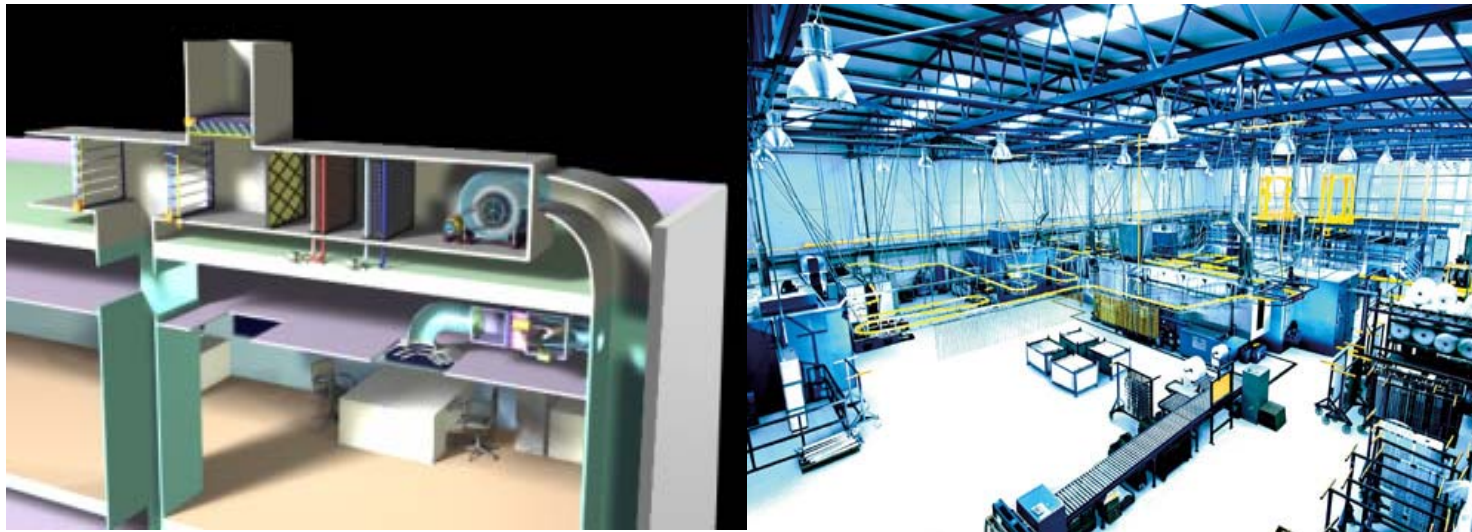


Development of an Automated Fault Detection and Diagnosis tool for AHU's

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ICEBO 2012



UCC

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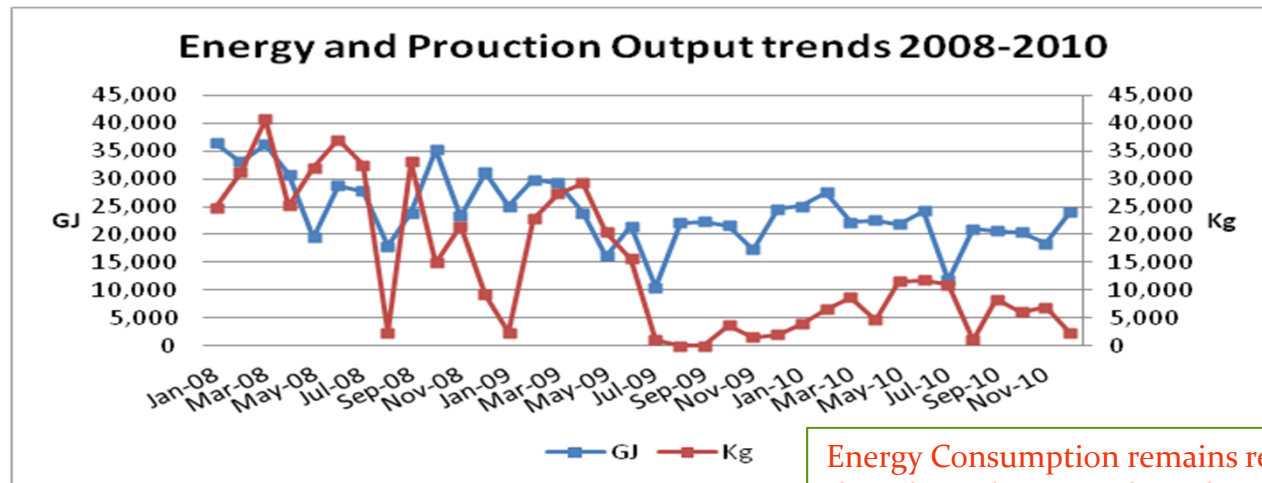
National University
Ollscoil na hÉireann

Agenda

- Why does industry need this work?
- Why Focus on HVAC?
- An automated solution
- AFDD techniques and objectives
- Early Pilot Test Results
- The Market Opportunity



Why does industry need this research work?



