DEMAND CONTROLLED VENTILATION IN RENOVATED BUILDINGS WITH REUSE OF EXISTING DUCTWORK

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ABSTRACT

Most existing non-residential buildings have Constant Air Volume (CAV) ventilation leading to over-ventilation in periods with low or no occupancy. Demand controlled ventilation (DCV) can considerably reduce the ventilation airflow rate and energy use for fans, heating and cooling compared to constant air volume (CAV) ventilation. There is a potentially enormous upcoming marked for converting from CAV to efficient DCV in existing commercial buildings.

Conversion from CAV to DCV with reuse of existing ductworks, was one of several energy measures carried out in Solbraaveien 23, a Norwegian office building. The building was originally built in the early eighties and is considered to be representative for a large number of buildings in need for an upgrade. Total delivered energy use was reduced from 250 kWh/m^2 to 80 kWh/m^2, and the indoor environment was improved.

Reuse of existing ductworks was very profitable. The ductwork cost in Solbraaveien 23 was roughly cut in half compared to the alternative which was demolition and new ductwork installation.

Based on the experiences from Solbraaveien 23, it is specified a step by step procedure for reuse of existing ductwork that can be used in all projects where such reuse is considered.

The following success criteria are identified for the successful conversion from CAV to DCV with reuse of existing ductwork:

- Can the original system partition be reused?
- Do shafts have sufficient capacity and availability?
- Does the ductwork have sufficient access and quality?
- Are there any visible corrosion?
- Are there risks for any duct parts with asbestos?
- Is the ductwork sufficiently airtight?
- Are the drawings up to date and easily accessible?

KEYWORDS

CAV, DCV, Reuse, Ductwork, Energy

1 INTRODUCTION

IEA reports that CO_2 emissions from buildings must be reduced from 50 $MtCO_2$ in 2010 to 5 MtCO2 in 2050 in the Nordic countries to avoid severe problems of global warming (IEA &

Nordic energy research, 2013). A consequence for the building sector is that a widespread conversion of buildings to very low energy consumption and even zero energy buildings is necessary.

Demand controlled ventilation (DCV) can considerably reduce the ventilation airflow rate and energy use for fans, heating and cooling compared to constant air volume (CAV) ventilation (Maripuu, 2009) due to relatively low simultaneous occupancy in office buildings (Halvarsson, 2012). The central ductwork-components will probably have more capacity in a DCV-system than in a CAV-system because of limited simultaneous use. Hence, conversion from CAV to DCV with reuse of existing ductwork could increase the system capacity and actually solve a former capacity problem. There is a potentially huge upcoming marked for converting from CAV to efficient DCV in existing commercial buildings (Mysen et. al., 2011).

A Norwegian office building has been upgraded from CAV to DCV with reuse of existing ductwork. This paper presents this upgrading to modern DCV (Mysen et. al., 2014)

2 DESCRIPTION OF SOLBRAAVEIEN 23

Solbraaveien (Figure 1) is an office building built early in the eighties. It is situated in the municipality of Asker, close to Oslo.

Figure 1. Solbraaveien 23 before and after refurbishment.

It was originally built with CAV-ventilation with reports of annoying noise from the ventilation system. The air inlet was below the windows, blowing upwards with room air induction. Such air inlets are space consuming (Figure 2).

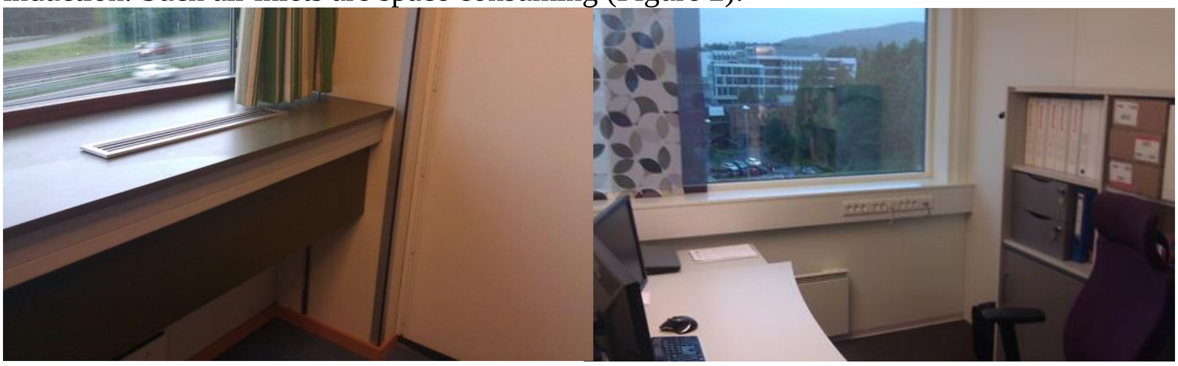

Figure 2. Left: Before retrofitting, the old air-inlets were space consuming. Right: After retrofitting.

