BIM WORKFLOW FOR MECHANICAL VENTILATION DESIGN

Object-Based Modeling with Autodesk Revit®

Mathias Bonduel

Master's thesis
May 2016
Degree Programme in Construction Engineering

ABSTRACT

Tampereen ammattikorkeakoulu
Tampere University of Applied Sciences
Degree Programme in Construction Engineering

MATHIAS BONDUEL:
BIM Workflow for Mechanical Ventilation Design
Object-Based Modeling with Autodesk Revit®

Master's thesis 132 pages, appendices 100 pages
May 2016

This study is conducted for the Belgian engineering firm CENERGIE, whose main business activities are within the fields of building systems and sustainable buildings. The company wants to change their current design workflows to adapt the use of Building Information Modeling (BIM) with Autodesk Revit.

The research focused on the development of a BIM workflow where no models are exchanged between building partners. The aim of this study was to develop such a Revit BIM workflow for the design of mechanical and hybrid ventilation systems in non-residential buildings.

Two sets of process maps were created to visualize the current and new workflow. A practical workflow is developed by examining and testing different modeling methods in the software.

Besides two Revit templates and several custom-made elements, additional tools were developed with Autodesk Dynamo®, the visual programming add-in for Revit. Customization was necessary because some built-in Revit modeling methods follow North-American design habits and standards.

Revit was successfully customized by using the earlier described methods. The steep learning curve implies that an adequate learning process and/or collaboration with specialized BIM companies will be necessary. Further research should incorporate the implementation of BIM in other CENERGIE business domains such as electricity, cooling systems, etc. Strategies for future BIM collaboration should be investigated as well.

Key words: revit workflow, mechanical ventilation, revit customization, building information modeling, dynamo

CONTENTS

ABBREVIATIONS AND TERMS

BIM	Building Information Modeling
CAD	Computer-Aided Design
Mechanical ventilation	Supply and extract air is moved by a mechanical created pressure difference. The air moves between the outside environment, the air handling unit and the indoor rooms via ductwork. This type is often called ‘System D’ ventilation in Belgium.
Hybrid ventilation	The combination of mechanical and natural ventilation.
Freecooling	Natural, hybrid or mechanical ventilation where cool outside air is used to cool down the thermal mass of a building. In this research, freecooling ventilation is used to describe hybrid ventilation (natural supply and mechanical extraction of air). This cooling method is used mostly during the night, but it can also be adapted during the daytime.
Supply air	The fresh air that flows from the air handling unit to supply air terminals located in rooms.
Outside air	The fresh air that flows from an outdoor air terminal to the air handling unit.
Extract air	The used air that flows from the extract air terminals located in rooms to the air handling unit.
Exhaust air	The used air that flows from the air handling unit to an outdoor air terminal.
Transfer air	Air that flows from one room to another via grilles, door gaps or other significant openings.
MEP	Mechanical, Electrical and Plumbing
CN	The abbreviation used in custom parameter and Family names is related to the company CENERGIE.
PM	Process Map
ER	Exchange Requirement
.dwg	Widely used file format for CAD drawings. It is the native file format of Autodesk AutoCAD. Other CAD software packages often support it as a non-natively file format.

AHU	Air Handling Unit
VAV	Variable Air flow Volume
CAV	Constant Air flow Volume
IDA classes	Indoor air classification according NBN EN 13779: 2010
ETA classes	Extracted air classification according NBN EN 13779: 2010
ARAB	Belgian general regulations about employment protection (Dutch: Algemeen Reglement voor de Arbeidsbescherming)
VEA	Flemish energy agency (Dutch: Vlaams Energieagentschap)
WTCB	Belgian Building Research Institute or BBRI (Dutch: Wetenschappelijk en Technisch Centrum voor het Bouwbedrijf)
IFC	Industry Foundation Classes
BCF	BIM Collaboration Format

1 INTRODUCTION

1.1 BIM – Building Information Modeling

The acronym BIM has a lot of different meanings ranging from Building Information Model over Building Information Management to Building Information Modeling. The BIM concept should not be confused with commercial software packages that can be used to produce BIM models, such as Autodesk Revit® and Graphisoft ArchiCAD®. The first concept emphasizes more the result, while the second definition focuses more on the management of (modeled) intelligent building data. The most-used meaning is BIM as Building Information Modeling. A common cited definition comes from the National BIM Standard-United States (National BIM Standard-United-States 2016):

> Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition.

This digital representation or model consists of 2D and 3D BIM objects, that together represent a building or facility. These intelligent BIM objects have one or more parameters and different relations between this objects and parameters can be established. Several mentioned advantages of using BIM over traditional CAD solutions are the reduced amount of data loss during the buildings life-cycle, better coordination during the design and construction phase (interference checking), shorter construction period and generally better designs. This should eventually result in lower building and maintenance costs.

The commercial BIM software that is used for this research is Autodesk Revit. More information will be given in section 2 ‘Methodology’.

1.2 BIM workflow

The advantages related to the application of BIM can become a new reality for building companies and even whole industries, depending on how the BIM concept is translated to a proper BIM workflow. Even without the use of BIM, a clearly described workflow can be beneficial for a building company. As generally known, a building has different life stages ranging from conceptual design to construction phase and demolition or re-use phase. The building industry can be called fragmented; a lot of different disciplines and corresponding actors need to cooperate in designing, constructing and maintaining a building. On the other hand, every building project is different. This will result in general applicable basic workflows that can be modified and fine-tuned according to the specific project.

Using workflows when implementing BIM will help companies with the transition from CAD to BIM-based design. It can be used as an instrument to teach the companies' way of using BIM to employees who are not familiar with their approach to BIM. Secondly, one uniform basic workflow can assist in producing consistent outputs and makes it possible for other employees to join a running project after a short meeting.

1.3 BIM stages

Just as there are multiple BIM definitions, there are various ways of describing the BIM capability of a company. A useful description was found in the work of Bilal Succar, where he chooses to define so-called BIM (capability) stages (Succar 2010, 7). In his opinion, there is a fixed starting point where no BIM is used (pre-BIM status) followed by three successive BIM stages that lead towards a variable post-BIM status (figure 1 FIGURE 1).

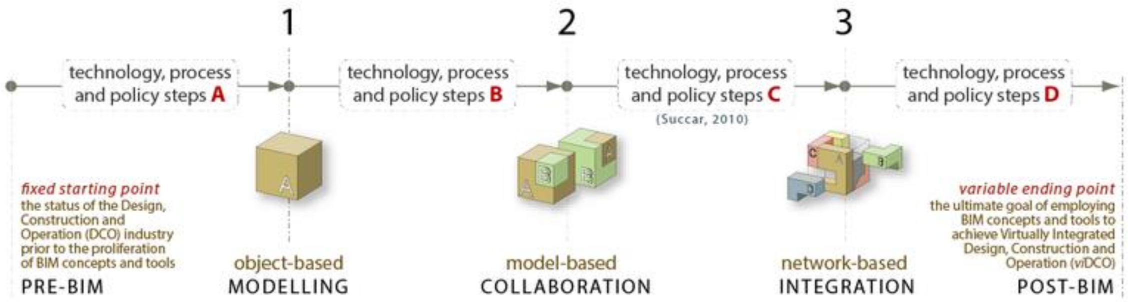


FIGURE 1. BIM stages (Succar 2013)

During the pre-BIM status, companies produce 2D and sometimes 3D drawings but there is no virtual connection between the calculations, documentation and drawings. If there are 3D drawings, they are typical non-object based. The workflow is called linear and asynchronous. BIM stage 1 is the first stage companies typically reach when adopting BIM. The use of object-based models is limited to one building discipline during design, construction or operation phase. The models are not exchanged between different building actors. The following stage is characterized as the model-based collaboration stage: collaboration between disciplines via exchanged models or parts of models takes place. The exchanged models can be in native file formats if both building actors use the same software package. If this is not the case, a neutral file format such as IFC is needed. In BIM stage 3 the model-based collaboration makes place for network-based integration: different single-disciplinary BIM models are combined by using a network technology solution to make one interdisciplinary model. The post-BIM phase covers different possible long term visions on BIM use. Real-time relations between an integrated BIM model and other databases such as Geographic Information Systems (GIS) can become a new reality (Succar 2010, 8).

This research focuses on the first step, between pre-BIM and BIM stage 1. Although the later stages are more attractive in the long run and can offer a lot of possibilities, it is necessary that companies move on step by step to make the radical change from pre-BIM to post-BIM possible.

1.4 Mechanical ventilation design

Ventilation of buildings is becoming more and more important, because of different reasons. The main reason to ventilate a building is to remove so-called indoor air pollutants such as Volatile Organic Compounds or VOC’s (e.g. aldehydes and aromatic hydrocarbons), carbon dioxide, radon, ozone, moisture, odors, bacteria and house dust mites. These pollutants can have a significant influence on both occupant health and comfort, but it can also cause deterioration of materials and equipment (Leving 2003, 4).

To reduce the amount of indoor pollutants, most buildings were ventilated in the past by using uncontrolled natural ventilation: opening a door or window manually and air infiltration. To ensure that the air change rates are sufficient on different moments, it is better to switch to controlled ventilation systems, which can be natural, mechanical systems or a combination of natural and mechanical ventilation. Mechanical ventilation uses mechanical equipment such as fans to create a pressure difference between the indoor and outdoor environment to move supply and or extract air through the building. Natural ventilation uses naturally created pressure differences, such as wind pressure and thermal buoyancy. Because recent buildings are built more and more airtight, controlled ventilation has become a necessity to keep indoor air quality acceptable (Howieson et al. 2013, 1).

In Belgium, four general ventilation system types are defined (Van den Bossche et al. 2007, 14). Natural supply and extraction (system A), mechanical supply and natural extraction (system B), natural supply and mechanical extraction (system C) and finally mechanical supply and extraction (system D). This research focuses on the design of system D ventilation systems, which we call mechanical ventilation in the rest of this text. This system offers an opportunity to add a heat recovery system which reduces the heat losses and improves thermal comfort by warming up the fresh outdoor air with the heat of the used extracted air.

In some building projects, freecooling is applied; it is a passive cooling method where cool, untreated outside air moves through the spaces to cool down the thermal mass of the building (Leenknegt et al. 2011, 1). This method is mostly used during nighttime when the outside air is cooler. In this case it is also called night ventilation. Essentially, it is also possible to use freecooling during the daytime if the outside temperature is low enough. The term freecooling covers both night ventilation and freecooling during the daytime. To achieve freecooling, the cool outside air can be moved with a ventilation system A, B, C or D. A common solution is natural supply with automated windows and mechanical extraction (system C), because this ensures the air flow quantity and the flow direction with minimal extra costs. This ventilation system is called hybrid, if the system switches between system C and D. It is possible that the extraction part, used for freecooling, has a separate duct system and extraction fan.

1.5 CENERGIE cvba

This research is conducted in commission of CENERGIE cvba, a Belgian building systems engineering firm located in Berchem, with offices in Berchem and Brussels. They design building systems (HVAC, electricity, building control systems), monitor energy usage of existing buildings and assist architects in designing durable and ecological buildings. They cooperate in all kinds of construction projects over Belgium, ranging from renovations to new buildings and (big) residential and non-residential projects.

Their main business activities focus on designing buildings systems and assisting architects in designing of ecological facilities for new non-residential buildings, mostly schools and office buildings, in both the regions of Flanders and Brussels.

CENERGIE wants to maintain its pioneering role in the Belgian construction industry, by adapting BIM software step by step in their workflows. Besides improving their existing workflow, they want to be able to join projects where the use of BIM is mandatory.

1.6 Research question and outputs

In this research, a BIM-based workflow with Autodesk Revit software will be built. More specific, this workflow is made for the company CENERGIE and will cover the design of mechanical ventilation systems where the use of freecooling is optional. The research focuses on the step between the pre-BIM status and BIM stage 1 (object-based modeling), with special attention for new, non-residential building projects in Belgium, which is the main business activity of CENERGIE.

Chapter 2 ‘Methodology’ covers the used research and documentation methods. First, an overview on the used sources is given. Next, important features of the used BIM software package Revit and add-ins will be explained, followed by the used approach for the implementation of the BIM software. The last part covers how process maps will be used to describe both a pre-BIM workflow and a workflow for BIM stage 1. Process maps can be an effective way to explain a certain workflow graphically and in an uniform way by determining tasks, decision points and exchange requirements (inputs and outputs).

Chapter 3 (including appendix 1 and 2) covers the current pre-BIM workflow. Textual information is present in addition to this first set of process maps. The content of this part is not published, because it contains confidential information about the current workflow of CENERGIE.

In chapter 4, the central part of the research, an effective workflow that suits BIM stage 1 with Revit is investigated. A second set of process maps, based on the one from chapter 3, is made. This method will be used to show the changes between both workflows. In the text of chapter 4, successful and less successful attempts to create a Revit workflow are described together with possible solutions and remarks. The documentation in appendix 4 explains the most suitable workflow step by step and can be used as a guideline together with the process maps in appendix 3. The goal is not to produce a complete manual, but to describe the crucial steps and decisions. Together with this set of process maps, the Revit loadable Families, templates and the Shared Parameter File are developed and described. In appendix 5 and 6, a list with changed settings to respectively the Revit ventilation template and the architecture template is given. Appendix 7 explains the data structure of the developed loadable Revit Families. Appendix 8 to 12 present the developed Dynamo tools that will support the workflow in Revit.

Finally, chapter 5 provides general conclusions and discussion: What is achieved? What should be considered as further research? The advantages and downsides of the proposed workflow are collected.

2 METHODOLOGY

This chapter will cover the methods that are used in this research. First the main sources are presented, followed by the used software packages and add-ons. In the third subchapter, the structure and naming conventions of the prepared Revit content is described. In the final part, the process mapping method is described.

2.1 Main research sources

Due to the type of research, no extensive literature review is needed. The main sources for designing the Revit workflow, template and Families are manuals and internet forums. For this research, the manual ‘Mastering Autodesk Revit MEP 2015’ (Bokmiller et al. 2014) is often used as a starting guideline. The most recent Belgian regulations and standards regarding ventilation are studied and correctly integrated in the workflow. During the phase of making the workflow and the Revit templates and Families, a lot of testing is done and by trial-and-error the best possible solutions are selected.

2.2 Commercial BIM software packages

2.2.1 Autodesk Revit 2016

The commercial BIM software package used for this implementation is Autodesk Revit version 2016 (built version: 16.0.490.0). Revit is defined as multidisciplinary BIM software because it offers functionalities for both architectural design, structural engineering and MEP engineering. Other BIM software that can be used to create ventilation BIM models, such as DDS-CAD® and Trimble MEP®, are not investigated during this research, so no comparison can be made. A recent Master’s thesis study suggests that Revit has in general a steep learning curve in comparison with Graphisoft ArchiCAD® BIM software (Marynissen & Moons 2015, 112). On the other hand, it offers the modeler different versatile options and tools, such as the ability to create Revit templates, with extra Project parameters and custom settings, and Revit BIM objects (Families) via the Family Editor environment. Users who want to get more out of Revit can use extra tools or add-ins. They can be downloaded from the Autodesk App Store (Autodesk 2016a) or from software companies specialized in making Revit tools. For this research the Dynamo 0.9.2 and IFC 2016 add-ins for Revit are used, which will be explained in the following sections. Users also have the opportunity to program add-ins by themselves by coding or by using the Dynamo add-in for visual programming.

The software company Autodesk® is based mainly in the US, which results in software that is made from the perspective of the US construction industry, with its own regulations (e.g. the MEP section in Revit is ASHREA-based) and design, construction and cooperation habits. Different non-US workflows can be established, but the developers need to take this original perspective into account. Examples of supporting ICT companies, that offer whole packages for Revit with specific workflows for MEP are Witas bvba (Witas Localizer®) and Progman (MagiCAD® for Revit). They offer specific Revit templates and content, extra add-ins, give training sessions and assist with the implementation of the software.

This thesis is written from the perspective of someone who already knows the basics of Autodesk Revit software. The focus of this text is on the functions and preparations needed specifically for the developed workflow.

Besides the full Revit version, there is also a Revit LT version which cannot be used for MEP engineering because the Systems tab is not available. Models made in one version of Revit can be exchanged to another version. Revit provides no backwards compatibility between older and newer versions. This feature becomes more important when models are exchanged between building actors in later BIM stages, because the different parties can be using older or newer versions of the software.

2.2.2 Dynamo 0.9.2 add-in for Autodesk Revit

Dynamo is a fast-developing and open-source program developed by Autodesk® that comes in two different versions: the first version, called Dynamo Studio, can be used as a standalone application and is only available on subscription while the second one is a free add-in for Revit, where it has its own parallel window called the Dynamo Interface (Autodesk 2015c). The Dynamo website provides the user with a download section, a manual called the ‘Dynamo Primer’, together with introductory videos and a very active community forum (Autodesk 2015c).

The goal of Dynamo is to expand the possibilities of Revit BIM software by means of visual programming instead of normal text-based programming (Kron 2013, 3). Visual programming can help BIM users that are not very familiar with the .NET compliant programming languages (VB.NET, C# and managed C++) to communicate with the Revit Application Programming Interface (.NET API).

A user selects prepacked ‘nodes’ from the Dynamo Library, which can be expanded with self-made nodes (‘.dyf’ file) or even free packages from different developers containing nodes with additional functionalities. Every node, representing some code, has inputs and/or outputs which can be connected to other nodes with simple wires, representing the flow of data. An application made in Dynamo with different connected nodes is called a ‘graph’ and can be saved for later use as a ‘.dyn’ file. A saved graph can only be used on another computer if all self-made nodes are saved in the same folder and all used free packages are installed. Two extra packages with nodes where downloaded via Dynamo Online Package Search and used for this research:

- ‘BumbleBee’ package (version 2016.2.8) (Sobon 2015)
- ‘spring nodes’ package (version 82.7.8) (Venkov 2016)

Dynamo is best known by certain architects who use it as a tool for the design of special geometry, generated according to certain algorithms, which can be imported in Revit. Next to methods for the creation of complex ‘free forms’, Dynamo also offers simple methods to read from or write to external databases (such as Revit). An eye-opener was the presentation of Marcello Sgambelluri for Autodesk University 2014 (Sgambelluri 2014). In this workshop, he showed the audience some Dynamo examples for everyday Revit problems. In one of his examples, he shows that parameters of different Families can be easily linked. With another example, he briefly explains how MS Excel® data can be linked to Revit data. Starting from this presentation, we found an online article (Kilkelly 2015) about methods to link Excel to Revit by using Dynamo.

2.3 Approach to Revit implementation

While developing a performant BIM workflow with Revit, we try to stay as close as possible to the standard software platform. Whenever a workaround is needed (e.g. because of the US-style approach to building design) a solution within Revit is prioritized, such as the creation of custom loadable Families and Project parameters. If no solution is found or the workaround is not efficient enough, other paths are examined, such as developing new tools that become a part of the final workflow. Additional supporting tools can be developed later and easily added to the proposed workflow to increase the design speed, quality of the model or the user-friendliness of the commands.

Whenever Revit terminology is used, the word starts with a capital letter to distinguish it from this word's general meaning. A duct system can have different definitions according to the context. A Duct System on the contrary, is an example of typical Revit terminology with specific definition and use. Family names, Family Type names, Dynamo tools, parameter names and parameter values are all written between single quotation marks.

2.3.1 Revit templates

The starting point of almost every successful software implementation is a good template:

> Project templates are the cornerstone to improving efficiency when you're working on an Autodesk® Revit MEP 2015 project. Revit for MEP is a design and documentation tool, and those who are paid to do design work should not have to spend time on anything other than achieving their design goals. (Bokmiller et al. 2014, 35)

Beside speeding up the model work, it helps to establish a corporation standard for modeling, which results in uniform models and exported drawings and other data. Templates should change over time, when users built up experiences with the starting template. On the other hand, not everyone should be able to change the templates at will. The suggested solution is having shared template files, which can be used by every employee. At the same time only a couple of persons (template managers) have the rights to make changes to it. When users have suggestions, they should report this so the template managers can decide if changes to the template(s) need to be made.

Two template files are made: one for the ventilation models and one for the architectural background models. Detailed information about the settings in each template can be found in appendix 5 and 6.

The templates contain the information that is needed in most projects. The settings range from general settings (language, metric/imperial units, project units), so-called Mechanical Settings (necessary for ventilation design), Project Information parameters and some prepared Levels, to all necessary Views (Floor Plans, Ceiling Plans, Elevations, Sections, 3D Views but also Schedules), a basic set of Sheets (defines printing layout and includes a Titleblock) and System Families such as Walls, Floors, Ducts, Duct Systems, Spaces, … provided with the necessary Project parameters. For each project, the modeler will probably have to change some small settings; most of the time this will be adding/deleting Levels and Views. Most loadable Families are already present in the template. Additional content (Revit Families) will have to be loaded from the companies library when needed. In this way, the model file size can be kept low and the model will be more performant.

2.3.2 Revit loadable Families

Besides system Families that can only be prepared and saved in template files, Revit provides loadable or model Families that can be loaded from an external library inside the project when needed. It is also possible to preload the most used loadable Families in the template. Model Families are made or modified in the Family Editor environment of Revit and they are saved as separate '.rft' files.

2.3.3 Shared Parameter File

Some of the parameters that are used in the loadable and system families are so-called Shared parameters. By using Shared instead of standard parameters (Family or Project parameters for respectively loadable and system Families), it is possible to display these parameters in Tags and Schedules. Revit demands that all Shared parameters are saved in a separate text file which they refer to as the Shared Parameter File. By doing this, it is possible to create single parameters that can be used in different Families and Projects. If in later phases new or modified content is made, the company can use the same Shared Parameter File developed for this research (‘CN_Shared Parameter File.txt’) to load the prepared parameters in the new Families.

2.3.4 Naming conventions for Revit Families and parameters

During the research, it was clear that a good naming convention is needed, to see the difference between Families (Loadable Families and System Family Types) and parameters. By looking at the name, it should be clear if the Family or parameter is custom-made or an out-of-the-box Revit Family or parameter, what the domain is of the element/parameter (architecture, project information, ventilation, …), the type of Space parameter (if the named element is a Space parameter) and finally the describing part of the Family or parameter name. This results in names that consist of minimum two and maximum four parts separated with an underscore. The proposed naming convention is not based on any specific wide-spread naming convention, but based on mere logical sense. This does not present a problem because no BIM models are exchanged in BIM stage 1.

To keep it easy to distinguish the self-created content (Families and their custom parameters) from the existing out-of-the-box Revit Families and their parameters they all start with the letters ’CN’ which refers to the company CENERGIE. The ’CN’ is also used in the name of Revit templates and the Shared Parameter File, developed for this research.

The second part of the name of a custom-made Family (loadable and System Families) or System Family parameter refers to the domain where they are used. This can be a ‘V’ for ventilation-related Families or parameters and ‘PI’ for Project Information parameters. If nothing is mentioned, the Family or parameter is considered to be not related to a specific CENERGIE domain (e.g. architecture, fire safety, bearing structure, annotation, …).

The third part relates only to Space parameters. As will become clear in chapter four, Spaces contain a lot of parameters. All custom-made Space parameters used in the proposed workflow can be changed, even when they are actually calculated in an third party software package and should not be changed afterwards. Three types of Space parameters are defined: the first type has no third part and relates to Space parameters that are not used in any calculation. The second type is marked with a 'D' as the third part of the name and refers to a design parameter that is used for calculation; the user can enter a value manually. The last type is marked with an 'R' and refers to a result parameter; it is the result of calculations that are based on manually-entered design parameters and/or out-of-the-box Revit parameters, whose parameter names cannot be changed.

The last part of the name is used to describe the Family or parameter in a short but accurate way.

2.3.5 Naming conventions for Revit Views

Views can be graphical (Floor Plans, Ceiling Plans, Elevations, Sections, 3D Views) or textual (Schedules) and they are both structured and presented in a different way.

Graphical Views

The graphical Views are sorted by 'Discipline', by 'Sub-Discipline' and finally by Family and Type of the View. These are all out-of-the-box parameters related to Views. The 'View Name' and 'Sub-Discipline' parameter can be changed at will. By giving each View an appropriate, structured 'Sub-Discipline' and 'View Name', it is a lot easier to refer to a specific View, but it is also very useful to find a View back when one of the above sorting parameters is changed by accident.

The 'Discipline' can only be chosen from a hardcoded list of types: 'Architectural', 'Structural', 'Mechanical', 'Electrical', 'Plumbing' and 'Coordination'. Only 'Mechanical' (ventilation) and 'Coordination' (architecture and ventilation) Disciplines are used in this workflow. The 'Sub-Discipline' can be custom-defined. For the presented BIM workflow, the following Sub-Disciplines under the Discipline 'Coordination' are defined in both templates:

- 'Coordination'

- ‘Filter – Bearing Elements’
- ‘Filter – Fire Compartments’
- ‘Filter – Thermal Insulation’
- ‘Filter – Updated Architecture Elements’

In the ventilation template, the following Sub-Disciplines are defined under the Discipline ‘Mechanical’:

- ‘Ventilation – Color Fill – Duct Air Velocity’
- ‘Ventilation – Color Fill – ETA’
- ‘Ventilation – Control Diagram’
- ‘Ventilation – Reference Planes’
- ‘Ventilation - Sheet Views’
- ‘Ventilation - Work Views’

The work Views should be used by the modeler while making the model. It allows the user to change View settings while modeling. Sheet-related Views are the Views that have specific View settings, needed for representation of the Views on Sheets. The View settings of the Sheet-related Views are controlled via View the View Templates. This will guarantee a uniform output of printed Views according to the companies’ standards.

The ‘View Name’ consists of minimum two and maximum three parts, all divided by a hyphen. The first part depends on the View Family/Type and can be the Level for Plans (‘Ceiling’ is added between round brackets if it is a Ceiling Plan), Elevation Orientation, Section code or just ‘3D’ for 3D Views. The second part refers to the ‘Sub-Discipline’. The last part is optional and describes the applied View Filter, if any.

Schedules

Textual Views or Schedules cannot be organized as graphical Views. The Schedules in the Project Browser are always in alphabetic order. Four kinds of Schedules are defined: bill of quantity (BoQ), control, Key and work Schedules. The difference between work and control Schedules, is the ability to enter data in the work Schedules. No changes should be made to control Schedules because they are made for reviewing data. Key Schedules are a special type of Schedule, because they define fixed Key parameters and can have other dependent Project parameters. The bill of quantity Schedules will help in making a simple quantity survey of the ventilation design model.

A Schedule name (‘View Name’) has minimum two and maximum three parts. The first part is related to the kind of Schedule: ‘BoQ’, ‘Control’, ‘Key’ or ‘Work’. The second part is separated from the first part with a hyphen. It defines, similar to Family and Project parameter naming conventions, the domain of the Schedule. This can be a ‘V’ for ventilation or nothing if it is not related to a domain specific for CENERGIE. The last part, separated with an underscore, is again a short and clear description of the content of the Schedule.

2.3.6 Naming conventions for Revit Sheets

Revit Sheets are organized according to three custom-made parameters: ’CN_Sheet Discipline’, ’CN_Sheet Sub-Discipline’ and ’CN_Sheet Size’. The first two parameter refer to the place of the Sheet in the CENERGIE specifications, while the last parameter simply refers to the paper size of the Sheet. The ’Sheet Number’ followed by the ’Sheet Name’ are displayed in the Project Browser. Only the ventilation template contains Sheets, as Sheets will only be printed from the ventilation model.

2.4 Process maps and exchange requirements

2.4.1 Process maps

Process maps or PM’s are used in this thesis to give a graphical overview on complex workflows. It defines who is responsible for a certain task in a certain phase of the project (Indigne 2012, 4). Although each building project is different and workflows can differ from the ones described in these PM’s, they are assumed to be relatively generic.

Two sets of process maps are defined: the first one describes the current pre-BIM workflow for a ventilation design, while the second set describes the workflow for a ventilation design at BIM stage 1. The first set (appendix 1) together with its documentation (appendix 2) is not published, because it contains confidential information about the current workflow of CENERGIE.

The software package Bizagi Modeler® v2.9.0.4 is used to produce these process maps according to the Business Process Model and Notation or BPMN 2.0 standards.

2.4.2 Exchange requirements

ER's or exchange requirements play an important role in process maps (PM's). They define what kind of documents (file format) will be exchanged during different moments of the workflow. ER's also define which building partners exchange data and how this is arranged.

Defining clear exchange requirements will help data exchanging building partners, even when both of them are still in the pre-BIM phase. When good agreements are made on this data exchange, it is possible to build more reliable and performant workflows. When BIM is used, even when no models are exchanged, these agreements turn out to be vital. Without them, the advantage of working faster with BIM may get lost because of extra waiting periods or additional workload.

2.4.3 Structure of the process maps

Each set of process maps consists of three levels, ranging from the overview on the different phases in the ventilation design to very specific tasks. Each lower level, breaks a complex task down into small tasks (figure 2). Tasks that consist of subtasks have a plus in their symbol. Every task in the process maps has been tagged with a code between square brackets. The code consists of three numbers representing the task number on each level. The code '[4.3.0]' for example, is related to task number 3 on level 2 that is a part of the more abstract task with the code [4.0.0] on level 1.

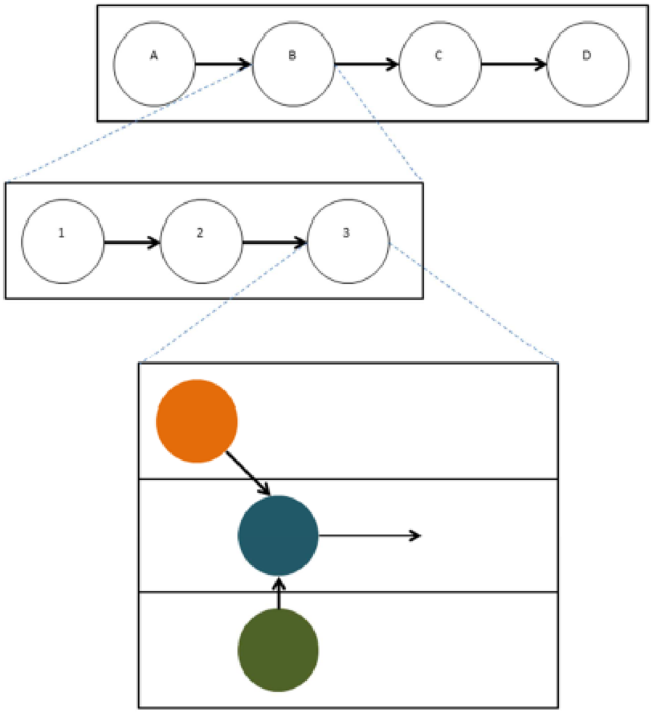


FIGURE 2. Process maps levels (Indigne 2012, 18)

When certain tasks remain unchanged between the pre-BIM set and the BIM stage 1 set, the same code is used. New and adjusted tasks are marked with an extra letter ‘n’ and ‘a’ after the last number different from zero.

While making process maps, there needs to be a balance between overview and completeness. For this reason, not every possible exception that can occur during a workflow can be included in a PM. Every process map consists of one ’pool’ with different ’lanes’ for each building actor. Lanes are rather linked to roles in the building process instead of real people, to make the scheme as clear and generic as possible. The lanes occupied by building actors are altered with blue-colored lanes that represent data exchange requirements. These can be internal (between building actors that are mentioned in the PM) or external (between one building actor and a third party that does not play an active role in the process). Internal data exchange requirements can also take place between the same building actor if a document is created/altered in one PM and reused or adapted in a later PM.

Tasks and documents are colored according to the specific software that is used. The colors can be green/red/blue/grey which represents respectively Excel/AutoCAD/Revit/Dynamo. If no specific software is used the task is not colored (standard light blue). With these colors one can see easily the difference between the pre-BIM set of PM’s and the BIM stage 1 set.

To keep the process maps clear, only ventilation-related tasks and decisions are presented. The main cooperation is between the architect and CENERGIE, because the architect is often the central person of a building project. If there are concurring constraints (e.g. the architect wants a false ceiling void of only 400 mm high and in this same ceiling void there is a concrete beam designed by the structural engineer that interferes with ductwork), it is the architect’s job to find a solution. This is the reason why the structural engineer is not mentioned in these PM’s. The (early) design phase is very often an iterative process; to keep the PM’s clear, not every possible iteration is included.

3 CURRENT PRE-BIM STATUS

The current pre-BIM status is described by means of process maps (three levels) and corresponding tables with a short description of the content of each task and the decision points after the task is finished, if any. The PM's and tables are presented in Appendix 1 and 2, which is excluded from this publication, because it contains confidential information about the current working methods of CENERGIE. The PM's range from the early concept phase until the final completion.

4 BIM WORKFLOW WITH AUTODESK REVIT - BIM STAGE 1

In this chapter, the making of the new workflow for BIM stage 1 with Revit is explained, parallel with the new set of process maps. The process maps describing this workflow can be found in appendix 3 (not published), while in appendix 4 a step-by-step overview in textual form is given. The structure of the Revit templates and Family content is described in appendix 5, 6 and 7.

4.1 Ventilation design [0.0.0]

The general overview of the workflow on level [0.0.0] is unchanged, because the general approach to a building engineering project will most likely remain the same in the period where Revit at BIM stage 1 is used within the company. On lower levels, several changes will occur, such as new, moved, removed and adjusted tasks and exchange requirements.

4.2 Concept [1.0.0]

The concept phase [1.0.0] will generally remain unchanged because at BIM stage 1, no notable advantages for ventilation design are expected from using BIM at such an early phase. As explained below, it will be important to make good agreements from the start between the different building partners regarding building data exchange of architectural plans, fire safety interventions, structural systems and building systems designs.

4.2.1 Data exchange agreements [1.7n.0]

Collaboration between building actors, even when no BIM models are exchanged, is vital and agreements are made to ensure the continuity and quality of the exchanged data. These agreements contain not only information about the different CAD and/or BIM software solutions that will be used by each partner, but also about the crucial moments of data exchange, exchange file formats, data sharing platforms and last but not least also about the way of drawing/modeling the project data that will be exchanged. In most building projects, the architect will be the central person: he or she collects design documents from the different building disciplines (architecture design, structural design, fire safety solutions, different building systems) and takes care of the overall design coordination. The mentioned agreements become more important when one or more partners implement BIM stage 1 and even more when the whole project team works together by exchanging BIM models (BIM stage 2, 3 and 4). In this part of the research, the focus remains on the consequences for the workflow in the case of BIM stage 1.

For this central part of the research concerning BIM stage 1, it is assumed that the architect only delivers traditional 2D building plans in '.dwg' (and optionally also in '.pdf') file format, even if the architect already uses BIM models or 3D drawings. This is still the normal way of cooperating between most building actors at the moment in Belgium; there is no such thing as a general BIM collaboration on a significant level. Companies that have BIM models generally use it to make their own design workflows easier, faster and more reliable (BIM stage 1). When they come to the point of data exchange (e.g. building plans), they use the BIM model (if they have any) for producing 2D building plans in '.dwg' format, because most other building actors do not use BIM models or do not have enough BIM skills for using them. Additionally, they can prevent other project partners, who can work with BIM software, to take advantage of their own work (BIM template, BIM elements, details about calculations and finally the model itself). When moving beyond BIM stage 1, it will be necessary to find a way to motivate building partners to exchange their BIM models as a whole or partially.

To make the architecture modeling part less time-consuming and more accurate, the architect should follow the structure below as much as possible while making '.dwg' building drawings:

- Use consequent drawing/model units in all drawings/models. Millimeters are preferable.
- Before giving the set of drawings to CENERGIE, the architect should check if all necessary elements show up the way they should appear. This needs extra attention when the architect used a non-Autodesk CAD/BIM software solution, because lines and other drawing elements can disappear or look different (see figure 3). A simple method for the architect then, is using an free Autodesk

DWG Reader, such as DWG TrueView®, to check if the '.dwg' plans show up correctly.