Energy Consumption remains relatively constant though production volume has decreased significantly



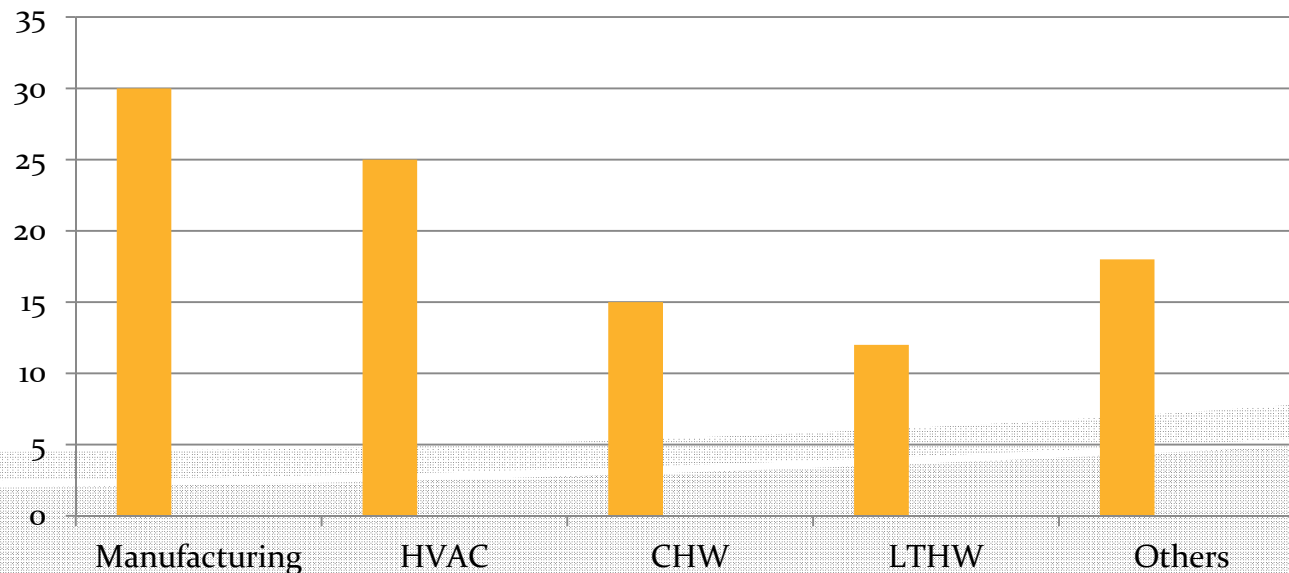
Focus on production output in lieu of efficiency for the last decade

Difficult to automatically track efficiency due to islands of information

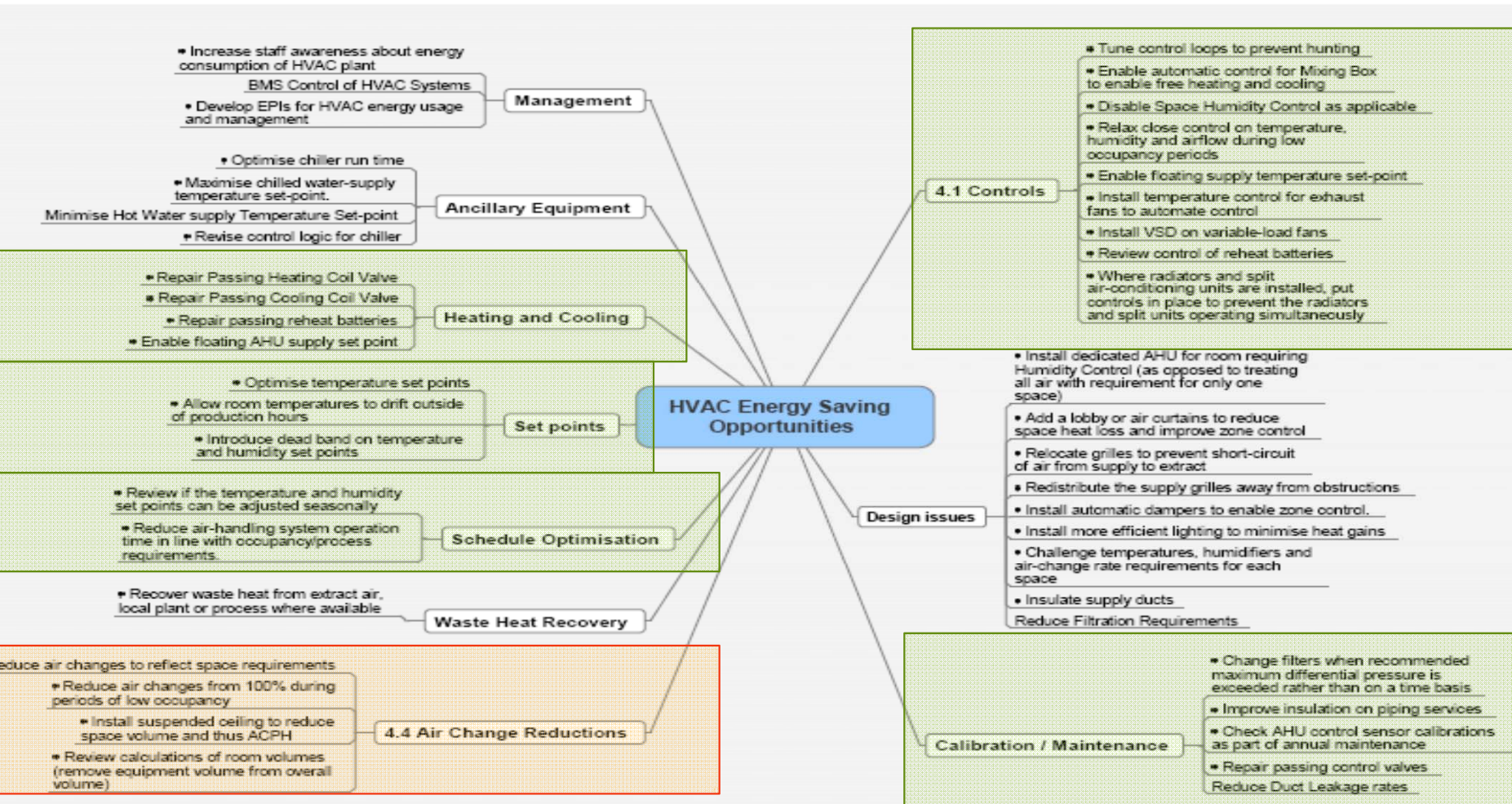
Competition from lower cost economies for investment

