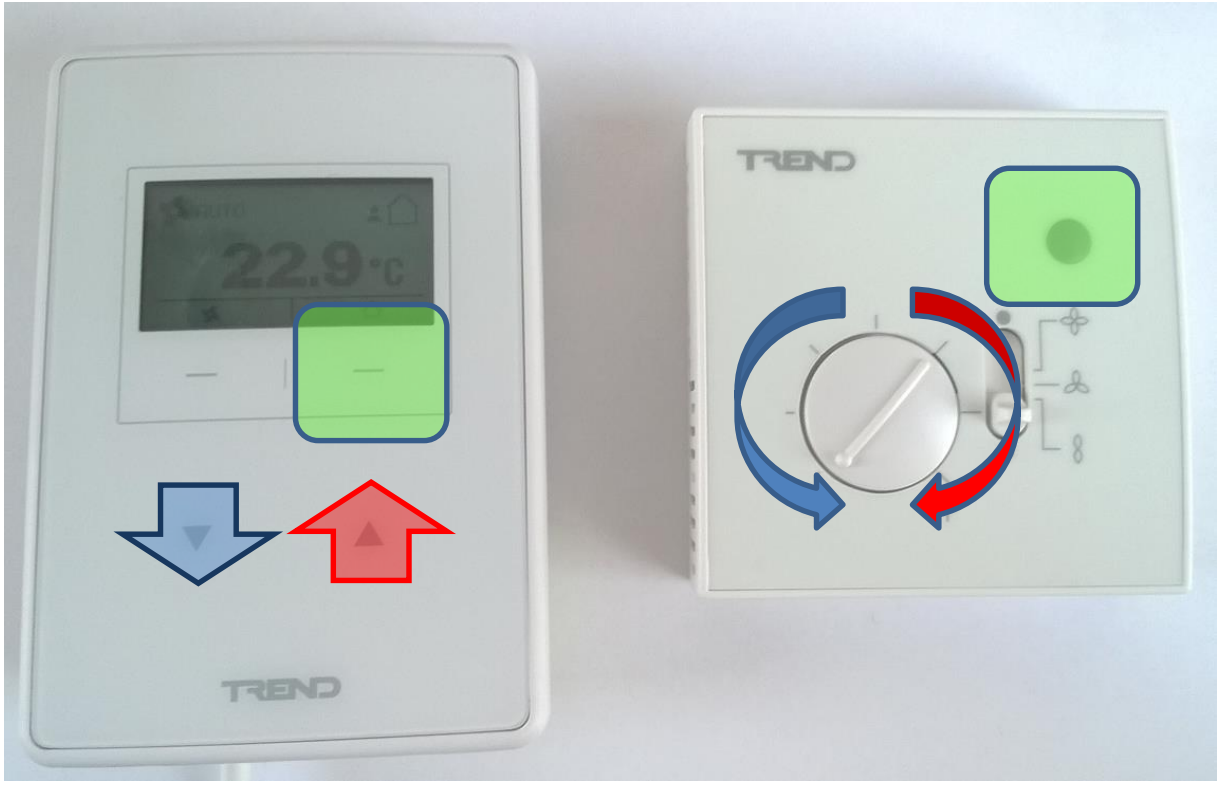
Despite technology development and wide plans to deploy smart metering in office buildings, there is still little knowledge of occupant energy use in offices. The objectives of the presentation is to investigate the effect of individual feedback on energy use at the workplace, and to show the relationship between occupant behavior, Facility Management strategy and building technology. Office energy use is influenced by variety of factors, some within the control of BeMS, while others are perhaps beyond the control. Our presentation is based partly on "Energy Cultures" framework presented by Stephenson et al.'s (2010), where he suggests that energy consumption behavior results from interactions between cognitive norms, material culture and energy practices." In the presentation we would like to show that Facility Management strategy driven by technological change would be more rational way to obtain minimal energy use in office building than implementation of pure energy-saving technology. Solving this problem actors must take interdisciplinary viewpoints (real estate, space management, finance, energy market, occupant behaviours, organizational behaviour, building technology). We would like to show how modern technology helps to overcome organization's unwillingness to consider changes to their energy behaviours and helps Facility Managers to do it properly. Energy management in office buildings is very important part of Facility Managers strategy. Presentation discusses the importance of adopting an integrated interdisciplinary approach. The need for a wide range of factors is initially required including occupants behaviours and their comfort zones, organizational primary processes, cost/benefit solutions etc. and all influence Facility Management practice. We would like to show that integrated energy management of an office buildings is necessary to use technical capabilities most effectively. The proposed Integrated Energy Management Model for Facilities Managers provides insight into the assessment of parameters that affect energy use, but also maintenance costs, organizational performance and risk in facilities. This model helps to create an energy strategy that addresses financial obligations and affords scalability for the future.

Agenda

- Why the BeMS?
- Building installations and BeMS
- Facts & results
- Energy cultures framework
- Energy optimisation methods & case studies
- Energy Clusters
- Central Energy Optimizer
- The Next Step

Trial introduction

- 4 participants (alone or in a small group), active participation in the trial
- Non-personalized results at the end of the presentation



Why The BeMS?

DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 19 May 2010

on the energy performance of buildings

(recast)

(3) Buildings account for 40 % of total energy consumption in the Union. The sector is expanding, which is bound to increase its energy consumption. Therefore, reduction of energy consumption and the use of energy from renewable sources in the buildings sector constitute important measures needed to reduce the Union's energy dependency and greenhouse gas emissions.

…their heating, cooling & lighting systems are responsible for ca. 25% of global CO2 emissions…

FROST & SULLIVAN

Ponad 40% światowego zużycia energii generują budynki – ich systemy ogrzewania, chłodzenia i oświetlenia odpowiadają za ok. 25% globalnych emisji CO_2. Co więcej, każdego dnia powstają nowe energochłonne budynki, a miliony już istniejących obecnie będą funkcjonować przez najbliższe kilkadziesiąt lat.

„Inteligent Energy", report by F&S, 2010

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Why The BeMS?