The following main retrofit measures were carried out:

- New air-handling-units
- Conversion from CAV to DCV
- The windows were changed, new U-value of 0,8 W/m^2K
- Additional insulation on walls and roof
- Reduced leakage
- Air-water heat pump

Total delivered energy use was reduced from 250 kWh/m^2 before retrofitting to 80 kWh/m^2 after retrofitting and the indoor environment was improved (Mysen et. al., 2014).

3 RESULTS

3.1 Premises and procedure for re-use of existing ductwork

The procedure for re-use is developed by the entrepreneur (GK AS) and SINTEF in the R&D-project UPGRADE Solutions (Mysen et. al., 2014). It is existing ductwork at the "user-side" of the air-handling-unit that is of interest to re-use in upgraded DCV.

A stepwise procedure is developed and shown in figure 3.

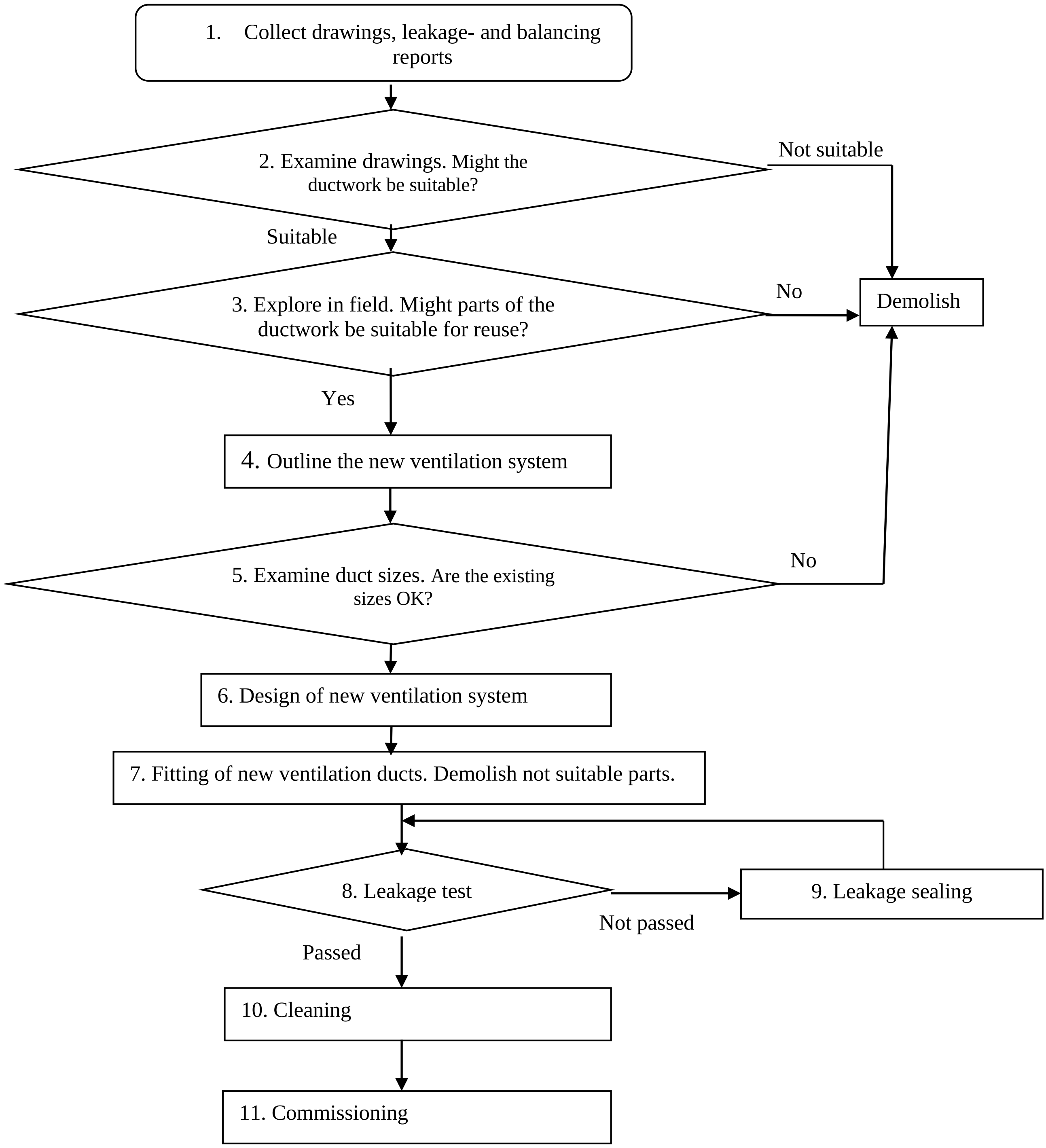

Figure 3. Stepwise procedure for re-use of duct-work.

3.2 DCV system solution

The ventilation system is upgraded with the use of variable supply air diffusers (VSAD). The DCV-units (same as VAV-damper) are integrated in the air diffusers, making it espcially suitable for upgrading to DCV. Figure 4 shows a schematic diagram where variable supply air diffusers are regulated by a controller, and communication is performed via bus.

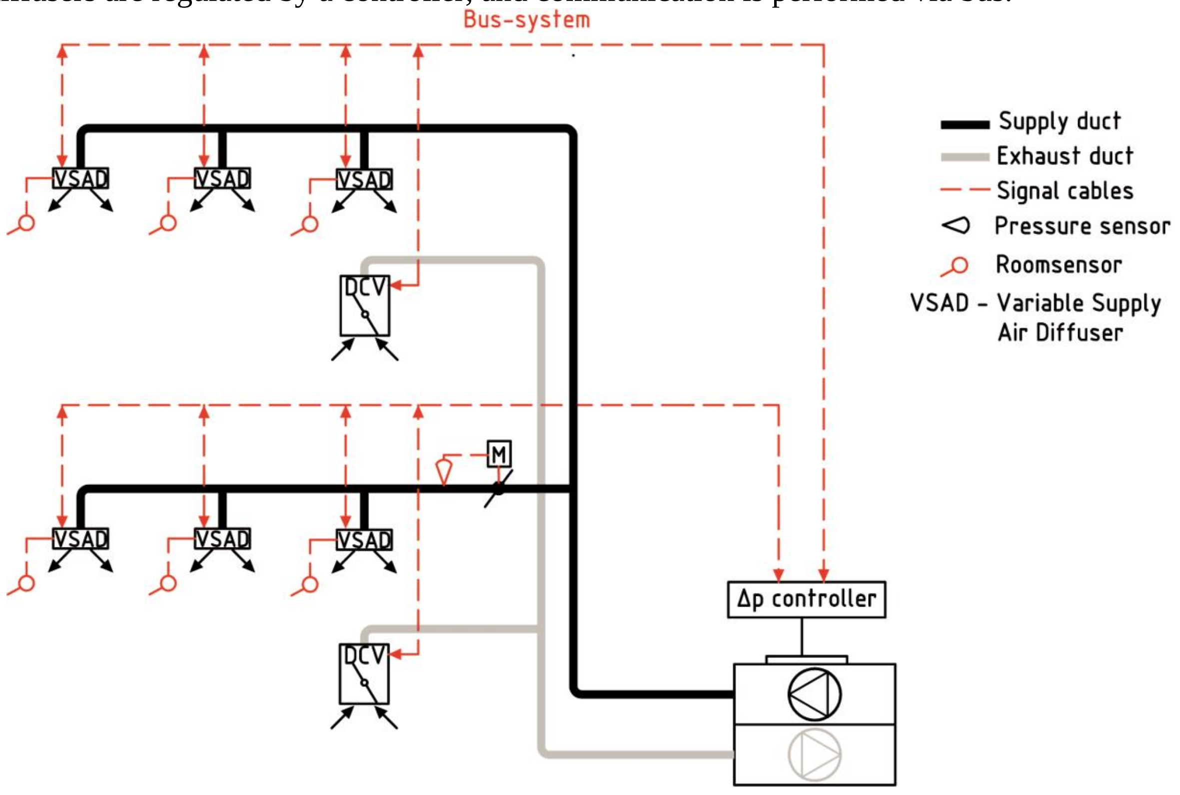

Figure 4.Schematic diagram with VASD regulated by a main controller.