Why Focus on HVAC Systems?

- Typically greater than 20% of an industrial site or buildings' energy consumption
- HVAC systems get less efficient over time
- Studies have indicated that 20-30% energy savings are achievable by re-commissioning HVAC systems to rectify faulty operation



Typical HVAC Projects



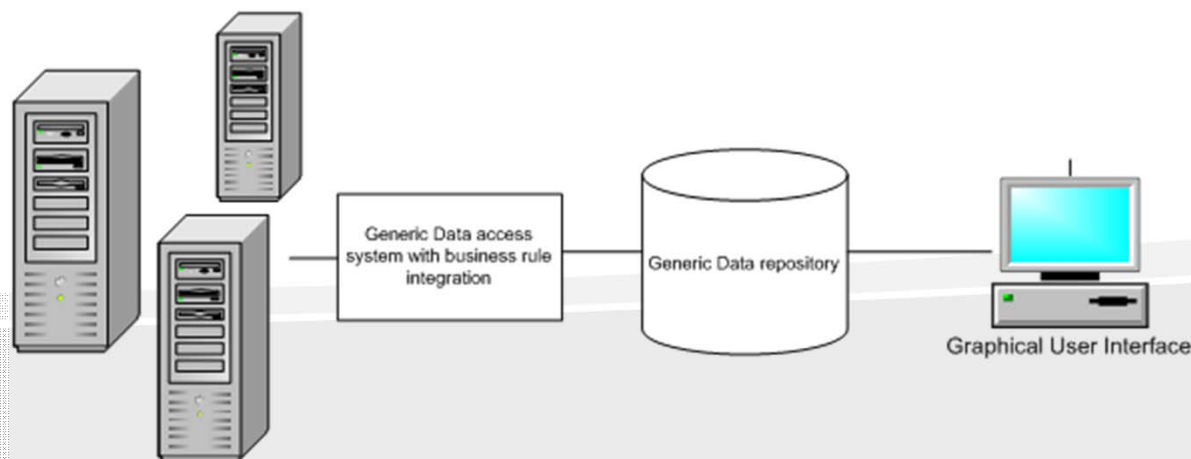
Why an automated tool?

- The number AHU's in a typical industrial site often outnumber those maintaining the system by 20 to 1
- Onsite personnel may not have the “knowledge” required to effectively maintain the system
- HVAC systems are growing in complexity