Table 6. Electricity consumption by end use, 2012

	Total electricity consumption (trillion Btu = ca 293 GWh)											
	Total	%	Space heating	Cooling	Ventilation	Water heating	Lighting	Cooking	Refrigeration	Office equipment	Computers	Other
Principal building activity												
Education	458	9	10	90	68	3	78	4	40	21	78	66
Food sales	208	4	2	6	12	0	16	10	147			
Food service	279	5	5	30	31	3	19	46	114			
Health care	365	7	4	69	82	1	61	8	19			
Inpatient	251	5	2	58	46	1	40	7	14			
Outpatient	114	2	2	11	37	0	21	1	4			
Lodging	304	6	8	39	49	3	40	10	33			
Mercantile	[illegible]	13	13	91	121	7	140	6	191			
Retail (other than mall)	281	[illegible]	5	40	47	1	72	2	53			
Enclosed and strip malls	424	8	8	52	75	7	68	4	139			
Office	865	16	19	116	214	2	148	2	28			
Public assembly	275	[illegible]	9	82	24	0	35	4	25			
Public order and safety	[illegible]	1	1	15	5	1	15	1	3			
Religious worship	81	2	3	15	13	0	9	1	4			
Service	127	2	3	16	14	0	37	0	5			
Warehouse and storage	284	5	4	34	13	1	85	0	47			
Other	191	4	3	26	16	0	37	0	15			
Vacant	26	0	1	2	4	0	5	Q	1			

Independent Statistics & Analysis
U.S. Energy Information Administration

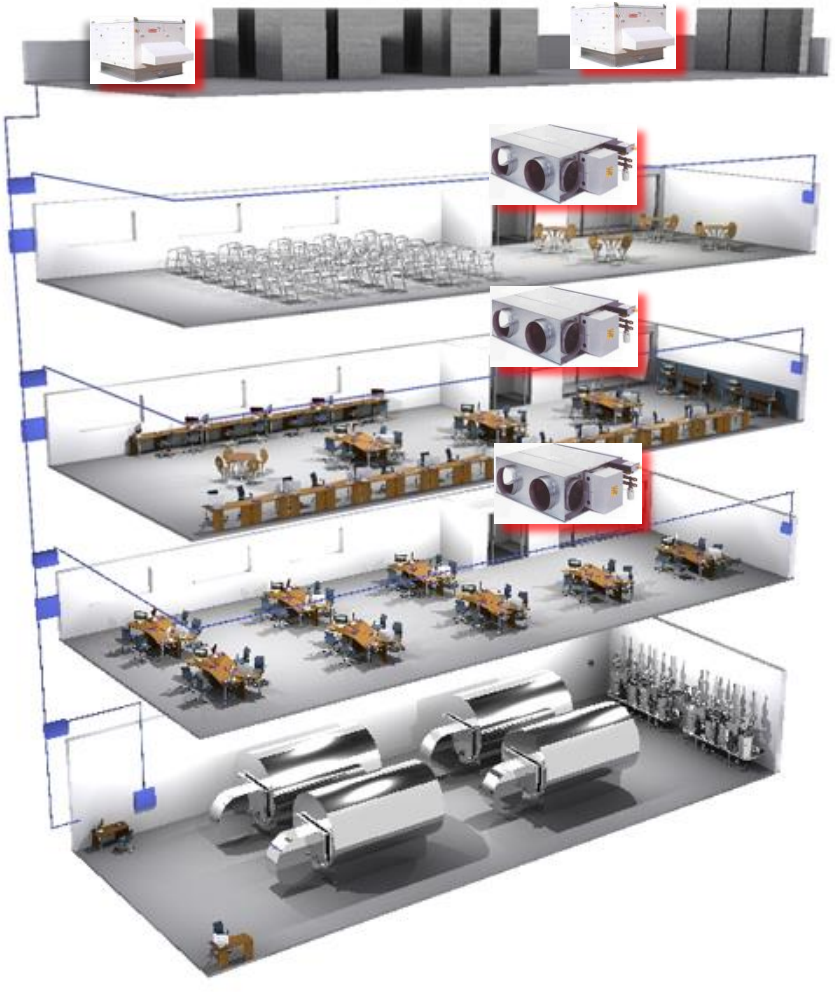
Table 7. Natural gas consumption by end use, 2012

	Total natural gas consumption (trillion Btu)					
	Total	%	Space heating	Water heating	Cooking	Other
Principal building activity						
Education	291	10	212	54	10	14
Food sales	53	2	29	3	19	2
Food service	227	8	35	40	152	0
Health care	265	9	159	61	32	12
Inpatient	219	8	121	58	30	10
Outpatient	46	2	39	4	2	2
Lodging	221	8	46	113	Q	6
Mercantile	291	10	159	58	66	8
Retail (other than mall)	74	[illegible]	63	4	6	2
Enclosed and strip malls	217	8	97	54	60	6
Office	282	10	22[illegible]	29	Q	13
Public assembly	135	5	[illegible]18	6	9	2
Public order and safety	41	[illegible]	22	16	2	1
Religious worship	87	3	67	Q	10	Q
Service	122	4	98	21	Q	Q
Warehouse and storage	139	5	109	10	Q	7
Other	81	3	55	2	1	Q
Vacant	13	0	11	Q	Q	Q

253.5 + 82.6=

336.1 TWh (/y)

Building installations



- Electricity
- Lights In/Ext
- Heating
- Cooling
- Mech. Vent.
- Natural Vent.
- A/C
- Water
- Gas
- Sewige
- Transport
- Parking
- Metering
- Monitoring
- (Security)

Building installations dressed in a tailored BeMS

- Building type
- End-user
- Design
- Quality
- For sale?

Schematics
Alarms
Calendars
Schedulers
Users
Energy monitoring
Site management
Integration

TCP/IP
BACnet IP

MS/TP
MS/TP
MS/TP

Mbus

ModBUS

TREND
micros FIDELIO
Andover
BACnet
M-Bus
Modbus
LonMark
KNX

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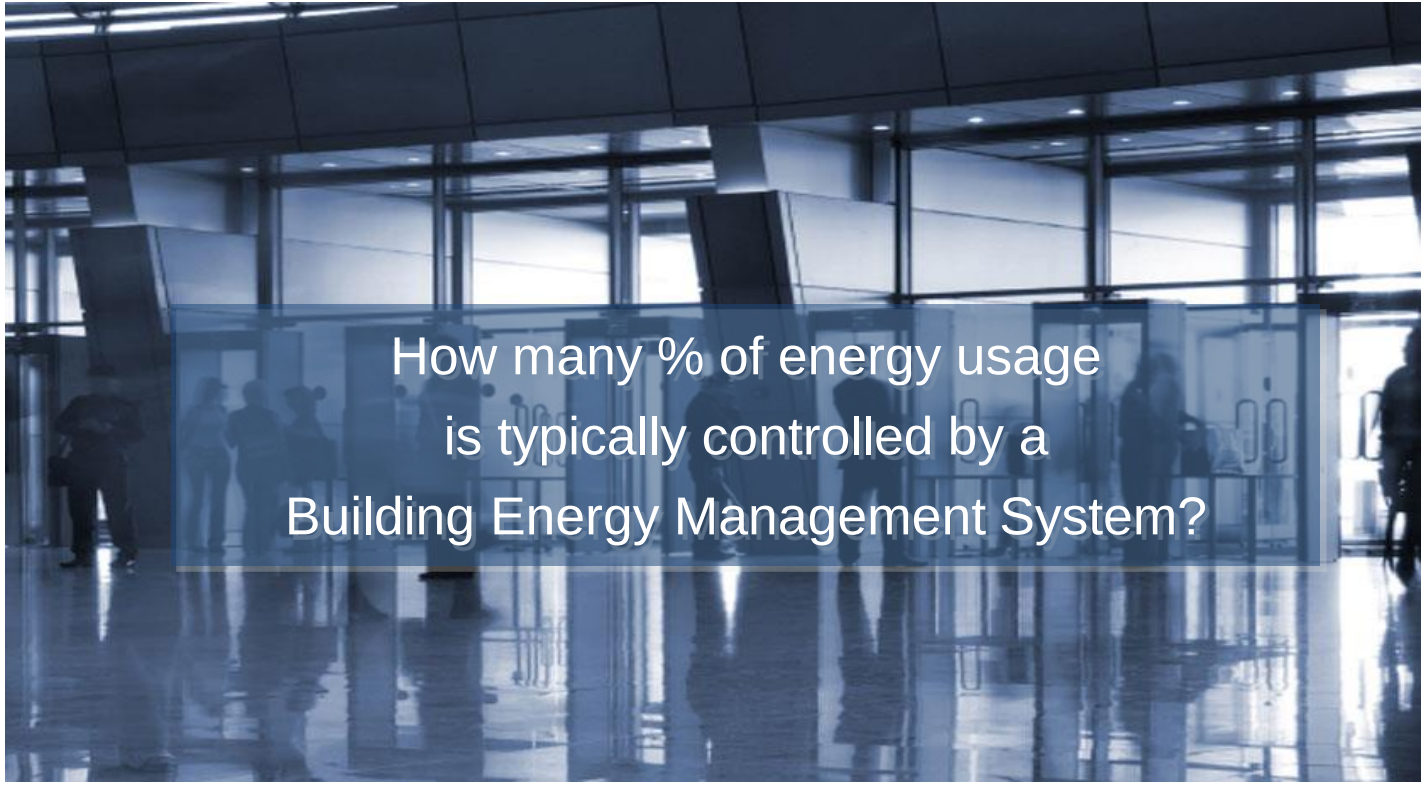
Quiz 1