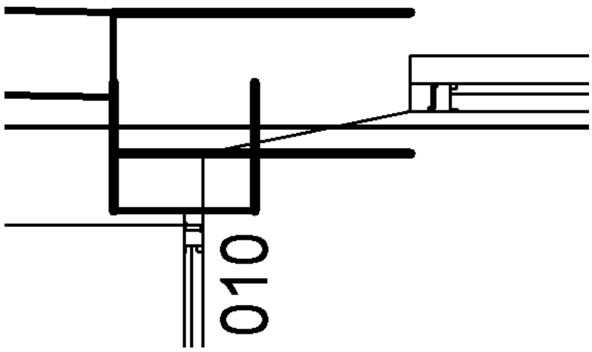


FIGURE 3. Non-native '.dwg' file Linked in Revit - wall corner plan detail with errors

- Every plan should be saved as a separate '.dwg' file that can be linked in different Revit Views.
- The different floor plans must have a common origin and coordinate system so they can be placed in Revit, using the "Auto – Origin to Origin" method.
- The coordinates of the building(s) inside the drawing should not be changed throughout the project, if possible. In this way, new plan versions can be updated by only reloading the link.
- A consistent architectural grid can be a great help to place all 2D drawings on the right location in the model. Each gridline should have a unique name, because it is not possible in Revit to have two different gridlines with the same name. The architectural section and elevation drawings should be provided with all floor levels and floor names. The location of the sections and the different elevations should be marked on each floor plan.
- Only '.dwg' files with elements in AutoCAD Model Space should be linked in Revit drafting views. Paper Space should be empty (no layout) when linking the CAD file in Revit, because otherwise error messages will keep on appearing every time the project is opened (VENG 2016).
- A consequent use of layers can speed up the modeling work in Revit. All walls, doors, furniture, windows, etc. should be on a different layer with a clear name, so it is easier to switch off temporarily some unnecessary layers while modeling.

- All elements should be close enough to the drawing origin. Revit can only manage to Link ‘.dwg’ file content without errors, if everything fits within cube with sides of twenty miles from this origin (Autodesk 2014). Beside this restriction by Revit, it will also help to track the Linked drawings inside Revit.

Plan documents in ‘.pdf’ format cannot be linked or imported directly into Revit; they need to be converted to image files first. The problem with images imported in Revit, beside the inability of snapping to it and the fact that you cannot update them, is that it asks more time to set the drawing to the correct scale, which cannot be done very accurately as well. Drawing documents saved only in ‘.pdf’ should be avoided as much as possible when using Revit. They should only be used to give an overview of all different drawings.

4.3 Preliminary design [2.0.0]

4.3.1 The need for an architecture BIM model

If the architect would exchange BIM models, they can be used directly as a underlay for the ventilation BIM model. We assumed however that the architect only exchanges CAD ‘.dwg’ documents and no BIM models with CENERGIE. This means that another way must be found to use the architect’s design documents as a underlay for the ventilation BIM model in Revit.

There are two possible workarounds: the first one links the CAD files (‘.dwg’ drawings) from the architect to the Revit model so the ventilation designer can use this as a underlay for a simple architecture BIM model. In the next step, he can link this simple architecture model in the ventilation model. The second solution focuses on ‘.dwg’ architecture documents that are linked directly in Revit where they are used as a 2D underlay for the ventilation BIM model. Both solutions have their downsides and advantages, as is explained in table 1.

TABLE 1. Comparison of solution 1 (architecture BIM model) and solution 2 (no architecture BIM model)

-	Some extra time is needed in the starting phase for making a useful architectural model. Only the necessary elements are modeled, so no time is lost on modeling redundant information. With good data exchange agreements (see section 4.2.1) between the architect and CENERGIE, this modeling process can become more efficient. The architecture BIM model can be updated when the architect produces new '.dwg' drawings, but this must to be done manually (see section 4.3.8).
+	It will be easier to model the ventilation design afterwards because visual controls in different Views, such as (3D) sections, are possible.
+	Communication with other building partners will be better if a ventilation design can be seen together with other building disciplines in 3D.
+	Extra parameters can be added to architectural elements (e.g. concerning fire compartmenting, insulation, etc.), which the user can query in different ways.
+	Revit Spaces can be made very quickly and accurately by using 3D Revit architectural elements (e.g. Walls, Floors, etc.) instead of using so-called Space Separation Lines in Revit. One Revit Wall can separate two Spaces, while otherwise two Space Separation Lines would be needed. Revit architectural elements (e.g. Walls, Floors, …) are more visible than Space Separation Lines. When Spaces are made, it is very easy to do the ventilation air flow calculations for each Space.
(+)	Once the architecture BIM model is made, it can also be reused for other design/simulation purposes taking place in the same engineering company, such as calculating heating/cooling loads, lighting simulations, natural ventilation and detailed thermal comfort analyses. If the model will be used for other design/simulation purposes than ventilation, it can be necessary to make extra Families, create additional Views and add new parameters.

It is clear that the first solution, where a simple architectural BIM model is made by the building systems engineering firm, is preferred. The following BIM workflow will be based on this method.

4.3.2 Preparing CAD underlay drawings [2.10n.0]

Before Linking the '.dwg' underlay drawings in Revit, time should be invested in gathering, organizing and 'cleaning' this 2D CAD files. This will make it easier to make the architecture model, keep it up-to-date and well-performing. If the architect does not draw according to the proposed drawing structure as described in section 4.2.1, the ventilation designer will need to do extra preparation work and controls.

AutoCAD offers simple commands such as *Purge* and *Audit*, to clean and check '.dwg' drawings. By purging the drawing, all unused drawing objects such as Layers, Dimension Styles, Text Styles and Blocks are deleted. This will result in a 'cleaner' drawing and a reduced file size, which makes it easier to Link and update the drawings in Revit. The *Audit* command checks the drawing elements for errors and offers a possibility to repair them.

It is also important to check if drawing elements are located close enough to the drawing's origin. All architectural drawings should be stored in a separate folder with a clear name including the date of the drawing. This will make it easier in later phases to update the '.dwg' CAD underlays in Revit.

4.3.3 Architecture BIM model [2.11n.0]

Starting Revit architecture model [2.11n.1]
A Revit architecture template is made during this research. It contains all necessary system Families, coordination Views and other settings. This template is used when the modeler starts with making the architecture model in Revit. It does not contain Sheets, Mechanical Views, ventilation-related Schedules and Families.

Linking CAD underlay drawings [2.11n.2]
When the '.dwg' drawings are prepared, they need to be Linked into the Revit architecture model. A detailed workflow based on the method described in the manual 'Mastering Autodesk Revit MEP 2015' (Bokmiller et al. 2014, 155), is added to the BIM stage 1 process maps (appendix 3) and corresponding description (appendix 4). The result is a

Revit model where all necessary '.dwg' drawings are Linked, making it possible to model the architectural elements by using the CAD underlays.

Note that the '.dwg' drawings are linked (*Link CAD*) and not imported (*Import CAD*); this makes it possible to update' .dwg' files and makes the Revit model more performant because no redundant information is transferred to Revit (e.g. layers, text styles, dimension styles, …) (Bokmiller et al. 2014, 140).

Modeling architectural elements [2.11n.3]

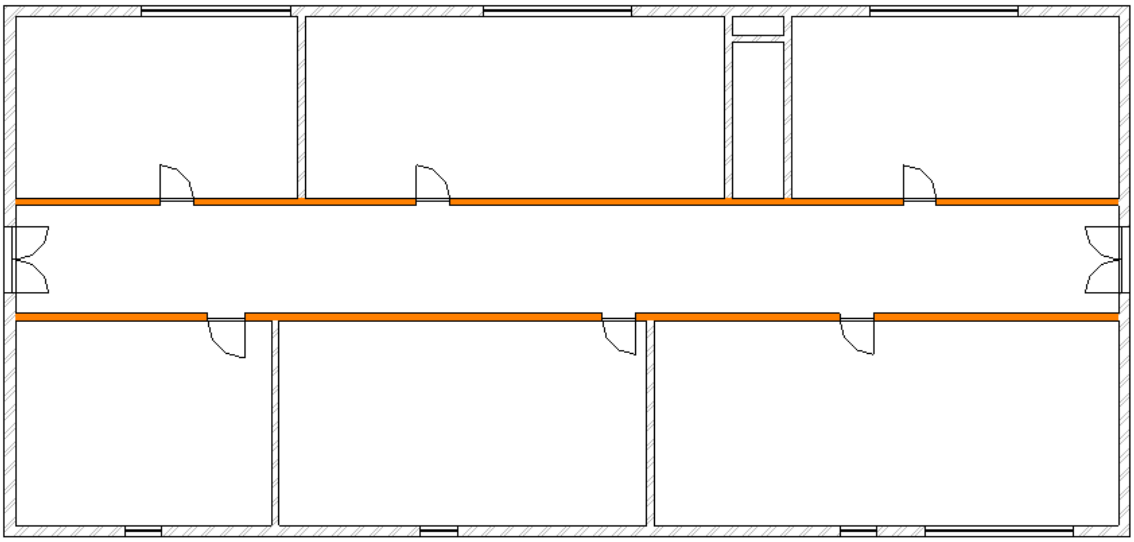
Only the necessary generic architectural and some optional structural elements that can have an influence on the ventilation design are modeled: Levels, Grids, Walls, Stairs, Floors, Roofs, Ceilings, Windows, skylights, elevators, Doors, Structural Beams and Columns. The System Families are included in the Revit template 'CN_Architecture Template' that is used for the architecture model, while the loadable Families are stored in the library folder.

The Walls, Roofs and Floors each have four extra instance parameters that contain important information for the later ventilation design (table 2). They are respectively related to fire compartments, thermal insulation, structural elements and fire resistance. The fire resistance codes (e.g. REI120, EI60, etc.) that can be selected from the drop-down list for each fire resistance key parameter are all prepared according to the valid European Standards for fire safety EN 13502-2 (Teirlinck 2011, 41). The value of the first three parameters can be changed at will when the fire resistance parameter is set to '(none)'. When the fire resistance parameter is set to a certain value from the respective Key Schedule drop-down list, the first three parameters will be set automatically according to the Key Schedule, because fire resistant Walls, Floors or Roofs always have thermal insulation and are of evidently part of a fire compartment. These elements are also defined as bearing if they have a fire resistance code with 'R' in it. It is important to know that if these first three parameters have a halftone checkbox (this is the case when the fire resistance parameter is set to '(none)', the parameter is neither 'Yes' nor 'No and needs to be activated by clicking.

Floor Plan and Section View Templates with proper View Filter settings are made for the first three parameters. This provides an easy way to check if the ventilation system, made in the later phases, interferes with the Wall, Floor and Roof elements (picture 1).

TABLE 2. Custom System parameters for Walls, Roofs and Floors

Parameter Name	Parameter Type	Data Type	Categories	View Filter
CN_Fire Compartment Part	Project	Yes/No	Walls, Roofs and Floors	Floors/Roofs/Walls – Fire Compartments (appearance: orange)
CN_Thermal Insulation	Project	Yes/No	Walls, Roofs and Floors	Floors/Roofs/Walls – Thermal Insulation (appearance: yellow)
CN_Bearing	Project	Yes/No	Walls, Roofs and Floors	Floors/Roofs/Walls – Bearing Elements (appearance: green)
CN_Wall Fire Resistance (R)EI	Key	Text	Walls	/
CN_Roof Fire Resistance REI	Key	Text	Roofs	/
CN_Floor Fire Resistance REI	Key	Text	Floors	/



PICTURE 1. Revit screenshot: View filter 'Floors/Roofs/Walls – Fire Compartments' for 'CN_Fire Compartment Part'

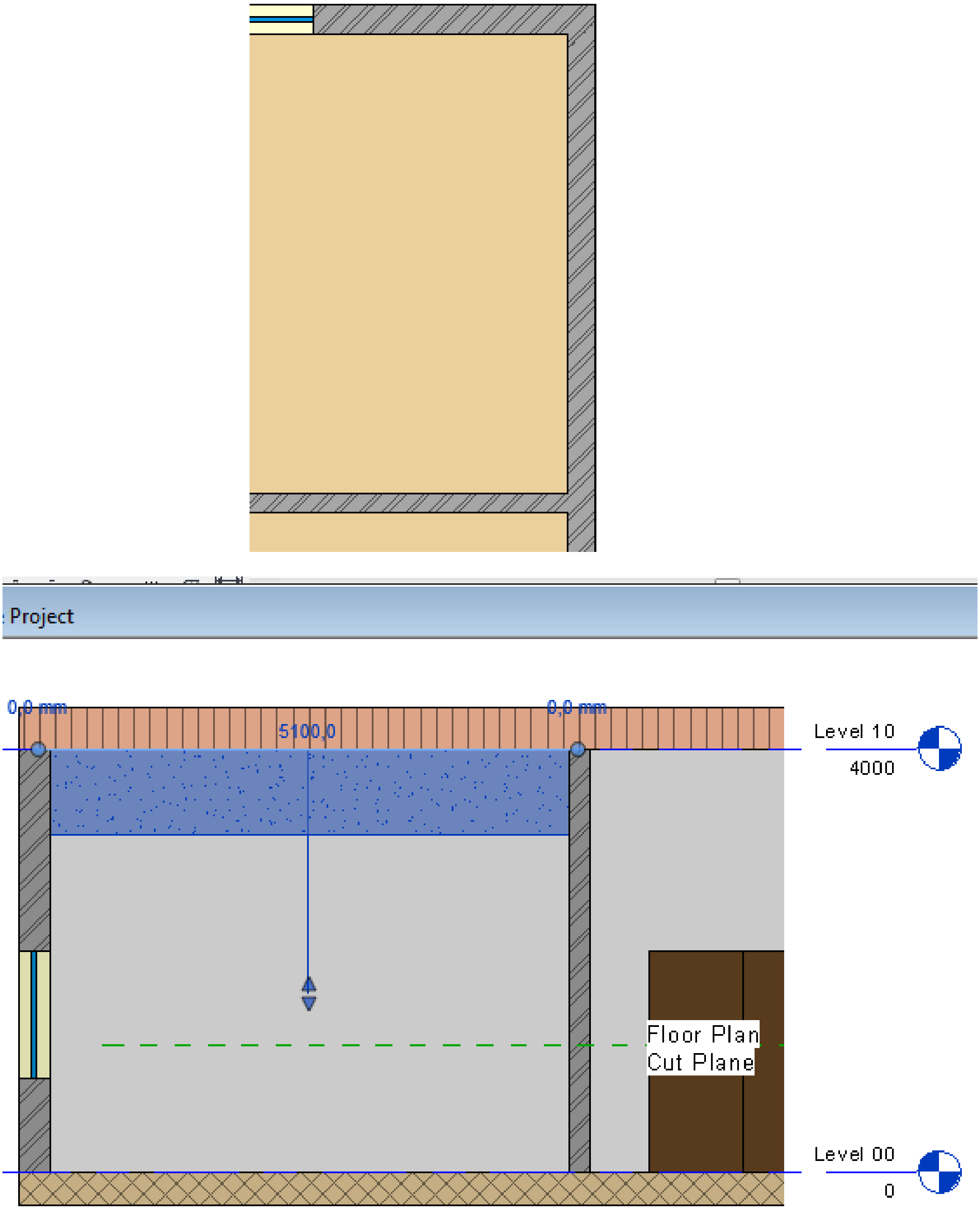
Finally, the modeler should check if some Walls, Ceilings or Floors should be not Room Bounding. This can be the case for a toilet room with multiple toilet equipment's, separated by thin Walls.

After the Walls are modeled, one can make the shaft openings for building systems and elevators, if any. Elevators can be modeled by using the Family 'CN_Generic Elevator' of the Category Generic Models.

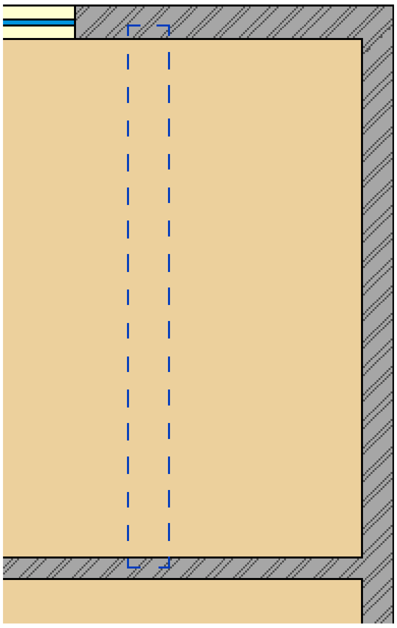
In the next phase, the generic Doors ('CN_Generic Door') and Windows ('CN_Generic Window' and 'CN_Generic Skylight') can be placed. New Families were made for this purpose and similarly to the new elevator Family, they contain as little redundant parameters and graphical elements (3D and 2D) as possible. This will make them easy to use, they will help to create an accessible model and at the same time they will not lower the overall performance of the model. The Windows and Doors can be adjusted with handles in Elevation and Section Views, because the height and width dimensions are Instance parameters. This can speed up the dimensioning of these elements and can be useful if the CAD underlay is visible for snapping.

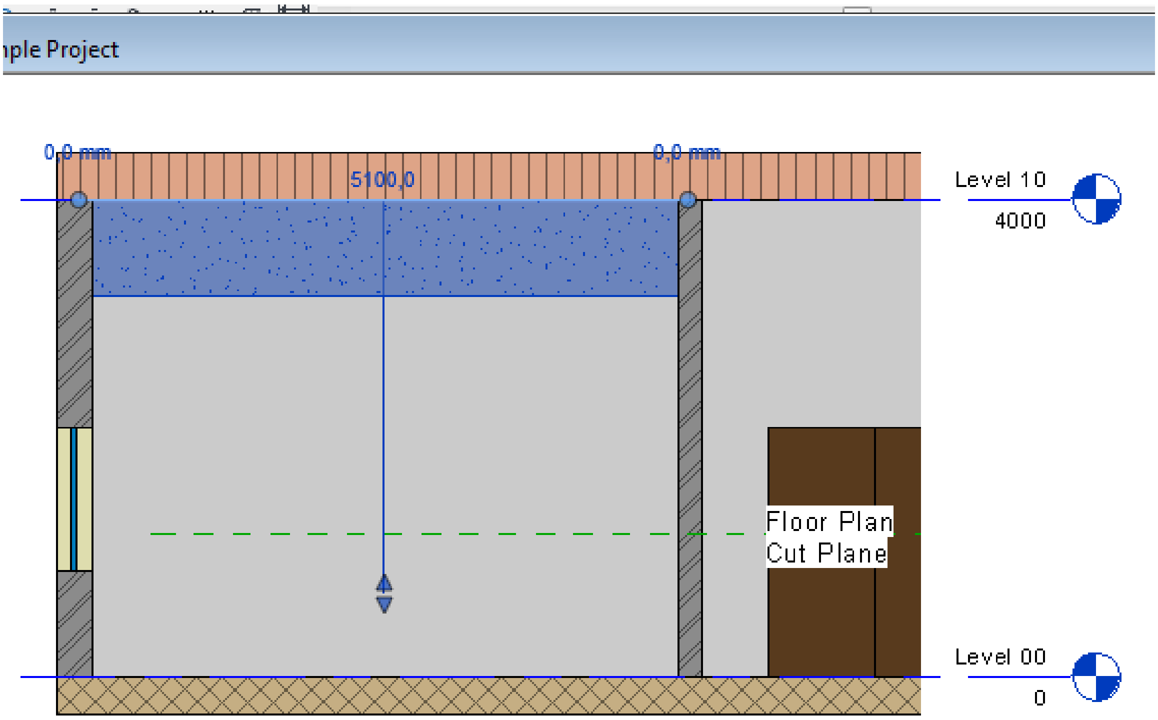
If the locations of the Beams and Columns are known, they can be modeled too. No extra content is made from scratch during this research; the modeler can make use of the out-of-the-box Revit Structural Families. Beams belong to the Revit Category Structural Framing. To make them visible in Floor Plans with hidden lines, these Revit Families will need some modifications via the Family Editor (Varga 2015). First Symbolic Lines are drawn, marking the projected beam. Then a Model Line is drawn from the top of the beam downwards. In the project, this line should be lower than the Cut Plane of that particular Floor Plan View in order to display the hidden lines (picture 2 and 3). Three common beam Families (one concrete and two steel beams) are modified for this research. They all have an extra Instance parameter named "CN_Length Invisible Line". With this parameter, it is very easy to adjust the length of this invisible line without having to open the Family Editor.

The surrounding topography can be modeled if necessary (e.g. in the case of fresh air intake via ducts below the ground). Topography modeling is not investigated in this research.



PICTURE 2. Revit screenshot: ‘CN_Concrete Beam’ – Invisible Line above Cut Plane





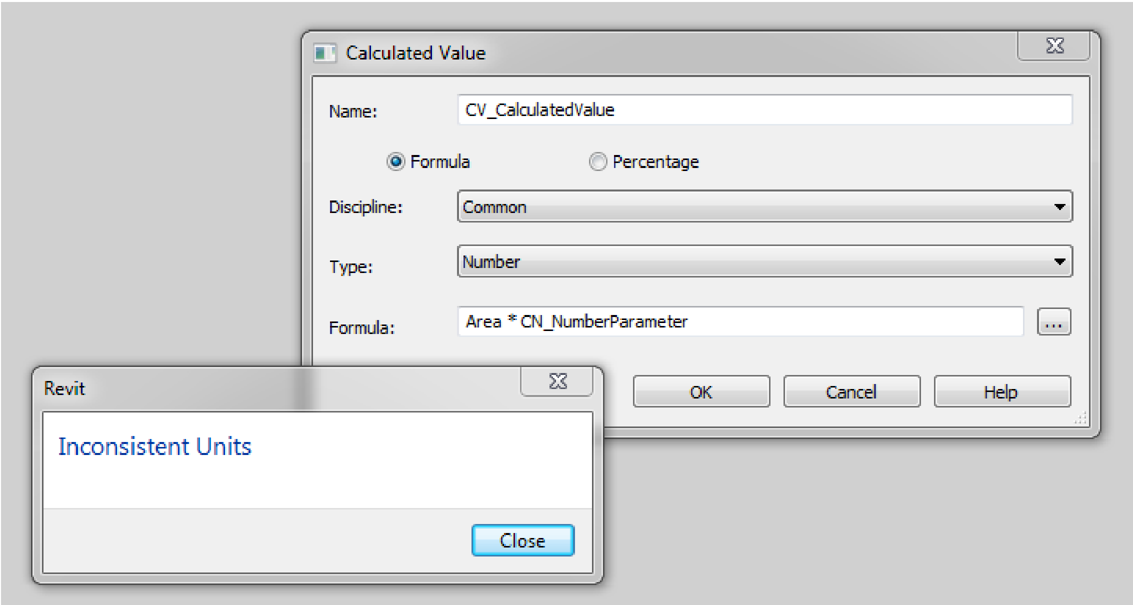
PICTURE 3. Revit screenshot: ‘CN_Concrete Beam’ – Invisible Line under Cut Plane

4.3.4 Starting Revit ventilation model [2.12n.0]

A new ventilation model is started by using the Revit template ‘CN_Ventilation Template’. The finished preliminary ventilation model contains Spaces, Air Terminals, Ducts, Mechanical Equipment (e.g. AHU) and Duct Systems.

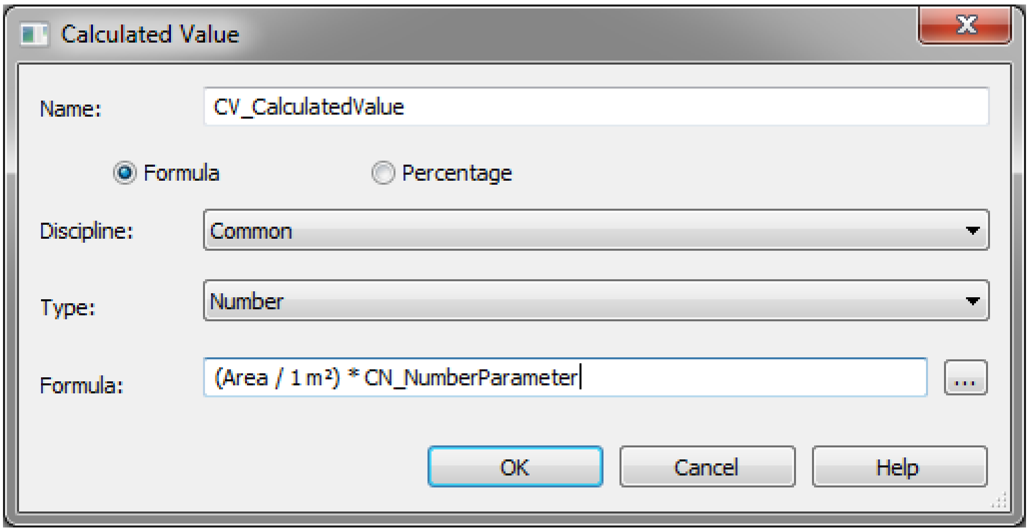
Revit parameter data types and corresponding units

It is important to know what the different parameter units are. In Revit Schedules, they are by default shown (but they can be hidden too). Whenever making Calculated Values in Schedules or calculated parameters in the Revit Family Editor environment, the user should always take the units of the parameters in the formula into account, otherwise an 'Inconsistent Units' error will appear. In the next formula we try to multiply the Area of a Space (data type: Area; units: m²) with another custom-made parameter 'CN_NumberParameter' (data type: Number; unitless). If the data type of the Calculated Value is set to Number, the error will appear (picture 4). When the data type is set to Area there is no problem because the units are consistent.



PICTURE 4. Revit screenshot: Calculated Value – Inconsistent Units

If you however want to make a unitless Calculated Value, a little workaround is needed (Munkholm 2011). While writing the formula, the parameter that you want to make unitless needs to be divided by one unit (picture 5).



PICTURE 5. Revit screenshot: Calculated Value – Consistent Units (unitless)

Except the built-in and area-related custom-made parameters, most other custom-made number parameters are from the data type Number or Integer. In this workflow, these data types are preferred above the more specific Revit data types (e.g. air flow, velocity, …). If these specific data types would be used, unit problems would occur while exporting these parameters from Revit using Dynamo (section 4.3.8). Apparently, Revit processes parameters in its source code as imperial units (e.g. air flow data type is in ft^3/s) and converts them through the user interface to the chosen metric units (e.g. m^3/h in the case of air flow data type). By choosing for the unitless Number data type, mistakes with unit conversion are avoided. To improve data consistency, every custom-made parameter that is a unitless number for Revit (data types Number and Integer) but not for the end user has the units added in the parameter name, at the end and between round brackets. An example is the parameter 'CN_V_R_Hygienic Air Flow (m^3/h)', which is a custom-made parameter from the data type Number.

4.3.5 Linking architecture model [2.13n.0]

It is considered good practice to create separate models for the architecture and ventilation model and to connect the architecture model to the ventilation model (host model) as a Linked Revit model. The Linked architecture model cannot be changed when working in the ventilation model project and mainly acts as an underlay (which can be updated if necessary) for the ventilation model. All parameters of the Linked model are visible after selecting the element while tapping the tab button. Another important advantage is that the ventilation model does not lose performance (the ventilation model file does not become much bigger and slower). If in a later stage, different models (e.g. electricity model, piping model) need to be checked together, it is very easy to view them together with this method. When an architect in the future starts exchanging his BIM model with the building systems engineering firm, a similar approach will be used to start modeling the ventilation system.

After Linking the architecture model in the ventilation model, it is very important to set the Linked Model to be Room Bounding. When in a later phase the Spaces are modeled, the elements from the Linked model will define the boundaries of the Spaces.

The Levels of the ventilation model should be Aligned with the Levels of the architecture model and set to Monitor them. When a Level of the architecture model changes, this will create a Warning in Revit. The user can then decide if the corresponding Level of the ventilation model should update too.

4.3.6 Project information [2.14n.0]

With the start of a new model, the user will first fill in the correct Project Information, such as project name and information about the different building actors. These parameter values will be filled in using the Project Information dialog. This information will be read automatically by the Titleblocks that are placed on the Sheets, by using so called Labels. In this way, all Project Information is stored in a central place, which makes it easier to adjust them during the project if the need should arise.

Because the out-of-the-box Project Information parameters were not complete (e.g. no parameter for the client’s address, the architect’s name, …) these parameters were manually added to the template. Some parameters already existed in Revit, but these are also replaced by custom-made parameters. In this way, mistakes such as filling in the wrong parameters should be avoided. All these parameters are Shared to make it possible to add them in the Labels of the Titleblock Families.

4.3.7 Revit Spaces [2.15n.0]

In the next task, we need to calculate the air flow rates per space. First, we make Revit Spaces. So-called Revit Rooms look similar, but have less parameters and options for calculations/simulations and are used mainly by architects. The Revit Spaces automatically display their floor surfaces and volumes via corresponding built-in parameters, they will be useful for adding data (e.g. type of space regarding ventilation) and will become a container for the results of calculations such as necessary supply ventilation air flow rates.

Space Separation Lines [2.15n.1]

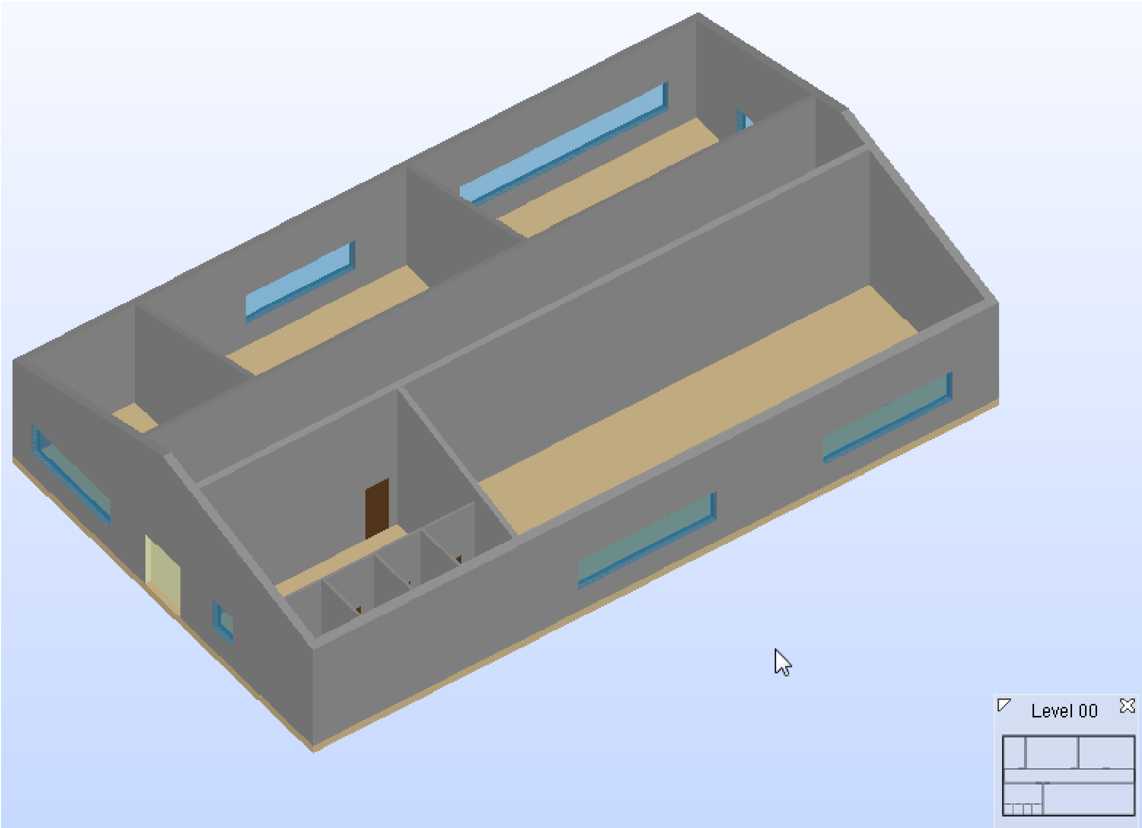
If Spaces should be combined (e.g. a public toilet space with individual toilet equipment separated by thin Walls) for the ventilation air flow calculation, this should be done while making the architecture model (setting the thin Walls to not Room Bounding) because Spaces cannot be joined together. Only separation of Spaces is possible in the ventilation model, by using Space Separation Lines in Floor Plan Views. This method should only be used in two cases: if one big open Space needs to be divided into smaller ones, and secondly for excluding the elevator instances from the Space(s) around it. Around each elevator Instance, Space Separation Lines should be drawn, as only certain system Families (Walls, Roofs, Floors and Ceilings) have a Room Bounding parameter. Loadable Families such as the elevator Family do not have a Room Bounding parameter. If too much Space Separation Lines are drawn in a plan, it can be very difficult to solve problems related to Spaces (e.g. interfering Spaces, double Spaces, …) because these lines are not always clearly visible. The built-in 'Room Bounding' parameter cannot be used in any Schedule or View Filter. With the prepared Dynamo graph 'Tool – Room Bounding.dyn' (appendix 8) it is possible to automatically copy the value of this parameter to the custom Shared Parameter 'CN_Room Bounding'. This last parameter can be used in the Wall, Ceiling, Floor and Roof Schedules and in the prepared View Filter 'Not Room Bounding'. The link between 'Room Bounding' and 'CN_Room Bounding' is not bidirectional, what means that the last parameter should not be changed manually.

Automatic generation of Spaces [2.15n.2]

Spaces can be automatically generated in Revit per Level according to the boundary elements in the Linked architecture model (System Families with Room Bounding parameter on) and the ventilation model (Space Separation Lines). If the floor area of an enclosed space is smaller than 0,023 m² (0,25 ft²), no Revit Space is made. If this tool is used, some Spaces are also placed in for example shafts, but on each Level. The redundant Spaces can be removed; this should be done in a Space Schedule View, otherwise they are not entirely removed from the project (visible in Schedule: 'Level' parameter is equal to 'Not Placed'). All Spaces have a Space 'Number' and Space 'Name' parameter, which should be filled in immediately after generating the Spaces. If a Space is made manually or changes are made to the architectural model, it is possible that a Space is 'Not Enclosed' if it misses some room bounding elements. These Spaces can only be discovered in the Schedule 'Work – Spaces General', by looking to the 'Are' or 'Volume' parameter value.

