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The development of low-pressure mechanical ventilation systems LeVent

Results of task 5.2 of the EU Joule project TipVent

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Synopsis

The target in this study was to decrease the energy use for transportation of air (fan energy) with a factor of three. Two real systems composed of existing components were constructed in a laboratory; a mechanical exhaust system and a balanced system. The flow rates through the systems were set at values according to the Dutch Building Regulations. This situation is called the reference situation. A number of improvements have been tested and studied. Some improvements studied:

- aerodynamic shape of the fan housing
- better aerodynamic shape of fittings
- more effective duct lay out
- developing a low pressure air terminal device

These measurements include:

- flow rates
- pressures differences in the ducting and before air terminal devices
- fan power

The results achieved show systems that have half to one third of the reference fan energy.
To show people in the field effects of duct lay out, duct sizing, fan choice, etc, a dynamic calculation model have been developed.

1. Introduction

The development of the LeVent system was part of an EU project TipVent [1].
The aim of the TipVent project is to achieve improved performances of mechanical ventilation systems and the introduction and wider use of innovative ventilation designs. TipVent is divided in 7 tasks.

Task 1 : Impact of ventilation requierements on energy demand
Task 2 : Field evaluation of system performances
Task 3 : Performance approach. Part 1: existing situation
Task 4 : Performance approach. Part 2: new procedures
Task 5 : Development of smart systems and concepts for improved performances
Task 6 : Performance approach. Part 3: checking in practice
Task 7 : Dissemination; Transfer of knowledge to industry

Task 5 Development of smart systems was divided in three parts:

- 5.1 Active noise insulation
- 5.2 Energy efficient and sustainable air distribution system for mechanical ventilation (LeVent)
- 5.3 Boost intake Valve

This publication describes briefly task 5.2.
The LeVent part of task 5.2 , is a collaboration between Bergschenhoek BV , a manufacturer of ventilation systems and TNO Bouw a research institute.

The goal for this task is:
To decrease the energy consumption due to transportation of air in practice with a factor of two.

2. Levent system

Levent is a ventilation system where the energy for the transport of air is reduced to at least 50 % of the reference value for a system available product before the TipVent project.

The development of LeVent include:
- low resistance ductwork
- low resistance fittings
- low resistance air terminal devices
- better controls
- energy efficient fans.

A lot of measurements were carried out in the laboratory as well as in the field. The development phase of the project was mainly done in the laboratory. The first step was to design an exhaust system and a balanced system for a reference house.
This system was designed according to the ventilation requirements in the Dutch Building Regulations [2] and commissioned according to the Dutch Standard NEN 1087. [3]

The construction, commissioning and functional checks was the second phase. The third phase was brainstorming and selection of ideas. The final stage was development and measurements.

3. Measurements

An exhaust system and a balanced system was set up in the laboratory of TNO Bouw. The installation was delivered and installed by Bergschenhoek BV. The commissioning was carried out by TNO Bouw.
Some brainstorm sessions were held together with Bergschenhoek BV to select from all ideas the best possible and practical features.

In the laboratory we have studied on a number of improvements. These improvements are:

- better aerodynamic casing fan
- DC fan instead of AC fan
- better duct lay out, parallel round ducting instead of rectangular ducting
- better aerodynamic fittings
- low resistance air terminal device (< 5 Pa)

The following properties have been measured.

- Static pressure
- Velocity pressure
- Airflow rates
- Accumulated fan power

Some results are given in figure 1. [4]

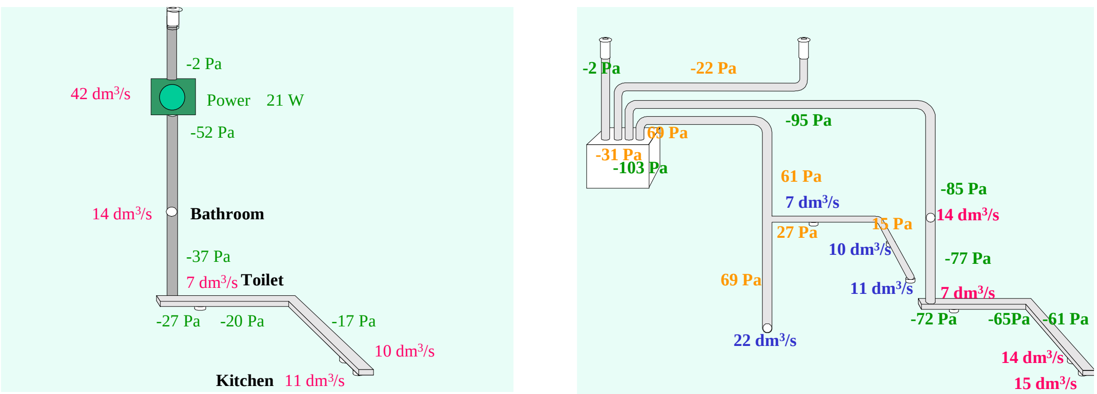


Figure 1 Measurement results of an exhaust only and a balanced system.

4. Energy Impact

The transport energy to run the system continuously at flow rates according to the required ventilation rates was in our reference situation:

- 21 W for an extract system at a total flow rate of 42 dm^3/s (0.5 $W/(dm^3/s)$)

- 198 W for a balanced system at a total flow rate of 63 dm^3/s (3.1 $W/(dm^3/s)$)

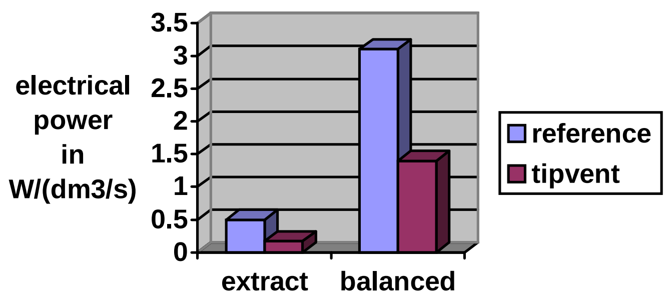
A remark can be made here. In the current practice the average electrical energy use for an exhaust only system in a dwelling is more in the range 40 to 50 W. For a balanced system with heat recovery that value is about 240 W.