How many % of energy usage
is typically controlled by a
Building Energy Management System?

BeMS fact


60 – 80% of energy usage
is typically controlled by a
Building Energy Management System

BeMS – is it enough? Other facts

fact:

Making use of daylight can reduce lighting costs by 19% in a typical office. In conjunction with staff action, the use of automatic controls can ensure these savings are achieved.

fact:

Used correctly, a BEMS can reduce total energy costs by 10% and increase comfort.

facts:

– It is estimated that up to 90% of heating, ventilation and air conditioning building control systems are inadequate in some way, costing industry and commerce over £500 million per year in additional energy costs.

– Inadequate or incorrect application of a boiler control can easily add 15-30% to fuel consumption compared to a well-controlled system.

top tip:

Maintain controls: Energy consumption can increase by more than 50% if regular maintenance is not undertaken.

fact:

In premises with well-controlled systems, heating bills can be 15-35% lower than in poorly-controlled buildings.

Building controls

Realising savings through the use of controls

CARBON TRUST

Making business sense of climate change

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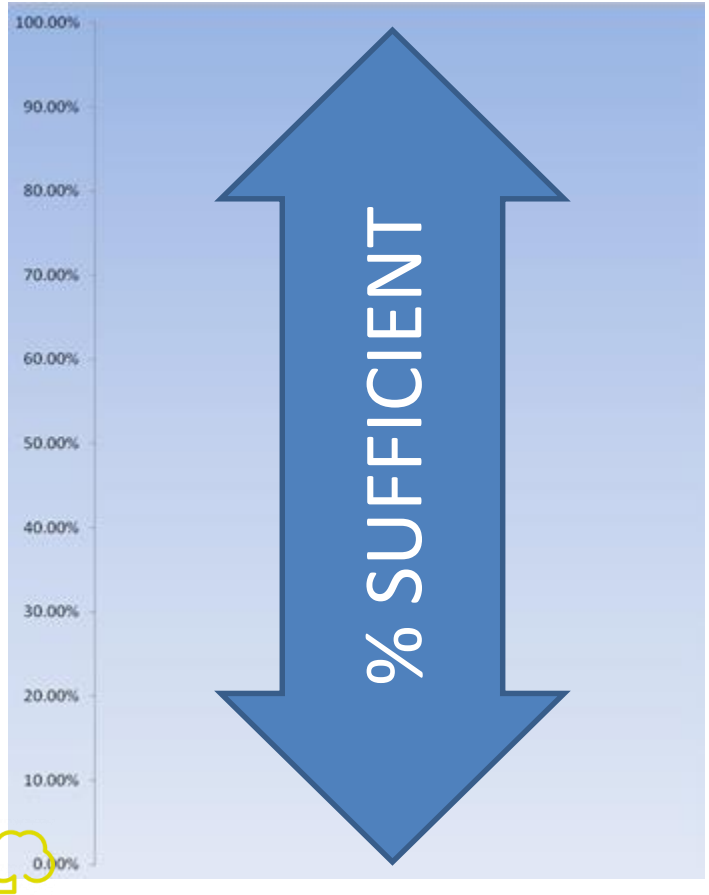
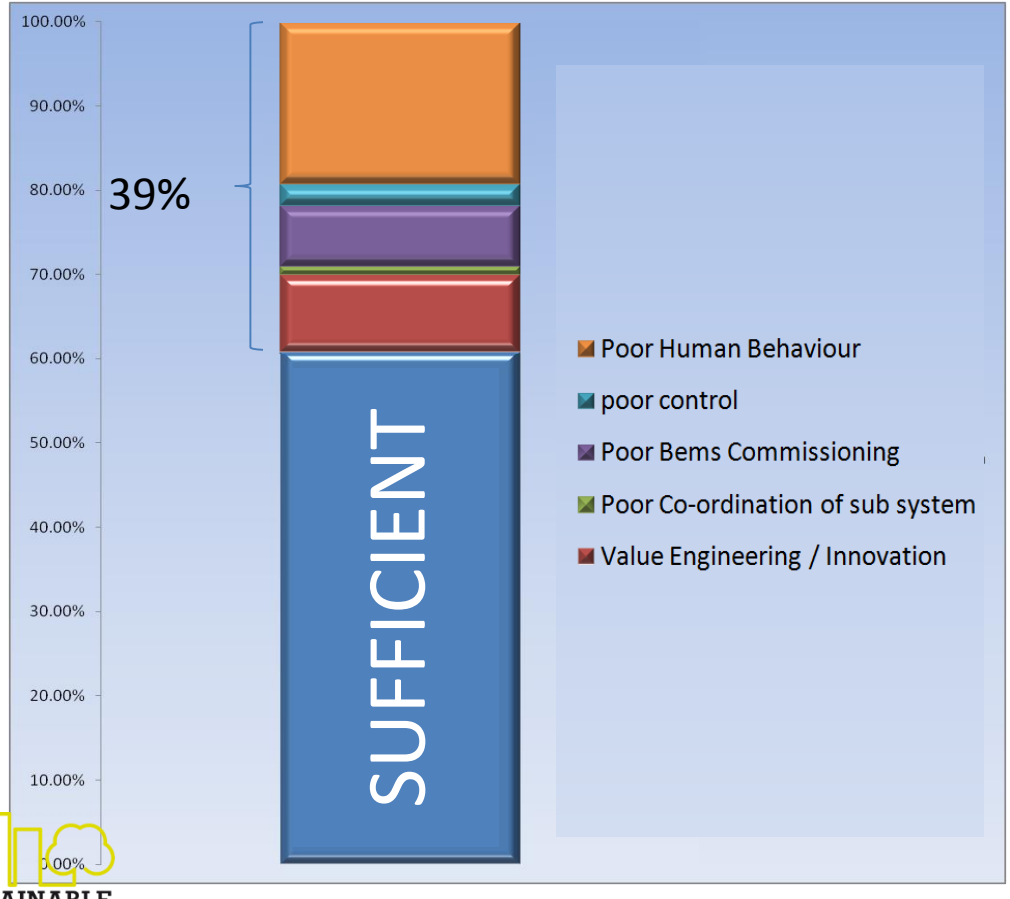
Quiz 2