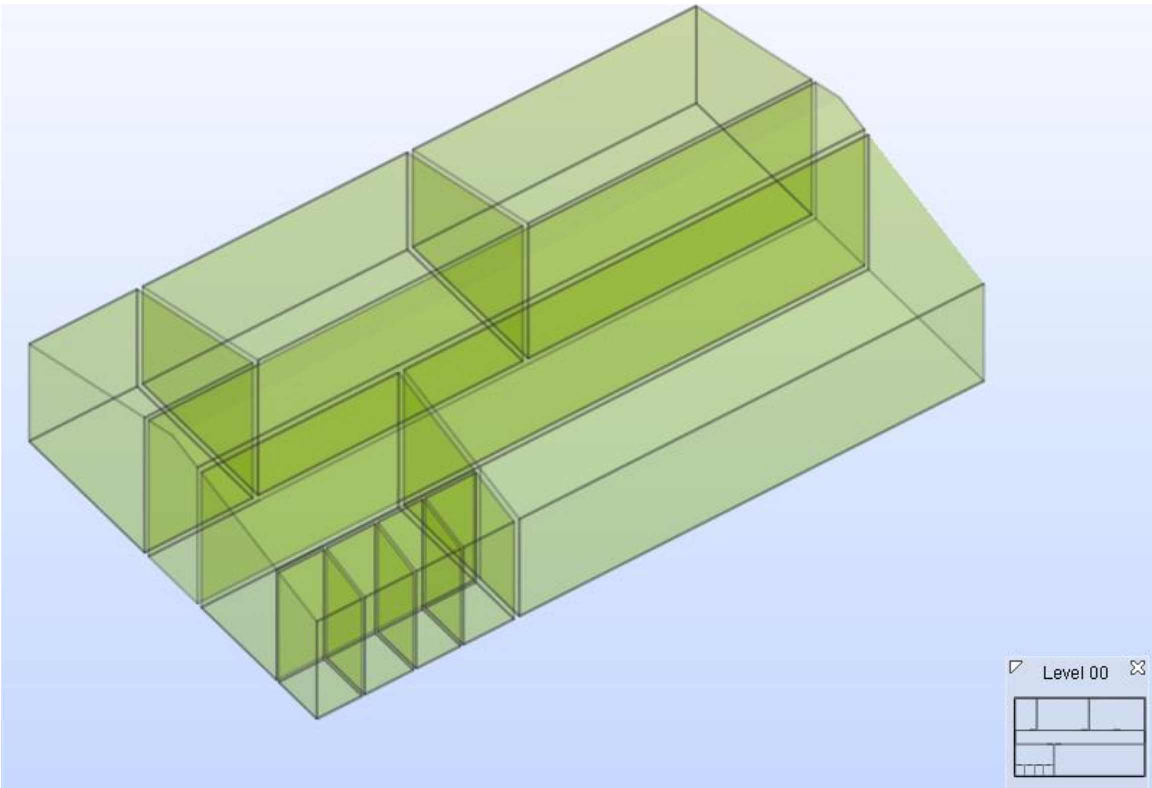
Geometry of Revit Spaces [2.15n.3]

For this workflow, it is very important to understand how Spaces can be made and what the limits are of what a Space can do. The modeler should always check his or her Spaces in Section Views, Space Schedules and/or in 3D. It can be useful to check the modeled Spaces in 3D, to see if the Spaces are modeled as wished (height, volume, overlapping Spaces, …). In Revit this is not possible. One workaround is to export the model as an IFC file. With an IFC viewer such as Solibri Model Viewer® it is possible to see the Spaces in 3D (pictures 6 and 7).



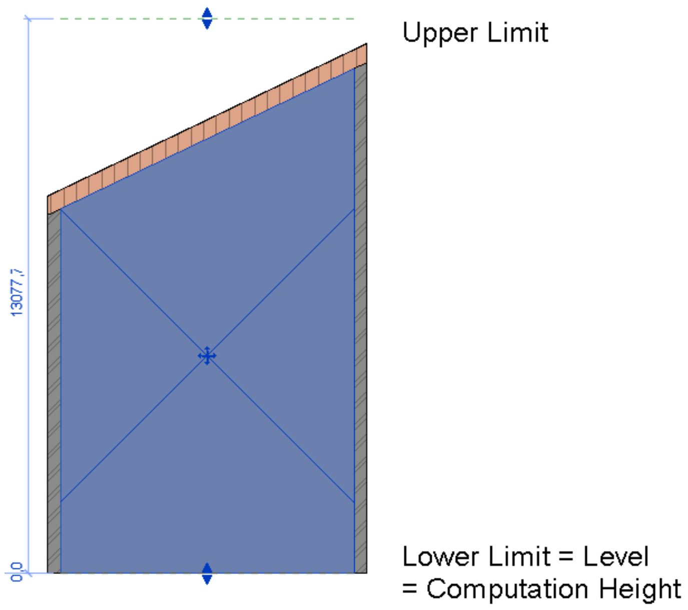
PICTURE 6. Solibri Model Viewer® screenshot: all elements visible except Roofs and Spaces

In Revit Section Views the result of the following Space parameters can be seen graphically: ‘Level’ (lower limit), ‘Upper Limit’, offsets (‘Base Offset’ and ‘Limit Offset’) and ‘Computation Height’ (an instance parameter of the Level). When a Space is placed, the floor area (‘Area’) of the Space is measured at the ‘Computation Height’ (Level parameter), which is by default set to 0 mm (offset from Level). The measured volume (‘Volume’) of the Space starts from the ‘Lower Limit’ and follows the bounding Walls until it reaches the ‘Computation Height’. After the ‘Computation Height’, it stops following these Walls and forms a vertical extrusion, until it reaches the lowest of the upper limit or a bounding Revit element (Ceiling, Roof or sloped Wall) that interferes with its extrusion. A normal Space in a Revit Section View is displayed in picture 8.

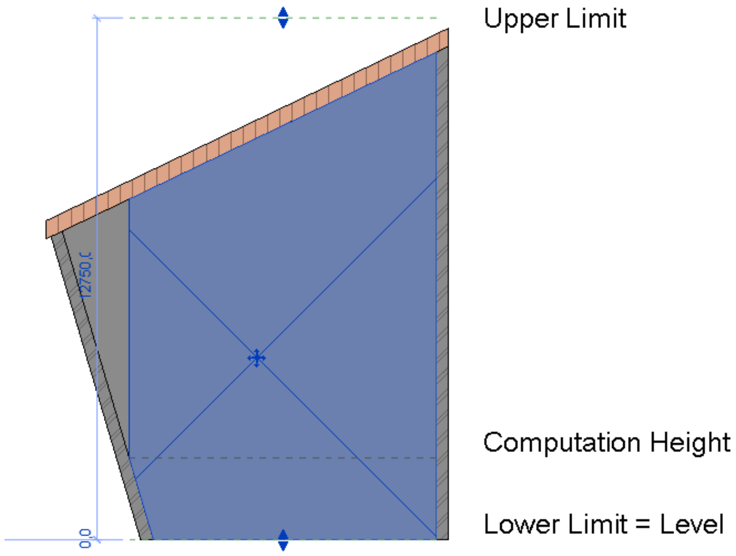


PICTURE 7. Solibri Model Viewer screenshot®: Spaces in 3D

In some cases with Walls sloping away from the Space center, the Space volume is not measured correctly anymore. Another problem is that elements (e.g. Air Terminals) placed outside the Space volume will not appear as located inside this Space. A possible solution can be to rise the Computation Height, as is shown in the picture 9. Several problems occur: first of all, this will result in a better Space volume but in a wrong value for the floor area. Secondly, this also influences other Spaces that are drawn on this Level, because the 'Computation Height' is an instance parameter of the Level. The best practice at the moment is to place every Space at the correct Level and leave the Computation Height to zero. If sloped Walls (sloping away from the Space center) occur in the architects design, this should be taken into account when using the volume for calculations via the custom Space parameter 'CN_V_Additional Volume'.

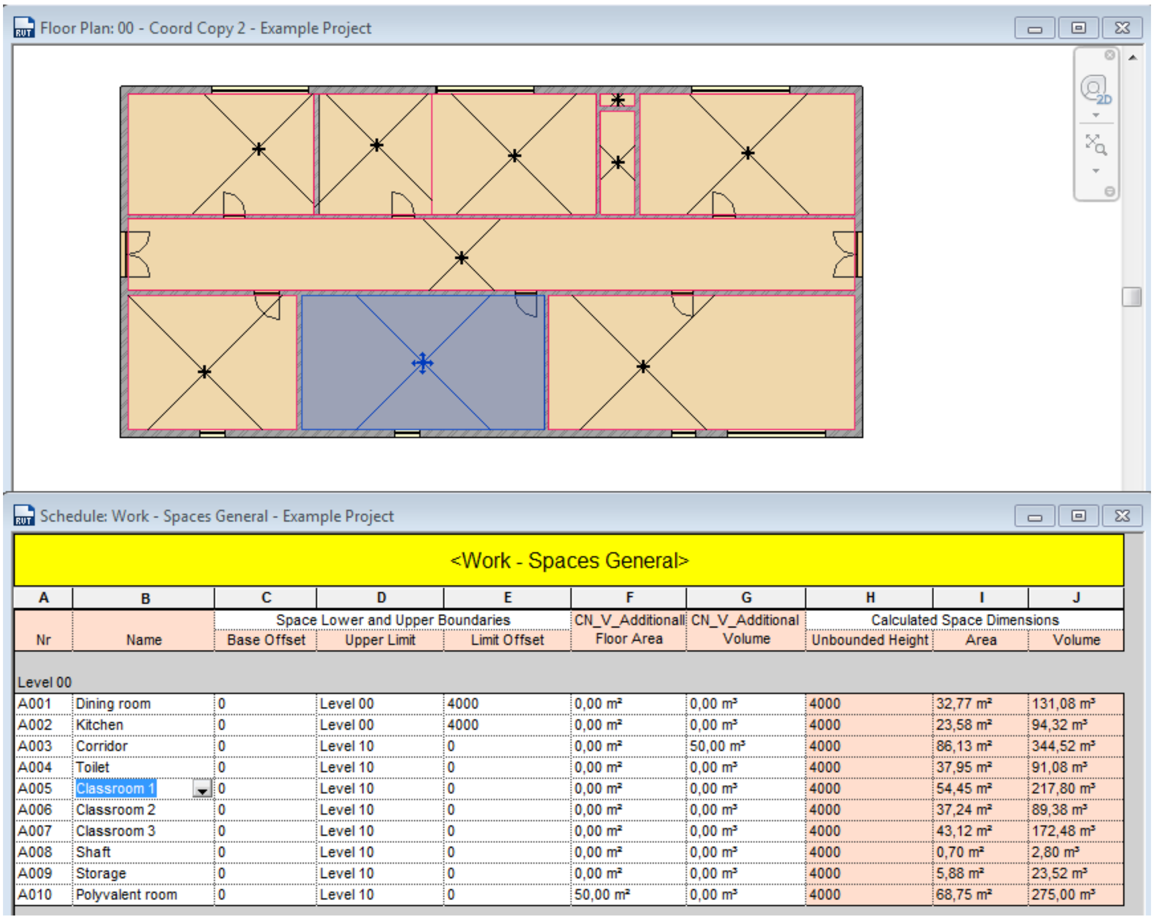


PICTURE 8. Revit screenshot: Section View through Space – vertical Walls



PICTURE 9. Revit screenshot: Section View through Space – sloped Walls

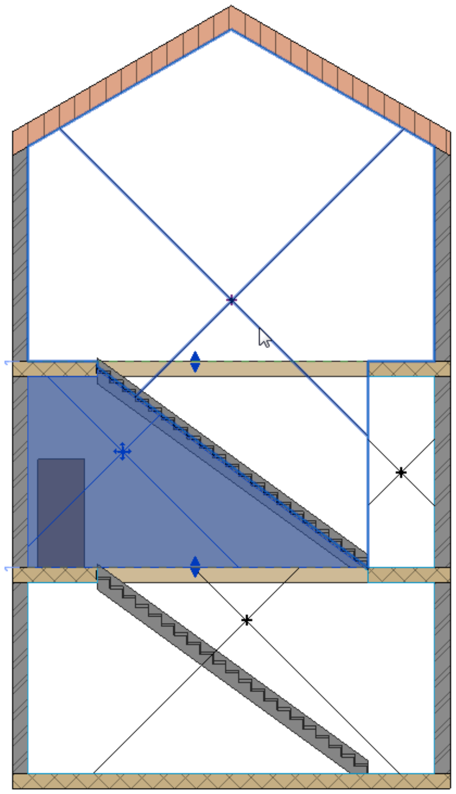
The modeled Spaces can also be controlled in list form, by viewing the Space Schedule ‘Work – Spaces General’ in combination with the corresponding Floor Plan View. While using these two Views, one can check the dimensions of a Space in the Schedule and see the corresponding Space located in the Floor Plan.



A	B	C	D	E	F	G	H	I	J
		Space Lower and Upper Boundaries			CN_V_Additionall	CN_V_Additional	Calculated Space Dimensions		
Nr	Name	Base Offset	Upper Limit	Limit Offset	Floor Area	Volume	Unbounded Height	Area	Volume
Level 00									
A001	Dining room	0	Level 00	4000	0,00 m²	0,00 m³	4000	32,77 m²	131,08 m³
A002	Kitchen	0	Level 00	4000	0,00 m²	0,00 m³	4000	23,58 m²	94,32 m³
A003	Corridor	0	Level 10	0	0,00 m²	50,00 m³	4000	86,13 m²	344,52 m³
A004	Toilet	0	Level 10	0	0,00 m²	0,00 m³	4000	37,95 m²	91,08 m³
A005	Classroom 1	0	Level 10	0	0,00 m²	0,00 m³	4000	54,45 m²	217,80 m³
A006	Classroom 2	0	Level 10	0	0,00 m²	0,00 m³	4000	37,24 m²	89,38 m³
A007	Classroom 3	0	Level 10	0	0,00 m²	0,00 m³	4000	43,12 m²	172,48 m³
A008	Shaft	0	Level 10	0	0,00 m²	0,00 m³	4000	0,70 m²	2,80 m³
A009	Storage	0	Level 10	0	0,00 m²	0,00 m³	4000	5,88 m²	23,52 m³
A010	Polyvalent room	0	Level 10	0	50,00 m²	0,00 m³	4000	68,75 m²	275,00 m³

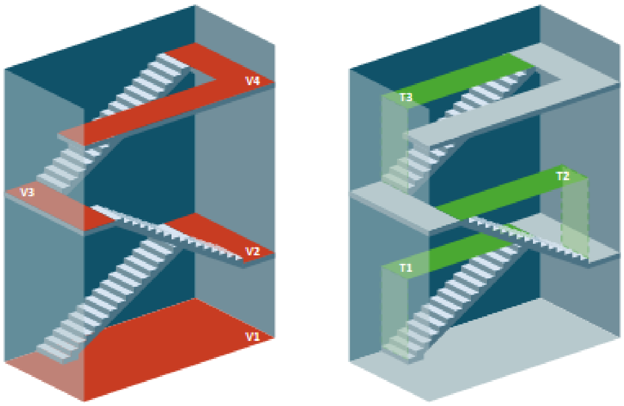
PICTURE 10. Revit screenshot: Space Schedule ‘Work – Spaces General’ and Floor Plan View

Difficulties can occur while modeling Spaces in a stairwell. First, Revit Stairs cannot be room bounding. This is no real problem if the stairwell is an open Space, except for the Space Volume which will be a little too big. In other cases (e.g. a stairway leading to a closed cellar with a parallel stairway above it) a more creative solution will be needed, such as drawing a sloped Room Bounding Ceiling or thin Roof, right below the Stairs. This is illustrated in the following screenshot: the stairway leading from the ground floor to the first floor has a sloped Room Bounding Ceiling following the Stairs (picture 11). In this way, the cellar Space is separated from the other Spaces.



PICTURE 11. Revit screenshot: Section View through Spaces in stairwell – Room Bounding Ceiling through Stairs

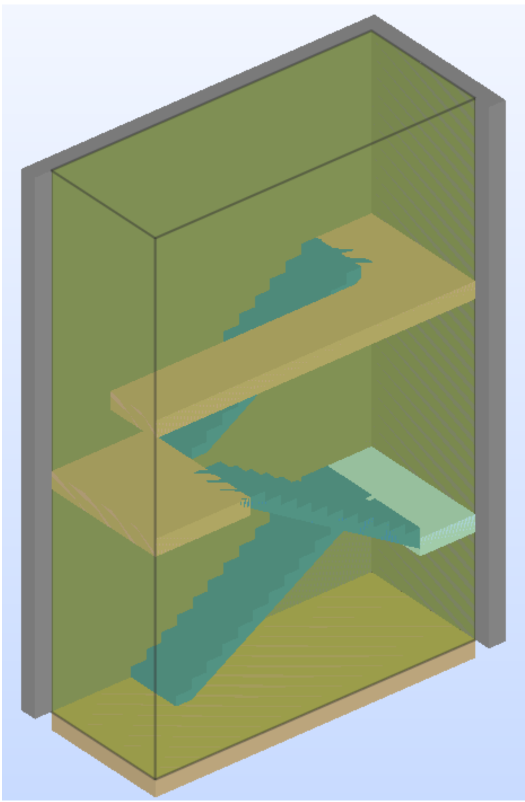
Another shortcoming of Spaces regarding stairwells, is that the horizontal area of the Stairs and landings, needed for the calculation of ventilation flow rates in a stairwell (VEA & WTCB 2015, 23), cannot be measured by the Revit Space. The designer is advised to place a Space on the lowest floor of the stairwell, set all above Floors in the stairwell to not Room Bounding and set the upper limit of the Space to the top of the stairwell. This will result in one Space with a slightly overrated volume (the volumes of the stairs, the landings and above Floors are not subtracted) and a wrong value for the Space Area, as only the lowest Floor is measured. This last problem can be solved by manually measuring the horizontal areas of the stairs, landings and above Floors and enter this entire extra area in the custom parameter 'CN_V_Additional Floor Area' (see section 4.3.8 for practical implementation). As an example (figure 4), we look at the same stairwell documented in the ventilation guidelines (VEA & WTCB 2015, 23). If we model a Space containing the whole stairwell, only the bottom floor area will be measured (V1). All the other areas need to be measured manually (V2, V3, V4, T1, T2 and T3) and added to the parameter 'CN_V_Additional Floor Area'.



Oppervlakte traphal = vloeroppervlaktes V1 + V2 + V3 + V4 + projectieoppervlaktes van de trappen T1 + T2 + T3

de gelijkvloerse verdieping	V1
projectie van trappen van de gelijkvloerse verdieping naar de eerste verdieping	T1 + T2
overloop tussen de gelijkvloerse verdieping en de eerste verdieping	V2
overloop van de eerste verdieping	V3
projectie van de trappen van de eerste naar de tweede verdieping	T3
overloop van de tweede verdieping	V4
totale vloeroppervlakte van de traphal	(V1+V2+V3+V4) + (T1+T2+T3)

FIGURE 4. Diagram explaining how the floor area in stairwells should be measured for the air flow calculation (VEA & WTCB 2015, 23)



PICTURE 12. Solibri Model Viewer® screenshot: stairwell Space in 3D

4.3.8 Air flow calculations [2.16n.0]

Heating and cooling air flow [2.2.0] and freecooling air flow [2.3.0]

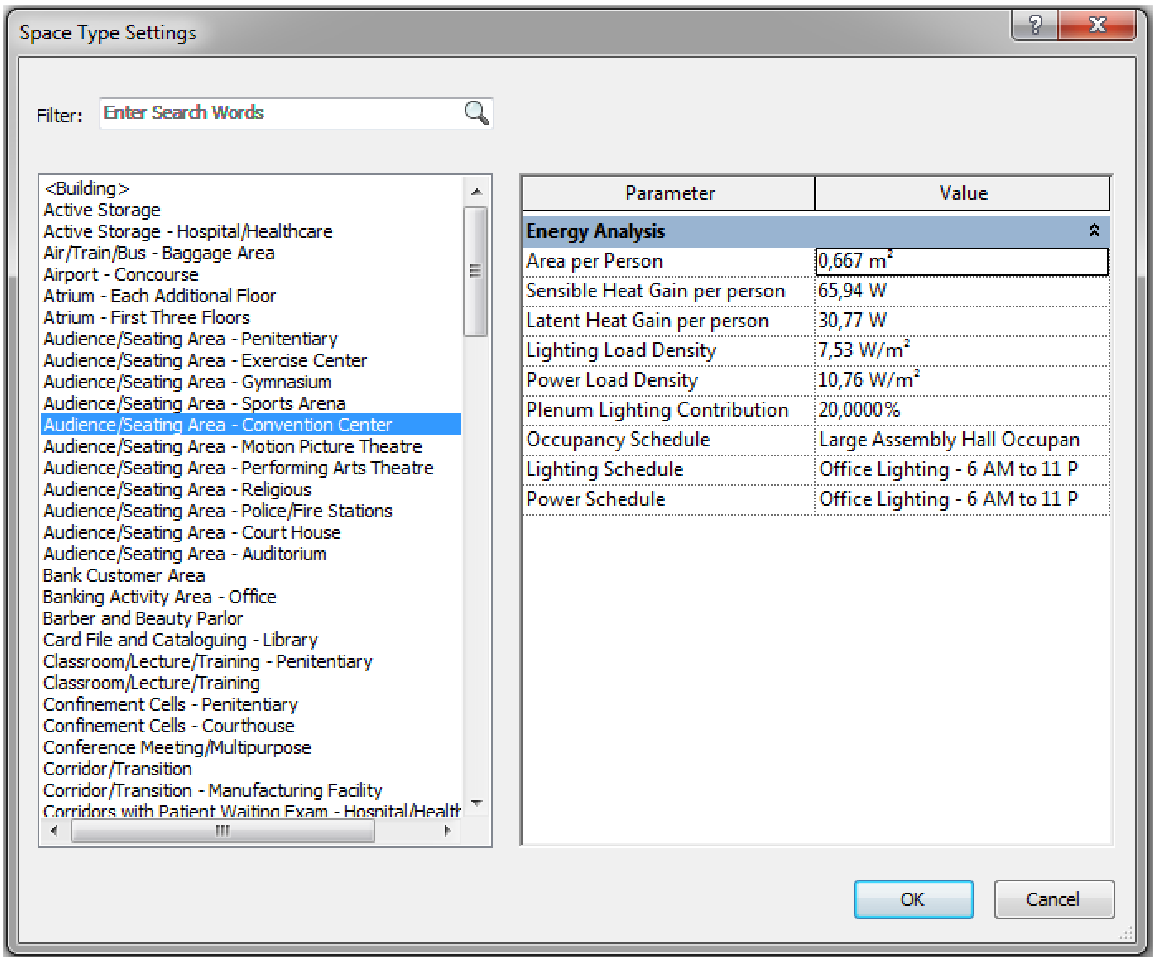
The calculation of the needed heating and cooling air flows together with freecooling air flows remains unchanged in comparison with the pre-BIM workflow. These calculations are done outside this workflow (e.g. with third party software or self-made Excel worksheets). The results of these calculations can be added to the Spaces inside Revit [2.16n.2] or in MS Excel after export from Revit [2.16n.3] as explained in the next paragraphs.

Revit Space types

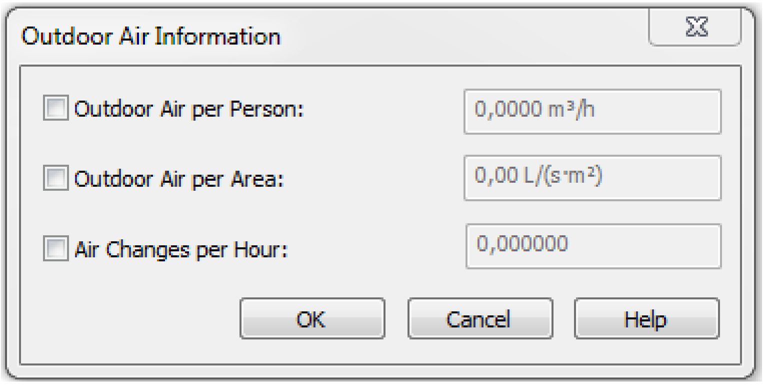
When the geometry of the Spaces is modeled, different Space parameters should be set. The built-in Space types parameter offers a long list with Space types that are all set up according to ASHRAE standards (picture 13). It is possible for a user to modify the (limited) calculation values, but no extra Space types can be made nor is it possible to rename the existing types. Secondly, Revit calculates the ventilation air flows per Zone (group of Spaces). Here there are only three methods for calculating the necessary ventilation air flows: ‘Outdoor Air per Person’, ‘Outdoor Air per Area’ and ‘Air Changes per Hour’ (picture 14). The Belgian rules however, ask for more detailed calculations (e.g. air flow per toilet/shower, smoking areas, special spaces, employees (ARAB), …). Influence of ventilation concepts such as freecooling and heating and/or cooling with air needs to be taken into account when calculating the necessary ventilation air flows.

Custom Space types [2.16n.1]

The method proposed for this workflow, is to define Space types with the custom Key parameter ‘CN_V_Space Type’. This Key parameter helps streamlining the air flow calculations, because a lot of calculation values according to Belgian rules can be connected to the Space Type. Picture 15 is a screenshot of a part of the Key Schedule defining custom Space types (table 3) related to ventilation.



PICTURE 13. Revit screenshot: built-in Revit Space types



PICTURE 14. Revit screenshot: built-in air flow calculation method

<Key - V_Space Type>

A	B	C
CN_V_Space Type	CN_V_Building Sector	CN_V_D_Air Flow Per Floor Area (
Kitchen, kitchenette	Catering Industry	0
Restaurant, cafetaria, buffet, canteen, bar, cocktailbar	Catering Industry	0
Cell, dayroom	Correctional facility	0
Subscription / registration / waiting room	Correctional facility	0
Watch post	Correctional facility	0
Classroom	Educational institution	0
Polyvalent room	Educational institution	0
Hospital ward, infirmary	Health care	0
Medical treatment and consultation room	Health care	0
Operating room, delivery-room, post-anesthesia care unit, intensive care, kinesthesia hall, physiotherapy room	Health care	0
Bedroom	Hotels, motels, holiday centers	0
Conference hall, meeting room, polyvalent room	Hotels, motels, holiday centers	0
Dormitory	Hotels, motels, holiday centers	0
Lobby, entrance hall	Hotels, motels, holiday centers	0
Other non occupied spaces (e.g. hallways, storage rooms, ...)	Non occupied spaces	1,3
Shower room	Non occupied spaces	5
Toilet compartment	Non occupied spaces	15
Main entrance	Office buildings	0
Office	Office buildings	0
Reception (room), conference hall	Office buildings	0
Magazine, warehouse	Other (occupied) spaces	0
Other (occupied) spaces	Other (occupied) spaces	0
Departure hall, waiting room	Public areas	0
Library	Public areas	0
Churches and other religious buildings, government buildings, law court, museums, galleries	Public meeting points	0
Hairdresser's salon, beauty salon	Retail business	0
Laundromat, launderette	Retail business	0
Salesroom, shop/store (except shopping malls)	Retail business	0
Shop for furniture, tapestries, textiles	Retail business	0
Shopping mall	Retail business	0
Supermarket, department store, pet supply store	Retail business	0
Changing room	Sport and recreation	0
Discotheque/dance hall	Sport and recreation	0
Spectator spot, tribune, stand	Sport and recreation	0

PICTURE 15. Revit screenshot: part of Schedule ‘Key – V_Space Type’

TABLE 3. Parameters in Key Schedule 'Key – V_Space Type'

'Key – V_Space Type'	
Space parameter	Space parameter description
'CN_V_Space Type'	Custom-made Space types, related to ventilation air flow calculations according to NBN EN 13779: 2010.
'CN_V_Building Sector'	Building sector, related to ventilation air flow calculations according to NBN EN 13779: 2010. Depends on the value for 'CN_V_Space Type'.
'CN_V_D_Air Flow Per Floor Area ($m^3/(h.m^2)$)'	Air flow per floor area (non-occupied Spaces), related to ventilation air flow calculations according to NBN EN 13779: 2010. Depends on the value for 'CN_V_Space Type'.
'CN_V_D_Floor Area Per Person (m^2/pers)'	Floor area per person (occupied Spaces), related to ventilation air flow calculations according to NBN EN 13779: 2010. Depends on the value for 'CN_V_Space Type'.
'CN_V_Min Supply Air Quality'	The minimum needed quality of the supply air (outside air or ETA2), related to ventilation air flow calculations according to NBN EN 13779: 2010. This will be important when using transfer air flow. Depends on the value for 'CN_V_Space Type'.
'CN_V_Extract Air Quality'	The minimum quality of the extract air (ETA1, ETA2, ETA3 or unchanged), related to ventilation air flow calculations according to NBN EN 13779: 2010. This will be important when using transfer air flow. Depends on the value for 'CN_V_Space Type'.

Setting Space parameters in Revit [2.16n.2]

To assist in the calculation of the air flows per Space, additional custom Space parameters are made. There are three methods to set the numerous custom Space parameters and each has its advantages. The first and the second one use Revit Views (respectively Floor Plans and Schedules), while the last one uses MS Excel. The first two methods will be discussed in this section, while the last method will be explained in the following section. An overview of all ventilation related Space parameters and their details is added in appendix 5.

Using the first method, the modeler can select a Space in a Floor Plan View and view the Space Properties via the Properties browser. It can be difficult to find the right parameters as this list contains all Space parameters (custom-made and built-in), sorted in numerous Parameter Groups. The custom parameters that are made for this workflow can be found in the Parameter Groups ‘Identity Data’ and ‘Other’. If one parameter from different Spaces needs to be set to the same value, this can be done quickly with this first method; simply select all Spaces in a View and go to the Properties window to change them all at once.

The second method uses of multiple prepared (‘Work’) Space Schedules that only contain the necessary Space parameters. Different Space Schedules assist in the workflow; the modeler can advance to a new Schedule if he or she is ready with the last one. The proposed order of Space Schedules and their changeable Space parameters is added in the next tables (table 4, 5, 6, 7, 8 and 9).

TABLE 4. Parameters in Schedule 1: ‘Work – V_Spaces Heating And Cooling With Air’

Space parameter	Space parameter description
‘CN_V_Heating With Air’	A Boolean parameter to flag if heating with air is used for this Space.
‘CN_V_D_Heating Air Flow (m^3/h)’	The heating air flow calculated outside Revit during task [2.2.0] can be filled in here.
‘CN_V_Cooling With Air’	A Boolean parameter to flag if cooling with air is used for this Space.
‘CN_V_D_Cooling Air Flow (m^3/h)’	The cooling air flow calculated outside Revit during task [2.2.0] can be filled in here.

TABLE 5. Parameters in Schedule 2: ‘Work – V_Space Freecooling’

Space parameter	Space parameter description
‘CN_V_Freecooling Day’	A Boolean parameter to flag if freecooling during the daytime is used for this Space.
‘CN_V_D_Freecooling Day Air Change (1/h)’	The necessary freecooling air change per hour, during the daytime, calculated outside Revit during task [2.3.0] can be filled in here.
‘CN_V_Freecooling Night’	A Boolean parameter to flag if freecooling during nighttime is used for this Space.
‘CN_V_D_Freecooling Night Air Change (1/h)’	The necessary freecooling air change per hour, during nighttime, calculated outside Revit during task [2.3.0] can be filled in here.

TABLE 6. Parameters in Schedule 3: ‘Work – V_Special Spaces’

Space parameter	Space parameter description
‘CN_V_Special Space	A Boolean parameter to flag if it is a so-called special Space according to NBN EN 13779: 2010.
‘CN_V_D_Special Space Air Flow (m^3/h)’	According to NBN EN 13779: 2010, these Spaces need different calculations, as mentioned in other standards or other specifications, for determining the air flow (see tasks [2.4.13] and [2.4.14]).

TABLE 7. Parameters in Schedule 4: 'Work – V_Spaces General'

Space parameter	Space parameter description
'CN_V_Space Type'	Custom-made Space types related to ventilation air flow calculations according to NBN EN 13779: 2010.
'CN_V_AHU Name'	This parameter can be used to mark in the early design phase if a certain Space is served by a certain AHU. This can be useful to quickly design the sizes of the duct shafts and AHU rooms.
'CN_V_D_Hygienic Air Flow Per Person (m^3/(h.person))'	The hygienic air flow per person (except employees).
'CN_V_Max Air Velocity Day (m/s)'	The maximum air speed in Ducts going through the Space during the daytime. This is typically 2 m/s for occupied Spaces, 4 m/s for non-occupied Spaces and 6 m/s for duct shafts and AHU rooms.
'CN_V_Max Air Velocity Night (m/s)'	The maximum air speed in Ducts going through the Space during nighttime. This can be 6 m/s for some Spaces if there is no occupation during the night.
'CN_V_Smokers'	A Boolean parameter to flag if this Space is for smokers. This value is by default set to (none). A Space for smokers needs extra air flow according to NBN EN 13779: 2010.
'CN_V_IDA Class'	Key parameter to set the IDA Class for the Space (IDA1, IDA2 or IDA3) according to NBN EN 13779: 2010. This parameter has no direct influence on the calculations, but can be used to flag Spaces with too little Air Flow in Excel.
'CN_V_Air Quality Control'	Key parameter to define the type of control (manual, sensors, …) according to NBN EN 13779: 2010.

TABLE 8. Parameters in Schedule 5: 'Work – V_Spaces Occupancy'

Space parameter	Space parameter description
'CN_V_D_#Occupants'	The maximum total number of occupants (employees and non-employees), determined by the design team.
'CN_V_D_#Employees'	The maximum number of employees in the Space, determined by the design team.
'CN_V_D_#Toilets'	The maximum number of toilets in the Space, determined by the design team.
'CN_V_D_#Showers'	The maximum number of showers in the Space, determined by the design team.

TABLE 9. Parameter in Schedule 6: 'Work – V_Spaces Comments'

Space parameter	Space parameter description
'Comments'	This built-in Space parameter can be used to make some remarks about the Space or its parameters.

An extra advantage of Schedule Views is that they can be filtered, sorted/grouped and formatted. Conditional formatting is used for Yes/No parameters (the values equal to 'Yes' (black ticked box) gets a red fill, while the values 'No' (non-ticked black box) and '(none)' (grey ticked box) have a green fill), so the user can assure that the right value is selected for the Space. Advanced conditional formatting, meaning the ability to mark a cell in one color if a first condition is fulfilled and another color is a second condition is fulfilled, is not possible in Revit at the moment of writing. Key parameters cannot be used in conditional formatting rules at all. Column headers in Revit Schedules cannot wrap the header title, which results in very wide columns.

In order to speed up this phase and to eliminate typing errors, two extra Key Schedules are made: 'Key – V_Air Quality Control' and 'Key – V_IDA Class'. The two Key Schedules only contain their Key parameter. These two lists are made according to the NBN EN 13779: 2010 standard (VEA & WTCB 2015, 28). The Key Schedule 'Key – V_Air Quality Control', can be expanded if certain combinations of air control systems are used for a Space.

Why exporting Revit Space parameters to Excel via Dynamo?

In the last section, only two of the three methods for entering Space parameter values were discussed. The last one makes use of the Dynamo graph ‘Tool - Link Revit-Excel.dyn’ (appendix 9) to export parameter values from Revit to a prepared Excel workbook. Different sources were used to make this Dynamo tool, such as web blogs about Dynamo (Kilkelly 2015) (Lenihan 2015) (BIM Troublemaker 2014), presentations given at Autodesk University (Sgambelluri 2014) and the Dynamo forum (Kulkul & Venkov 2016).

There are a lot of advantages of pushing Revit parameter values to Excel by using Dynamo. First of all, it is necessary to perform all Space-related calculations outside Revit, because the standard Revit calculation methods are not adapted to the specific Belgian regulations and because it is not possible to make calculated Space parameters (Project or Shared) inside Revit. These calculations can be made without exporting data to Excel, by only using Dynamo to read the parameter values from Revit, process them and give them back in other Revit parameters. The following reasons explain why using Excel is a good idea:

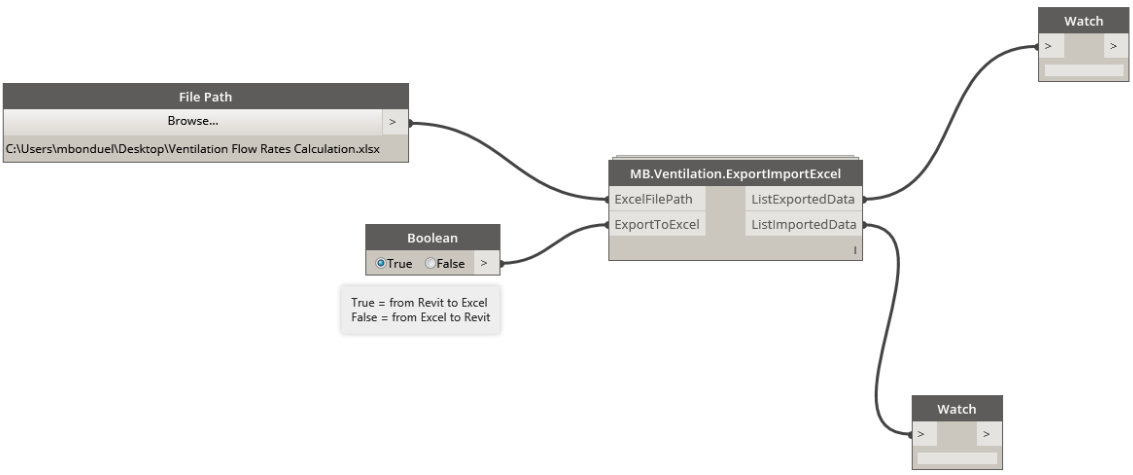
- The MS Excel environment is well known by most engineers. People generally know what the possibilities are and how to use the program.
- The users have control over the calculations (parameters with a green heading in Excel), as they can see the formulas by just clicking on a cell in Excel. If the whole calculations were only performed in Dynamo, extra documentation and training would be needed. It is also possible to unlock the workbook and change the calculations if necessary.
- This Excel file can be archived for later use or performing checks. When for example proposals from contractors need to be checked, this overview will be useful to see what the differences are and if they are acceptable.
- Cells in Excel have a lot more layout options (colored cells and text, freezing rows and/or columns, wrapping text, …) in comparison with Revit Schedules. This can make the Space list, containing a lot of data, more accessible.
- Some Revit parameters can be changed in Excel and will again update the corresponding Revit parameters in the project whenever the Excel file is exported back to Revit. This can be useful when a certain parameter (e.g. ‘CN_V_D_Heating Air Flow (m³/h)’) actually is the result of other calculations

outside the workflow described in this paper. Excel is also very useful to fill in values faster by using the fill handle for data series.