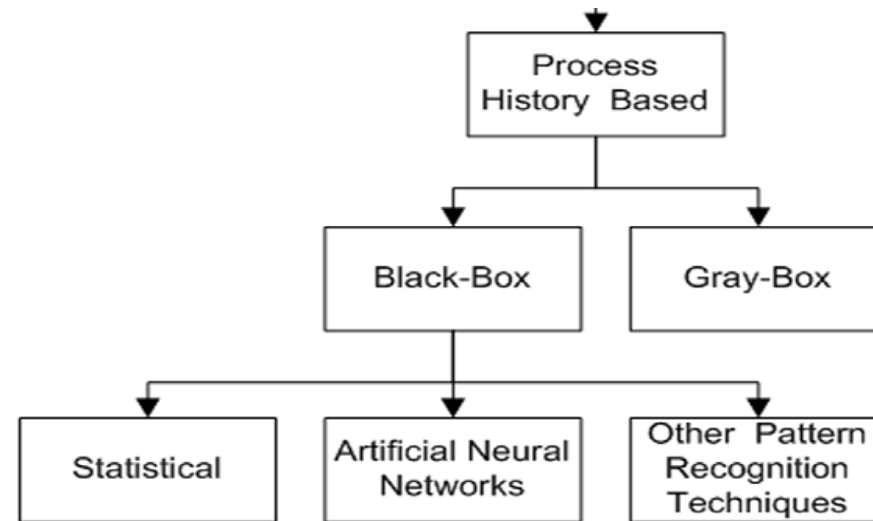
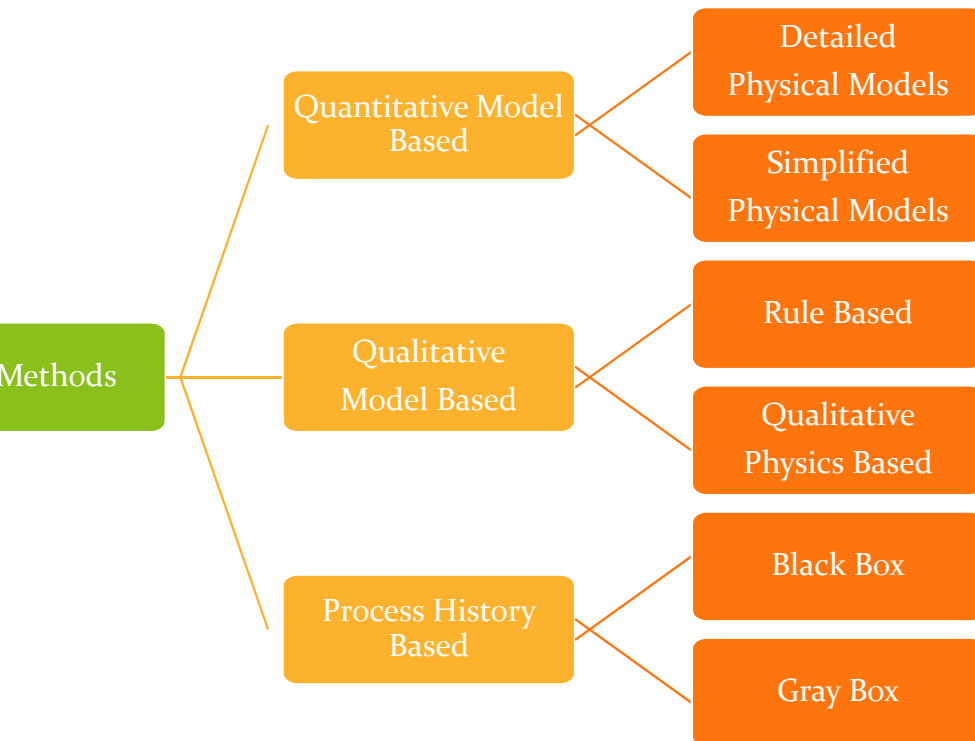
AFDD tool objectives

- Flexibility to work with any BMS
- Flexibility to work with any combination of sensors and components found in typical AHUs
- To use already available measurement
- Capable of evaluating the ongoing performance of AHUs
- Minimal setup time per AHU
- Economic quantification and prioritisation of the diagnosed faults