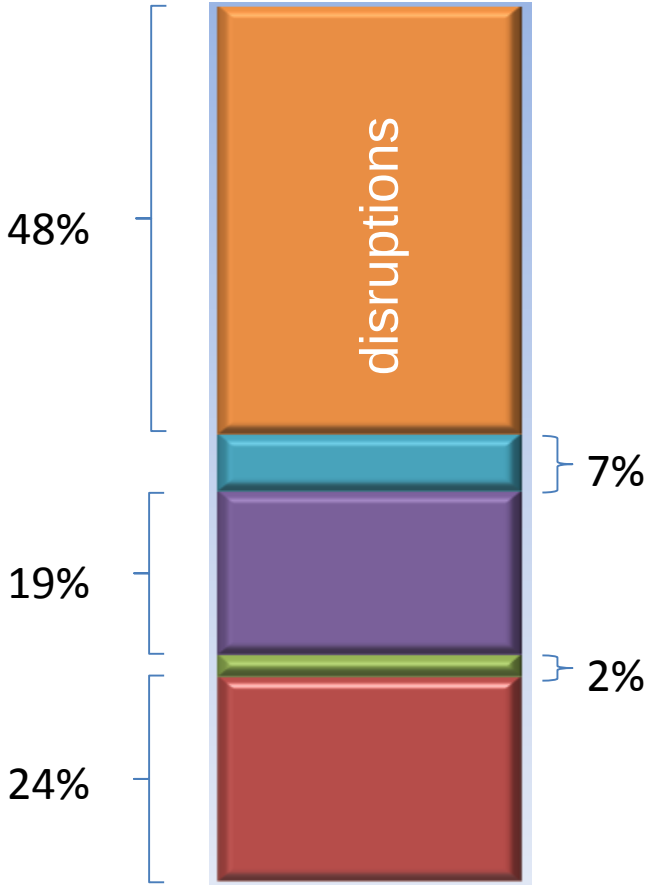


How much
of a total energy usage
is sufficient to keep
a commercial building
in operation?

[%]

Minimum energy level and reasons of waste





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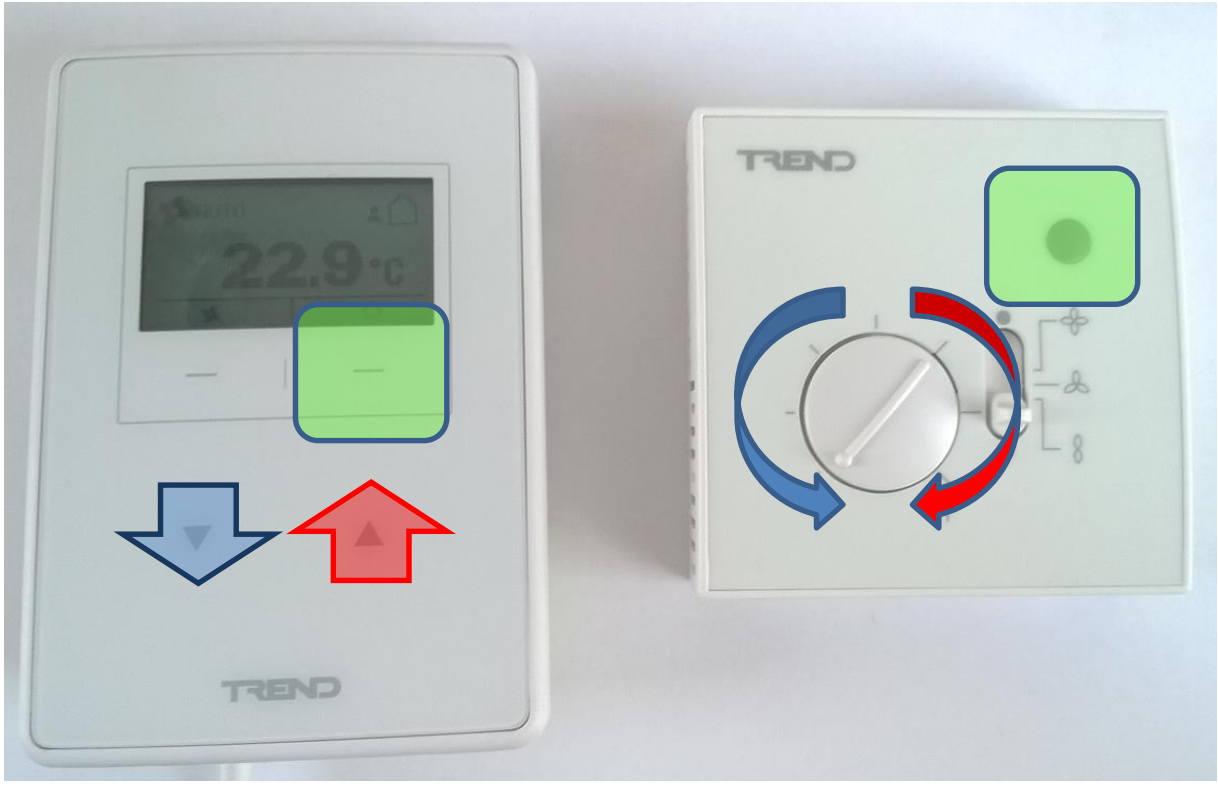
Time to adjust SP