- In Excel it is possible to lock columns that contain read-only parameters; there is no option in Revit to prevent users from changing Space parameters.
- MS Excel offers a lot of extra possibilities for conditional formatting compared to Revit Schedules, such as complex formulas and using key parameter values.

Export from Revit to Excel [2.16n.3]

The used Dynamo graph 'Tool - Link Revit-Excel.dyn' (appendix 9) contains only five nodes: two input nodes, one central processing node and two output nodes (picture 16). The central processing node, 'MB.Ventilation.ExportImportExcel.dyf', is a custom node which contains the actual program and consists of other nodes (appendix 10). In this custom node, another custom node with the name 'MB.List.AddItemToEnd.dyf' (appendix 11) is used. Both of them need to be stored in the same folder as the graph. Three nodes are found in extra, free Dynamo Packages: 'Read Excel' from 'Bumble-Bee' package (version 2016.2.8) and 'Number.ToString' and 'NullSetParameter' from 'spring nodes' (version 82.7.8). Both packages need to be installed before the Dynamo tool will work. The user of this graph only needs to select the Excel file and switch between export from Revit ('True') or export from Excel ('False'). The two output nodes are added so the user can do a quick check if the exported data looks as expected.



PICTURE 16. Dynamo screenshot: 'Link Revit-Excel.dyn' graph

Sometimes, the connection between Dynamo and Excel is broken (e.g. when changing parameter values in Excel or Revit between two subsequent exports from Revit respectively Excel). When this happens, this can only be seen by checking if a particular parameter value changed or not after an export. To restore the connection, it is often enough to click ‘Browse’ in the file path node and select the file again. If this does not work, it is recommended to close and reopen Dynamo and Excel before running the graph again.

Dynamo can be set to run manually or automatically. The automatically Dynamo run can look attractive as it will update all changes immediately, but it can also lower the overall performance of Revit and Dynamo. For this tool, it is advisable to let it run manually. This will not only improve the software performance, but also fewer problems, such as unwanted override of data, will occur.

Setting Space parameters and air flow calculation in Excel [2.16n.4] [2.16n.5]

In the prepared Excel document with the name ‘Ventilation Flow Rates Calculation.xlsx’, the user can change the imported parameters in the ‘IMPORT’ Excel sheet. The Excel sheet ‘CALCULATIONS’ is connected with this first sheet. It gives an overview of all ventilation-related Space parameters and takes care of the calculations (see tables 10 and 11 for a list of all calculated parameters in Excel). Finally the sheet ‘EXPORT’ is connected with the ‘CALCULATIONS’ sheet. When all values are entered and the calculations are checked, the user can export this Excel file back to Revit, using the same Dynamo graph. Dynamo reads the Excel sheet ‘EXPORT’ row after row, until all parameters of all Spaces are read.

In the ‘CALCULATION’ and ‘EXPORT’ tab, the values and formulas of all cells are locked. In the ‘IMPORT’ tab, all cells are unlocked because they must be accessible for writing data from Revit via Dynamo. It is still possible to do cell formatting of locked cells.

TABLE 10. Revit parameters calculated in Excel - part 1/2

Space parameter	Space parameter description
‘CN_V_R_#Occupants’	Intermediate result parameter. This parameter is the maximum of the calculated and the design total amount.
‘CN_V_R_Hygienic Air Flow (m³/h)’	Intermediate result parameter. This parameter is calculated according to NBN EN 13779: 2010.
‘CN_V_R_Total Mechanical Supply Day Air Flow (m³/h)’	Final result parameter. This parameter is the maximum of ‘CN_V_D_Heating Air Flow (m³/h)’, ‘CN_V_D_Cooling Air Flow (m³/h)’, ‘CN_V_D_Special Space Air Flow (m³/h)’ and ‘CN_V_R_Hygienic Air Flow (m³/h)’.
‘CN_V_R_Total Freecooling Supply Day Air Flow (m³/h)’	Final result parameter. The parameter is equal to the Space ‘Volume’ multiplied with the ‘CN_V_D_Freecooling Day Air Change (1/h)’ parameter.

Not all parameters can be changed in Revit via Excel. Examples are key parameters, the ‘Level’ parameter, ‘Volume’ parameter, etc. These parameters are only exported from Revit to make the Space data list complete. They have a light blue colored heading in all Excel sheets. The parameters with a red-colored heading are parameters that can be changed in both Revit and Excel, while the green parameters are parameters that are calculated in Excel, before exporting them back to Revit (picture 17).

	B	C	D	T	U	V	W	X	Y
1	Spaces General				V_Spaces Occupancy				
2	Level	Number	Name	CN_V_Air Quality Control	CN_V_D_# Occupants	CN_V_R_# Occupants	CN_V_D_# Employees	CN_V_D_# Toilets	CN_V_D_# Showers
3									
4									
5	Level 00	A003	Corridor	IDA-C6 (pollution sensors)	20	20	2	0	0
6	Level 00	A004	Toilet	IDA-C6 (pollution sensors)	0	10	20	0	0
7	Level 00	A005	Classroom 1	IDA-C6 (pollution sensors)	16	16	1	0	0
8	Level 00	A006	Classroom 2	IDA-C6 (pollution sensors)	1	8	0	0	0
9	Level 00	A007	Classroom 3	IDA-C1 (no control)	1	11	0	0	0

PICTURE 17. Excel screenshot: ‘Ventilation Flow Rates Calculation.xlsx’ – part of ‘IMPORT’ tab

TABLE 11. Revit parameters calculated in Excel - part 2/2

Space parameter	Space parameter description
‘CN_V_R_Total Mechanical Extract Day Air Flow (m³/h)’	Final result parameter. This parameter is equal to the maximum of ‘CN_V_D_Heating Air Flow (m³/h)’, ‘CN_V_D_Cooling Air Flow (m³/h)’, ‘CN_V_D_Special Space Air Flow (m³/h)’, ‘CN_V_R_Hygienic Air Flow (m³/h)’ and ‘CN_V_R_Total Freecooling Supply Day Air Flow (m³/h)’.
‘CN_V_R_Total Mechanical Supply Night Air Flow (m³/h)’	Final result parameter. This parameter is equal to the maximum of ‘CN_V_D_Heating Air Flow (m³/h)’ and ‘CN_V_D_Special Air Flow (m³/h)’. For complex buildings where there are different Spaces without and with occupation during the night, the following value is calculated as the maximum of ‘CN_V_D_Special Air Flow (m³/h)’, ‘CN_V_D_Heating Air Flow (m³/h)’, ‘CN_V_D_Cooling Air Flow (m³/h)’ and ‘CN_V_R_Hygienic Air Flow (m³/h)’. This common exception is set for the following Space Types: ‘Cell, dayroom’, ‘Watch post’, ‘Bedroom’ and ‘Dormitory’. The user can change the used formula in Excel, if there would be a specific exception in the project.
‘CN_V_R_Total Freecooling Supply Night Air Flow (m³/h)’	Final result parameter. The parameter is equal to the Space ‘Volume’ multiplied with the ‘CN_V_D_Freecooling Night Air Change (1/h)’ parameter.
‘CN_V_R_Total Mechanical Extract Night Air Flow (m³/h)’	Final result parameter. This parameter is equal to the maximum of ‘CN_V_R_Total Freecooling Supply Night Air Flow (m³/h)’ and 'CN_V_R_Total Mechanical Supply Night Air Flow'

The Space list rows can be sorted in the ‘IMPORT’ worksheet. By using the Unique ID code of each Space instance, it is possible for Dynamo to write an Excel row with parameter values from one Space back to the right Revit Space element (BIM Troublemaker 2014). This Unique ID is placed in the first column of each Excel sheet and is by default hidden on the sheets ‘CALCULATIONS’ and ‘IMPORT’.

Export from Excel to Revit [2.16n.6]

The same Dynamo graph can be used to export the Space related parameters back to Revit, by just switching the input Boolean parameter to ‘False’ and clicking on ‘Run’. The mentioned calculated Excel parameters are used to populate the corresponding custom Revit Space parameters. All Space air flows, both calculated in Excel (‘R’ in third part of the parameter name) and elsewhere (‘D’ in third part of parameter name), are displayed in the Space Schedule ‘Work – V_Spaces Calculated Air Flow Summary’ (picture 18).

<Work - V_Spaces Calculated Air Flow Summary>

A	B	C	D	E	F	G	H
General Information		Intermediate Results				CN_V_R_Total Freecooling Supply Day Air Flow (m³/h)	CN_V_R_Total Freecooling Supply Night Air Flow (m³/h)
Number	Name	CN_V_D_Cooling Air Flow (m³/h)	CN_V_D_Heating Air Flow (m³/h)	CN_V_D_Special Space Air Flow (m³/h)	CN_V_R_Hygienic Air Flow (m³/h)		
Level 00							
A003	Corridor	0	0	0	270	0	0
A004	Toilet	0	0	0	600	0	0
A005	Classroom 1	0	0	0	816,75	0	0
A006	Classroom 2	0	0	0	558,6	0	0
A007	Classroom 3	0	0	0	319	0	0

PICTURE 18. Revit screenshot: part of Schedule ‘Work – V_Spaces Calculated Air Flow Summary’

Parameter values that are calculated in the Excel sheet, should not be filled in (or changed if they are already calculated) manually by the user in Revit. It is for example possible to make changes to these parameters and add values in the Schedules (method 2) and in other Views (method 1). To help the designer, the Schedule columns containing Revit parameters that should not be changed in Revit, have a light red filling. This principle is used for example in the Space Schedule ‘Work – V_Spaces Calculated Air Flow Summary’ (picture 18).

4.3.9 Dimensioning AHU rooms and duct shafts [2.6.0]

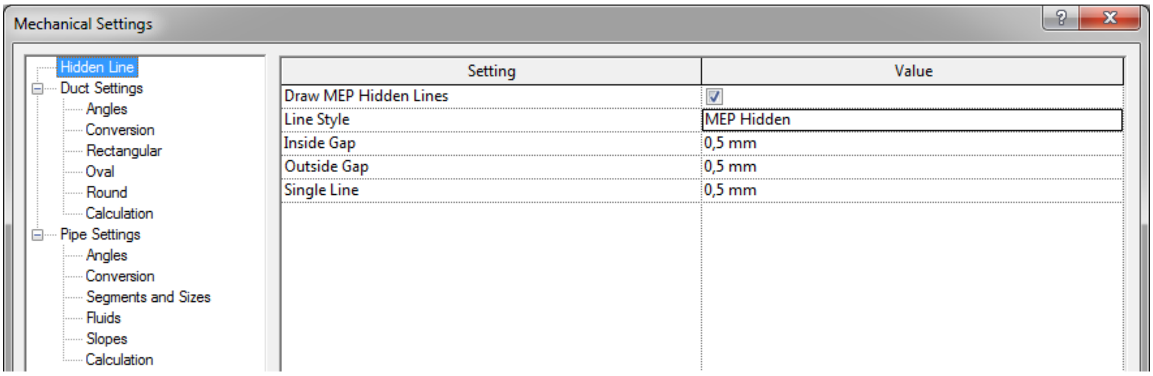
The content of this task remains the same as in the workflow during the current pre-BIM status. The Excel sheet with data from task [2.16n.0] can be used indirectly for dimensioning the AHU rooms and duct shafts. The rows in the Excel file should be sorted primary by ‘CN_V_AHU Name’ and secondary by ‘Level’ to collect the total air flow values for each AHU and duct shaft. With this information, it is possible to get an idea of the needed space for the AHU and the duct shaft.

4.3.10 Ventilation related settings [2.17n.0]

Mechanical Settings

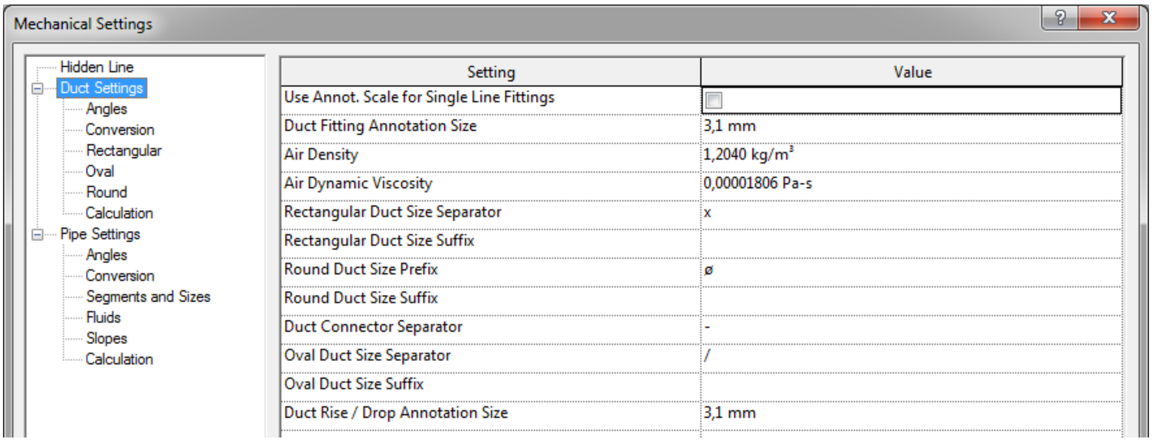
Before it is possible to start with the ventilation system design, we need to take a closer look at the so-called Mechanical Settings, containing the Duct Settings. They have an influence on the graphical representation of Ducts and values used for duct sizing and automatic duct layout tools. Extra information about each function can be found on the website of Autodesk Revit (Autodesk 2015a). An overview of all settings in the template can be found in appendix 5.

The ‘Hidden Line’ section (picture 19) contains information about how Ducts and other Mechanical elements will be displayed. If the Hidden Line setting is set on, Revit will display hidden lines for the Ducts or other Mechanical elements that is located below another element. This graphical effect is only visible in Mechanical Discipline Views.



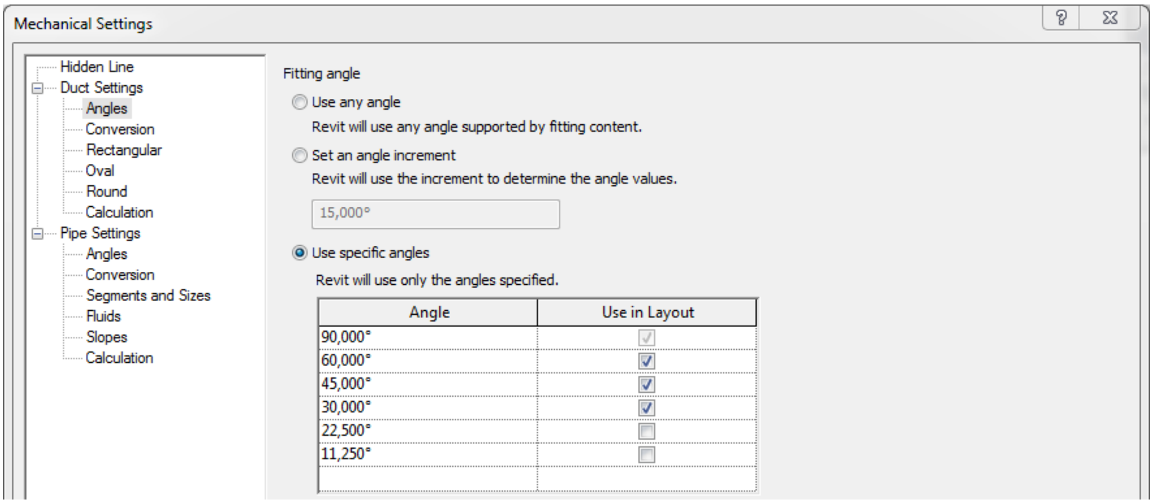
PICTURE 19. Revit screenshot: Mechanical Settings – Hidden Line

Under the 'Duct Settings' section, several properties related to Ducts can be changed. The general tab is shown in the next screenshot (picture 20). The most important settings are the Air Density and the Air Dynamic Viscosity. Both values are found in the WTCB report 15 (Delmotte et al. 2014, 14) and are taken for normal air conditions (20°C, dry air, normal atmospheric air pressure of 101325 Pa).



PICTURE 20. Revit screenshot: Mechanical Settings – Duct Settings

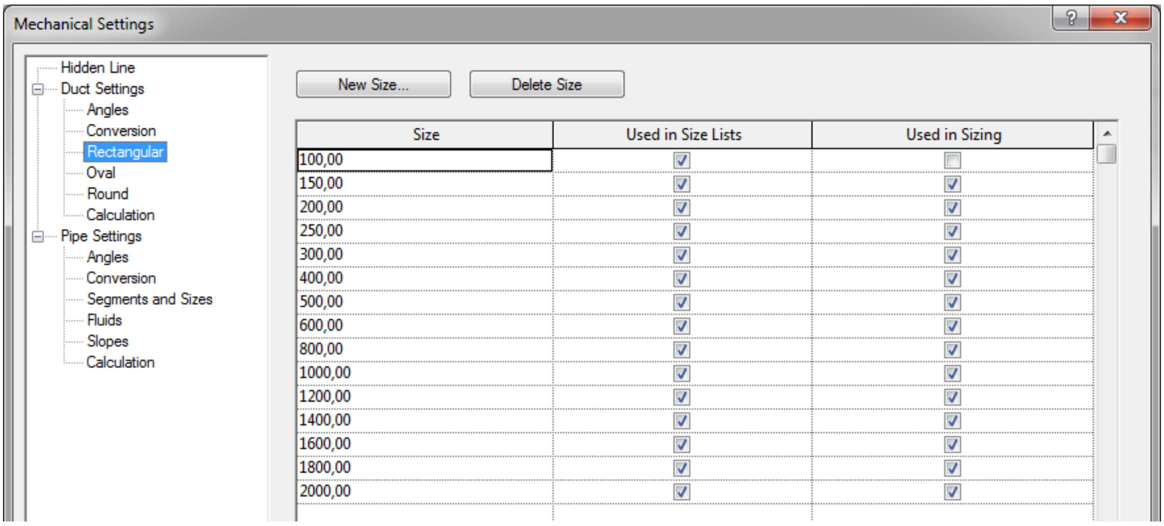
The next tab called 'Angles' (picture 21) determines which (horizontal and vertical) angles the Ducts can make while modeling them manually or with the use of the automatic layout tool. For this workflow, the restricted angles are determined according to the standard CENERGIE specifications, being angles of 15°, 30°, 45°, 60° or 90°. With the limited options in this setting dialog under specific angles, it is not possible to draw angles of 15° and no extra angles can be added in this menu. If the option is changed to 'Set an angle increment' of 15°, all allowed angles can be drawn. The only problem with this solution is that a not standard angle of 75° can be used. The best option is to use the specific angles of 30°, 45°, 60° and 90°. If an angle of 15° is needed, it can be drawn manually by starting from the bend fitting without any Ducts attached. An unconnected fitting has an editable angle, which can be any value between 0° and 90°. Then two pieces of Duct need to be drawn towards the bend Duct Fitting. The maximum angle that the bend and elbow fittings will allow is always 90°.



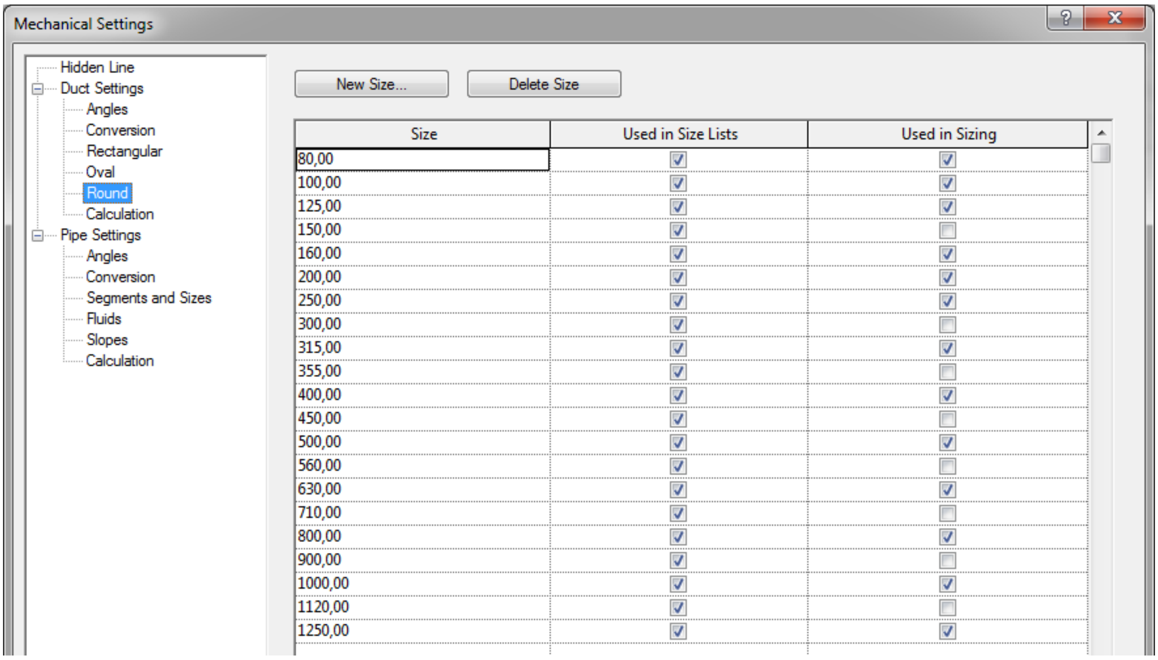
PICTURE 21. Revit screenshot: Mechanical Settings – Duct Settings – Angles

Next, there is the 'Conversion' tab which presents the settings that will be used by Revit, when it is proposing an automatic layout (*Generate Layout* or *Generate Placeholder* command). The settings for the Offset (distance between Level and middle of the Ducts) and the Duct Type can be set for each Duct System Classification (Supply, Exhaust and Return Air). More information about Duct System Classification will be given in the next section. There is also an option for flexible ducts (Flex Ducts Category). If this is filled in, a Flex Duct between the Air Terminal and the branch will be modeled. These settings can change a lot while using the automatic layout tool and the Revit developers made these settings accessible while using the tool.

The three tabs following after the 'Conversion' tab, are all related to the Duct sizes of respectively Rectangular (picture 22), Oval (not used) and Round Ducts (picture 23). CENERGIE has lists with common and uncommon Duct sizes. Some sizes are not used at all. The dimensions in the column with title 'Used in Size List' will be accessible while modeling normal and Flex Ducts manually, or when using the automatic layout tool. This list contains all common and uncommon Duct Sizes. The last column ('Used in Sizing') lists all Duct sizes that will be used by the Duct Sizing tool. This list contains only the common Duct sizes used by CENERGIE (general specifications). We notice that for rectangular Ducts, there is only one dimension present, which can be used for the Duct width and/or height. The CENERGIE list with Duct sizes divides the common and uncommon sizes in groups where for a given Duct height, there are only several values possible for the Duct width. It is not possible in Revit to restrict sizes in such a way that the available width dimensions are dependent on the chosen height dimension. This means that all possible height and width combinations are possible (e.g. 2000x100 which is not a common Duct size).

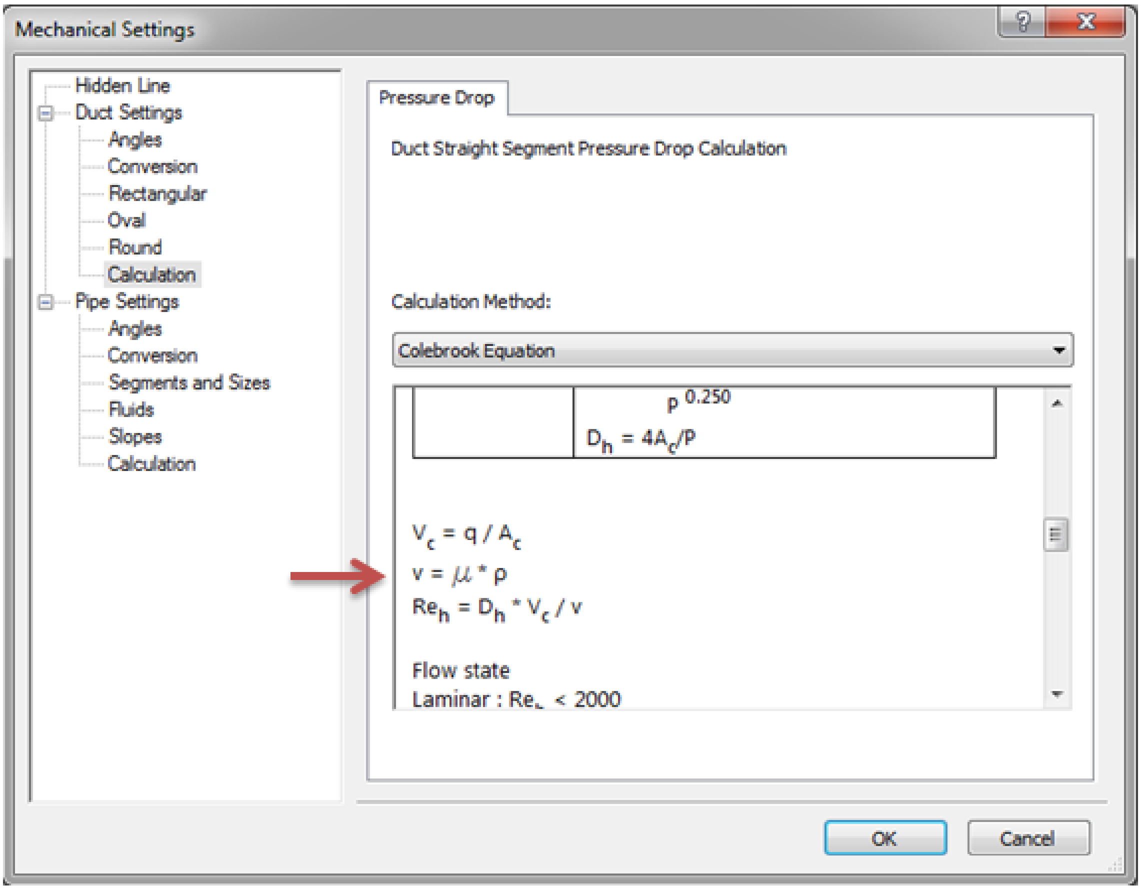


PICTURE 22. Revit screenshot: Mechanical Settings – Duct Settings – Rectangular



PICTURE 23. Revit screenshot: Mechanical Settings – Duct Settings – Round

The last setting tab related to Ducts, is about the used formulas for calculation of linear friction losses in Ducts. The selected method is the 'Colebrook Equation', which is also mentioned in the WTCB report 15 (Delmotte et al. 2014, 15). When an equation is selected, Revit shows what kind of formulas are behind that method. While checking the formulas, there seems to be an error: the kinematic viscosity ν should be equal to the dynamic viscosity η divided by the air density ρ. The documentation in Revit however shows ν to be equal to η multiplied by ρ (picture 24). After a manual control calculation, it seems that Revit uses the correct formula while sizing, so only this documentation file contains the error.



PICTURE 24. Revit screenshot: Mechanical Settings – Duct Settings – Calculation

Duct System Classifications and Duct System Types

Duct Systems are used to group different Ducts, Duct Accessory (e.g. fire valve) and Mechanical Equipment (e.g. AHU) elements. Beside the physical connection between these elements, the Duct Systems provide a connection between these elements on a higher level, which allows engineering data to flow between these elements. This extra layer is also useful for visualization of the systems, including View Filters and Tags. It can be used to separate different air systems, such as supply from outdoor air systems. The Revit Duct System Category has three built-in Duct System Classifications: Supply Air, Exhaust Air and Return Air. New Duct System Types can be made in the Revit template, but they must be grouped under one of the built-in Duct System Classifications. Whenever making a new loadable Family with Duct Connectors (Air Terminal, Duct Accessory, Duct Fitting or Mechanical Equipment), the Duct System Classification needs to be defined for each Duct Connector, so it can connect without a warning to a Duct System which is grouped under the same Duct System Classification.

For this workflow, five Duct System Types are prepared in the template: ‘Supply Air’, ‘Outdoor Air’, ‘Extract Air’, ‘Exhaust Air’ and ‘Transfer Air’. An overview of the data structure in Revit is presented in figure 5. These Duct System Types (including color codes and abbreviations) are based on NBN EN 13779: 2010. No Duct System Types from the Return Air Classification are used in this workflow, because the use of recirculation air in ventilation systems is judged to be rather limited in Belgium. An exception is made for ‘Transfer Air’; this is not really recirculation air (air that goes back to the distribution system), but it is the most suitable Duct System Classification besides Supply and Exhaust Air. New Duct System instances are made from these Types. The name of the Duct System instance is automatically generated by Revit when the modeler creates a Duct System and starts with the prepared System Type abbreviation (e.g. ‘ETA -’ for Extract Air) followed by a counting number (figure 5).

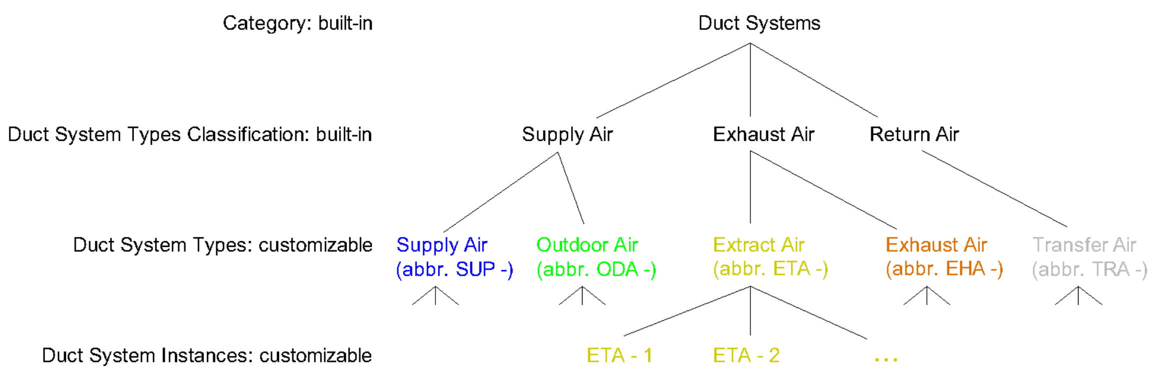


FIGURE 5. Data structure of Duct Systems in Revit

Different Duct System Types and Instances can be visually distinguished by using different colors for the Lines and Patterns. This can be prepared in the Visibility Graphics Overrides of the Duct System Types (only Lines) or via specific View Filters (Lines and Patterns). If color fill Patterns are used in a View, it should have the same color as defined in the Visibility / Graphics of the Duct System Type, while the Lines should be black. Because ‘Transfer Air’ needs to be colored grey, which is not very visible in plans, a View Filter is used to color the lines in fuchsia. View filters can also be useful to switch on and off different Duct Systems in Views.

The built-in parameter 'Calculations' can be switched temporarily from 'All' (default setting) to 'Performance' when working on complex MEP projects to improve the Revit modeling performance (Autodesk 2015b). For the Duct System Type 'Transfer Air' this parameter is set to 'Flow Only', as no sizing is needed here. If necessary, the Duct Rise / Drop Symbol can be changed.

Mechanical Equipment and Air Terminals that have an open Duct Connector, can be seen in the System Browser in the folder 'Unassigned'. This Browser is very useful to maintain the overview on the designed Duct Systems. The list of all Mechanical Equipment and Air Terminals in the Duct Systems is not hierarchical (e.g. AHU > Duct Shaft > Level). A possible workaround for making this list hierarchical, can be found in the 'System Splitter'-method described in the presentation of Andrew Duncan for Autodesk University 2014 (Duncan 2014).

The same Project parameter 'CN_V_ AHU Name', as used for the Spaces, is added to the Duct Systems and the Mechanical Equipment (AHU). This makes it possible to choose an AHU for the whole Duct System before they are physically connected.

Duct Types and Flex Duct Types

Different Duct Types from the Rectangular Duct or Round Duct System Family can be defined (Category Ducts). The Oval Duct Family is not used, because its application in the Belgian building industry is limited. The Duct Types contain information about the material ('Roughness' parameter, used in the linear pressure loss calculation of Revit) and the prioritized Duct Fittings that will be used while either modeling Ducts manually or by using the automatic layout tools ('Routing Preferences'). With the basic install, Revit already provided four Rectangular Duct Types and four Round Duct Types. All Duct Types have a 'Roughness' of 0,09 mm which is a typical value for galvanized steel spiral ducts (Delmotte et al. 2014, 15). Extra Types can be made, if a material is used that is less common. All Rectangular Duct Types remain unchanged regarding their Fittings, except the union Duct Fitting that is replaced by a modified Family called 'CN_V_Duct Fitting – Rectangular Union' (see section 4.5.1). The Round Duct Type 'Default' is removed because it has no practical use (no Duct Fittings loaded); all other

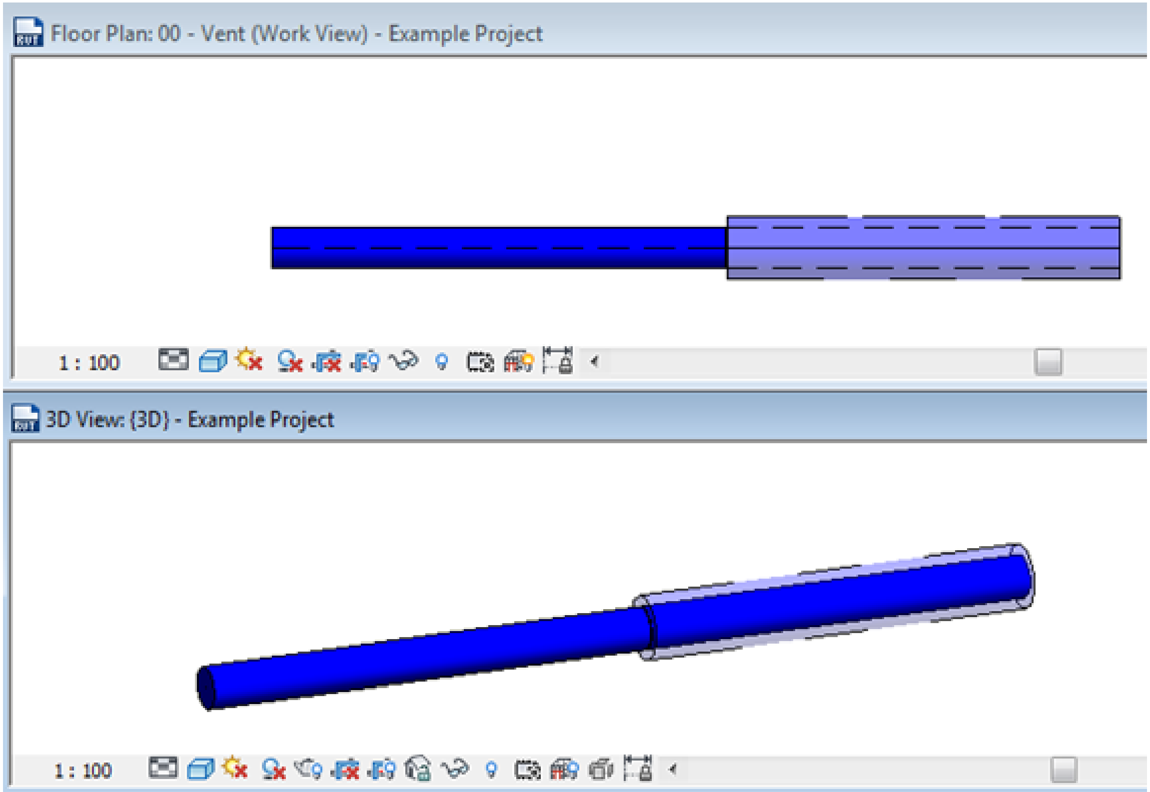
Round Duct Types remain unchanged, except the union Duct Fitting ('CN_V_Duct Fitting – Round Union'). Beside the Duct Fittings stored in the 'Routing Preferences', the user can load other Duct Fittings from the Revit library if necessary.