FDD Techniques

FDD automates the process of detecting and diagnosing faults

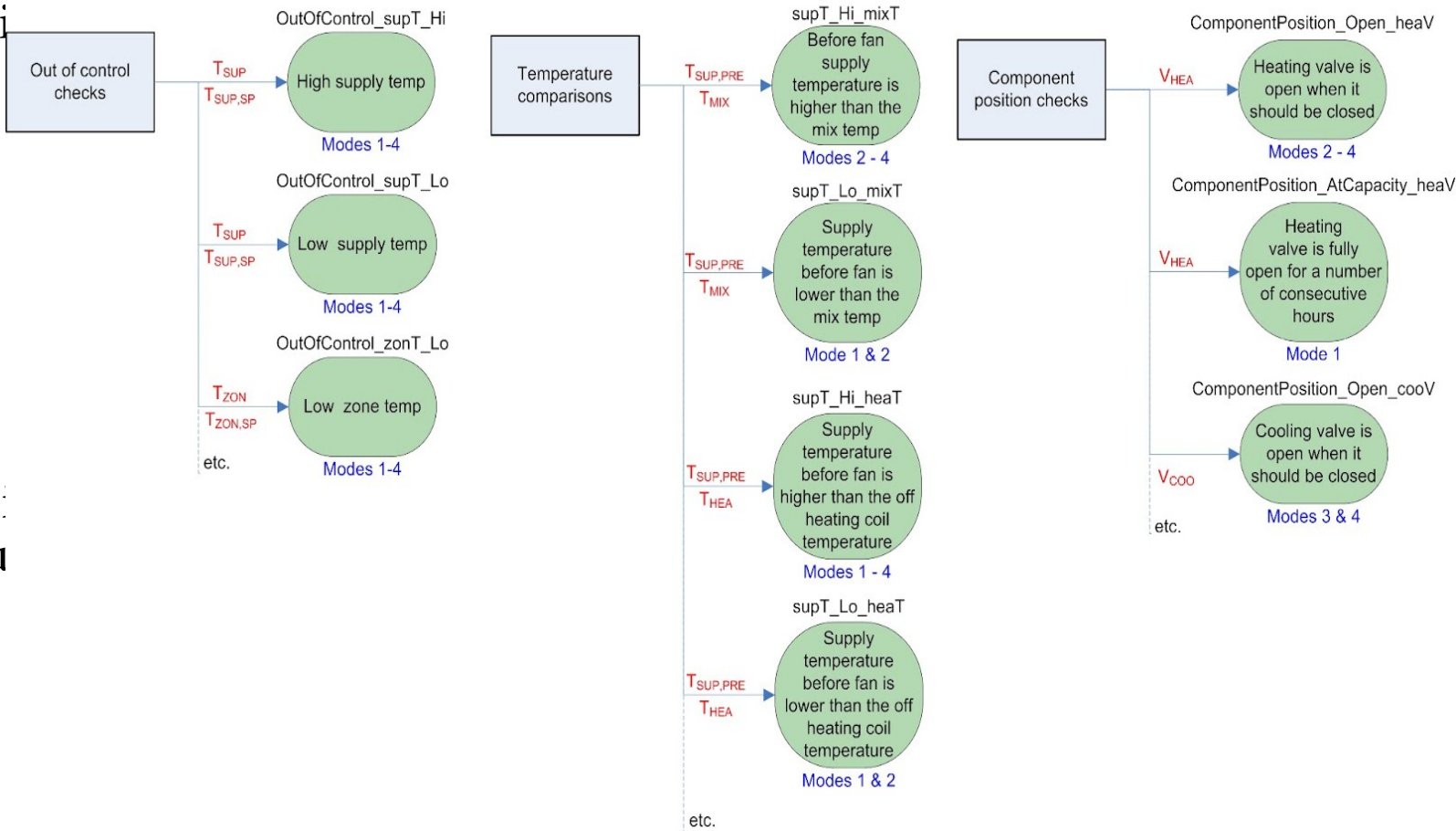


A rule based FDD tool can be developed and implemented in industry relatively quickly utilising existing equipment

The Business Layer

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Pilot Study

Hundreds of AHU's were available across 7 industrial and commercial sites for inclusion in the study

AHU's were selected for the purpose of developing and validating the tool using the following criteria;

- Different component and sensor layouts in order to ensure that the AFDD tool could be applied effectively and comprehensively
- Varying levels of instrumentation in order to alleviate concerns regarding the level of instrumentation needed to perform AFDD effectively
- The potential for duplication to ensure scalability to maximise savings



AFDD tool in RFTA testing

Current display time
2011-12-07 07:00 Wed

Mode:
Economiser with heating or cool

Return
Rise 1

21.7°C V
44%

VSD
Flow 21

Temperature [°C]
07 13

Description of current fault:
The supply temperature is higher than the mix temperature, when it should be identical (2) or lower (3,4).

No. fault hours... 92
... as % of period 27%
... as % of run hours 32%

ENGINEER'S REPORT & DAYWORKS SHEET



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REPORT NO. 31779

| | | | |
|--------------|--------------|------|----|
| SITE | DEPUT | | |
| CUSTOMER | ALIGHTY | | |
| SITE CONTACT | DAVE COYAREL | | |
| ENGINEER | TOM DEASY | | |
| PROJECT NO. | MOSS | P.M. | VC |

SURVEY ON OPERATIONS OF CONTROLS ON PRODUCTION FLOOR
AHU'S 6, 7, 8, 9

• CHECKED ALL C.H.W + L.P.H.W VALVES FOR SIGN'S OF PASSING
• ALL TEMPERATURE SENSORS CHECKED CORRECTLY CALIBRATED AND ADJUSTED WERE REQUIRED
• CHECKED CORRECT OPERATION OF FRESH, RECIRC AND EXHAUST DAMPER
• ALL ASSOCIATED FIELD EQUIPMENT (IE V.S.D'S, ACTUATOR) CHECKED

FOUND FOLLOWING ISSUE'S
AHU 6 (A) CHECKED DIFFUSER ON LEGS FOUND 3 AIR DIFFUSER ON LEG 3 NOT OPERATING.
AHU 7 (A) RETURN MOTOR FAULTY RECOMMEND REPLACING AS THIS IS EFFECTING OPERATION OF SYSTEM'S DAMPER'S AND IS CAUSING AREA TO OVERHEAT (B) FRESH AIR DAMPER ACTUATOR ON UPPER DAMPER FAULTY
AHU 8 (A) RECIRC DAMPER NOT SEALING CORRECTLY LOUVERS DAMAGED (B) COOLING VALVE SLIGHTLY PASSING CAPPING AROUND VALVE TO BE REMOVED TO DETERMINE WHAT SIZE VALVE.
AHU 9 (A) RECIRC DAMPER NOT SEALING CORRECTLY LOUVERS DAMAGED