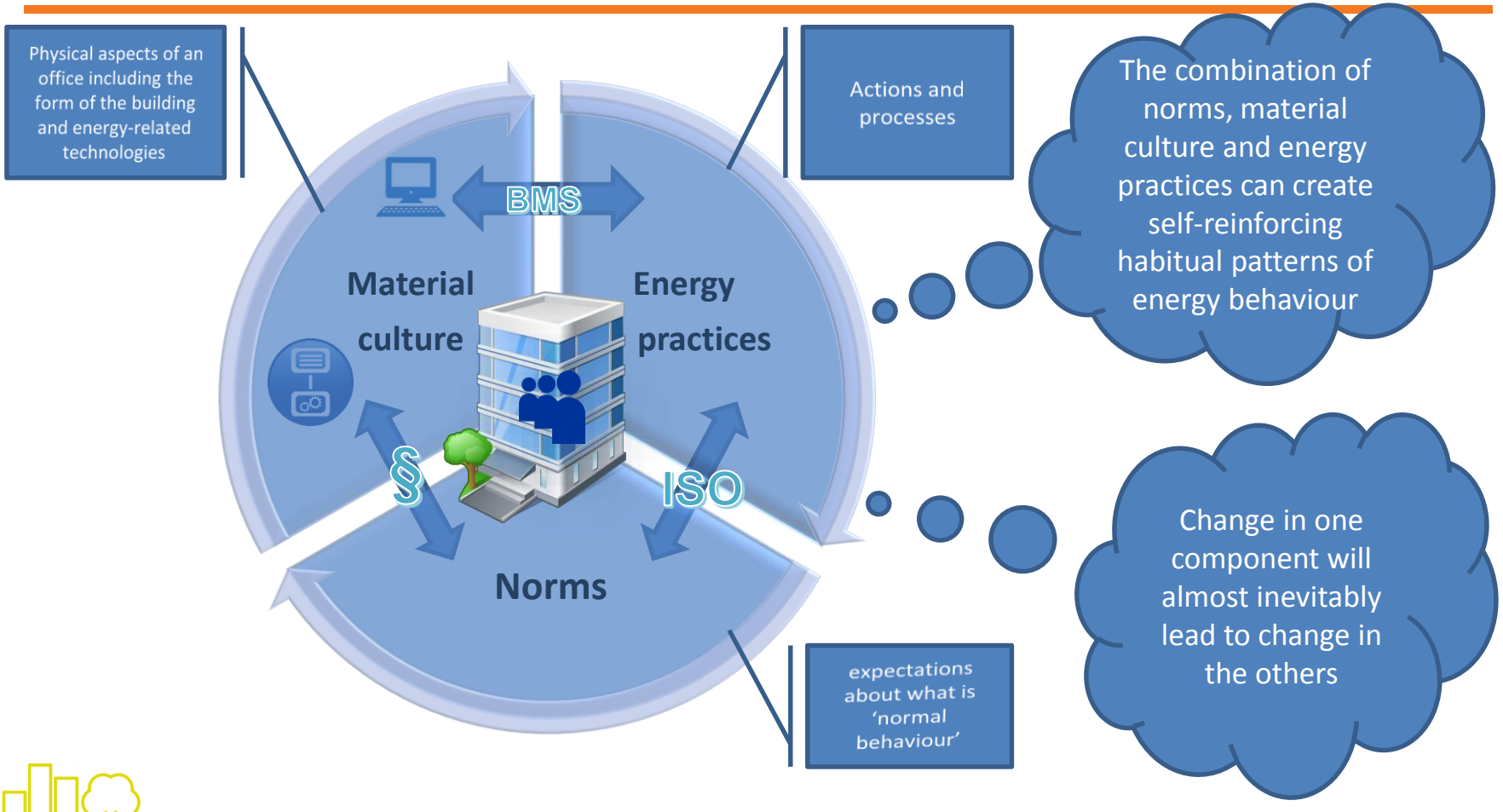


VOTE

ADJUST

TEMP

Energy cultures framework



Based on „Energy Cultures" Framework by Stephenson (for residential buildings)

Material culture – BeMS based technical improvement

VSD frequency inverters

Pumps, fans >1kW
Avoiding resonant frequencies
Easy to reduce comfort
Auto adjustment of volume/pressure

Reduces energy usage by lowering pump/fan speed
P1/P2≈ (n2/n1)^3 (near a rated operating point)

IQeco IRC Controllers

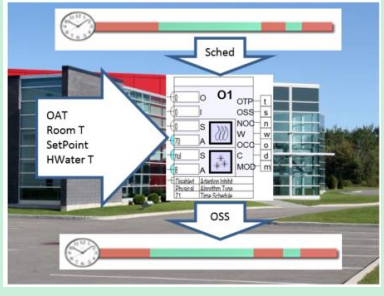
Dedicated for room/zone control (HVAC, lighting)
100s of controllers in non-domestic buildings.

Reduced power consumption on stand-by.

IQeco: 7VA@230V / 10VA@24V vs others (12VA).
Warsaw in 2013: 196 hotels, 30226 beds, ca 13000 rooms.
12-7=5VA, 5VAx13000=65kVA @0.55PLN/kWh -> 73kEUR/year

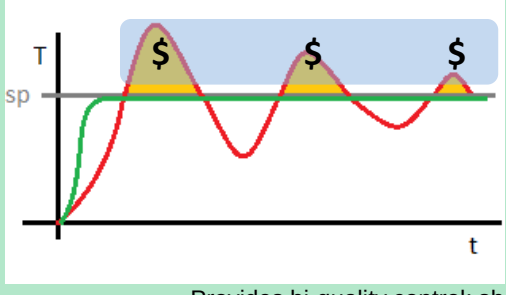
OSS – Optimum Start-Stop

Model based and statistical algorithms.
For heating & cooling installations



Provides required parameters just-in-time
Saves energy, avoids peaks

PID Auto Tuning – adjusting dynamic controller paramaters



For all PID control loops
Based on Z-N methods:
-Step
- Limit cycle
- Multistep
- Estimates Kp,Ti, Td

Provides hi-quality control: short time, no setpoint deviation
Saves energy by removal of oscillations.

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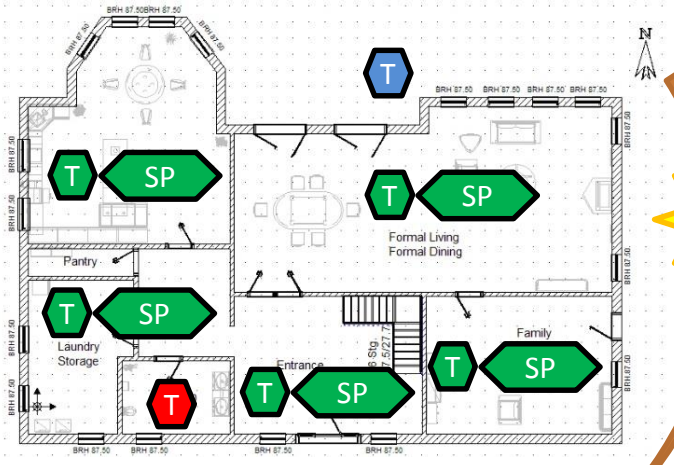
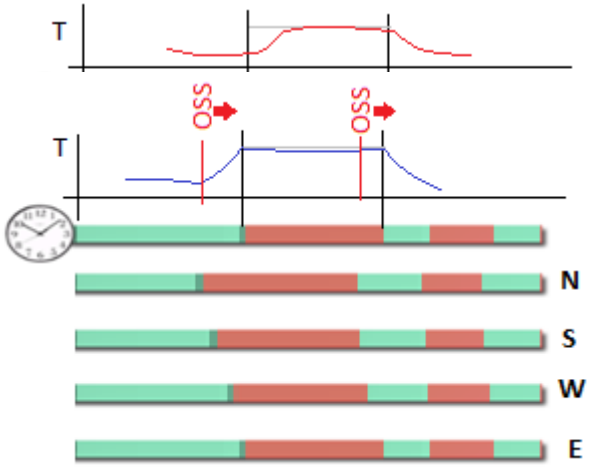
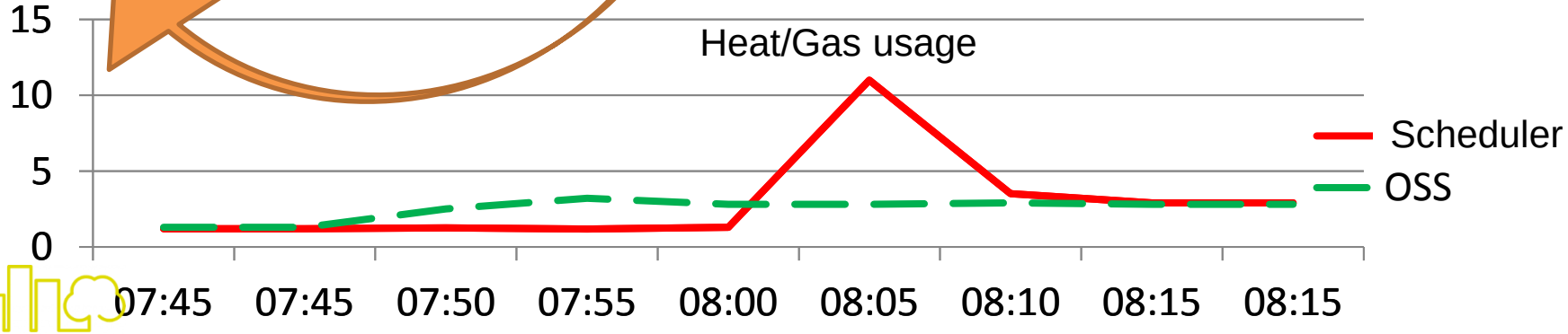
Example – saving Energy & increasing human satisfaction with OSS







