4.3 Results from pilot phase testing of the AFDD tool

4.3.1 General Observations

The most unexpected observation during the pilot study was the number of potential opportunities for improvement present in each of the pilot AHU's. The AFDD tool identified numerous physical and control system faults with all the units under analysis.

Manual interaction with the AHU's was identified as a major cause of energy inefficiency in the HVAC units under observation. Supply and zone set points were found to be manually adjusted to overcome what were actually ineffective control issues or physical faults in the system

There were significant difficulties encountered in obtaining data from the on-site BMSs due to a wide variety of issues. Most of these issues could be resolved by developing and using a standard that would provide a consistent naming convention for sensors and components and a normalised relational database schema for archiving long term BMS data. Unfortunately, to the best of the authors' knowledge, no such standard currently exists.

Aside from the issues in obtaining measured data, it was quite difficult to obtain design details of some AHUs. This was due to the age of many of the AHUs (resulting in a lack of documentation), frequent retrofits that have occurred on most sites (as the requirements for manufacturing environments change quite regularly), and difficulty in physically accessing the units in order to obtain measurements using temporary sensors and handheld devices.

4.3.2 Energy Savings identified by the AFDD tool

The AHUs on several of the sites have been analysed in detail using the AFDD tool and a number of faults have been detected. Table 4 provides an overview of the faults identified to date across the pilot AHU's and their associated costs which totalled over €121,000. These faults have been verified by physical inspection using airside measurements. The costs associated with the faults were estimated assuming conservative annualised unit costs of associated energy.

Table 3: Savings identified to date.

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

5. Future work

Currently, the business layer of the AFDD tool is procedural in design. While this was appropriate in order to rapidly test the initial FDD method for a limited number of AHUs, this approach is not effective on varying types of AHU's. Therefore, the next step is to redevelop the business layer using an object-oriented approach to allow its expanded and scalable use across all types of AHU's. In conjunction with this work, further capabilities will be added to consider different types of faults, such as fan, motor, filter and variable frequency drive (VFD) faults using the pressure, power, and flow sensor data that is available in many of the AHUs.

Other future work will focus on further validation of the savings using an established international standard for measurement and verification such as ASHRAE Guide 14[16] of the International Measurement and Verification protocol (IPMVP) [17].

Fully automated fault diagnosis is the key next step in the project. As described earlier, users must currently manually diagnose the root-cause of a particular fault given a number of suggested possibilities. A method to fully automate this process is currently under testing in conjunction with the development of a method of prioritisation to aid end users in selecting which faults to repair first.

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