Mode
0

apply air
1.0°C V

Zone
19.2°C
20.9°C

Flow
25.0m³/s

Overall occurrences

DeltaT_supT_Hi_mixT, 92
FOSIC 15
DeltaT_supT_Lo_mixT, 2

AFDD tool in BETA testing

site3 : ahu6
 2012-09-10 20:59 Mon

Reset schematic diagram

Temps Other cond
 Humidities Virtual valu
 Valve/damper positior

List faults by...
 ...frequency ...cost

Fault selection
 ComponentPosition_AtCapacity

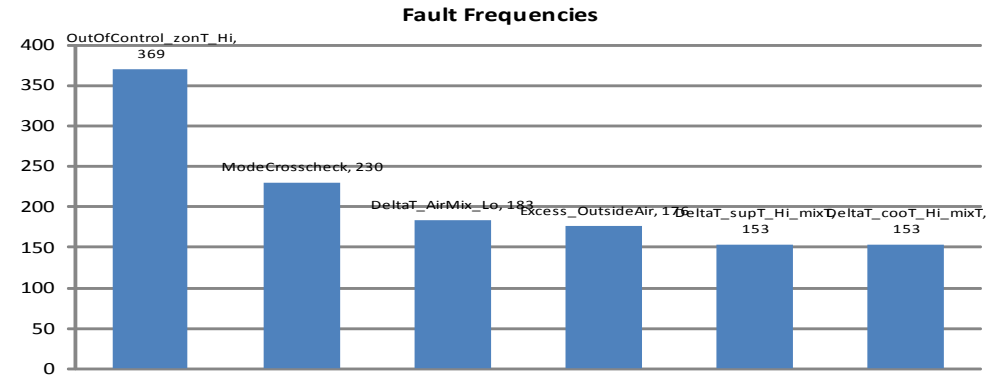
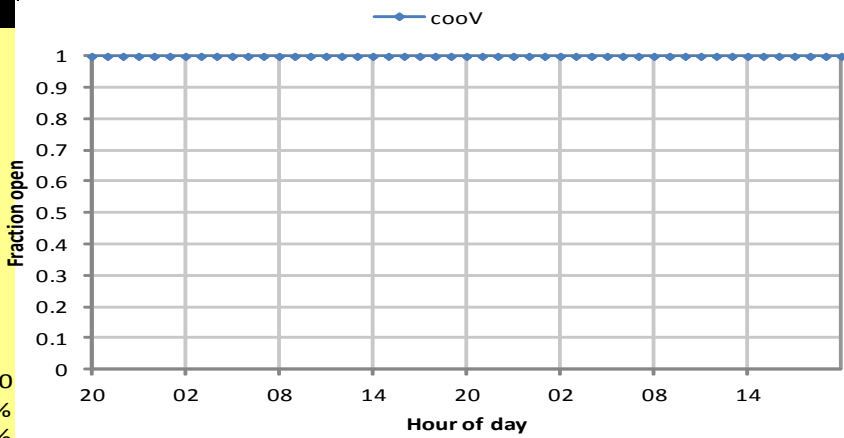
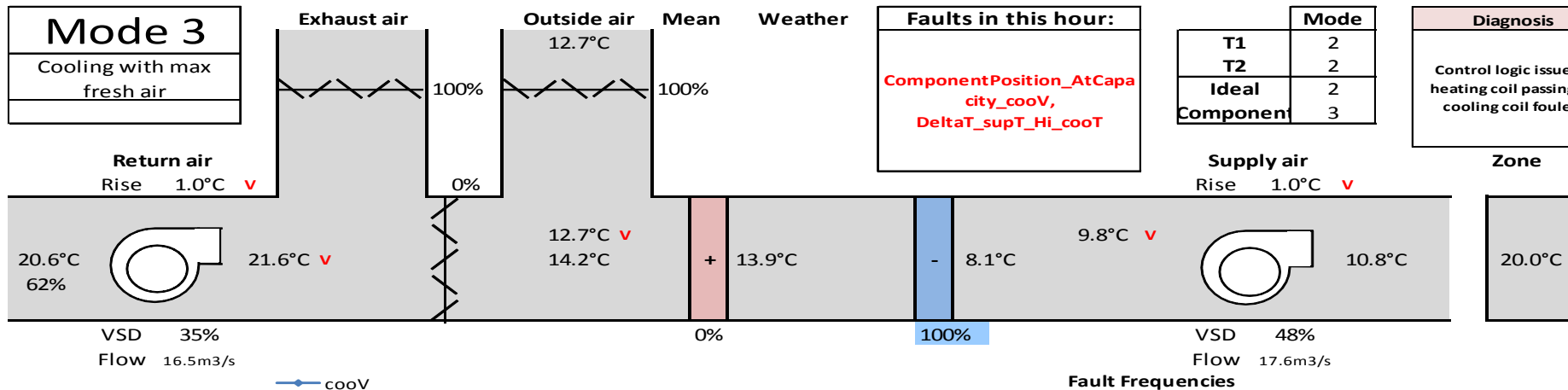
Go to fault instance