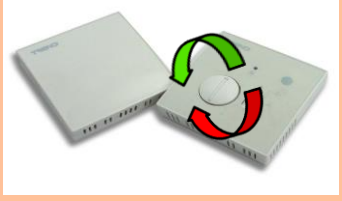
Energy practices & norms – BeMS services, tricks & awareness support

Periodical BeMS audits and optimization

Energy efficiency ALWAYS gets lover in time
Periodical BMS optimization helps to slow down it.

2008-2011,
933 audits, 3,420 days on site,
Annualised saving:
Energy: 194,878,252 kWh
Money: 9,505,692 mln GBP, payback for investment in audit: 3 months
Emissions: 147,827 tons CO2,

Approved algorithms for reducing energy consumption



Dedicated for zoned buildings where users, by default, do not care about energy: hotels, offices, shopping galeries:

The impact on the senses rather than effective action (fan noise)
Auto-return adjustment of setpoints after manipulations

Green Building certification - BREEAM

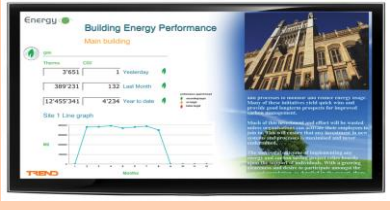
The word's leading sustainability assessment method for masterplanining projects, infrastructure and buildings

BREEAM®

Environmental Section	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.50%
Waste	7.50%
Land Use & Ecology	10%
Pollution	10%
Total	**100%**
Innovation (additional)	10%

BMS allows for better certification
It affects the highest rated areas:
Health & Wellbeing, Energy, Water,
Also: Management and Innovations

Trend EnergyEYE – raised awareness



Big screen application
Combined functionality of Energy dashbord and advertising media

Green/Yellow/Red icons:
Simplified „**broadcast**" to indicate current and past energy conditions:
Multimedia display to promote „green" behaviours and raise people's awareness

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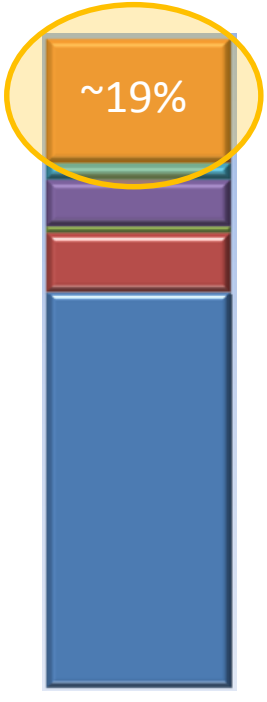
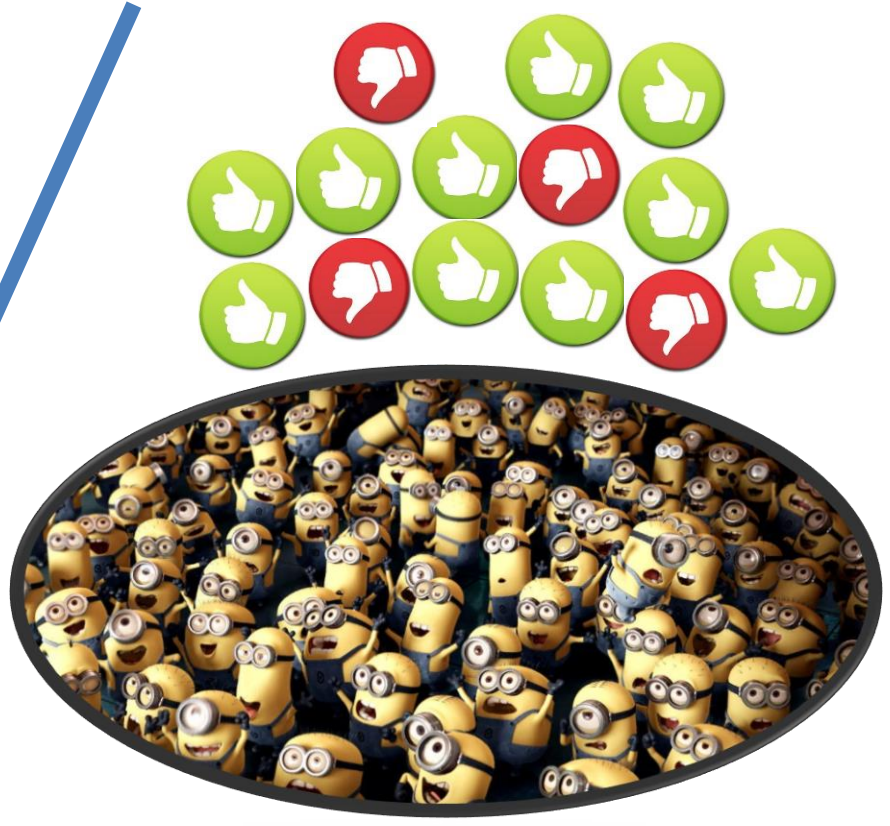
Energy Clusters

- Identification of occupants clusters



Occupant „cluster”	„Energy economic”	„Energy extravagant”	„Energy easy”	„Energy efficient”
Basic characteristics	Envinronmentally aware CO2 concerns	No Energy saving practiques No environmental concerns	No Energy saving practiques No environmental concerns	Efficiency Value for money
Dominant influence by:	Energy practices	Material culture	Material culture	Norms
Demographics:	Young people, Students, unemployed, poorer people	Parents, aged under 50, Highest income	Middle aged & retired Few children 2nd highest income	Older Empty nesters, part time work, owner occupied
	6% Unclassified	24%	19%	31%	20%

Save a % on ENERGY…



…or Satisfy each of Min(ll)ions?