Ductwork can be drawn with elements of the normal Ducts or Placeholder Ducts Categories. If the Duct is drawn as a Placeholder Duct, it is visualized with a single 3D line regardless of the View Detail Level Setting and no Duct Fittings are placed. This method can be used to quickly draw a layout and to do the necessary flow calculations and Duct Sizing. In a next step, it is possible to convert the Placeholder Ducts to normal Duct elements. If some routes where modeled rather unrealistically, it is possible that Revit will fail to convert the whole Duct run. If the final goal of the model is to make a Duct System with 3D geometry, it is advisable to draw them from the beginning as normal Ducts, because no time is wasted with converting the Ducts and solving related problems. A second advantage is the opportunity to control the model visually and to coordinate the full geometry of the Ducts. If a single line drawing from a normal Duct run is needed, it is possible to simply switch the View Detail Level to Coarse. Duct Fittings will then be displayed with a corresponding symbol.

Beside the normal Ducts Category, Revit also has a Flex Ducts Category for flexible ducts. Flex Ducts also have a 'Roughness' parameter and some preferred Duct Fittings can be selected. The actual linear pressure loss of flexible ducts however, is dependent on its compression factor, a coefficient related to the Duct size and the linear pressure loss calculated for a not compressed flexible duct (Delmotte et al. 2014, 18). No compression factor parameter is prepared by Revit. A manual control calculation clarifies that no correction is used by Revit; it executes the same calculations as if the flexible duct was a normal Duct. The importance of this extra linear pressure loss is most of the time negligible because flexible Ducts are only used for small lengths (maximum 1 m) and avoided as much as possible. If flexible ducts are used, CENERGIE demands them to be made of an interior reinforced with glass silk. The 'Roughness' is set correspondingly to 0,9 mm; this is a typical value for such a flexible duct if it is not compressed (Delmotte et al. 2014, 15). No preferred Duct Fittings are stored in both the Flex Duct Rectangular and Flex Duct Round Families. This will prevent users from modeling longer duct routes with Flex Ducts than is allowed.

Duct Insulation

Revit also has Duct Insulation and Duct Lining System Families. Duct liner (interior duct insulation and/or protection) is not used in the Belgian building industry and will be not discussed in this thesis. Duct Insulation Types only contain information about the insulation material. The thickness can be selected while placing the Duct Insulation on a Duct or Duct Fitting, but this can also be modified later if needed. Duct Insulation is visualized in 3D Views as a transparent layer around the Duct with a dashed line pattern by changing the Visibility Graphics settings. In 2D Views (Floor Plans, Sections, Elevations) it is also possible to set the insulation transparent in the Visibility Graphics, but the color fill pattern of the Duct will not come through. A possible solution is to use transparency for the Duct Insulation in those Views in combination with a Duct System specific View Filter (picture 25). These Filters will make it possible to add color fill patterns to the Duct insulation with the same colors as the corresponding Duct System. The transparency makes it possible to easily distinguish insulated from non-insulated Ducts.



PICTURE 25. Revit screenshot: Duct visibility without and with Duct Insulation – specific filter used in Floor Plan View

4.3.11 Air Terminals [2.18n.0] and [2.23n.0]

The first ventilation elements that will be placed in the model are the supply and extract Air Terminals. In a later phase, after the placement of the AHU's and Ducts, exhaust and outdoor Air Terminals are modeled. Each of these supply and extract Air Terminals will bring air to or take air from the Space where it is placed in. Three Air Terminal groups are made for this workflow: mechanical Air Terminals (supply, extract, exhaust, outdoor), Air Terminals for freecooling supply air and Air Terminals for transfer air (supply and extract). Except the Air Terminals for freecooling supply air, all of them will become part of a Duct System. The freecooling supply Air Terminals are a non-geometric representation of windows that can be opened to let cool, outside air flow through the building. The Air Terminals for transfer air can be transfer air grilles, a door gap or simply the flow of air between two adjacent Spaces without physical boundary (open plan). Only the transfer air grilles have a geometry, while the two others are just flow representations.

Air Terminals and hosting methods

There are three hosting methods for loadable Families: object-based, Face-based and generic (Bokmiller et al. 2014, 570). The selected hosting method defines how a loadable Family is built and how it will be placed in the project model. The following diagram (figure 6) gives an overview of all three hosting methods and their use in this workflow. The prepared Air Terminal and Mechanical Equipment Families are sorted in the scheme according to their hosting method.

Families made according to the object-based hosting method only have a limited use in MEP projects, because the host object (e.g. Wall, Ceiling, …) needs to be present in the project model. This means that no host objects from Linked models can be used. In this workflow, the architecture model is Linked in the ventilation model. Air Terminals for freecooling supply air cannot have a geometric window representation, as it is not possible to make an opening in a Linked model Wall. We will discuss a possible solution with the Face-based hosting method. The normal Windows placed in the architecture model, are an example of object-based hosting.

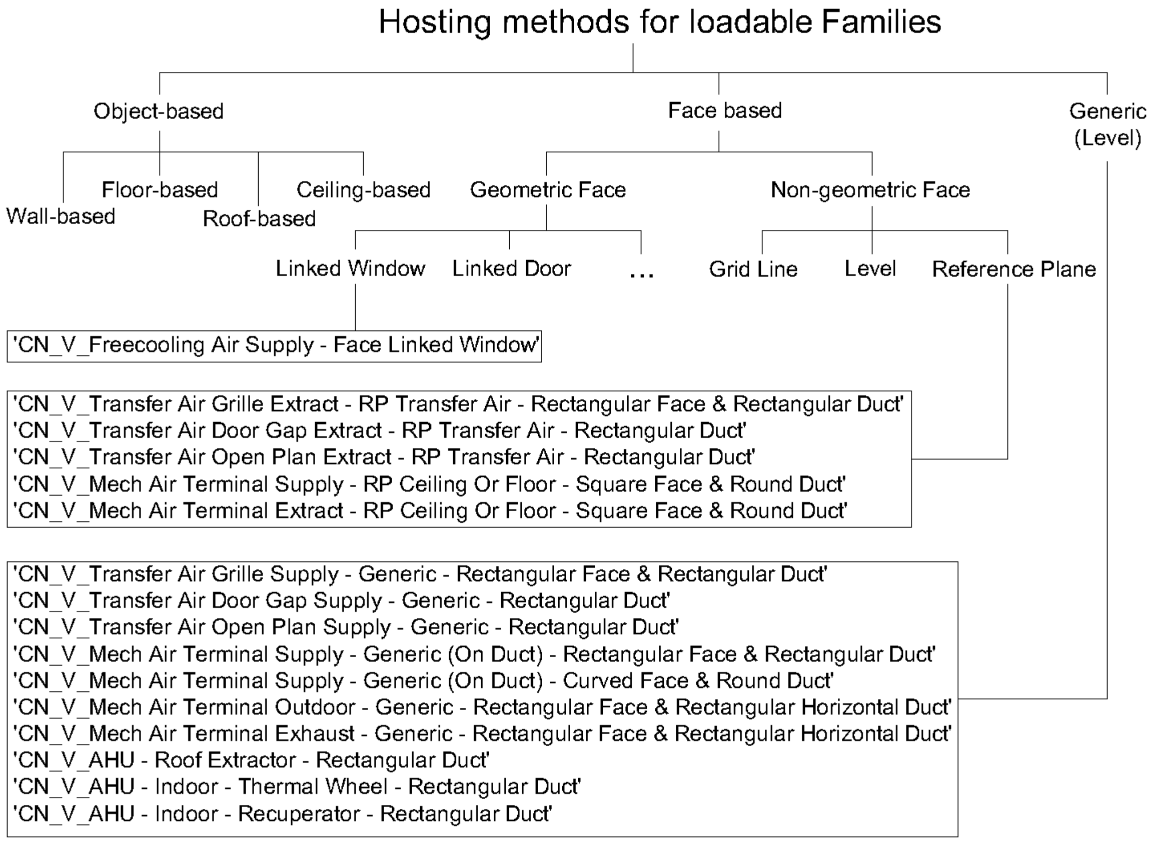


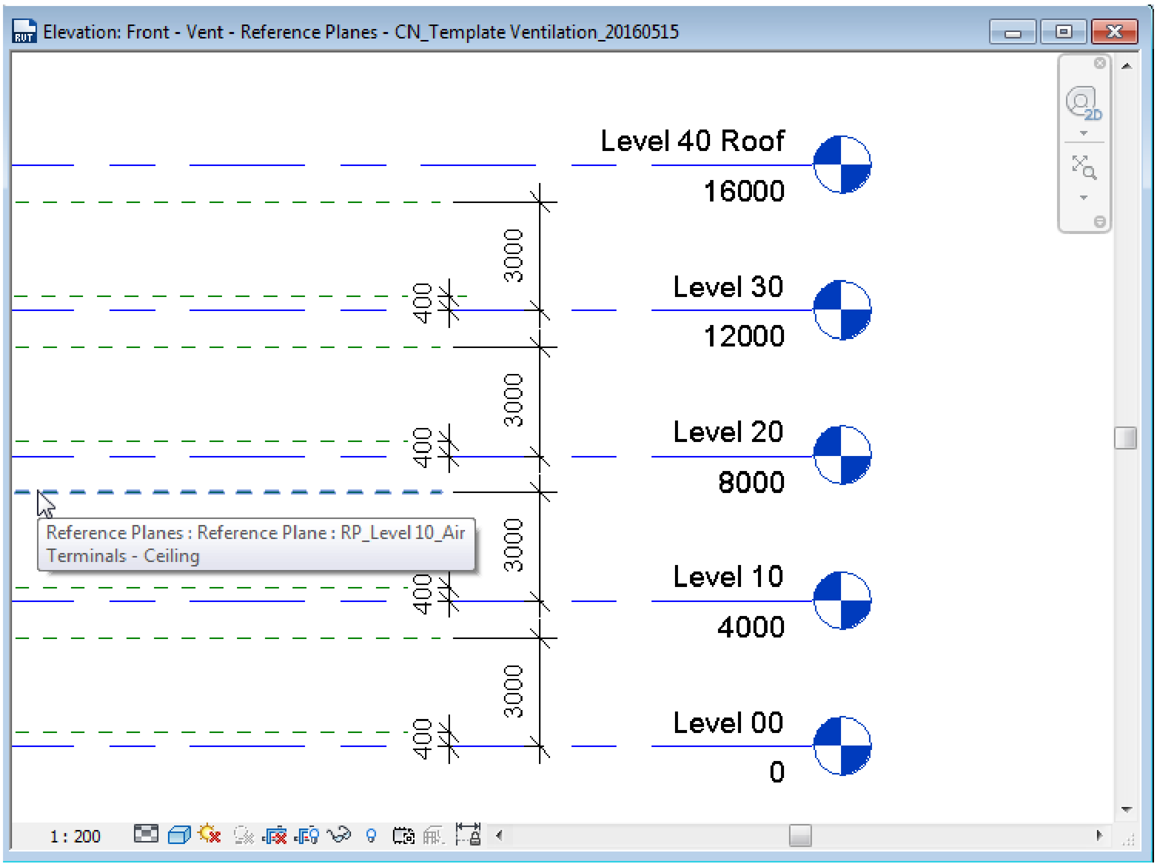
FIGURE 6. Hosting methods for loadable Families in Revit

The second hosting method is called Face-based and is useful when the placed object should move together with its host Face. The Face can be a geometry Face (e.g. the Face of a Wall, Window, Door, etc.) or a non-geometric Face (Work Plane) such as a Level, a Grid Line or a Reference Plane. The Faces can be located in the active model or in a Linked model.

The geometric Face-based hosting method is used for Air Terminals for freecooling supply air. Families made according to this hosting method can be hosted by Faces of geometric elements from the Linked model (e.g. Floors, Walls, Roofs, Doors and Windows). It is not used for mechanical Air Terminals and Air Terminals for Transfer Air. When the Face of a Linked model object moves in a later phase of the architecture design, it is possible that the connected ductwork will disconnect without any option to control this.

The non-geometric Face-based hosting method is used for the normal supply and extract mechanical Air Terminals (except duct Air Terminals) and the extract Air Terminals for transfer air. The used Faces are horizontal Reference Planes (RP's) that are located in the ventilation model. If a Reference Plane is moved by the modeler, all Air Terminals that are placed on this Reference Plane will move along. With this method, it is very convenient to place Air Terminals in Floor Plans because the correct height is stored in one place, being the height of the Reference Plane. It offers a method to quickly change the height of multiple Air Terminals that are hosted on one Reference Plane. To avoid coordination problems, the height of the RP should always be defined as the distance above the Level where its hosted Air Terminals supply or extract air. This proposed method makes it easier to compare the Air Terminal height (via the host RP: height distance above Level) and the height of Ducts (Offset above Level). Ducts are generic hosted and are always placed on a Level, with a defined Offset.

In the ventilation model template, two Reference Planes per Level are prepared with the names 'RP_Level xx_Air Terminals – Ceiling' and ''RP_Level xx_Air Terminals – Transfer Air'. Extra Reference Planes can be necessary if different Air Terminals are placed on one Level and at different heights. The RP should always be drawn from left to right (except if the Air Terminals are used as floor diffusers) in a Section or Elevation View. This will make that all Air Terminals are modeled in the right position and not upside down. After drawing the RP, it must be labelled before it becomes visible in the drop down list that appears while placing/moving Air Terminals. A separate Elevation View named 'Front – Vent – Reference Planes' is saved in the template. It contains all height dimensions of all Reference Planes (picture 26). A dimension is only visible in the View where it is made and to keep track of all important dimensions, they are all made in one specific View that is only used for this purpose.



PICTURE 26. Revit screenshot: Elevation View ‘Front – Vent – Reference Planes’

One downside of using this method is that the built-in Revit parameters that indicate the used Face are not visible in Schedules and cannot be used in View Filters. To make it possible to control this, three extra Project parameters are made for Air Terminals (table 12). These custom parameters can be populated easily with another Dynamo graph called ‘Tool – Air Terminals Location.dyn’ that is made for this workflow (appendix 12). Dynamo can read the built-in Revit parameters and paste theses values in the custom made Revit parameters. These parameters should be used for controlling only, as changing a value here will not result in an actual update of the modeled Air Terminals. Custom-made parameters can be used in View Filters and Schedules, such as the control Schedule ‘Control – V_Air Terminals Location’, which is saved in the ventilation template (picture 27).

TABLE 12. Custom Project parameters for Air Terminals

'CN_V_Face'	If the Air Terminal is Face-based (geometric or non-geometric), Dynamo reads the built-in 'Work Plane' parameter and pastes it in this custom-made Project parameter.
'CN_V_Level'	Dynamo reads either the built-in 'Level' parameter for generic placed Families or 'Schedule Level' parameter for Face-based (geometric or non-geometric) Air Terminals and pastes this values in this custom-made Project parameter. The built-in parameter 'Schedule Level' can be changed for Face-based Air Terminals, if they are not hosted by the Face of a Level.
'CN_V_Offset From Face Or Level'	Dynamo reads the built-in 'Offset' parameter of the Air Terminals, which can be an offset from a Face or a Level, depending on the hosting method. For an Air Terminal hosted on a Reference Plane, this offset is not the distance between the Air Terminal and the 'Schedule Level', but the distance between the Reference Plane and the Air Terminal. This last offset value should normally be equal to zero.

A lot of different Revit Families are generically placed, such as Furniture Families and other equipment. They are constrained to the Level where they are placed on and they can have an Offset from this Level. In this workflow, supply Air Terminals for transfer air and the mechanical exhaust and outdoor Air Terminals are generically placed. Mechanical Air Terminals that are placed directly on Ducts are also placed in the same way. These Air Terminals do not follow any Wall, Door or other geometric Face. The main advantage of using this method is that connected Ducts, which are also generic hosted, will not break their connection when something changes in the architecture model. The built-in 'Offset' parameter of the Air Terminals cannot be Scheduled and this makes it difficult to keep track of their location. With the above Dynamo graph 'Tool – Air Terminals Location' and custom parameters (table 12) this value becomes also visible in Schedules (picture 27) and can be used for View Filters.

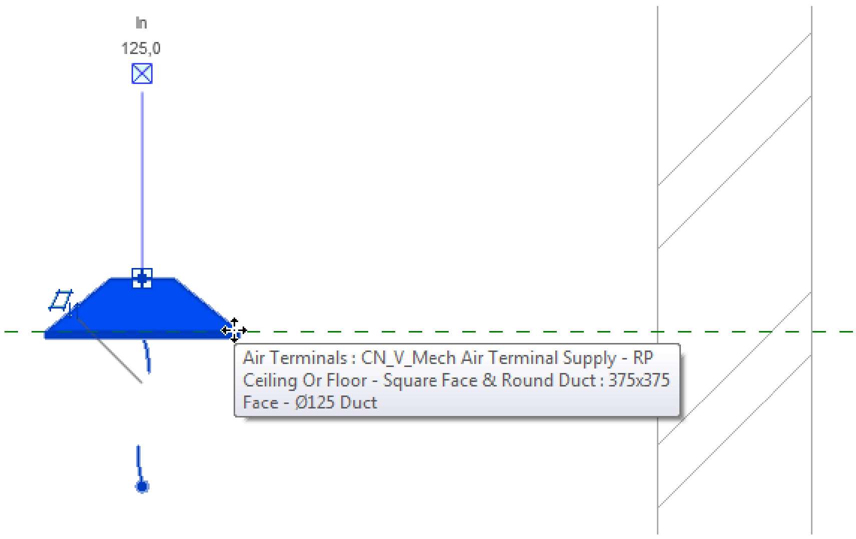
<Control - V_Air Terminals Location>		
A	B	C
CN_V_Face	CN_V_Offset From Face Or Level	CN_V_Level
Extract Air		
CN_V_Mech Air Terminal Extract - RP Ceiling Or Floor - Square Face & Round Duct: 480x480 Face - Ø160 Duct		
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Supply Air		
CN_V_Mech Air Terminal Supply - RP Ceiling Or Floor - Square Face & Round Duct: 375x375 Face - Ø125 Duct		
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Ceiling	0	Level 00
Transfer Air		
CN_V_Transfer Air Grille Extract - RP Transfer Air - Rectangular Face & Recangular Duct: Acoustic - 400x100 Duct		
Reference Plane : RP_Level 00_Air Terminals - Transfer	0	Level 00
Reference Plane : RP_Level 00_Air Terminals - Transfer	0	Level 00
CN_V_Transfer Air Grille Supply - Generic - Rectangular Face & Recangular Duct: 400x100 Duct		
	400	Level 00
	400	Level 00
Undefined		
CN_V_Freecooling Air Supply - Face Linked Window: Single Awning Window - 20° Opening - 1 m/s		
Linked Revit Model : Spaces model.rvt	-100	Level 00

PICTURE 27. Revit screenshot: Schedule ‘Control – V_Air Terminals Location’

When the modeling of the Air Terminals is ready, the height dimensions of all Reference Planes that host them should be locked (making a ‘Constrained Dimension’ in Revit terminology). When the architecture model changes and a Level is moved here, a Coordination Monitor alert appears as a Warning when the architecture model is reloaded in the ventilation model. The alert can be viewed in the Coordination Review window; if the selected action is ‘Move Level’, the Level from the ventilation model will move to the same location as the corresponding Level from the architecture model.

Air Terminals and Spaces

It is essential for this workflow that each Air Terminal (except the exhaust and outdoor mechanical Air Terminals) is located in the correct Revit Space. For Air Terminals there seem to be two methods: the one with the use of the Room Calculation Point and the one without. If no Room Calculation Point is used, Revit defines by itself if an element is inside a Space and it is not clear how this is defined. If the Room Calculation Point is activated, Revit looks to the location of this point only. If this point is inside a Space, Revit will see the whole element as inside a Space. To activate this Room Calculation Point, the Family Editor environment of the Air Terminal Family needs to be opened. In the Properties, the Room Calculation Point parameter should be ticked in order to switch to this location method. In the Views inside the Family Editor environment, the Room Calculation Point is visible and can be moved in any direction. If this adjusted Family is loaded back in the project, this point becomes visible (but its location is not adjustable) whenever the Air Terminal is selected (picture 28).



PICTURE 28. Revit screenshot: selected Air Terminal in Section View

With an extra Schedule named ‘Control – V_Air Terminals – Not In Space’, it is possible to check if every Air Terminal is located inside a Space. Air Terminals for outdoor air and exhaust air are never inside a Space, so they do not need a Room Calculation Point.

Air Terminals and air flows

In task [2.16n.0], the necessary air flow per Space is calculated and this results in six parameters (see left-hand side parameter column of figure 7). Six mirror parameters are stored inside the different Air Terminal Families (see right-hand side parameter column of figure 7). All Air Terminals placed inside a Space should together provide the different necessary air flows.

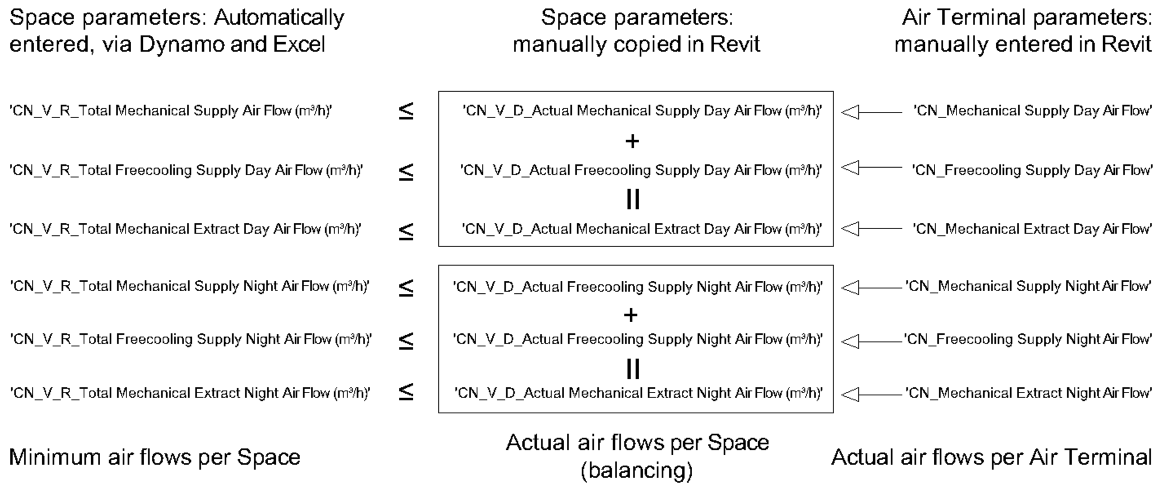
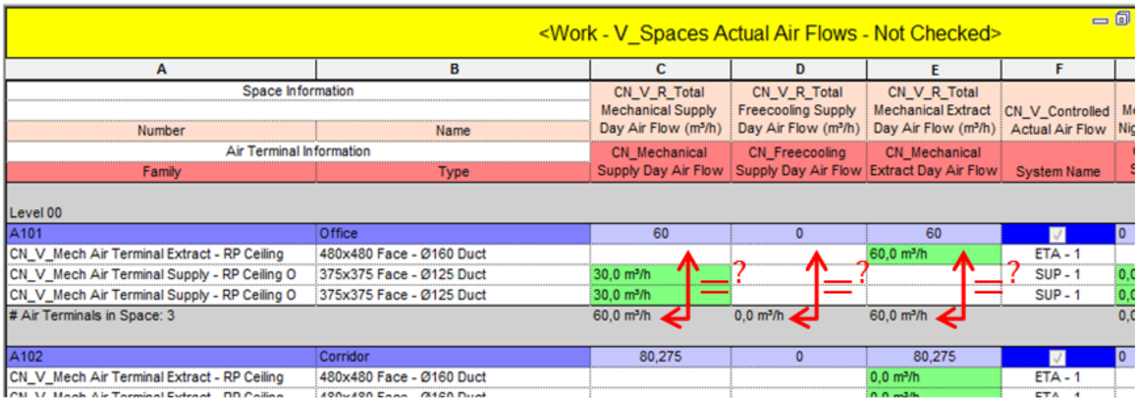


FIGURE 7. Custom air flow parameters of Spaces and Air Terminals

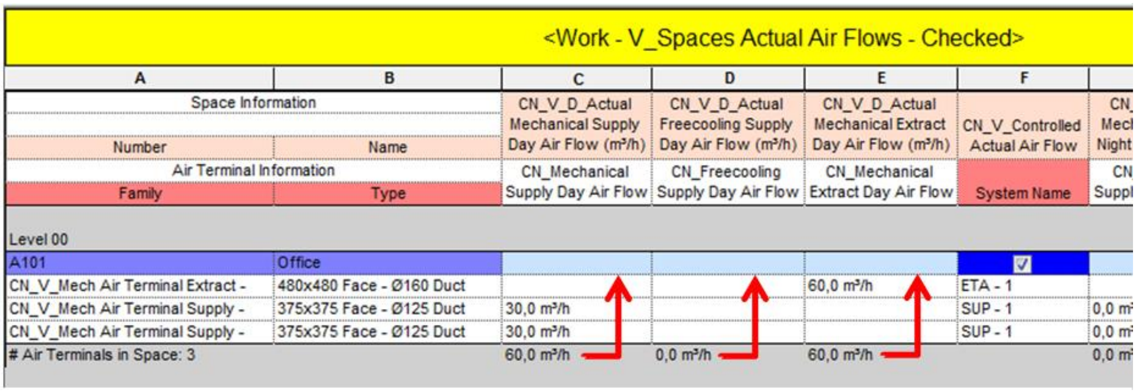
The standard Revit method to collect actual air flows per Space makes use of built-in actual air flow parameters for each Duct System Classification. Revit checks dynamically if an air terminal is located in a Space. Then it reads the built-in ‘Flow’ parameter of the Air Terminal and adds this value to the ‘Actual Supply Airflow’, ‘Actual Exhaust Airflow’ or ‘Actual Return Airflow’ depending on the Duct Classification of the Connector in the Air Terminal Family. This method cannot be used in this workflow, because Spaces can have multiple different necessary air flow values and the Air Terminals can have multiple air flow parameters representing the actual air flows.

The method that is proposed for this workflow, makes use of the Schedule ‘Work – V_Spaces Actual Air Flows – Not Checked’ (picture 29). In this Schedule there is an embedded Air Terminal Schedule for each Space. The total actual air flow from the Air Terminals is calculated in the Schedule for each of the six Air Terminal air flow parameters. These values can be compared with the corresponding required air flows per Space. The same Schedule can be used to control quickly if the Space has balanced air flows, meaning that the supply and extract air flow at day- and nighttime is equal.



PICTURE 29. Revit screenshot: Schedule ‘Work – V_Spaces Actual Air Flows – Not Checked’

When a Space has enough Air Terminals with sufficient air flow, the Space parameter ‘CN_V_Controlled Actual Air Flow’ can be ticked. This will remove the Space from the Schedule and move it to the Schedule ‘Work – V_Spaces Actual Air Flows – Checked’ (picture 30). In this Schedule, it is possible to manually enter the total actual air flow values (six parameters; see middle parameter column of figure 7) for each Space. When the Spaces are tagged in a later phase, this Tags will display the actual air flows of the Space that are entered here. To speed up this work, it is possible to make an extra Dynamo tool to automate this task. If the actual air flows per Space are entered in the corresponding Space parameters, it is possible to get an overview of the situation in Schedule ‘Control – V_Spaces Air Flow Summary’. If in a later phase, the air flows would be recalculated, the Spaces with inadequate air flows (not enough or not balanced) can be found here.



PICTURE 30. Revit screenshot: Schedule ‘Work – V_Spaces Actual Air Flows – Checked’

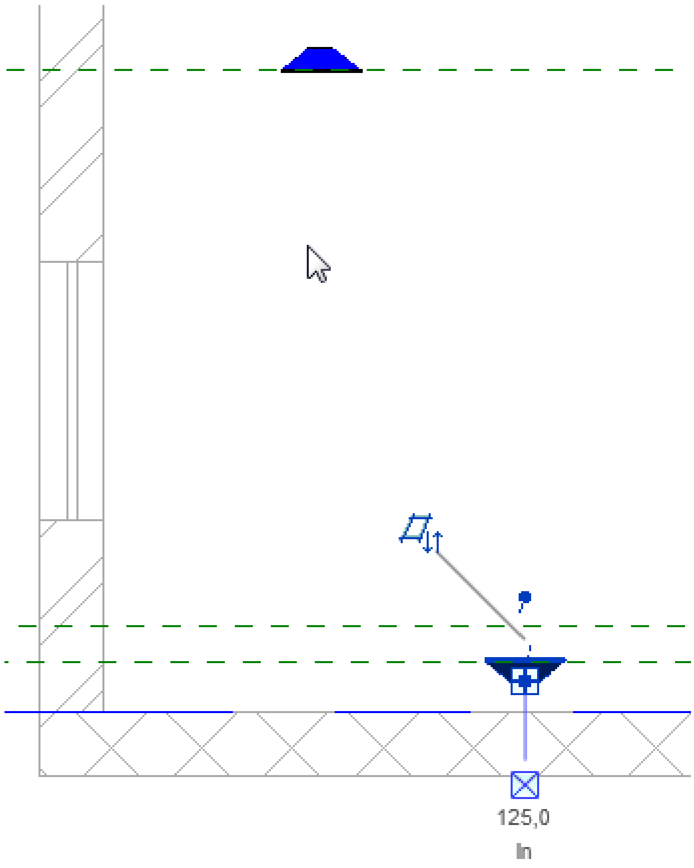
Mechanical Air Terminals

Six mechanical Air Terminals are prepared for this workflow:

- 'CN_V_Mech Air Terminal Supply – RP Ceiling Or Floor – Square Face & Round Duct'
- 'CN_V_Mech Air Terminal Extract – RP Ceiling Or Floor – Square Face & Round Duct'
- 'CN_V_Mech Air Terminal Supply – Generic (On Duct) – Rectangular Face & Rectangular Duct'
- 'CN_V_Mech Air Terminal Supply – Generic (On Duct) – Curved Face & Round Duct'
- 'CN_V_Mech Air Terminal Outdoor – Generic – Rectangular Face & Rectangular Horizontal Duct'
- 'CN_V_Mech Air Terminal Exhaust – Generic – Rectangular Face & Rectangular Horizontal Duct'

Four are made starting from existing basic Air Terminal Families provided by Revit. The outdoor and exhaust Air Terminal are made from scratch. The two last ones are only placed (task [2.23n.0]) when the entire 'Supply Air', 'Extract Air', 'Outdoor Air' and 'Exhaust Air' Duct Systems are made, connected to the AHU and sized. All Air Terminals have a generic geometry and are easy to use during the preliminary design phase. It is possible to add extra information about the Air Terminal type via the key parameter 'CN_V_Air Terminal Type'. Default prepared values include for example 'Ceiling Diffuser', 'Jet Nozzles' and 'Swirl Diffuser'. Extra types can be made by adding key values in the key Schedule 'Key – V_Air Terminal Type'. The Revit Family Type (not the Air Terminal type defined by a key value) defines the size of the Duct opening and the Air Terminal's Face. New Types can be added easily by duplicating an existing Type and changing the Type name and size parameters. If extra geometry (e.g. plenum boxes) and/or Connectors (round/rectangular and horizontal/vertical direction) are needed, they can be modeled in the Family Editor environment by starting from a copy of the existing mechanical Air Terminal Families.

The Reference Plane, used to place the supply and extract Air Terminals should always be drawn from left to right (except in the case of a floor diffuser) in a Section or Elevation View so all Air Terminals are modeled in the right position and not upside down. The next screenshot of a Section with an Air Terminal instance that supplies air from above, and one that supplies air from below (hosted by Reference Plane that is drawn from right to left), illustrates this clearly (picture 31).



PICTURE 31. Revit screenshot: Face-based mechanical Air Terminals and Reference Planes (the highest RP is drawn from left to right, the lowest from right to left)

Two Families represent supply Air Terminal grilles that are placed directly on the sides or bottom of round, respectively rectangular Ducts. The grille in the case of a round Duct can adapt its curve to the Duct if the Duct Diameter parameter of the Air Terminal is manually changed to match the host Duct Diameter.

Each Air Terminal has two air flow parameters containing a flow value that it delivers to or takes from a Space in day- or nighttime. The supply Air Terminals give the air flow during the day immediately to the Connector that will transport the air flow through the connected Ducts. The supply air flow during the day will always be greater or equal than the supply air flow in nighttime. The Air Terminals for extraction of air however, can transport more air during nighttime if freecooling is used in the project. The custom Air Terminal parameter ‘CN_Daytime’ can be used as a switch, to let the air flow during the day- respectively nighttime pass through the Connector to the connected Duct System.

It is good practice to immediately add the mechanical Air Terminals to the correct Duct System after placement. There will be four Duct Systems connected to every AHU and each of them will be from one of the following Duct System Types: 'Supply Air', 'Extract Air', 'Outdoor Air' or 'Exhaust Air' (except the roof extractor AHU Family, which only has one Duct System of the Type 'Extract Air'). When the Air Terminals are mapped to a Duct System, it is possible to add the name of the AHU to the Duct System via the Shared Project parameter 'CN_V_AHU Name'. This value can be entered in the Schedule 'Work – V_Duct Systems AHU Name', which lists all Duct Systems in the project, except the one's from the 'Transfer Air' Duct System Type. When they are later connected to the Connector of an AHU instance, it is possible to check if the right AHU is connected to the right Duct Systems. During earlier design phases, Spaces have received a value for the Space parameter 'CN_V_AHU Name' from the modeler to indicate the name and/or number of the AHU that will serve them. It is possible to activate the Color Scheme 'AHU Name' from the Category Spaces in Floor Plan Views. It is also possible to make View Filters to see which Air Terminals are part of the same Duct System.