A number of improved components were tested in the systems.
The final results in terms of electrical transport energy were [5]:
- 7 W for an extract system at a total flow rate of 42 dm^3/s (0.17 $W/(dm^3/s)$)
- 85 W for a balanced system at a total flow rate of 63 dm^3/s (1.4 $W/(dm^3/s)$)

The reduction of the transport energy is thus:

- a factor of 3 for the mechanical extract system
- a factor 2.3 for the balanced system.

The goal to reduce the transport energy with a factor 2, was reached.



The electrical transport energy is only a small part related to the energy demand for heating the ventilation air during the heating season. The effect on the energy demand of a single dwelling is estimated rather low. The saving is with respect to the reference, taking into account other control positions, about 10 W for a mechanical extract system. Hence the saving in electrical energy is 87 kWh per year or 0.9 GJ primary energy. In terms of money with 0.14 Euro/kWh about 12 Euro per year. Individual inhabitants of dwelling can never be motivated to save this small amount of money. But looking to the national or European level, it becomes an important amount of energy. For instance in the Netherlands about 80 % of all 6 million houses have mechanical extraction. In terms of primary energy it means for the Netherlands at least 4.3 PJ !!! At least 4.3 PJ because in current practice the average electrical fan Power will be closer to 40 W, instead of the 21 W in our reference case.

5. TipVent duct Program

TipVent duct is a program with a fixed duct network layout to test the performance of a fan, duct sizes and fittings. [6] The TipVent duct program is based on COMIS. It is dynamically calculating flow rates and pressures, while the user is changing a certain component or fan.
In the file menu you can Open different pre "commissioned" files with input data, resulting in optimal conditions for the chosen ventilation system.
So for an exhaust only system and a balanced system:

a. current practice
b. TipVent reference
c. LeVent

The lay out of the program is given in figure 3.

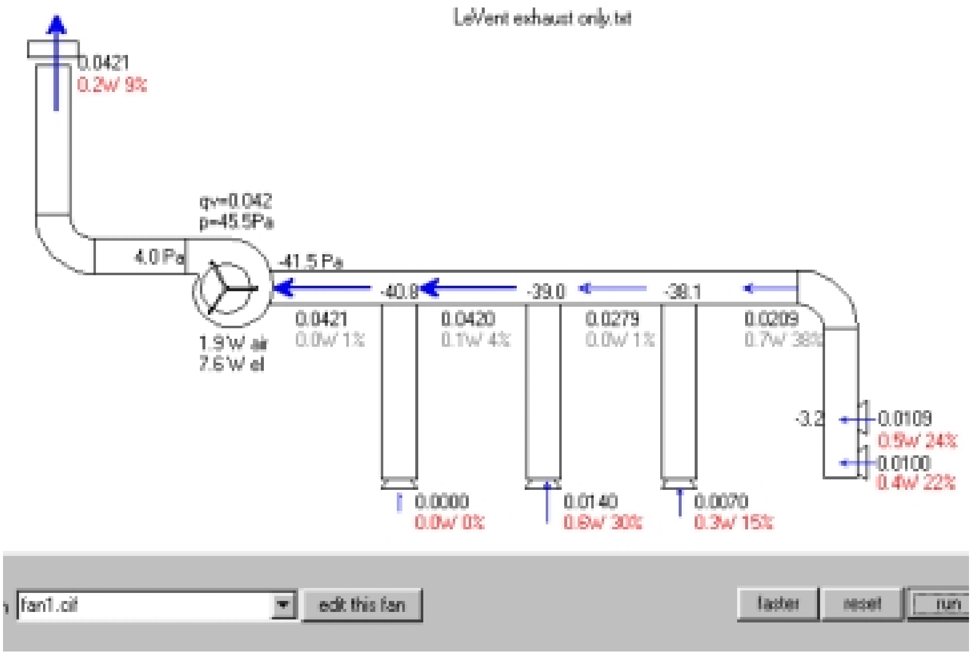


Figure 3 Scheme of the TipVent duct program

One can click on each item. That means on a part of a duct, an air terminal device or the fan. You then can change a component. For instance an air terminal device to another resistance or a fan to another rpm, and directly see the effect. You even can change the fan characteristic or make your own.
The program has in the Help-file a brief description of all components.

6. Conclusions

- The electrical energy use for fans in domestic ventilation can easily be decreased by a factor of two. Taking into account current practice it can be as big as a factor of five.

- It is almost impossible to motivate individual dwelling owners to invest in an energy efficient fans and ductwork. The individual saving is simply to low. (12 Euro per year)

- The annual saving in primary energy due to the application of LeVent systems on national level delivers for the Netherlands an energy saving of at least 4.3 PJ.

- The main contributors in the Levent system for saving electric energy were:

⇒ Improvement on fittings, better aerodynamic shape.
⇒ Replace AC to DC fan
⇒ Improve ductwork lay out: parallel round ducting instead of rectangular ducting
⇒ Low resistance air terminal devices (<5 Pa)
⇒ Low resistance roof-outlet/cowl.

- A practical and instructive tool has been developed as TipVent duct computer program. This tool can be used to:

⇒ instruct people how to commission a system
⇒ help people in the design process to size systems
⇒ to educate students by showing directly effects of their choices.

7. References

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