IQ®CEO - The important step on the way to sustainable satisfaction

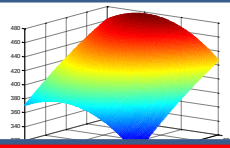
- Central Energy Optimizer - Model Predictive Control (MPC) based on historical and current data
- Keeps zone (human's) comfort unchanged, adjustes main HVAC setpoints

The solution schematics

iQ CEO

Learning time:
Min 7 days
Best 90+ days
1 day ON/ 1 day OFF

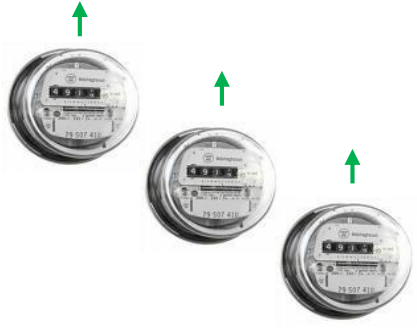
Model update



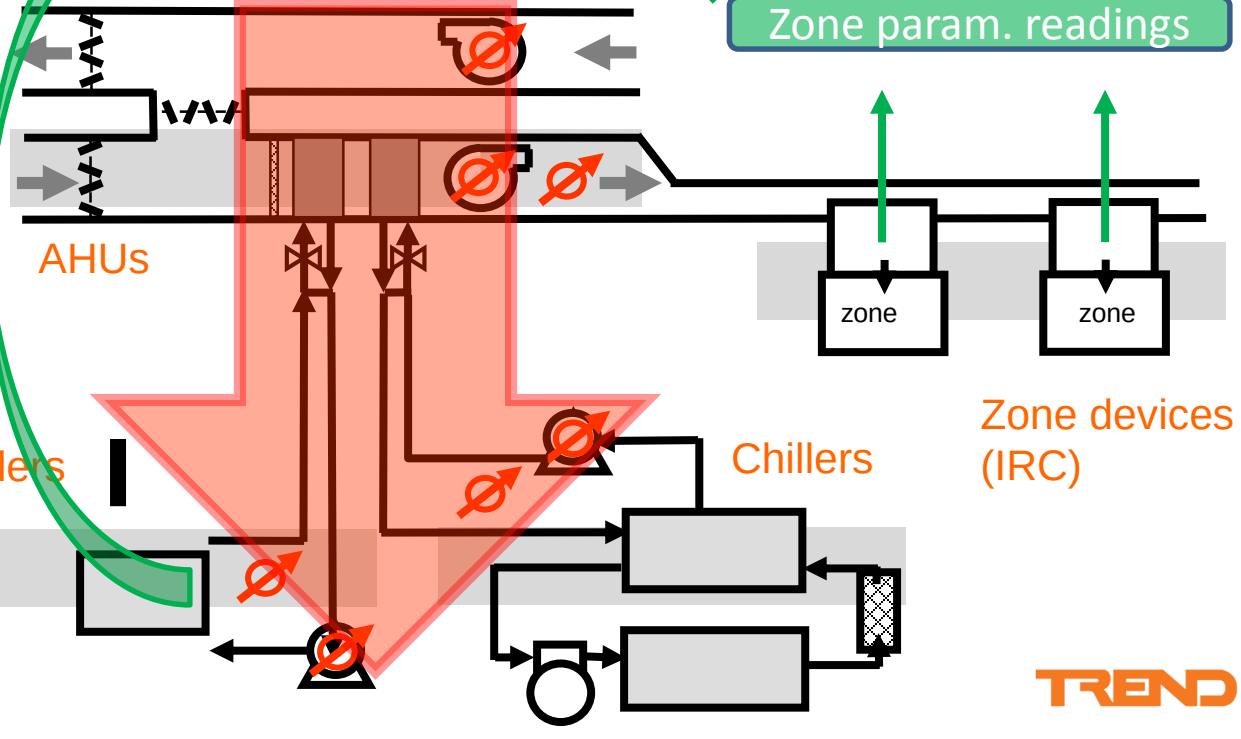
Estimated SetPoint changes

Optimization goals:
1) Energy usage
2) Cost
3) CO2 Emission

Meter readings



Zone param. readings



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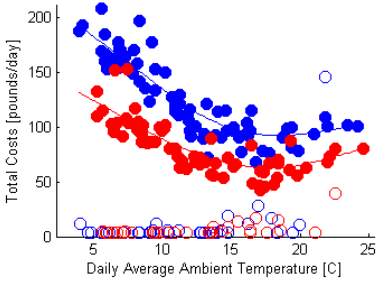
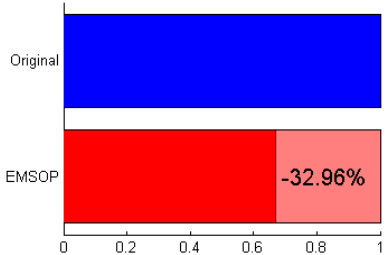
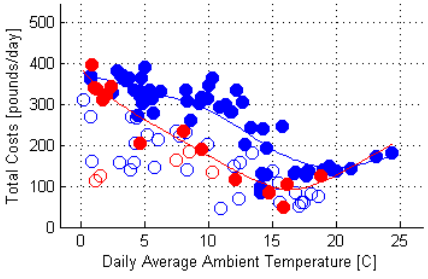
Early pilot site savings achieved

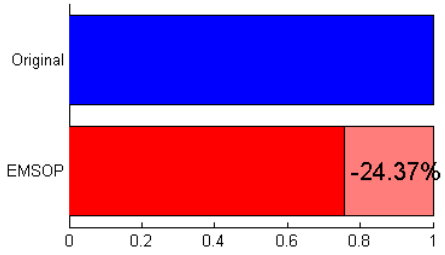
Office bldg (Manchester) - **33% savings**



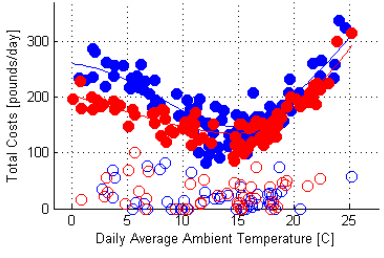


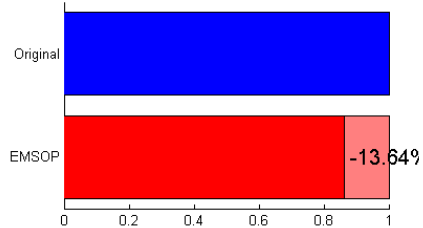
Workshop (Warwickshire) - **24% savings**