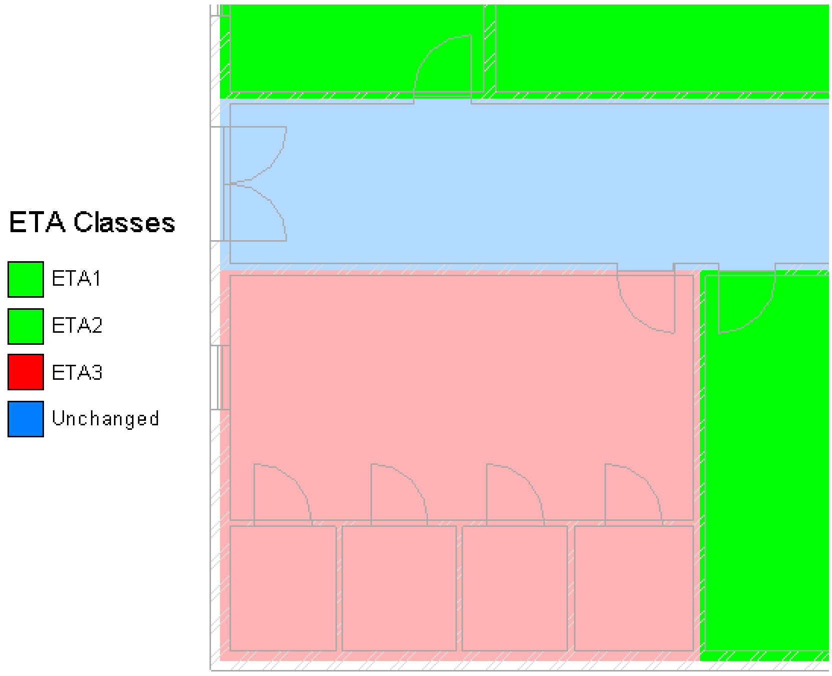
Air Terminals for transfer air

The standard Revit Family library does not contain any transfer air grilles or methods to model the transfer air flow between two adjacent, open Spaces. For this workflow, six Air Terminal Families are made to represent transfer air trough grilles (in Walls or Doors), through a door gap or simply the air flow in the situation of an open plan:

- 'CN_V_Transfer Air Grille Extract – RP Transfer Air – Rectangular Face & Rectangular Duct'
- 'CN_V_Transfer Air Grille Supply – Generic – Rectangular Face & Rectangular Duct'
- 'CN_V_Transfer Air Door Gap Extract – RP Transfer Air – Rectangular Duct'
- 'CN_V_Transfer Air Door Gap Supply – Generic – Rectangular Duct'
- 'CN_V_Transfer Air Open Plan Extract – RP Transfer Air – Rectangular Duct'
- 'CN_V_Transfer Air Open Plan Supply – Generic – Rectangular Duct'

To determine which Spaces can deliver transfer air to other Spaces, the Color Scheme 'ETA Classes' is used; only ETA1 and ETA2 classified air can be reused. The ETA class of the air leaving a certain Space was already determined when the Space type parameter was filled in (see task [2.16n.0]). With the View Filter 'Spaces – Min Supply Air Quality ETA 2', all Spaces that can receive transferred air are flagged in the same

Floor Plan. By setting the View Filter on Transparent, it is easy to see the Spaces that can use transfer air (picture 32).

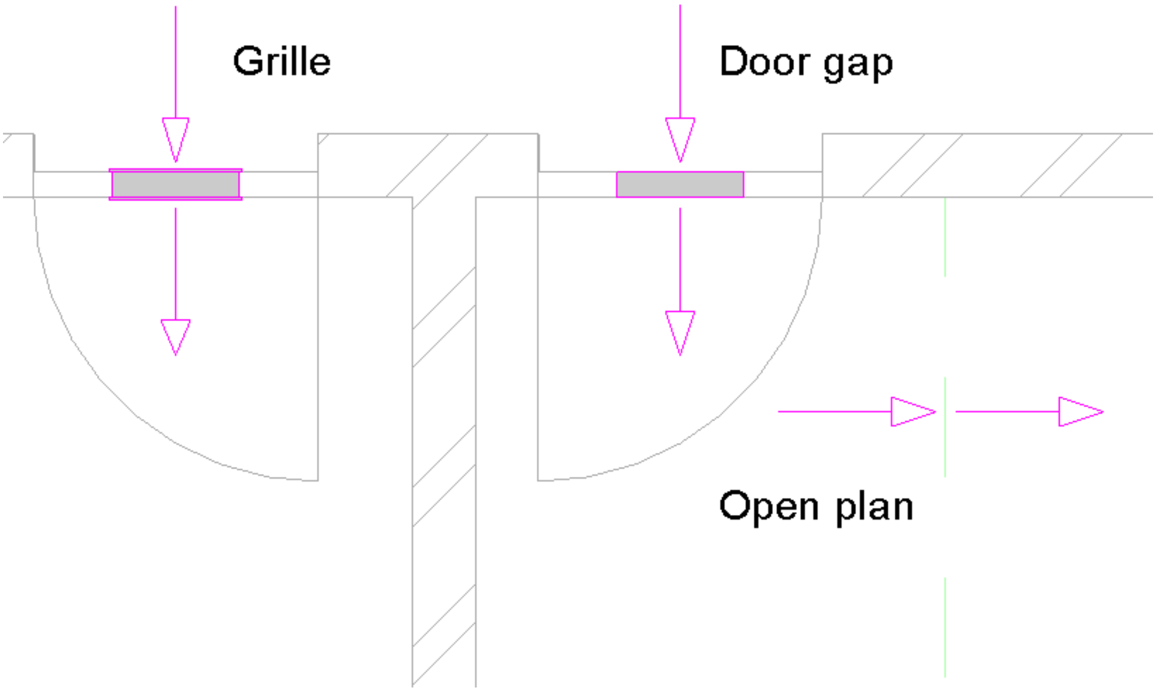


PICTURE 32. Revit screenshot: Color Scheme ‘ETA Classes’ and View Filter ‘Spaces – Min Supply Air Quality ETA 2’

Because an Air Terminal can only be located in maximum one Space and can only take care for supply or extract air flow, two Air Terminal Families are needed to represent transfer air between two Spaces. The extract Air Terminal contains extra information about the transfer air grille (acoustic or normal grille) or door gap (dimensions of the door gap and calculated minimum door gap height).

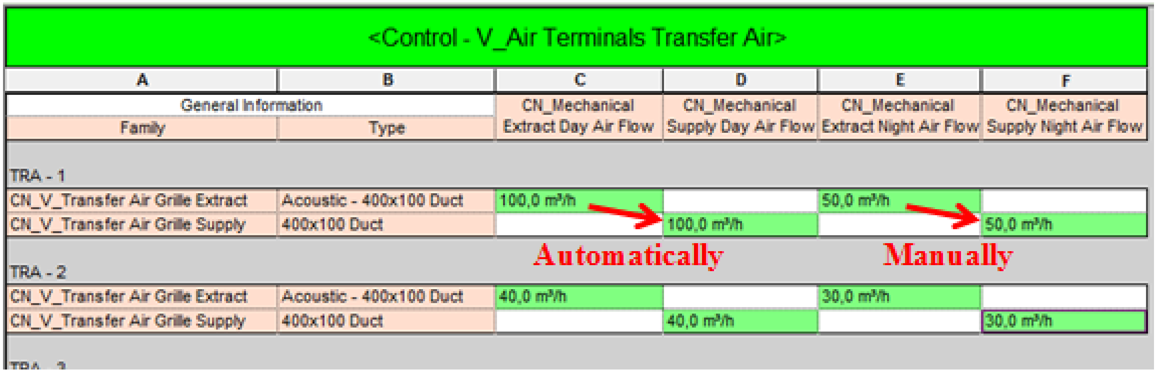
The Air Terminal Families for extract transfer air are placed vertically in a Mechanical Floor Plan View. They are Face-based hosted on a horizontal Reference Plane. In the next step, a short piece of Duct is modeled, starting from the Air Terminal. At the end of the Duct, an Air Terminal for supply transfer air is placed (picture 33). Because this Air Terminal is generically placed, it is very easy to connect it to the Duct by moving over the open Duct Connector while tapping the space bar to rotate it to the right position. When the second Air Terminal is placed on the Duct, both Air Terminals are connected and will follow each other’s movement. If transfer air is modeled in the case of an open plan (two Spaces directly connected), it is a good idea to place the extract Air

Terminal perpendicular on the Space Separation Line that indicates the boundary between the Spaces. The supply Air Terminal can be connected directly on the Connector of the extract Air Terminal. It is good practice to lock the Space Separation Line and one of the two connected Air Terminals. At the moment, only Families for horizontal transfer air are prepared, but it is possible to make extra Families for vertical transfer air transport between Spaces.



PICTURE 33. Revit screenshot: All six Air Terminals for transfer air

If both Air Terminals are connected, one air flow value can pass from the extract to the supply Air Terminal. Because in most cases transfer air during the daytime alone is enough to model the situation, this extract air flow is passed via the connected Duct to the supply air flow parameter of the supply Air Terminal. In the case of transfer air in nighttime, the parameter needs to be copied manually. The Schedule 'Control – V_ Air Terminals Transfer Air' helps to find the Air Terminals for transfer air that have air flow values that do not match (picture 34).



<Control - V_Air Terminals Transfer Air>					
A	B	C	D	E	F
General Information		CN_Mechanical Extract Day Air Flow	CN_Mechanical Supply Day Air Flow	CN_Mechanical Extract Night Air Flow	CN_Mechanical Supply Night Air Flow
Family	Type				
TRA - 1					
CN_V_Transfer Air Grille Extract	Acoustic - 400x100 Duct	100,0 m^3/h		50,0 m^3/h	
CN_V_Transfer Air Grille Supply	400x100 Duct		100,0 m^3/h		50,0 m^3/h
TRA - 2					
CN_V_Transfer Air Grille Extract	Acoustic - 400x100 Duct	40,0 m^3/h		30,0 m^3/h	
CN_V_Transfer Air Grille Supply	400x100 Duct		40,0 m^3/h		30,0 m^3/h
TRA - 3					

PICTURE 34. Revit screenshot: Schedule ‘Control – V_Air Terminals Transfer Air’

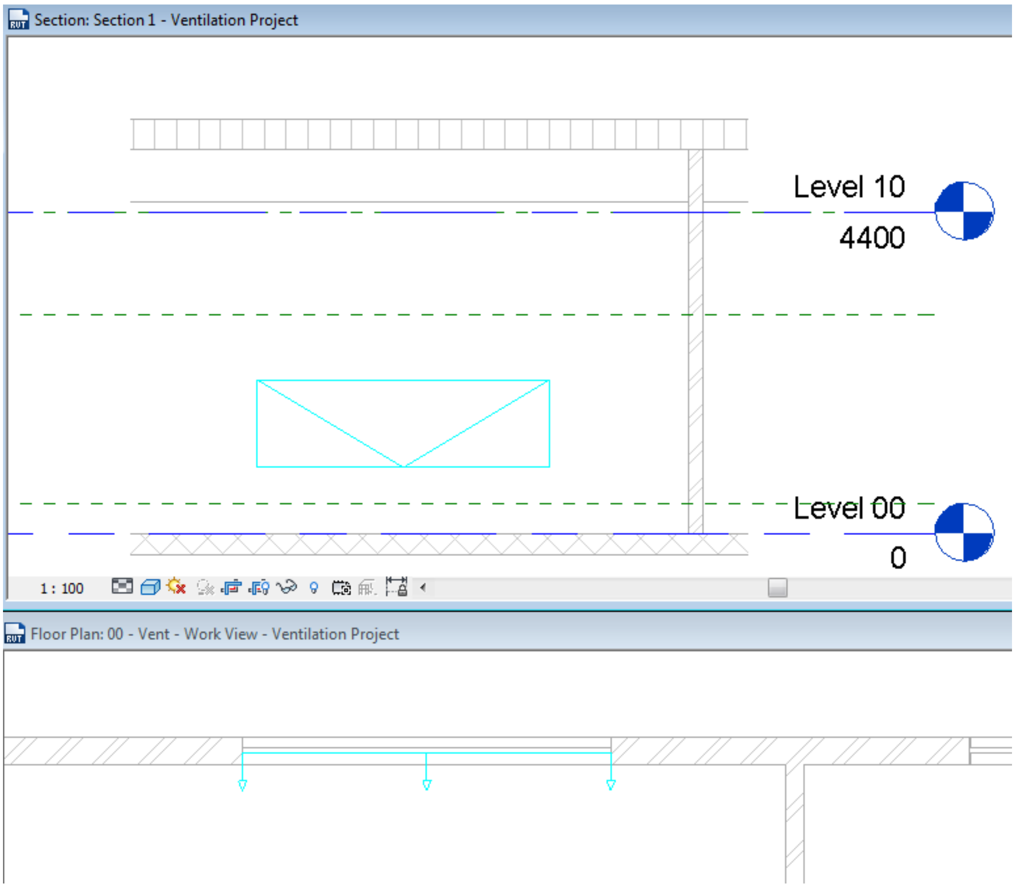
The Family ‘CN_V_Transfer Air Door Gap Extract – RP Transfer Air – Rectangular Duct’, has an additional parameter that calculates what the minimum door gap height should be (VEA & WTCB 2015, 6), given the door width, the air flow (maximum of day and night transfer air flow) and the pressure difference between the Spaces (2 or 10 Pa). Again, it is possible to quickly check the selected door gap height and compare this with the calculated value in the prepared Schedule ‘Control – V_Air Terminals Door Gap Height’. The parameter ‘CN_Door Gap Height’ of the Air Terminal is a Type parameter, which means that a new Family Type needs to be made with a different door gap height.

The annotation arrows indicating the flow direction in Floor Plan Views, can be switched on and off for the two Families representing a transfer air grille. Without flow arrow, entities of the other Families would become invisible in the project, because there is no 3D geometry. For this Families there is no option provided to switch of this annotation flow arrows. It is always possible to make the whole Family invisible with for example Visibility/Graphics settings or View Filters if necessary.

Air Terminals for freecooling supply air

This last type of Air Terminal Family, ‘CN_V_Freecooling Air Supply – Face Linked Window’, is made to represent the freecooling supply air flow that enters a Space via an outdoor Window. The proposed solution is to model normal Windows in the architecture model and place Air Terminals (face-based hosting method) without geometric representation (only 3D Model Lines representing the opening direction of the Window), connected to the Face of these Windows. The Air Terminal Family will give information about the air flow, while the Window Family contains the window 3D geometry.

Because this kind of Air Terminal has no Duct Connectors and thus no Ducts can (dis)connect, the Face-based hosting method is chosen. If the host, a Window element from the Linked architecture model, moves, the Air Terminal will move along. There is no possibility to transfer parameter values from the host to the hosted Air Terminal. The Window size can be entered manually in the corresponding parameters of the Air Terminal, but it is easier to set the correct dimensions in a Mechanical Section or Elevation View. The window size parameters in the Air Terminal are Instance parameters, which means that handles can be used to visually snap the dimensions of the Air Terminal unit to the sides of the Window from the Linked model (picture 35). When the size of the architecture Window is changed, this will not update the size values in the Air Terminal instance. Visual control in a 3D or Elevation Views will be needed to find the Air Terminals with different sizes than their host Window.



PICTURE 35. Revit screenshot: ‘CN_V_Freecooling Supply – Face Linked Window’ in Section and Floor Plan View

Because this Air Terminal has no Connector, it has no Duct System Classification. To make this Family better visible in Floor Plan Views, the View Filter 'Duct Systems – No Duct System Classification' is used to color the instances of this Family cyan.

When an Air Terminal is placed in the correct location and has the right size, a design value for the freecooling supply air flows in day- and nighttime can be given. It is possible to control quickly if the Window size is sufficient regarding a typical outdoor wind speed (standard 1 m/s) and a given air flow (maximum of the freecooling supply air flow in day- and nighttime) during the preliminary design phase. The Air Terminal Family calculates directly the maximum air flow it can bring into the Space given the current Window sizes (width, height and maximum opening angle) and wind speed. The definition of the opening area used in this calculation is given in the next schematic drawing (figure 8). In addition, the opening area definition needed by the contractor in a later phase is also given.

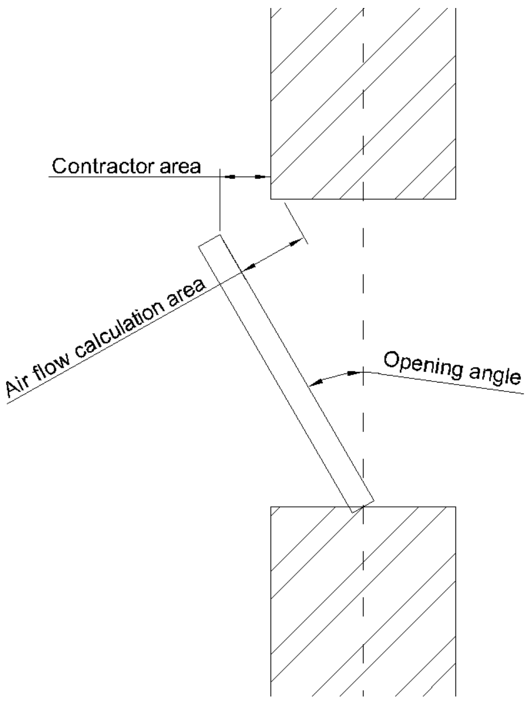


FIGURE 8. Window opening area (section) used in air flow calculation

In the Schedule 'Control – V_Air Terminals Freecooling' it is possible to get an overview of the situation. Air Terminals with Windows that are too small for the defined freecooling supply air flow, are flagged.

4.3.12 Air handling units [2.19n.0]

Introduction

When all Air Terminals are placed and every Space has enough actual air flow coming in and out, the air handling unit (AHU) can be placed in the AHU room. Three generic AHU Families (Category Mechanical Equipment) are made:

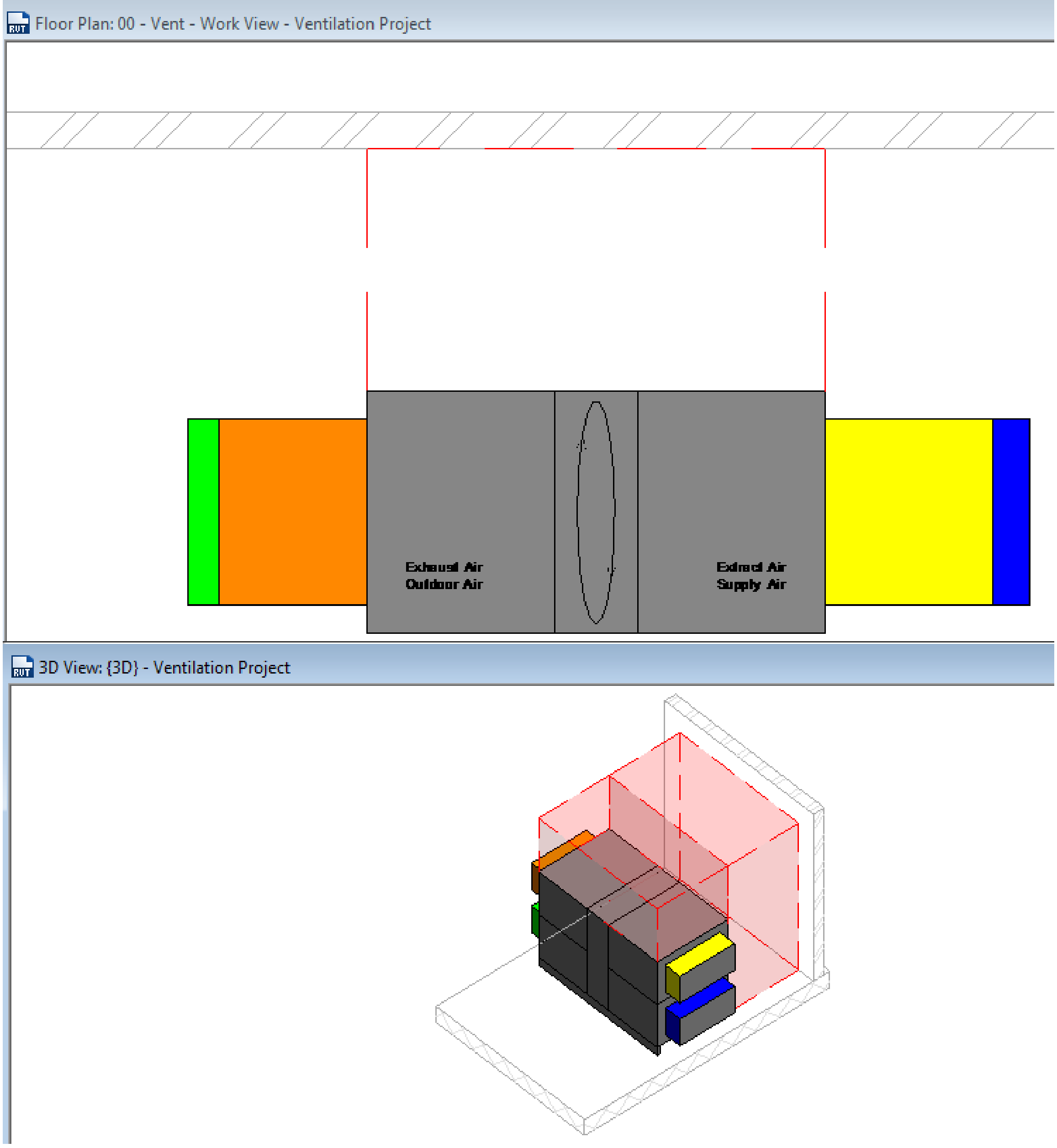
- 'CN_V_AHU – Indoor – Recuperator – Rectangular Duct'
- 'CN_V_AHU – Indoor – Thermal Wheel – Rectangular Duct'
- 'CN_V_AHU – Roof Extractor – Rectangular Duct'

The first two Families look very similar. They are separated in two different Families because the heat recovery system has an influence on the location of the Duct Connectors. They both have four Duct Connectors for the following Duct System Types: 'Supply Air', 'Extract Air', 'Outdoor Air' and 'Exhaust Air'. The last Family is typically used in projects where a lot of freecooling is used. It only has one Connector for the System Type 'Extract Air'. Because the exhaust grilles are assumed to be a part of this AHU, no extra Connector for the 'Exhaust Air' is placed.

All air handling unit Families are made with parametric dimensions. In the case of the indoor AHU's, every part around the central heat recovery system can be changed in length. The whole AHU height and width can be changed while these dimensions are linked to the Connector sizes. It is possible for the indoor AHU's to change between a concrete base or a skid mounted AHU. These Families are all generically placed in Floor Plan Views.

Clearance zones

An extra advantage of having an intelligent 3D model is the ability to create 3D clearance zones for maintenance that are visible in all different Views. With the built-in *Interference Check* command (see section 4.3.17 for more details), it is possible to list all interferences between the AHU (including its clearance zone) and any other element. Clearance zones are used for the indoor AHU's (picture 36), but this method can also be used in any other Air Terminal, Duct Accessory or Mechanical Equipment Family, if needed. The clearance zones left and/or right of the AHU are controllable with simple Yes/No Instance parameters. The horizontal offset of the clearance zone is the maximum of the AHU width and 1 m. The vertical offset can be changed via a Type parameter of the AHU.



PICTURE 36. Revit screenshot: air handling unit with connected Duct in Floor Plan View and 3D View

Air flows in the air handling units

The air flow data is brought to the AHU via the connected supply and extract Ducts. The AHU supply and extract Connectors read these values and write it to the corresponding parameters of the AHU. These AHU parameters are linked with the outdoor and exhaust Connectors, that will deliver the corresponding air flows to the Duct Systems of Duct System Type ‘Outdoor Air’, respectively ‘Exhaust Air’. The following scheme clarifies the flow of data between interior Air Terminals, AHU and exterior Air Terminals (figure 9).

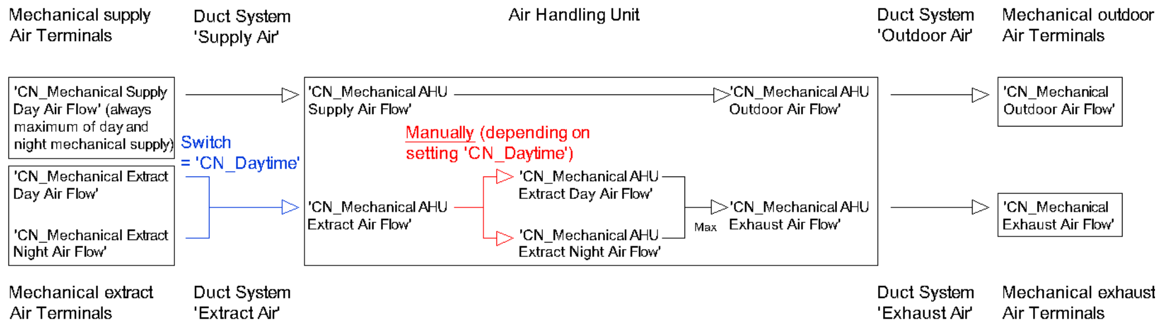


FIGURE 9. Air flows between interior Air Terminals, AHU and exterior Air Terminals

The air flow value coming from the supply Connector (‘CN_Mechanical AHU Supply Air Flow’) is always equal to the sum of the ‘CN_Mechanical Supply Day Air Flow’ parameter values of all supply Air Terminals that are connected to this Connector. This AHU parameter is then passed to the ‘CN_Mechanical AHU Outdoor Air Flow’ parameter that will be send it to the outdoor air Connector. The extract Connector delivers the sum of the air flows of the connected extract Air Terminals to the AHU parameter ‘CN_Mechanical AHU Extract Air Flow’. This last parameter value can change depending on the setting for ‘CN_Daytime’ of the extract Air Terminals. If this parameter is set to ‘Yes’, all Air Terminals will send their ‘CN_Mechanical Extract Day Air Flow’ data through the Duct System. If it is set to ‘No’, the ‘CN_Mechanical Extract Night Air Flow’ data will pass. The modeler should manually copy the incoming extract air flow from ‘CN_Mechanical AHU Extract Air Flow’ to ‘CN_Mechanical AHU Extract Day Air Flow’ or ‘CN_Mechanical AHU Extract Night Air Flow’ depending on the setting of ‘CN_Daytime’. The maximum of the last two parameters will be given to the exhaust Connector.

AHU settings

The name and/or number of the AHU should be entered in the Project parameter ‘CN_V_AHU Name’ of the AHU. In the earlier mentioned Schedule ‘Work – V_Duct Systems AHU Name’ (picture 37) it is possible to check if the correct Duct Systems are connected to the AHU. The Mechanical Equipment Schedule is an embedded Schedule in the Duct Systems Schedule.

<Work - V_Duct Systems AHU Name>		
A	B	C
Duct System: Type	Duct System: System Name	Duct System: CN_V_AHU Name
Family	System Name	AHU: CN_V_AHU Name
Exhaust Air	EHA - 2	AHU 01
CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	EHA - 2,ODA - 1,ETA - 2,SUP - 2	AHU 01
Extract Air	ETA - 2	AHU 01
CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	EHA - 2,ODA - 1,ETA - 2,SUP - 2	AHU 01
Outdoor Air	ODA - 1	AHU 01
CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	EHA - 2,ODA - 1,ETA - 2,SUP - 2	AHU 01
Supply Air	SUP - 2	AHU 01
CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	EHA - 2,ODA - 1,ETA - 2,SUP - 2	AHU 01
Extract Air	ETA - 1	AHU 02

PICTURE 37. Revit Schedule: 'Work – V_Duct Systems AHU Name'

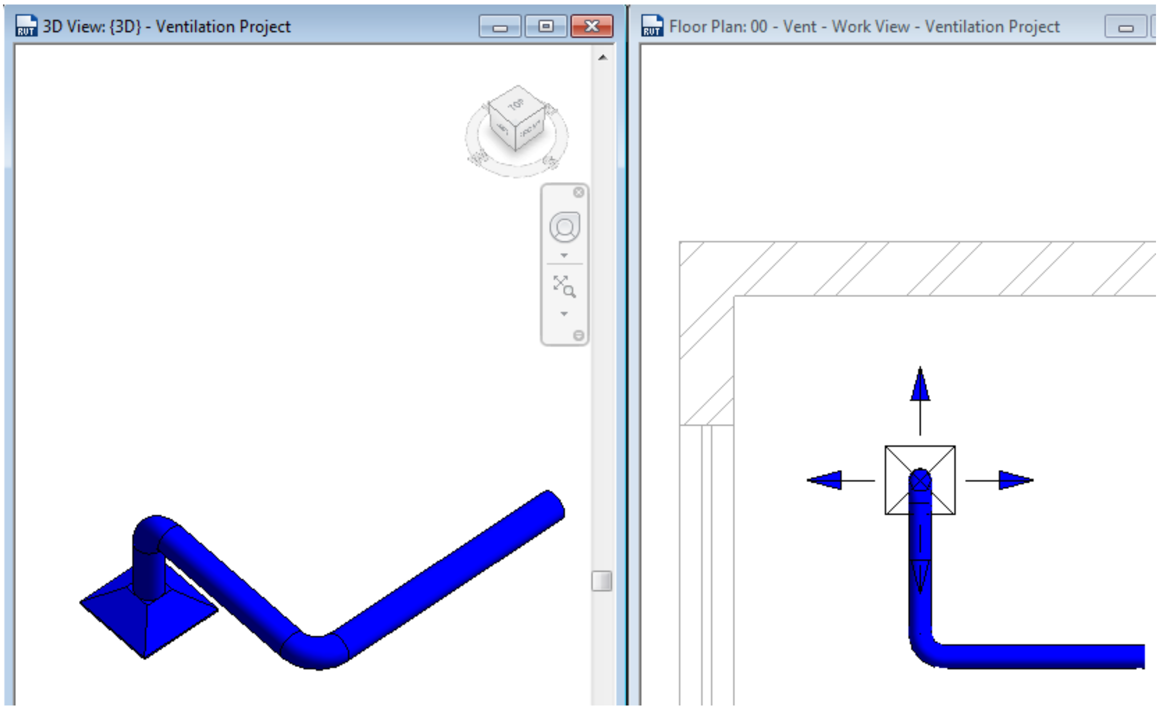
Depending on the project phase, it is possible to add extra information to the AHU, such as fan types ('CN_Supply Fan Type' and 'CN_Extract Fan Type'), calculated fan power ('CN_Supply Fan Power' and 'CN_Extract Fan Power'), filter type(s) ('CN_Filter Type'), heat recovery efficiency ('CN_Heat Recovery Efficiency') and if applicable heating and/or cooling battery types and power ('CN_Heating Battery Type', 'CN_Heating Battery Power', 'CN_Cooling Battery Type' and 'CN_Cooling Battery Power'). To make it easier to fill in this data, the Schedule 'Work – V_Mechanical Equipment AHU Settings' can be used. More parameters can be added via Family Editing of the AHU Families, if this would be needed.

4.3.13 Duct routing [2.20n.0]

Introduction

After the placement of the Air Terminals and the AHU's, the connection between these elements must be made by using Ducts (normal or Placeholder Ducts). Revit ductwork can be modeled manually or semi-automatically by using the *Generate Layout* and *Routing Solutions* tools. Both normal and Placeholder Ducts can be modeled with these methods. Normal Ducts are preferred if the end result will be a Duct model with 3D geometry; Placeholder Ducts can be converted to normal Ducts, but because of the lack of initial 3D geometry it will be difficult to do the transformation without having to reconnect a lot of Ducts.

Because the Ducts are modeled in 3D, it is a good idea to open at least a Floor Plan View for modeling and a 3D View for controlling the Duct route (picture 38). Section or Elevation Views can be used when Ducts with different elevation need to be modeled or connected.



PICTURE 38. Revit screenshot: controlling ductwork in 3D View and modeling ductwork in Floor Plan View

Model background information

It can be useful to display different model information in Floor Plan Views, such as the maximum air velocity in each Space, the location of fire compartments, bearing elements and thermal insulation compartments. The maximum air velocity per Space can be displayed with the Color Schemes 'Max Duct Air Velocity Day' and 'Max Duct Air Velocity Night'. The last three parameters regarding fire compartments, bearing elements and thermal insulation can be displayed by using the View Filters that were discussed in section 4.3.3.

Manual Duct routing

Ducts or Flex Ducts are typically started from the AHU or Air Terminal Connectors. It is also possible to start somewhere in between. In the last case, the Ducts are not connected automatically to the right Duct System.

Different Duct placement and modification tools are offered by Revit, such as *Automatically Connect*, *Justification*, *Inherit Elevation*, *Inherit Size*, etc. Ducts can be modeled horizontal, vertical or with a certain slope or sloping distance. A useful command is the *Trim/Extend to Corner* to connect two open ends of non-parallel Ducts.

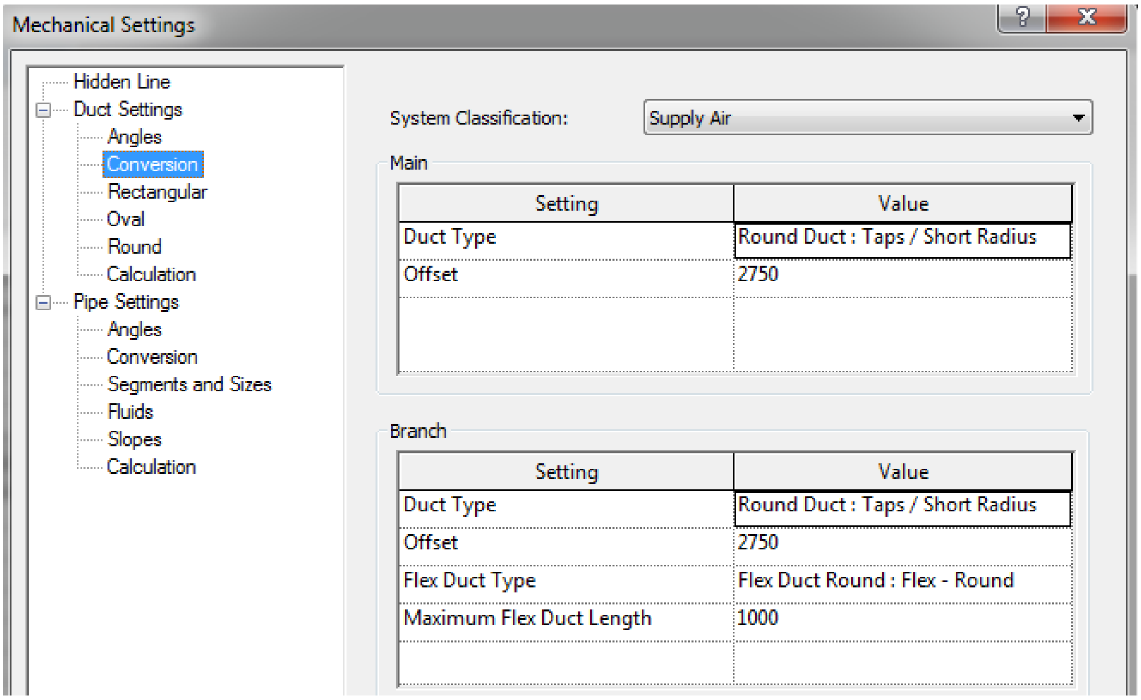
Duct Fittings are placed automatically when needed, according to the settings of the Duct Type Properties. It is possible to change a certain Duct Fitting (other Type or other Family) if the standard Fitting is not wished in a certain situation. Extra Fittings can be loaded from the out-of-the-box Revit library.

After modeling Duct elements, it is always possible to make some adjustments. If an Duct is moved to much, Revit will give an error where it gives you the option to delete the element(s) or to cancel your action. Adjustments can be made by moving a Duct in any View, or by changing parameter values of the Duct or Duct Fitting.

Semi-automatic Duct routing

Revit has two similar tools to model Ductwork semi-automatically. It asks some time before this modeling method is mastered and becomes useful (Autodesk 2016b). Unless the building project has a lot of similar rooms, manual Duct routing will be always faster. Most problems are related to different heights of the Connectors (e.g. the Air Terminal Connector is located too high in comparison with the Mechanical Equipment Connector and no route is found) and Duct Fittings that need to much space to be placed (e.g. bends with a large radius). In almost all cases manual adjustments will be needed to finish the Duct routing. To make good use of this tool, only small Duct runs should be modeled one at a time.

The *Generate Layout* tool can be activated by selecting one or more Air Terminals together with a Mechanical Equipment with an open Connector. They all need to be located in the same Duct System. The tool makes several proposals for the Duct run and the user can choose the one that suits his or her needs the most. It is still possible to change the Duct Conversion Settings (picture 39) used by the *Generate Layout* Tool, even when it is active. The modeler can make some changes to the selected proposal before the solution is finalized. Because of the distance between the AHU and most Air Terminals, another Mechanical Equipment Family from the out-of-the-box Revit library, such as ‘M_VAV Unit – Parallel Fan Powered’, can be used as a dummy while modeling the ductwork.