Oldest Newest
 Next Previous

Description of current fault

Component has been design loaded (fully open) for a number of consecutive hours

60 fault instances
 as % of period 9%
 as % of Total 9%



AFDD tool in BETA testing

site7 : ahu1

2012-10-11 15:45 Thu

17
2
0

Reset schematic diagram

Temps Other cond
 Humidities Virtual valu
 Valve/damper positior

List faults by...
 ...frequency ...cost

Fault selection
 DeltaT_supT_Hi_mixT

Go to fault instance

Oldest Newest
 Next Previous

Description of current fault

The supply temperature is higher than the mix temperature, when it should be identical (2) or lower (3,4).

o. fault instances 308
 as % of period 46%
 as % of Total 46%

Mode 2

Free Cooling/Heating

Outside air Mean Weather
 10.4°C

Faults in this hour:

ModeCrosscheck,
 DeltaT_supT_Hi_mixT

| MODE | 1 |
|-----------------|---|
| Ideal Component | 2 |

Supply air Rise 1.0°C V

10.4°C

+

0%

-

0%

18.6°C V

ON

20.0°C

19.6°C

VSD Flow

Diagnosis

Heating coil passing or supply/ outside temperature sensor fault

2D Diagnosis

#N/A

— mixT — mixTvirtual — supTBF

Fault Frequencies

| Fault Name | Frequency |
|------------------------------------|-----------|
| ModeCrosscheck_DeltaT_supT_Hi_mixT | 308 |
| OutOfControl_supT_Hi | 112 |
| OutOfControl_supT_Lo | 37 |
| ComponentPosition_Open_coolV | 3 |