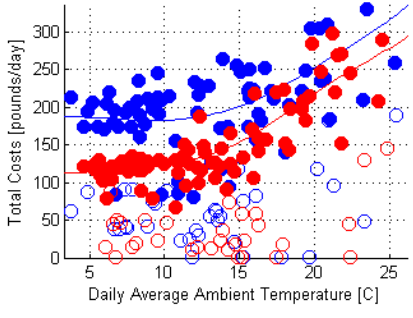


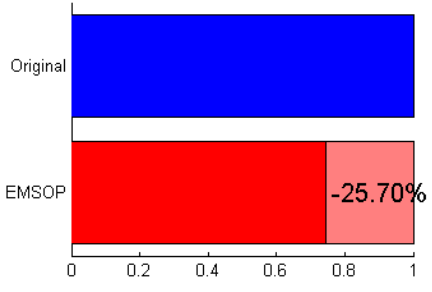
Office bldg (Bristol) -**14% savings**





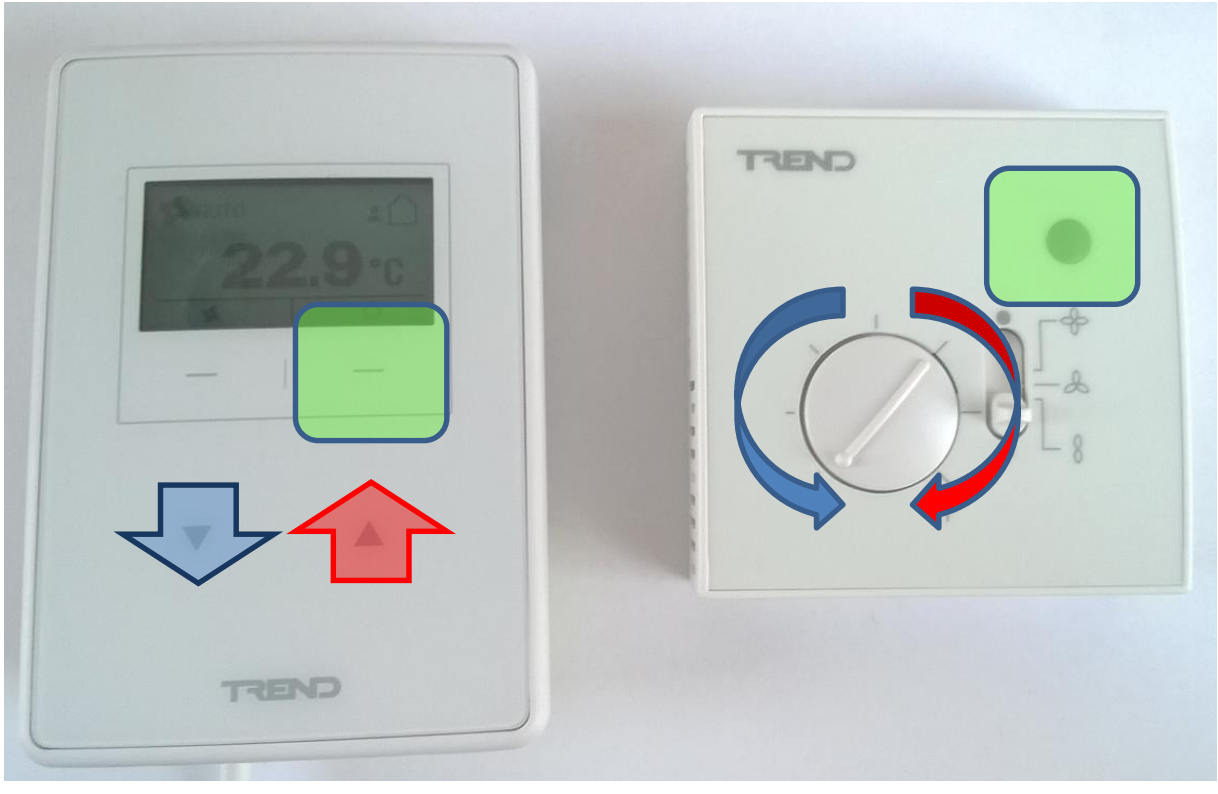
University (North London) - **26% savings**





10 - 35% savings on HVAC energy costs over typical building control

Time to adjust SP



VOTE

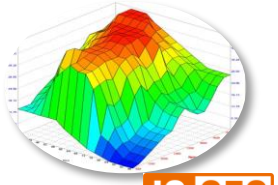
ADJUST

TEMP

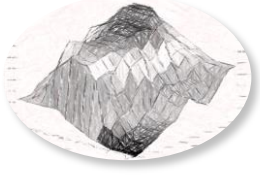
The next step…

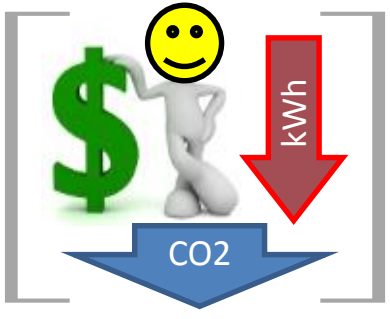
… soon ?

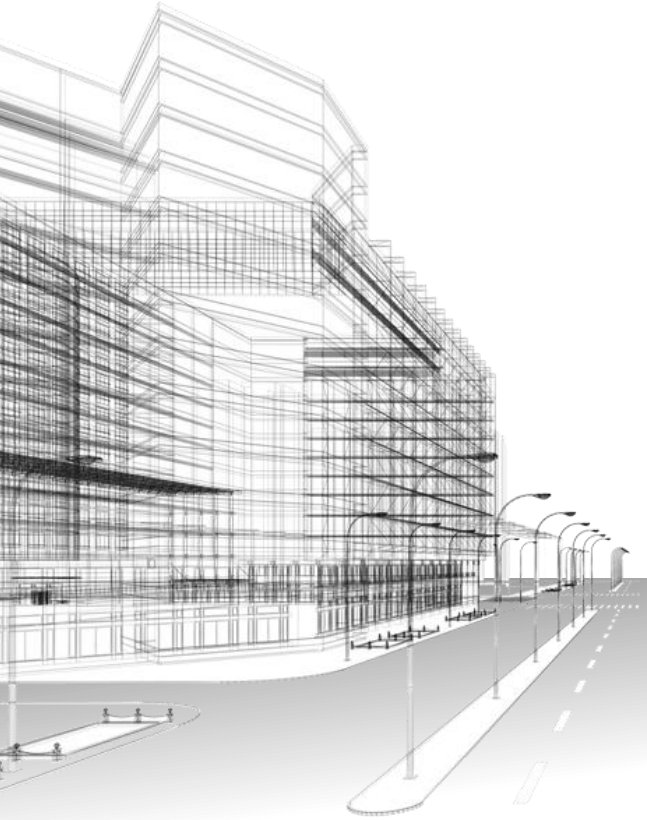
TEMPERATURE
HUMIDITY
SETPOINT
METERING
H/C DEMAND



BEHAVIOUR
PRODUCTIVITY
MOVEMENT
SATISFACTION
@ IoT+ERP+SAP







Thank you & go to the dashboard

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