PICTURE 39. Revit screenshot: Duct Settings - Conversion

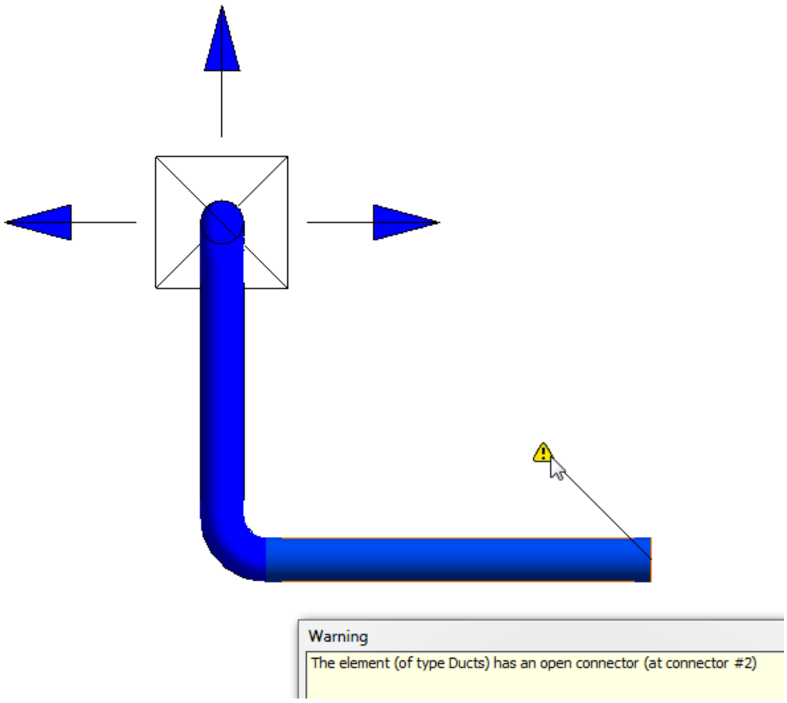
The second tool is called *Routing Solutions*. It can be used to connect two Ducts with open Connectors or to simplify/modify an existing Duct run. Again, Revit proposes several solutions and the modeler can select. With this tool, the modeler can only do some modifications to the proposed solution after closing tool-environment.

Duct insulation

Duct Insulation can be added easily after selecting a Duct run. First the prepared Duct Insulation Type (material) must be selected and then the thickness can be chosen. In the Schedule ‘Control – V_Ducts Duct Insulation’ it is possible to control if all Ducts are insulated. The Duct Insulation can be adjusted in later phases if necessary.

4.3.14 Controlling Duct Systems [2.21n.0]

When all Ducts between the Air Terminals and the AHU are modeled, the model can be checked for open Connectors. First, the System Browser can be used to find Unassigned objects (Air Terminals or Mechanical Equipment with Duct Connectors that are not part of a Duct System). If this is controlled, the *Show Disconnects* tool can be used to see if there are any open Duct Connectors (picture 40). The command *Check Duct Systems* can be used to control a specific Duct System. These last two tools should not be used during the modeling, because they can lower the overall performance of the program. Finally, the list with Warnings can be controlled to see if there are still parts of the model that need the attention of the modeler (*Review Warnings* tool).

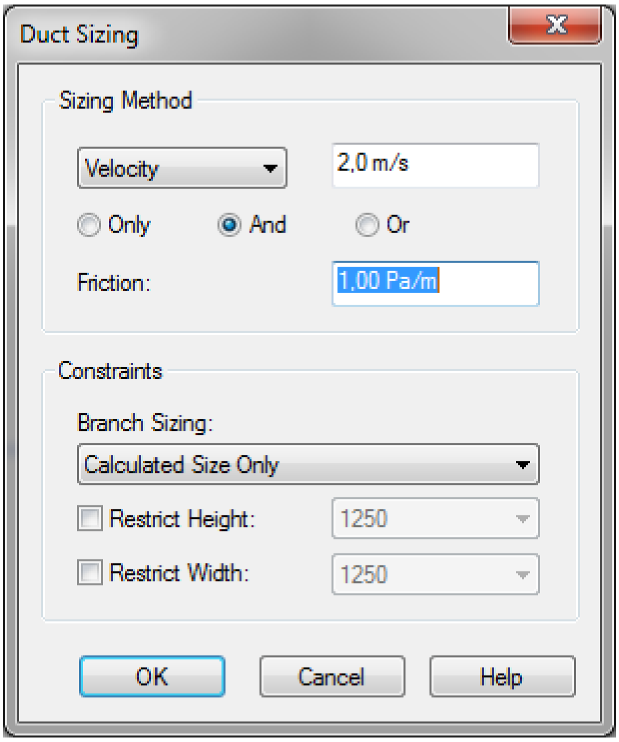


PICTURE 40. Revit screenshot: *Show Disconnects* tool

4.3.15 Duct sizing [2.22n.0]

Duct Sizing methods

Revit has a simple and easy to use built-in tool to size Ducts. A Duct run must be selected and then the *Duct Sizing* tool can be opened. It is possible to use different sizing methods, e.g. Equal Friction, Static Regain, Friction and Velocity (picture 41). The method used in this workflow restricts the Duct air speed together with the Duct linear pressure loss per meter (Friction). The Duct air speed limit changes from Space to Space and between day- and nighttime. The earlier mentioned Color Schemes ‘Max Duct Air Velocity Day’ and ‘Max Duct Air Velocity Night’ can be used to visualize these Duct air limits per Space in a Floor Plan View. The flow and linear pressure loss for each Duct is calculated automatically if the ‘Calculations’ parameter of the Duct System Type is set to ‘All’. It is possible to set this parameter to ‘None’ during the modeling of the Ducts to increase the overall performance of Revit. The results of the linear pressure loss per meter or ‘Friction’ parameter are based on the ‘Flow’ through the Duct, the ‘Roughness’ of the Duct Type and the Duct Settings (Air Dynamic Viscosity, Air Density and Calculation method). The ‘Friction’ parameter is typically restricted to 1 Pa/m for every Duct to minimize excessive energy losses.



PICTURE 41. Revit screenshot: *Duct Sizing* tool

It can be necessary to divide long a Duct in shorter Ducts (e.g. Tap Fittings do not divide a Duct in smaller parts, while Tee Fittings do), otherwise the whole Duct will have the same dimensioned size. If a Duct size should not be changed by the sizing tool, the Duct size can be locked by ticking the ‘Size Lock’ parameter of the Duct. This parameter will lock both the Duct Height and Duct Width in the case of a Rectangular Duct and the Duct Diameter in the case of a Round Duct. A noticed problem, is that when all Ducts around a Duct Fitting have a locked size, the Duct Fitting will still change according to the Duct sizing settings. It is better to set constraints directly in the Duct Sizing dialog window (picture 41). It is possible to set a maximum Duct Height and Duct

Width for Rectangular Ducts. The diameter of Round Ducts are constrained to the minimum of the restricted Height and Width. It is also possible for Ducts close to a Connector of an Air Terminal or Mechanical Equipment, to use the Duct Connector size or the maximum of this Connector size and the calculated size. These settings will apply for all selected Ducts, so it is a good idea to dimension Ducts of a Duct System in smaller parts, starting from the Air Terminals.

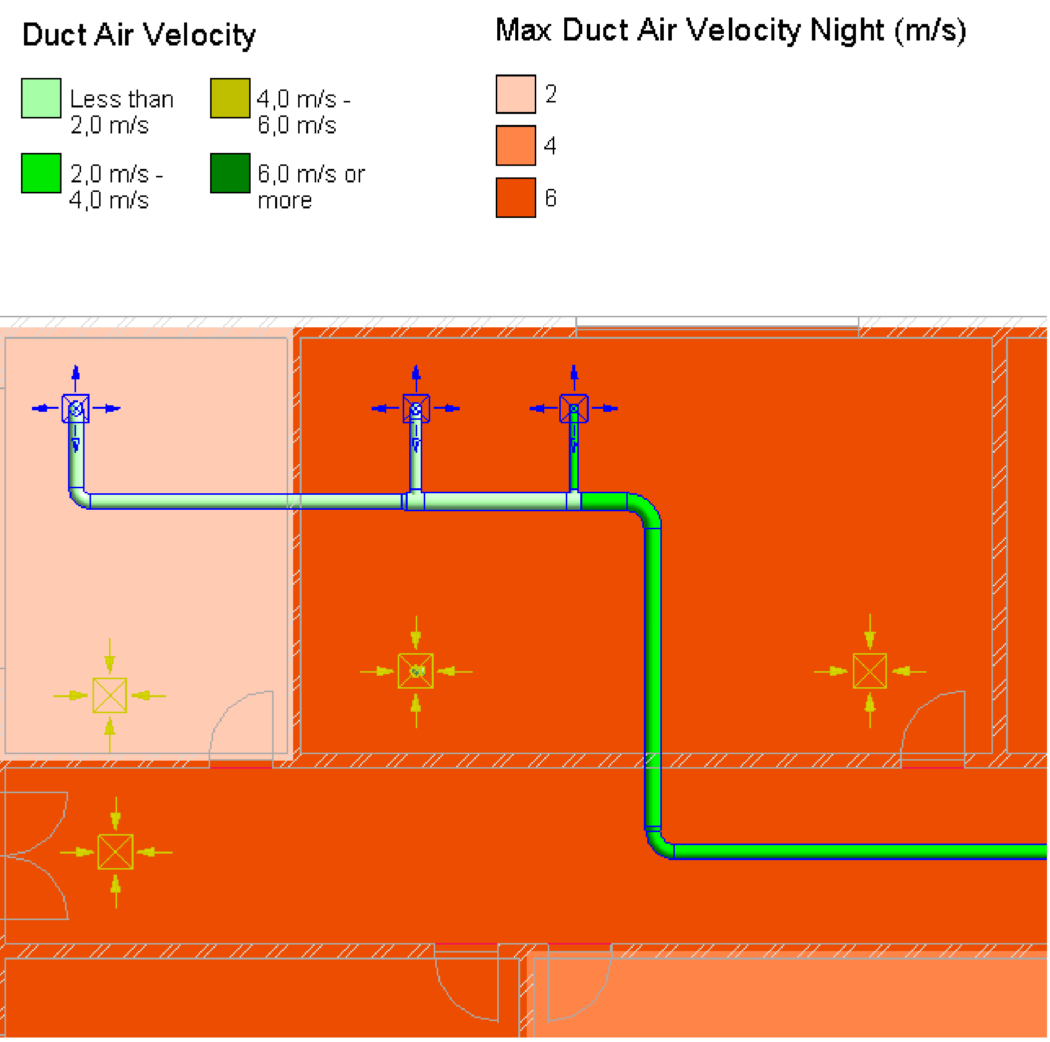
Duct dimensioning in day- and nighttime for extract Duct Systems

Because every extract Air Terminal has two different air flow values ('CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow') and the air flow during nighttime can be higher than the air flow during the daytime if freecooling with mechanical extraction is used, it is necessary to do the Duct Sizing of Duct Systems of the Type 'Extract Air' in two steps.

First, all Air Terminals will send their daytime extract air flow through the Duct Systems ('CN_Daytime' set to 'Yes' for all Air Terminals) and all the Ducts can be sized as described in the last section. In the second phase, the Air Terminals send the nighttime extract air flow through the Duct Systems ('CN_Daytime' set to 'No' for all Air Terminals). If the 'Extract Air' Duct Systems have their 'Calculations' parameter set to 'All', changing the air flows at the Air Terminals will update the flows, air velocity and linear pressure loss per meter for every Duct of that Duct System Type. The recommended workflow is to control the linear pressure loss per meter ('Friction' parameter of the Duct) via the Schedule 'Control – V_Ducts Friction And Velocity', where all Ducts per Duct System are listed. The Ducts with a linear pressure loss per meter higher than 1 Pa/m are flagged.

The air velocity is more difficult to control, because the its limits can change from Space to Space in nighttime if some Spaces are still occupied (e.g. dormitory rooms). If no Spaces in the project are occupied and there are no restrictions to the indoor ventilation noise, the air velocity in the Ducts may rise for example to 6 m/s. In the earlier mentioned Schedule 'Control – V_Ducts Friction And Velocity', Ducts with an air velocity higher than 6 m/s are flagged. If the building is still occupied in nighttime, it may be necessary to lower the air speed to minimize ventilation noise. The Space Color Scheme 'Max Duct Air Velocity Night' can be used in combination with the Duct Color Scheme 'Duct Air Velocity' to control horizontal Ducts in Floor Plan Views (picture

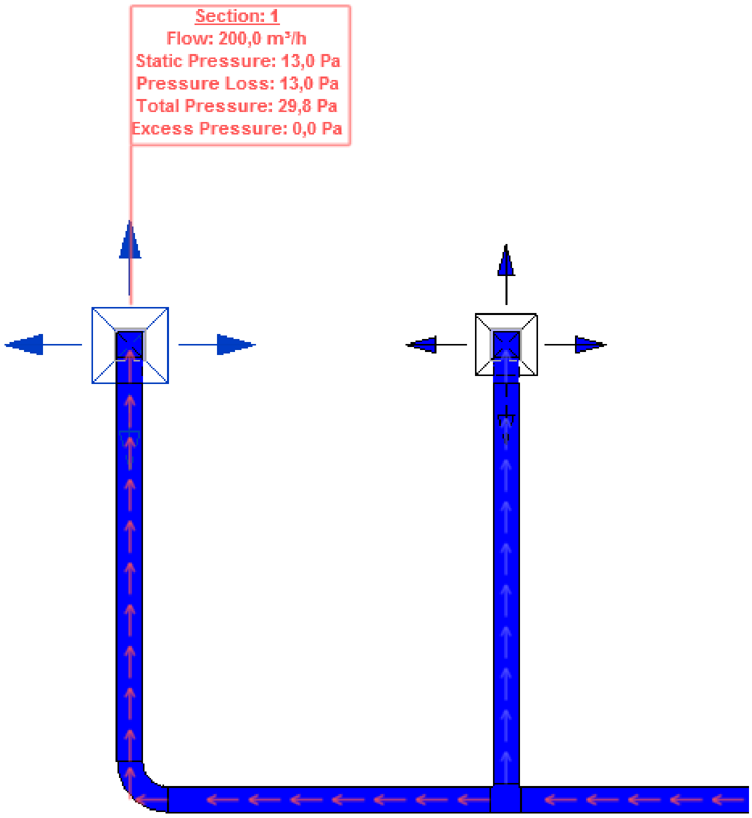
42). Duct Color Schemes cannot be used together with View Filters, so this method can only be used in Floor Plans without View Filters.



PICTURE 42. Revit screenshot: Duct Color Fill Scheme ‘Duct Air Velocity’ and Space Color Fill Scheme ‘Max Duct Air Velocity Night’

4.3.16 System Inspector [2.24n.0]

The built-in tool *System Inspector* can be used to temporary visualize the flow direction, the Flow, the Pressure Loss and Static Pressure of a Duct (picture 43). Before the tool can be used, the Duct System must be well connected and all local pressure losses must be entered in the elements where they occur (see also section 4.4.2). The critical duct path is marked with red arrows, while the others are marked with light colored arrows. The same tool can be used for Air Terminals, to control their Pressure Loss, Static Pressure, Flow, Total Pressure Loss of the path and Excess Pressure. If the local pressure losses are not defined or not correctly entered, the pressure related values will be very big, to signal that some values are not correctly entered.

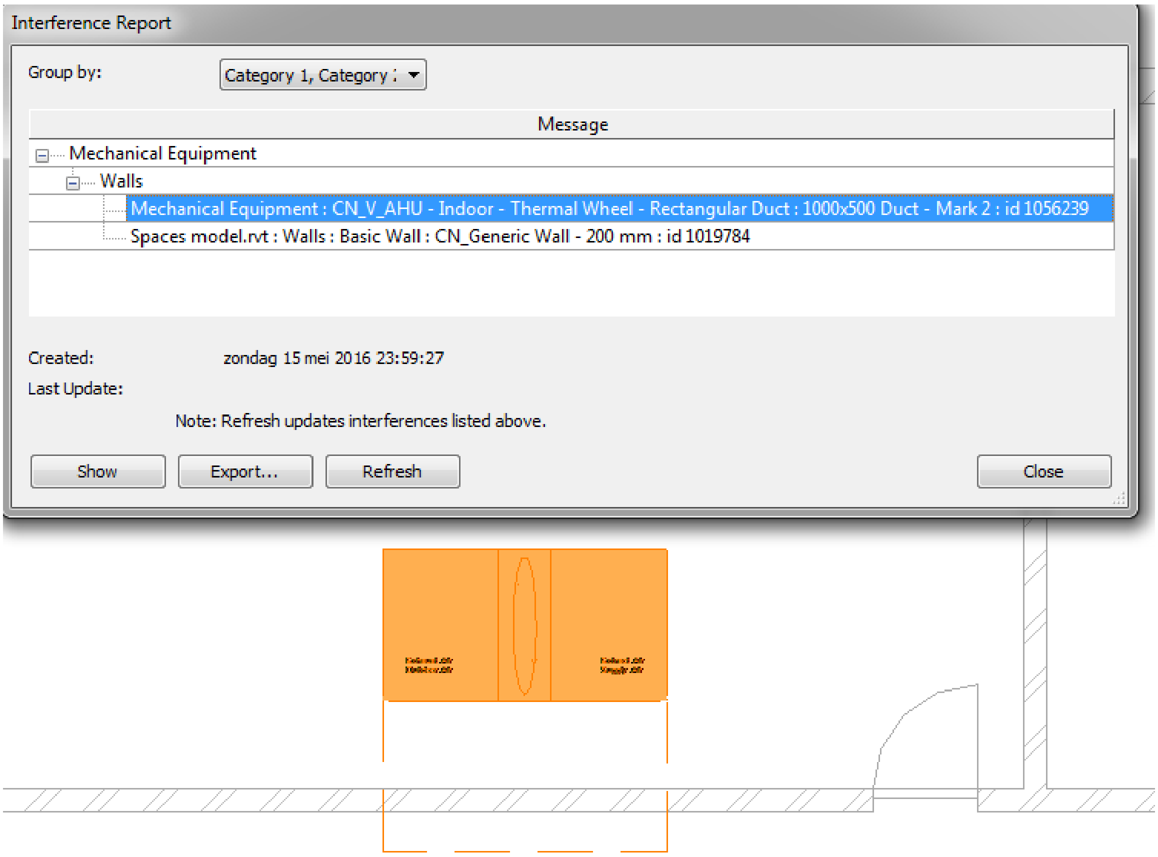


PICTURE 43. Revit screenshot: *System Inspector* tool

4.3.17 Interference Check [2.25n.0]

It is possible to perform an Interference Check between all sorts of elements from the ventilation model, but also with elements from the Linked model. Typical examples are Interference Checks between Structural elements from the Linked architecture model and any ventilation related element (Ducts, Duct Accessory, Duct Fittings, Duct Insulation, Mechanical Equipment, etc.). It can also be useful to check if these elements interfere with Floors, Roofs, Ceilings or Walls. Finally, it is also possible to simply check for interferences between different Ducts, Duct Insulation, Air Terminals and Mechanical Equipment.

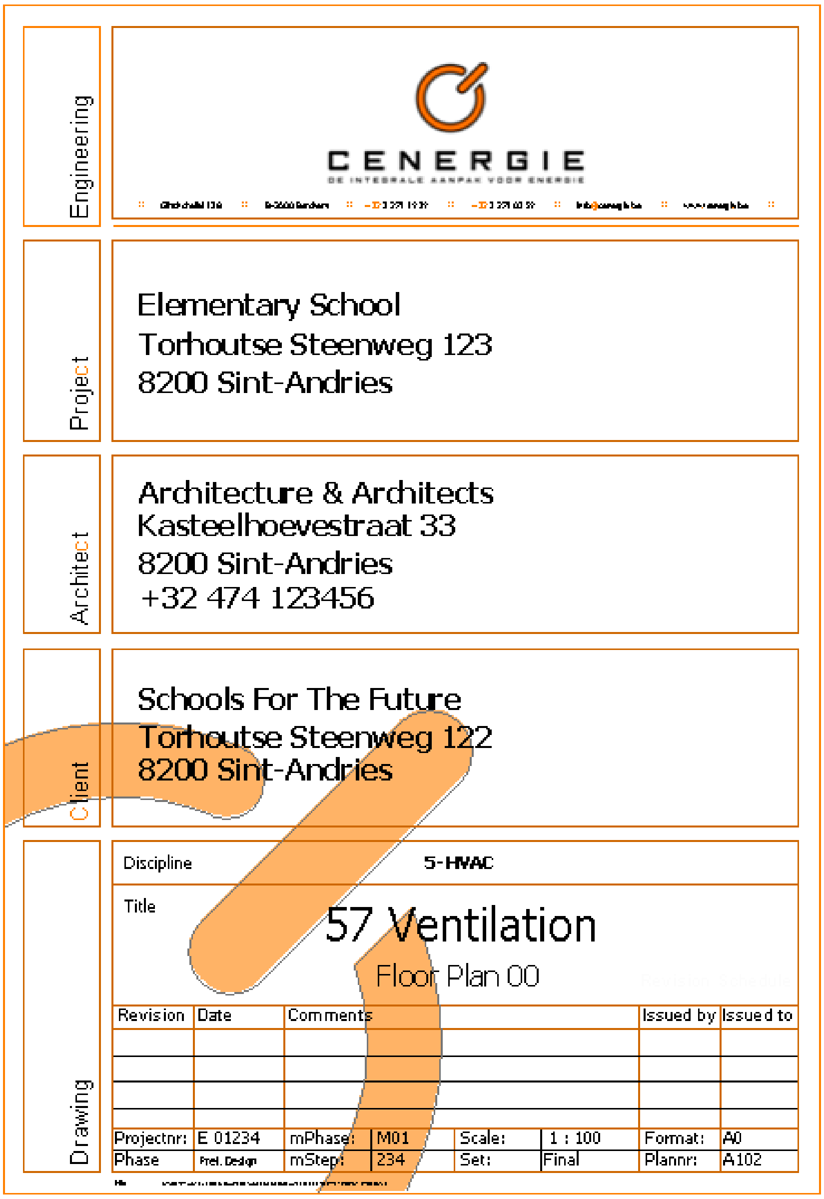
In the following example, an Interference Check between a Wall from the Linked architecture model and the AHU from the ventilation model is executed (picture 44). Because the clearance zone of the AHU is partial located in and trough the Wall, Revit produces an Interference Report with information about the two intersecting elements (picture 44). If necessary, Revit can show the flagged elements in different Views.



PICTURE 44. Revit screenshot: Interference Report

4.3.18 Ventilation plan documents [2.7a.0]

When the preliminary design is ready, it is possible to print or export 2D '.pdf' plan documents by using the prepared Sheets in the Project Browser. Two Sheets with paper format A0 and A1 are made and can be used directly. If extra Sheets would be needed, the existing Sheets can be duplicated. First the Sheet Name, Number and Issue Date must be set. Additionally, names of the approver, designer, checker and author can be added together with the issue date, to the Properties of a Sheet. When this is filled in, the Views can be added to the Sheet. The loaded Titleblock (picture 45) on each Sheet is dynamically connected to the Project Information (see section 4.3.6), Sheet, View and Revision parameters. A certain View can only be placed on one Sheet.



PICTURE 45. Revit screenshot: ‘CN_Titleblock A0 metric’ placed on Sheet

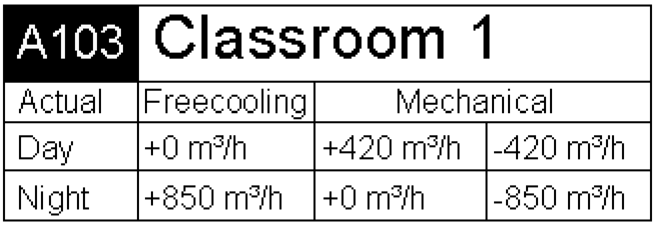
If necessary, the Views that will appear on the Sheets can be annotated with elements such as text, Detail Lines, Symbols, Dimensions, Color Fill Legends, Tags and Revision Clouds. Tags can display all Shared and most built-in parameter values of an element. They are saved as loadable Families of the Category Annotation Symbols and can be loaded whenever needed. To assist in this workflow, the following Tag Families and Types are made in addition to the out-of-the-box Revit Tags:

- ‘CN_Air Terminal Tag’:
  - ‘System’

- ‘System - Mechanical Supply Air Flow’
- ‘System - Mechanical Extract Air Flow’
- ‘System - Mechanical Outdoor Air Flow’
- ‘System - Mechanical Exhaust Air Flow’
- ‘Freecooling Supply Air flow’

- ‘CN_Duct Tag’
- ‘CN_Revision Cloud Tag’
    - ‘Revision Number’
    - ‘Revision Number – Comments’
- ‘CN_Space Tag’:
    - ‘Number – Name’
    - ‘Number – Name – Actual Air Flow Day’
    - ‘Number – Name – Actual Air Flow Night’
    - ‘Number – Name – Actual Air Flow Day & Night’ (picture 46)

Additional Tag Families and Types can be made for these and other Categories if necessary. The Family names of the Air Terminals, Duct Accessory and the Mechanical Equipment (AHU’s) designed for this workflow are very long. They are not placed in the Tags to keep the Views clear. It is easier for Ducts to display Air flow, Duct System, duct air velocity and linear pressure loss per meter information via Color Schemes instead of Tags. For Duct sizes, the ‘CN_Duct Tag’ can be used.



A103	Classroom 1		
Actual	Freecooling	Mechanical	
Day	+0 m³/h	+420 m³/h	-420 m³/h
Night	+850 m³/h	+0 m³/h	-850 m³/h

PICTURE 46. Revit screenshot: ‘CN_Space Tag’ – ‘Number – Name – Actual Air Flow Day & Night’

Component Legend Views can be made, but they are not dynamically linked to a certain View or Sheet; it is a simple, static list of Revit Family elements and annotation elements. This means that it can contain legend symbols of elements that are not even used in the Project. On the other hand, it is possible that some used elements are not added to this list. Extra Families that are loaded in the project, must be added manually to this list. In Legend Views, Revit Families and Types can be displayed in some but not all view directions, depending on the Family. Another problem is that the graphical display of building elements can differ a lot between Views by settings in the Visibility

Graphics, Visual Style, Detail Level, Object Styles, View Filters, View Scale, View Discipline, etc. While waiting for Autodesk® to improve this Legend feature, Dynamo can be used to make a tool for generating project or even View-specific Legends. Developing such a tool is considered beyond the scope of this research.

Revision Clouds can be added to Views, to mark parts of the design that need the attention of the modeler or another building partner (e.g. the architect). When they are placed and information about the problem(s) is given in the 'Comment' parameter , it is possible to group them under a certain Revision. Information about a Revision can be added in the Sheet Issues/Revisions dialog. The Revision groups that contain Revision Clouds that are placed on the Sheet or the Views it contains, will be visible in the Titleblock of that Sheet. If a Revision is marked as 'Issued' in the Sheet Issues/Revisions dialog, it will be impossible to make new Revision Clouds for this Revision or modify existing Revision Clouds and Revision information.

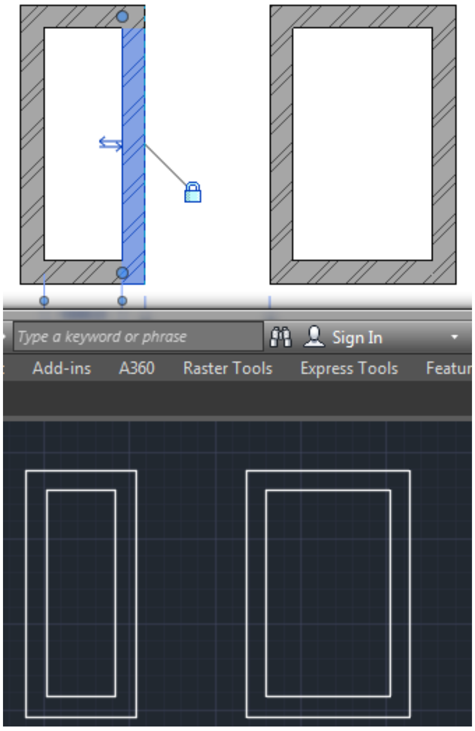
Annotation objects can be added to specific Views but also to Sheets containing a certain View. In the last case, the annotations are only visible on the Sheet and not in the View. To avoid duplication of annotations, it is advisable to only add annotations in the specific Views. This is possible by double clicking the View placed on a Sheet or by navigating via the Project Browser to the specific View.

4.3.19 Architecture model update [2.26n.0]

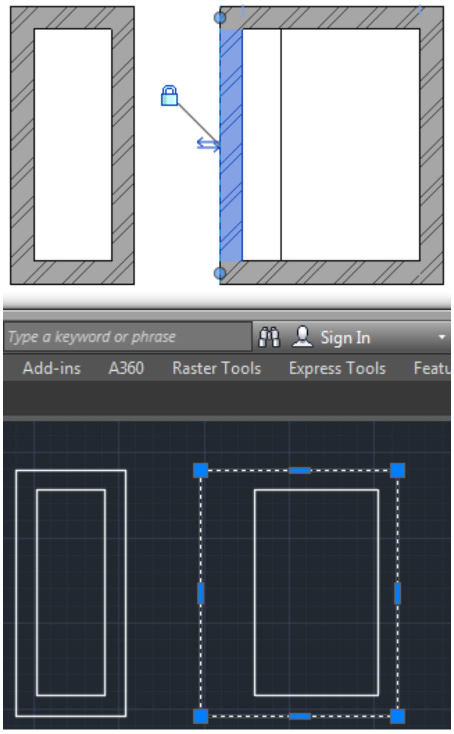
For most building projects, it is completely normal that the architecture design changes throughout the preliminary design phase. On several moments during the design process, CENERGIE can be asked by the architect to make a new ventilation design based on the changed architecture design. Different methods that should make this updating phase more efficient, are investigated. In a first step, the architecture BIM model needs to be updated starting from new '.dwg' drawings from the architect. In the next phase, the ventilation BIM model should be updated starting from the new architecture model.

Method 1: Constraints between Linked '.dwg' files and architecture BIM objects
In the ideal case the architecture BIM model updates directly according to changes made to the '.dwg' underlay plan documents of the architect. It is possible to model for

example Walls in Revit and make a so-called Alignment Constraint or locked dimension between the Revit Wall and a line from the Linked ‘.dwg’ file. When this line is moved in the ’.dwg’, the connected Revit wall moves along. In the next two screenshots this principle is described (picture 47 and 48). A simple ‘.dwg’ plan is made in AutoCAD: the walls from the left building are drawn with Lines, while the walls from the right building are made with Polylines. The ‘.dwg’ is loaded into the architecture Revit model and Walls are modeled over the underlay lines. The Walls and underlay lines are locked in Revit.

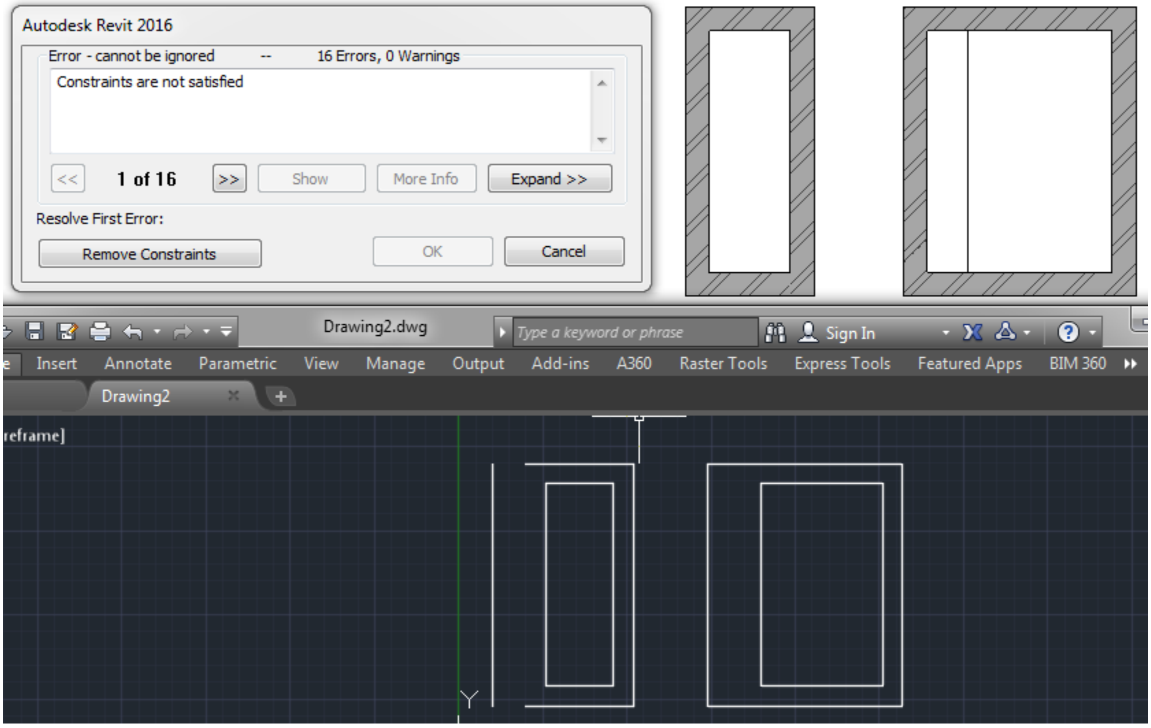


PICTURE 47. Revit and AutoCAD screenshot: locked ‘.dwg’ underlay and Revit Walls



PICTURE 48. Revit and AutoCAD screenshot: moved Polyline in AutoCAD and Wall update in Revit

If one '.dwg' Polyline is removed or even trimmed, the connection between all constrained Revit elements and the corresponding CAD-lines is deleted. This also happens when a normal '.dwg' Line is moved (picture 49). If the architect moves the other line representing the other face of the wall, nothing will update in the Revit model because there is no Alignment Constraint between the Revit wall and this other line. We can conclude that this first method does not improve the efficiency of the updating phase.