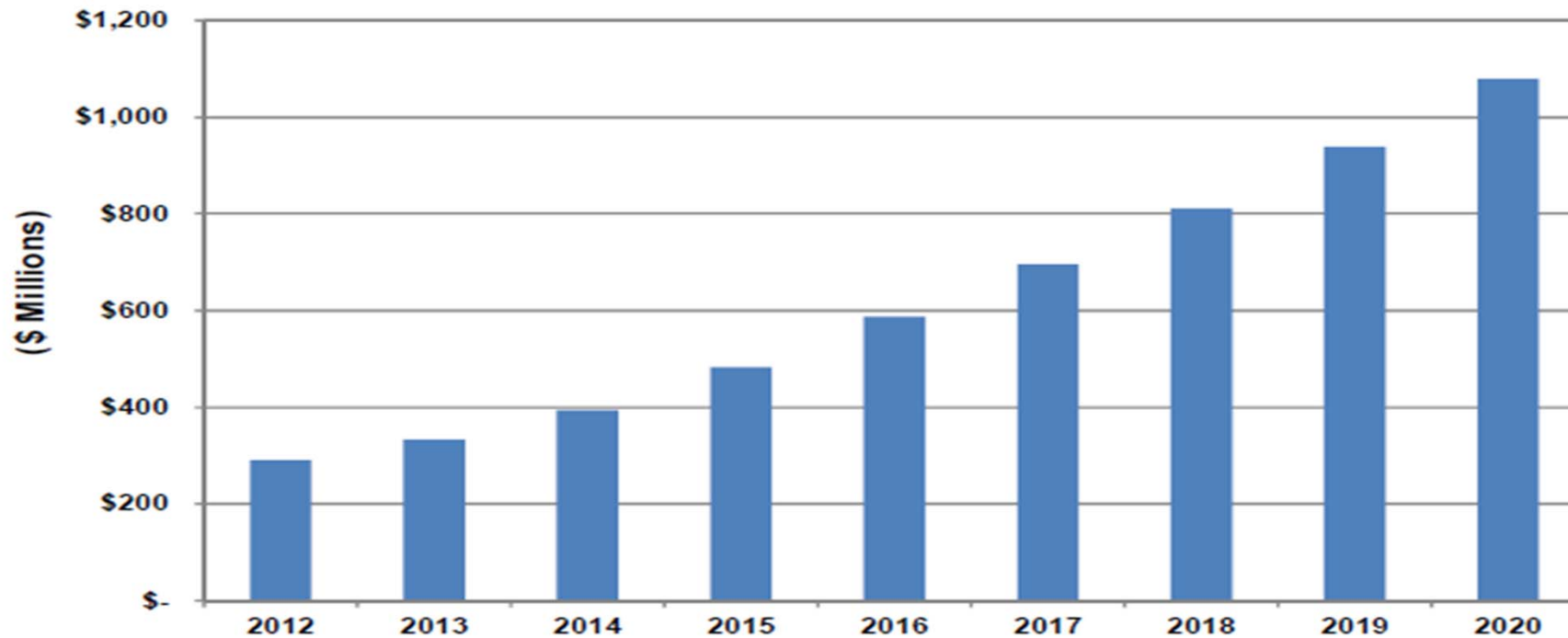
Early Results

| Site | No. of AHUs investigated | Faults identified by the FDD tool | Annual savings opportunities (approx) | Verification method |
|------|--------------------------|--|---------------------------------------|---|
| 1 | 2 | Passing heating coils | €48k | Physical (airside) survey by the authors |
| 3 | 4 | Damaged dampers, low supply temperature, passing cooling coil | €23k | Physical (airside) survey by the authors |
| 4 | 4 | Damaged dampers | €3k | Physical (airside) survey by the authors |
| 5 | 4 | Poor design, passing frost coils & incorrect set-points | €44k | From extensive BMS data and confirmed independently |
| 6 | 1 | Passing heating coil, poor frost protection control setup, leaking dampers | €3k | Independent physical survey |



The Market

Smart Building Managed Services Spending, World Markets: 2012-2020

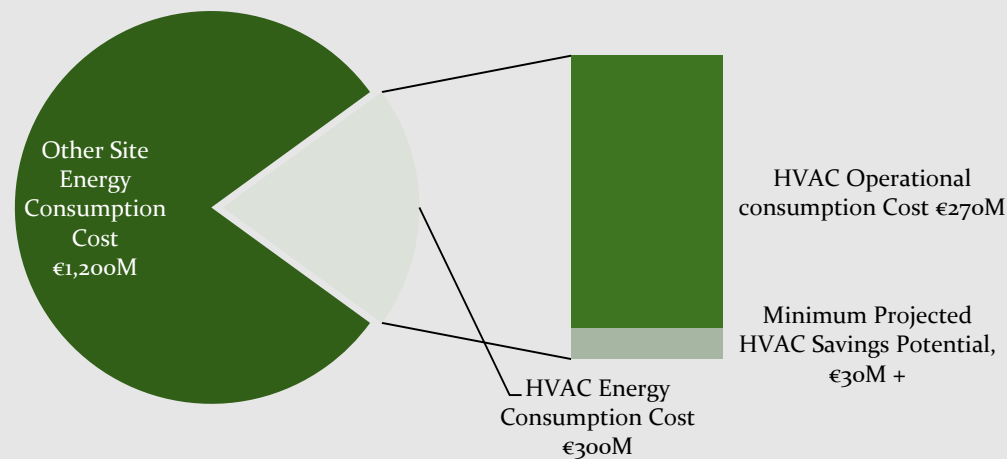


(Source: Pike Research)



Commercial Opportunity

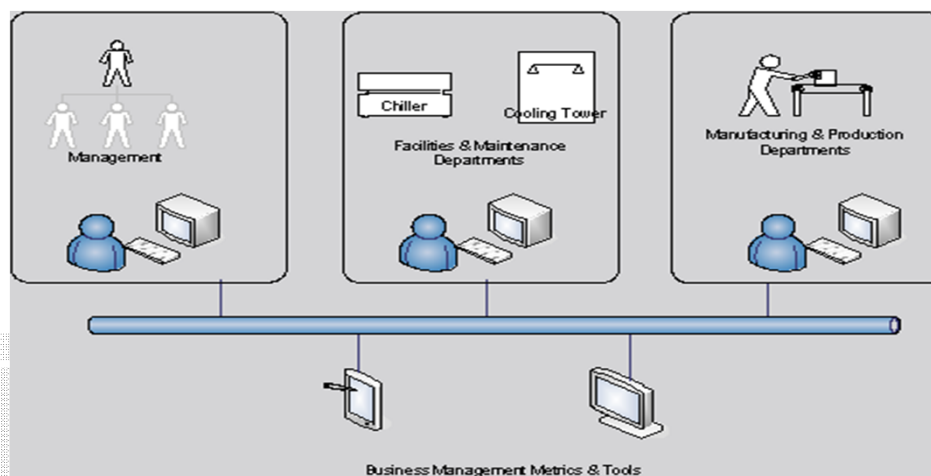
- Only a small number of automated AFDD tools on the market
- These tools are not generic and are time consuming and costly to install
- Proposed solution is not vendor specific and requires little set up
- Potential for over €600,000 savings in the 7 sites taking part in the project



- Potential savings in the wider Large Industry Energy Network (LIEN) of 135 companies of greater than €30M

Next Steps

- Expand rule library and ensure it is extensible
- Quantify and prioritise faults
- Transition to a cloud based solution
- Develop prognostic capabilities
- Integrate with third party applications
- Expand capabilities of AFDD tool
- Measure & verify savings





If we knew what it was we were doing, it would not be called research, would it?

Albert Einstein

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