The controller records the required airflow rate, the supplied airflow rate and the damper angle for all the DVC-dampers, and regulates the fan speed such that one of the VSAD is in a maximum open position opened on the supply side, and such that one of the DVC-damper is in a maximum open position on the exhaust side. The integrated motor-driven damper makes sure that the pressure remains in the working range of the VSADs. This damper should normally remain in a maximum open position and only throttle if the pressure in the duct becomes too high relatively to the working range of the VSADs. Such a situation can happen in the branches closest to the fan in large ventilation systems.

VSAD is combined with overflowing arrangement from the offices to corridors and outlets controlled by traditional VAV-dampers.

Table 1. New and re-used parts of the ventilation system after retrofitting.

Ductwork	90-95% is re-used
Air inlets	New VSAD
Air outlets	New, controlled by new VAV-dampers
Air-handling-units (AHU)	New
All ventilation-parts between outside air and AHU (main building air-intake and air exhaust)	New

3.3 Investment costs for re-use versus new ductwork

Table 2 shows the estimated costs in Solbraaveien 23 compared with a new ductwork-solution. Additional costs related to demolishing or fitting of new duct-work is roughly estimated based on Norwegian prices and experiences from Solbraaveien which has a total net area of 10.000 m^2.

Table 2. Costs with reuse of ductwork compared with new ductwork.

Activity	*Total cost in Solbraaveien (with reuse) [Euro/10.000 m^2]*	*Total costs with new ducts (traditional solution) [Euro/10.000 m^2]*
1. Collect drawings, leakage- and balancing reports	1 250,-	
2. Examine drawing. Might the ductwork be suitable?	1 250,-	
3. Explore in field. Might parts of the ductwork be suitable for reuse?	1 250-13 000,-	
4. Outline the new ventilation system	No difference	
5. Examine duct sizes. Are the existing sizes OK?	2.500 – 6.000	
6. Design of new ventilation system	0	
7a. Demolish not suitable parts.	19 000,-	150 000 – 200 000,-
7b. Fitting of new ventilation ducts	50.000-62.500,-	400 000 - 500 000,-
8. Leakage test	No difference	
9. Leakage sealing	6.250	
10. Cleaning	112.500 -225.000	
11. Commissioning	0	
12. Unforeseen costs		
SUM	194 000 – 328 000	550 000 – 700 000

This rough estimate shows that reuse was a very profitable alternative to new ventilation ductwork in Solbraaveien 23. Maximum additional cost for reuse was estimated to 40 Euro/m^2, while the minimum alternative cost for demolishing and installation of new ductwork was estimated to 70 Euro/m^2. Reduction of the demolishing costs is an important cause of the profitability.

4 DISCUSSION AND CONCLUSIONS

Conversion from CAV to DCV was one of several energy measures carried out in Solbraaveien 23. Total delivered energy use was reduced from 250 kWh/m^2 to 80 kWh/m^2, and the indoor environment was improved.

Reuse of existing ductwork might require some compromises when it comes to normal requirements for specific fan power, maximum air velocity, noise generation and leakage. Before considering ductwork reuse, one has to clarify that the builder owner has a pragmatic attitude towards such normal requirements.

Furthermore, one must clarify if the ductwork is suitable for reuse as early as possible in the process. Based on the experiences from Solbraaveien 23, it is specified a step by step procedure for reuse of existing ductwork that can be used in all projects where such reuse is considered (Figure 3).

The following success criteria are identified for the successful conversion from CAV to DCV with reuse of existing ductwork:

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Reuse of existing ductworks was very profitable in Solbraaveien 23. The ductwork cost was roughly cut in half compared to the alternative which was demolition and new ductwork installation. Reuse of the existing ductwork can potentially reduce the refurbishment period and therefore reduce loss of rental income. This is not included in the economical consideration.

5 ACKNOWLEDGEMENTS

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