PICTURE 49. Revit and AutoCAD screenshot: moved Line in AutoCAD and Error in Revit

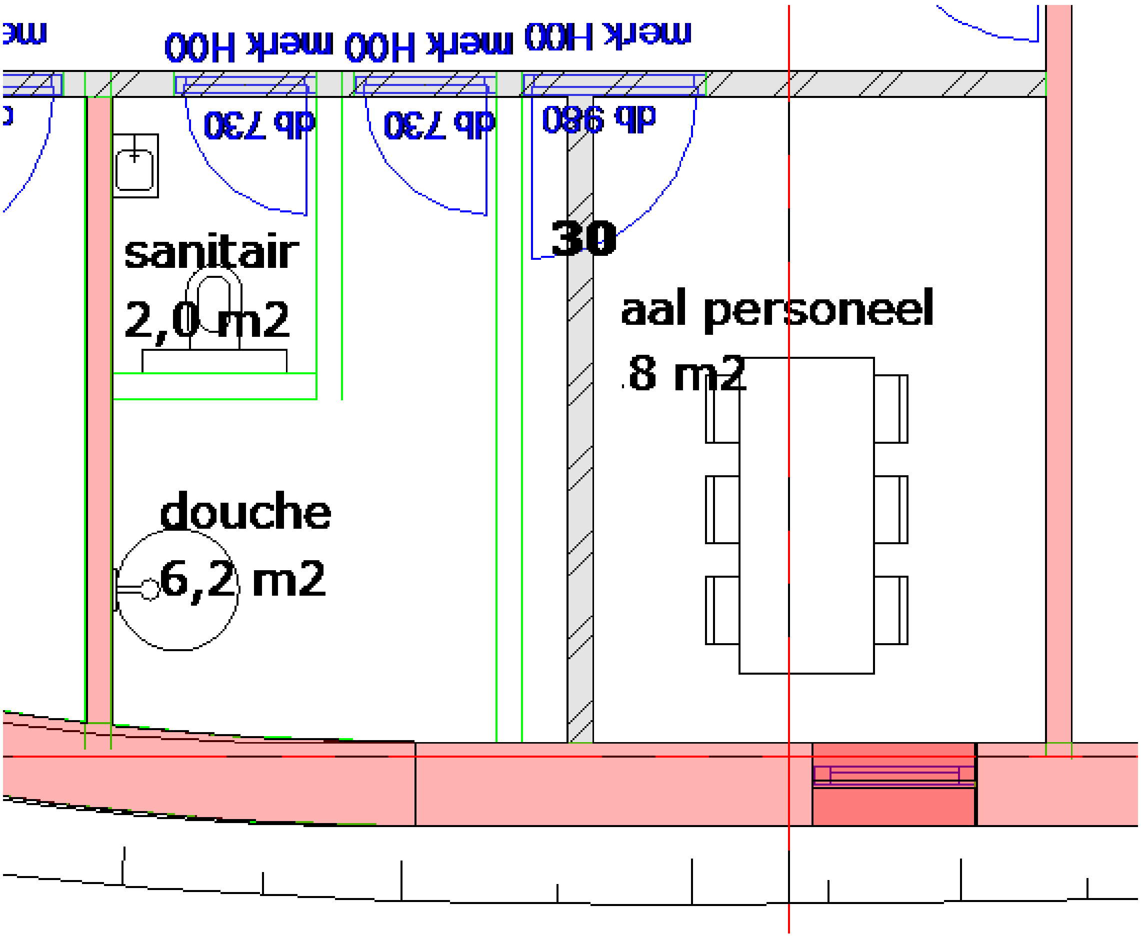
Method 2: Changing Revit visibility options

Because no real efficiency improvements resulted from the first described method, another workflow is investigated. The best results were found by simply using the big range of Revit visibility options to make the differences clear between the reloaded CAD underlay and the architecture BIM model objects.

First, all Linked CAD files are replaced (Reloaded) with the corresponding new architecture '.dwg' drawings. In an Elevation or Section view, where all Revit architecture elements are made invisible except the Levels and the Grids, the location of the Revit Levels should be compared with the levels from the '.dwg' section or elevation drawings. In the prepared Revit templates, the Grid Family Types have their Grid line color changed from black to red. Levels are already visible enough with the standard settings (blue lines). In Plan and Section Views, the location of the building Grids should be controlled and adjusted if needed.

All Revit elements (Grids, Levels, Walls, etc.) can have a lot of visibility changes, while the CAD underlay can only be colored per '.dwg' file or per CAD layer of one '.dwg'. If good agreements are made, the architect will make his or her drawings in a consistent way, by placing for example all wall lines on the same layer. These wall lines can get a visual override in Revit with a bright color, to make them better visible in Views. The Revit architecture (Walls, Floors, Roofs, Ceilings, Generic Models (elevator), Stairs, Doors and Windows) and structural elements (beams and columns) also need adapted visibility settings; it is recommended to set the Floor Plan View to the Shaded Visual Style, while at the same moments the architecture and structure elements Visibility/Graphics Override settings are set with a certain transparency. Both the Revit and CAD elements are now clearly visible and the remodeling can be done. While comparing the original architecture BIM model with the new '.dwg' drawings, it can be necessary to hide Revit Wall elements temporarily, to control if there is still a CAD line under the element. If Revit elements are modeled exactly above the CAD lines, the last ones can become invisible. While remodeling the Revit Walls, the Windows and Doors can be made temporarily invisible. All these View related settings are saved in prepared Views of the Sub-Category 'Filter – Updated Architecture Elements'.

When a Revit architecture or structure element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Model (elevator), Stairs, Structural Column or Structural Framing (beam)) is in the correct place, it can be marked with the Shared Project parameter 'CN_Updated Architecture Element'. If it is ticked ('Yes') the View Filter 'Updated Architecture Element' will mark the object with a red fill. If the elements would already be flagged as updated from the last update, it is possible to reset this parameter for all elements via the Schedule 'Work – Multicategory – Reset 'CN_Updated Architecture Element''. In the following screenshot (picture 50) of a Floor Plan View of the Sub-Category 'Filter – Updated Architecture Elements', a '.dwg' underlay is visible (green, black and blue lines) together with updated (red color fill) and non-updated (grey with pattern) Revit Wall and Window elements.



PICTURE 50. Revit screenshot: '.dwg' underlay and Revit architecture elements – updated and non-updated

When the Floor Plans are updated (horizontal location and dimensions of Revit elements) the vertical situation of the Windows and Doors can be controlled in Section and/or Elevation Views. Similar View settings, as mentioned for Floor Plans, can be used here.

The additional parameters related to fire resistance, thermal insulation and structural function of the Walls, Floors and Roofs can be controlled and changed if necessary. It is also necessary to control the 'Room Bounding' parameter of the Walls, Roofs, Ceilings and Floors.

4.3.20 Ventilation model update [2.27n.0]

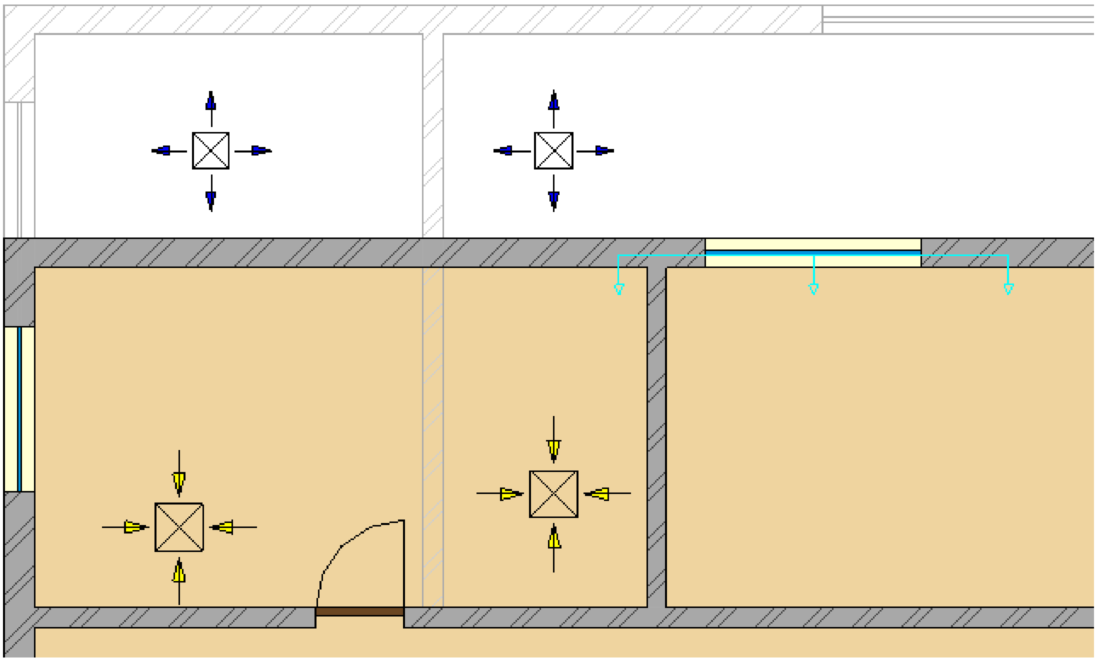
The updated architecture model is used to update the ventilation model accordingly. Depending on the situation, it can be difficult to keep track of all ventilation elements and their location. The simplest updates, where no Levels are changed, are probably the most frequent ones and will be discussed first. If Levels change, adapted methods and controls will be needed. These methods will be discussed in the second part of this section.

Unchanged architecture Levels

If no architecture Levels change, no Levels of the ventilation model will change. This paragraph discusses a solution for the situation where only changes to the horizontal location, size, orientation and/or attached parameters of the architecture elements are made.

It is possible to just reload the old architecture model with the new one, but doing so can produce inaccurate data. An Air Terminal that was located in one Space (bounding elements of the old architecture model), can now be located in another Space (bounding elements of the new architecture model) because the separating Wall was moved. Except the Air Terminals for freecooling air, all Air Terminal and Mechanic Equipment Families are generic or Face-based hosted on Reference Planes (constraint between the Reference Plane and the Level below) and only adjust their vertical coordinate when the Level in the ventilation model moves. The 'CN_V_Freecooling Air Supply – Face Linked Window' will move together with its host Window Face and in any direction (horizontal, vertical and/or rotational). If the Window is removed in the new architecture model, the Air Terminal for freecooling will become Unassociated. These Families can be found easily, if the 'CN_V_Face' parameter is used to filter in the Schedule 'Control – V_Air Terminals Location' after the Dynamo graph 'Tool – Air Terminals Location.dyn' is used to populate these parameters (see section 4.3.11 and appendix 12).

A better method, is to replace the old with the new architecture model (Reload From), and to load the old model again separately. Both models should have their Type parameter 'Room Bounding' switched off initially. When both architecture models (old and new) are in the same ventilation model, it is very easy to switch between them. The old model can be set to ‘Underlay’ via the Visibility/Graphics settings of the Linked model (picture 51).



PICTURE 51. Revit screenshot: old (underlay) and new loaded (shaded) architecture model

First, all Space Separation Lines need to be controlled and modified if necessary. If the ‘Room Bounding’ parameter of the new architecture model is switched on, all existing Spaces will adapt automatically to the new situation. Some extra Spaces should be created, while some existing Spaces will be moved or deleted. Information (name, number and location) of the old and/or new rooms designed by the architect can be visualized by changing the visibility settings of the old and/or new architecture model; it is still possible to change the visibility of the CAD underlays of both models that contain textual information from the architect about the rooms. When the Space parameters are controlled, the calculation of the necessary air flows with Dynamo and Excel can be executed again, as described in chapter 4.3.8.

When all existing Air Terminals are moved manually to the correct Space, it is possible to simply check the actual air flows per Space again in the Schedule ‘Work – V_Spaces Actual Air Flows – Not Checked’. All Spaces that were checked before the update, still have their ‘CN_V_Controlled Actual Air Flow’ parameter to ‘Yes’. To switch them all at once back to ‘No’, the Schedule ‘Work – V_Spaces Actual Air Flows – Switch All’ can be used. The values of the actual air flows at the Air Terminals can be modified and new Air Terminals can be placed in Floor Plans.

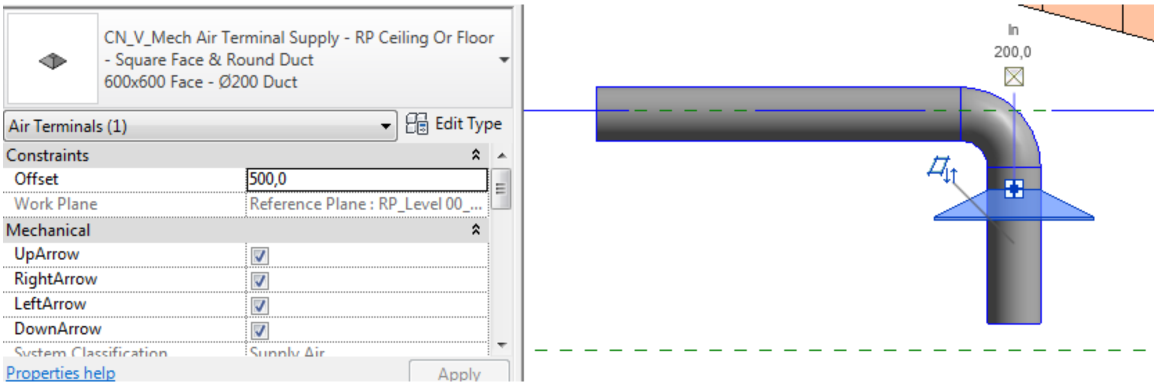
After this part of the update is finished, the location of (horizontal) duct routes will probably need some attention of the modeler. The size of some Ducts may have become too big or small in relation with the changed air flows. The same methods can be used to size them as described in section 4.3.15. If only small changes are made to the ventilation model, it may be enough to control the duct air velocity and linear pressure loss per meter with Schedules, Color Fill Schemes and/or View Filters.

In the last phase, it may be necessary to control the location of the used annotations, such as Tags, text, dimensions, etc. in the Views that will be printed.

Changed architecture Levels

When the Levels in the architecture model are changed, it will influence the Levels from the ventilation model.

When the old architecture model is reloaded with the new one, a Coordination Monitor alert will appear as a Warning. This happens because the Levels of the first version of the ventilation model, based on the initial architecture model, were set to Monitor the Levels of the architecture model (see section 4.3.5). Via the Coordination Review dialog it is possible to select one of the following actions: ‘Postpone’, ‘Reject’, ‘Accept Difference’ or ‘Move Level ‘LevelName’’. If the last action is chosen, the monitored Levels of the ventilation model will move to the location of the Levels of the new architecture model. When a ventilation Level is moved, the corresponding Air Terminals will remain at the same height relative to the Level, because the Reference Planes all have a dimension constraint towards the Level below. When this method is used, a strange bug is noticed: the Air Terminals remain hosted to the same Reference Planes and connected to the ductwork, but they get a random Offset from this Reference Plane (picture 52). When moving the Ducts or the Air Terminals just one step in any horizontal direction, the Offset goes back to zero. The easiest method to solve this problem, is to select all Air Terminals or Ducts in a 3D View and move them one step back and forth using the keyboard arrows. This workaround does not always solve this problem for all Air Terminals. It is advisable to control the ‘Offset’ parameter of all Air Terminals. This parameter is not Schedulable, so the same Dynamo tool from section 4.3.11, 'Tool – Air Terminals Location', can be used to automatically copy this parameter value to the custom-made Project parameter 'CN_V_Offset From Face Or Level'. In Schedule 'Control – V_Air Terminals Location' the copied values can be controlled.



PICTURE 52. Revit screenshot: Air Terminal with random 'Offset' from its Reference Plane after updating the Levels of the ventilation model

Some Ductwork and other ventilation elements can now be located in the above Space. The dimensions of the Reference Planes that host the Air Terminals can now be unlocked again, to move the Reference Planes to a new height if needed.

The height of the different Ducts must be changed manually, which can take some time. Most ductwork will try to remain connected to the Air Terminals and AHU's, but sometimes a connection is broken. With the earlier described built-in Revit tools such as *Show Disconnects* and *Check Duct Systems* (section 4.3.14), it is very easy to spot the parts of the ductwork that need the attention of the modeler. A last visual control of the complete ductwork in 3D is recommended.

4.4 Design [3.0.0]

During the design phase, roughly the same steps are performed as during the preliminary design. The architecture design is now getting finalized and the final ventilation design must be made. The main differences between both phases will be explained in this section.

4.4.1 Duct Accessory [3.19n.0]

When the location of all Air Terminals, AHU's and Ducts is known, it is very easy to add so-called Duct Accessory Families representing silencers, control valves, fire dampers, heating and/or cooling coils, sensors, duct fans, cleaning covers, etc. During this research, no custom Duct Accessory Families are made, because the out-of-the-box Revit library contains already several useful Families.

Duct Accessory elements can be placed directly on an existing Duct, without having to connect them manually. The size of these elements adapts automatically to the size the Duct. If the Ducts would be sized using the built-in Revit tool, the size of the Duct Accessory element will change too. If the Ducts at both sides of the element are manually changed however, the element will not change its size automatically.

4.4.2 Duct Pressure Loss Report [3.25n.0]

Revit has a built-in tool to calculate the pressure losses (local and linear) of all sections of a Duct System. The tool generates a Duct Pressure Loss Report in '.html' format for every selected Duct System. Besides the critical path, it also summarizes which calculation values were used during the process. With this information, it is possible for an engineer to select an appropriate fan unit. The fan information (fan type and fan power) can be added to the corresponding AHU parameters (see section 4.3.12).

Local pressure loss

The local pressure losses of all Air Terminals that can connect to a Duct System are stored in the Type parameter 'CN_Local Pressure Loss'. Two local pressure loss Instance parameters are defined for the indoor AHU's: one for the Supply/Outdoor Air ('CN_Local Pressure Loss AHU Supply') and one for the Extract/Exhaust Air ('CN_Local Pressure Loss AHU Extract') Duct Systems.

All these specific values are Type parameters and are by default set to zero. If a certain fixed local pressure loss value is used by the building system engineering firm, they can add this values to the different Types of the Air Terminal and AHU Families.

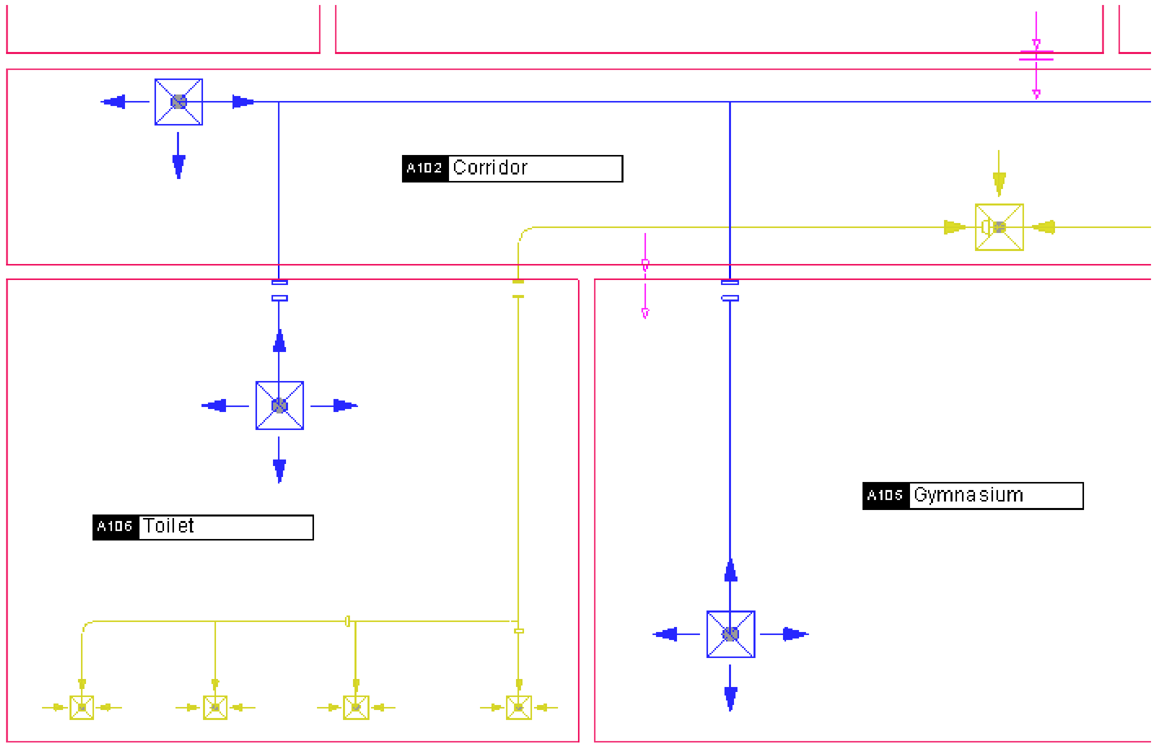
The Duct Accessory and Duct Fittings Families from the Revit library typically have Instance parameters to control the pressure loss calculation. It is possible to enter a fixed value for the total local pressure loss over the element, but it is also possible to let Revit do the calculation of the local pressure loss depending on coefficients of ASHRAE tables, the air flow and the Duct size. It is also possible for third party software developers to make their own Pressure Loss Method, that can be used in Revit for calculating the local pressure losses (Autodesk 2015d).

Linear pressure loss

The linear pressure losses for straight Ducts are calculated according to the Duct Settings under Mechanical Settings (see chapter 4.3.10). The calculated pressure drop depends on the air flow, the Duct size, the air density, the air viscosity and the Duct material roughness.

4.4.3 Ventilation control diagrams [3.8a.0]

There is no built-in tool to quickly generate a ventilation control diagram. It is possible to draw this manually with Revit or a CAD software package, but there will be no direct link between the drawing and the ventilation model. A better solution may be to make a simplified Floor Plan for every floor. If the Detail Level of the View is set to ‘Coarse’, all Ducts (except the vertical ones) will be displayed as single lines. With some additional specific view settings, such as hiding the Linked architecture model and only displaying the Space borders and ventilation elements, it is possible to make a View that resembles a control diagram of each Floor Plan. In the ventilation template, the Views of the Sub-Discipline ‘Ventilation – Control Diagram’ are prepared for this purpose. When these Views are placed on a Sheet, it is possible to manually draft some lines between the different Floor Plans for the representation of the duct shaft. An example of such a Floor Plan ventilation control diagram is presented in picture 53.



PICTURE 53. Revit screenshot: Floor Plan ’00 – Vent – Control Diagram’

4.5 Call for tenders [4.0.0] and Construction [5.0.0]

Although the ventilation design is already finished by CENERGIE in the last phase, the BIM model can still be useful to extract the bill of quantities. Additionally, the ventilation designs of the contractors can be compared with the ventilation model. No differences between the pre-BIM status and BIM stage 1 are made regarding the construction phase [5.0.0].

4.5.1 Quantity survey [4.2a.0]

A great advantage of having an intelligent model, is that it creates opportunities to extract building data. Before the call for tenders is send, CENERGIE needs to make a bill of quantities of their ventilation design.

There are two different methods to extract data from a Revit BIM model. The first method counts the number of elements while the second method measures the used Materials. The geometric elements in the described workflow have no Materials assigned to them and if they have any, they are generic. If we want to count the number of elements and collect their parameters, a normal Schedule can be made. If Materials should be counted, a Material Takeoff Schedule is necessary. In both cases, it is possible to make a hierarchical Keynote list with a code number and a corresponding title according to the used classification standards. These codes can be assigned to Revit objects but also to specific Materials. The Schedules can be exported in the next phase to Excel for a more detailed analysis and formatting. The built-in Schedule export from Revit produces a delimited '.txt' file that can be imported in Excel. Specialized add-ins can automate this task; it is possible to make an export to Excel via a Dynamo tool that has a similar structure as the one used in section 4.3.8 for the calculation of necessary air flow values per Space.

A detailed study of the above methods is considered out of scope. To make a simple data extraction possible, the necessary (object) Schedules are prepared. The tables 13, 14, 15, 16, 17, 18 and 19 give information about which elements are counted. The parameter fields can be changed, which means that extra parameters can added and others can be removed (except the ones used for filtering) from the Schedule. It is not possible to filter on a Family and/or Type name, so extra parameters are added to some Families to make it possible to filter them out. Filter rules can only make use of one or more 'AND' statements.

TABLE 13. Bill of quantities Schedule 'BoQ – V_Air Terminals – Freecooling Supply Window'

'BoQ – V_Air Terminals – Freecooling Supply Window'	
Fields	'CN_V_Level' / 'Type' / 'Window Width' / 'Window Height' / Calculated Value: 'CV_Window Area' / 'CN_Window Opening Area Contractor' / 'Count'
Filter	Only Air Terminals for freecooling supply air are filtered by controlling if the parameter 'Window Width' exists.
Sorting/Grouping	'Type' > 'CN_Window Width' > 'CN_Window height'

TABLE 14. Bill of quantities Schedule 'BoQ – V_Air Terminals – Mechanical'

'BoQ – V_Air Terminals – Mechanical'	
Fields	'System Name' / 'CN_V_Level' / 'CN_V_Air Terminal Type' / 'Type' / 'Count' / (Header: 'System Type')
Filter	The Air Terminals from the Duct System Type 'Transfer Air' and Air Terminals for freecooling supply air (no Duct System) are filtered out of this list. Both filters control the Duct 'System Name'.
Sorting/Grouping	'System Type' (header) > 'System Name' > 'CN_V_Air Terminal Type' > 'Type'

TABLE 15. Bill of quantities Schedule 'BoQ – V_Air Terminals – Transfer Air'

'BoQ – V_Air Terminals – Transfer Air'	
Fields	(hidden field: 'System Name') / 'CN_V_Level' / 'CN_V_Air Terminal Type' / 'Type' / 'Count' / (hidden field: 'CN_Geometric Extract Transfer Air Terminal')
Filter	Only Air Terminals from Duct System Type 'Transfer Air' are listed. This filter controls the Duct 'System Name'. The Air Terminals for transfer air are always pared (extract and supply). For the quantity survey there is only one element that must be counted and this is the extract air terminal with geometric representation. 'CN_V_Transfer Air Open Plan Extract - RP Transfer Air - Rectangular Duct' has no geometry because it only represents the air flow between two Spaces. The filter controls if the custom Shared parameter 'CN_Geometric Extract Transfer Air Terminal' is set to 'Yes'.
Sorting/Grouping	'CN_V_Air Terminal Type' > 'Type'

TABLE 16. Bill of quantities Schedule 'BoQ – V_Duct Accessories'

'BoQ – V_Duct Accessories'	
Fields	(Header: 'System Type') / 'System Name' / 'Family' / 'Type' / 'Size' / 'Insulation Type' / 'Insulation Thickness'
Filter	No Ducts from the Duct System Type 'Transfer Air' are included, because these are only used to connect two Air Terminals for transfer air. Only Ducts that are part of a Duct System are filtered. Both filters control the Duct 'System Name'.
Sorting/Grouping	'System Type' > 'System Name' > 'Family' > 'Type'

TABLE 17. Bill of quantities Schedule 'BoQ – V_Duct Fittings'

'BoQ – V_Duct Fittings'	
Fields	(Header: 'System Type') / 'System Name' / 'Family' / 'Type' / 'Size' / 'Insulation Type' / 'Insulation Thickness' / 'CN_Union Not In BoQ'
Filter	No Ducts from the Duct System Type 'Transfer Air' are included, because these systems normally do not have Duct Fittings. Only Ducts that are part of a Duct System are filtered. Both filters control the Duct 'System Name'. Union Duct Fittings, used when two identical Ducts that are joined and in line, should not be counted, as they only appear when one long Duct is split in multiple shorter pieces. These Fittings are filtered out of this list if the 'CN_Union Not In BoQ' parameter added to the custom Union Fittings ('CN_V_Duct Fitting – Rectangular Union' and 'CN_V_Duct Fitting – Round Union') is equal to 'Yes'.
Sorting/Grouping	'System Type' > 'System Name' > 'Family' > 'Type' (Grand totals give total amount of Duct Fittings in all Duct Systems. A total number of Duct Fittings per Duct System is given.)

TABLE 18. Bill of quantities Schedule 'BoQ – V_Ducts'

'BoQ – V_Ducts'	
Fields	(Header: 'System Type') / 'System Name' / 'Size' / 'Length' / 'Insulation Type' / 'Insulation Thickness'
Filter	No Ducts from the Duct System Type 'Transfer Air' are included, because these only connect two Air Terminals. Only Ducts that are part of a Duct System are filtered. Both filters control the Duct 'System Name'.
Sorting/Grouping	'System Type' > 'System Name' > 'Size'

TABLE 19. Bill of quantities Schedule 'BoQ – V_Mechanical Equipment – AHU'

'BoQ – V_Mechanical Equipment – AHU'	
Fields	'System Name' / 'Level' / 'Family' / 'Type' / 'CN_Mechanical AHU Outdoor Air Flow' / 'CN_Mechanical AHU Exhaust Air Flow' / 'CN_Heat Recovery Efficiency' / (Header: 'CN_V_AHU Name')
Filter	Only AHU's should appear in this list. To filter between other Mechanical Equipment Families, the filter checks if the 'CN_Mechanical AHU Exhaust Air Flow' parameter exists.
Sorting/Grouping	'CN_AHU Name'

4.5.2 Controlling contractor's design [4.11a.0]

When the ventilation design of the different contractors is controlled by CENERGIE, the existing BIM models can be used as a tool to check calculated values and simulate alternative designs. During the construction phase, the model can be used to validate decisions made on-site by the contractor. It can be used to quickly control possible coordination issues in 3D (e.g. structural walls or beams in combination with ventilation ductwork). The Excel file with the results of the necessary air flows per Space can be reused to control the proposed air flow values from the contractor.

5 DISCUSSION

5.1 Achievements

A BIM workflow with Autodesk Revit was developed during this research. The pre-BIM workflow is described with process maps and is successfully transformed to a new workflow for BIM stage 1 with Revit. Process mapping can be mentioned as a useful method to analyze an existing design workflow, but also to develop a new way of working with different BIM-related software packages. Beyond the application in this research, they can be reused for teaching employees in adapting new working methods with Revit BIM software, in order to produce a ventilation model according to the company's design standards.

The general structure of the process maps does not differ much between the pre-BIM phase and BIM stage 1. Just as in the pre-BIM workflow the ventilation design changes from a rough concept, to a preliminary design that is gradually turned into a final, detailed ventilation design. On the lower levels of the process maps set structure, the differences between both workflows are more explicit. The use of BIM solutions, even during BIM stage 1, creates additional and more software specific tasks that should be executed in a certain order to create a good BIM model. Exchange requirements are not radically different between the two workflows, because no BIM models are exchanged in BIM stage 1.

Because Revit is originally developed for the North American architecture, engineering and construction industry, it mainly supports workflows that are specific for this region, with their own design customs and legislation. Other workflows can be implemented by customizing the standard modeling system and creating workarounds. It is possible to create specific templates that contain custom-made Project parameters. Additional BIM objects or so-called Families can be made in the Family Editor environment of Revit, without having to know any programming language. With custom Project parameters and Families alone, it is not possible to create an efficient workflow. Workflow-supporting tools or Revit add-ins can be developed by programming directly or by using Dynamo, a free visual programming add-in for Revit. This last method proved to be very useful during this research; solutions for workflow-related problems in Revit were found, without having to know any specific programming language and details about the Revit Application Programming Interface (API). Dynamo tools are made of pre-loaded functions or nodes. If these nodes do not provide enough functionality, it is also possible to load additional nodes from expanding packages or custom nodes can be made from scratch.

The Dynamo graph ’Tool – Link Revit-Excel.dyn’ that was made for this workflow, exports Space parameters to Excel, where they can be analyzed and processed. This export to Excel has several advantages, such as better visibility, more layout and conditional formatting options and control over the used calculations. This method can also be used to link existing Excel engineering tools to the Revit model data in both ways.

Despite a lot of attention, the proposed workflow is not completely foolproof. All future users of this workflow should be aware of the errors they can make during different phases of the model. Again, the set of process maps can be used as a tool to keep the overview over the whole modeling process. In order to produce and maintain a ventilation model with consistent data, different control methods are needed. Beside built-in Revit control tools, such as *Check Duct Systems* and *Show Disconnects*, parameters can be controlled in Schedules by using conditional formatting and in other Views by using View Filters and Color Fill Schemes. Automated tasks with built-in and custom-made tools do not only speed up the modeling, but they also helps in reducing the number of design errors.

The change from a pre-BIM to a BIM stage 1 workflow will still ask quite some time and effort. The employees will have to learn the basics of the Revit BIM software and the custom-made workflow. During this research, no comparison between Revit and other commercial BIM software packages for MEP was conducted. As mentioned before, Revit can be customized quite easily on different levels, but it can take some time before an efficient, custom-made workflow is established. The Revit-workflow proposed in this research will inevitably become a subject of change over time because of new design standards, software developments and the search for a higher efficiency. It is advisable for CENERGIE to assign certain key figures that are responsible for the maintenance of the templates and the Family content, in harmony with the used Revit BIM workflow. These figures can be employees of the company or even other companies that offer Revit support. The end-users of the workflow should get the opportunity to communicate with the responsible persons about possible changes to the workflow, templates and Revit content. The rise of Revit supporting companies makes sense regarding the steep learning curve and the effort it asks to customize a Revit workflow. The offered services range from simple tools to full packages, including a specific Revit content library, templates and workflow supporting tools.

5.2 Further research

The proposed workflow for BIM stage 1 with Revit can still be improved. Extra Dynamo tools can be developed to automatize certain phases of the workflow, such as the population of the actual space air flow values. Additionally, more adapted ventilation-related Families can be developed, such as all kinds of Duct Accessory Families and extra Mechanical Equipment and Air Terminal Families. With some additional research, it may be possible to create tools for additional design calculation methods regarding ventilation noise, local pressure losses and balancing of the different duct runs of a Duct System. Finally, a tool for a more sophisticated quantity survey data extraction can be developed.

Besides ventilation, it is possible to integrate other domains of building systems in the Revit BIM model such as electricity, lighting, heating and cooling piping systems, sewage and fresh water piping systems (Duncan 2014). To make a multi-disciplinary parametric model, extra Connectors have to be added to the different Families. With some modifications, it is also possible to export the architecture model, made in the proposed BIM workflow, to other third-party software packages for further analysis (e.g. heating and cooling loads, detailed light simulations, analysis of the air conditions in different spaces, etc.).

When BIM stage 1 is reached for all crucial project domains where CENERGIE is active, the change to the following BIM stage can be started. It is a good idea for the company to develop their own vision on these future BIM stages and how they should be reached. Because the following BIM stages focuses more on collaboration via BIM, it will be crucial to think about exchange requirements and the corresponding responsibilities. Different developments in this field can be studied, such as the use of a software independent file formats for BIM models such as IFC or Industry Foundation Classes (buildingSMART 2015b) and the collaboration via BIM Collaboration Format or BCF files (buildingSMART 2015a). BIM standards and regulations will become more and more important in the future as they will imply and/or suggest if BIM models are mandatory, how certain models should be made and how the collaboration with BIM between building partners should be managed.

REFERENCES

Autodesk, 2015a. About Duct Settings. Available at: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2015/ENU/Revit-Model/files/GUID-42A2BFEA-33A0-4B67-A0D3-5D5F385B6E9A-htm.html [Accessed April 15, 2016].

Autodesk, 2016a. Autodesk App Store. Available at: https://apps.autodesk.com/RVT/en/Home/Index [Accessed April 27, 2016].

Autodesk, 2015b. Customize System Types. Available at: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2015/ENU/Revit-Model/files/GUID-0E860EB4-62A7-4B5A-89A4-FEA563232E18-htm.html [Accessed May 1, 2016].

Autodesk, 2015c. Dynamo BIM. Available at: http://dynamobim.org/ [Accessed December 18, 2015].

Autodesk, 2014. Revit 20 mile origin limit for imported and model geometry. Available at: https://knowledge.autodesk.com/support/revit-products/troubleshooting/caas/sfdcarticles/sfdcarticles/Revit-20-mile-origin-limit-for-imported-and-model-geometry.html [Accessed March 2, 2016].

Autodesk, 2015d. Specify a Pressure Loss Method for Fittings and Accessories for Duct and Pipe. Available at: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2015/ENU/Revit-Model/files/GUID-6708486B-6D46-49DF-8438-14EAAA6F0818-htm.html [Accessed May 6, 2016].

Autodesk, 2016b. Troubleshooting: Layouts for Duct and Pipe. Available at: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/Revit-Model/files/GUID-F0BEEB3D-34F8-4314-9EF6-E40BA0C84976-htm.html [Accessed May 3, 2016].

BIM Troublemaker, 2014. Practical Dynamo - Excel Linking 2: Keeping track of Your Families. Available at: http://bimtroublemaker.blogspot.fi/2014/09/practical-dynamo-excel-linking-2.html [Accessed March 20, 2016].

Bokmiller, D., Whitbread, S. & Morrison, D., 2014. *Mastering Autodesk Revit MEP 2015*, Indianapolis, Indiana: John Wiley & Sons.

Van den Bossche, P. (WTCB), Prieus, S. (WTCB) & Cootjans, P. (DNI), 2007. *Ventilatiegids - stappenplan voor comfortabel en energiezuinig ventileren*, Available at: http://www.wtcb.be/homepage/download.cfm?dtype=publ&doc=Ventilatiegids woningen.pdf&lang=nl [Accessed April 26, 2016].

buildingSMART, 2015a. buildingSMART BCF intro. Available at:

http://www.buildingsmart-tech.org/specifications/bcf-releases [Accessed November 28, 2015].

buildingSMART, 2015b. buildingSMART Summary of IFC Releases. Available at: http://www.buildingsmart-tech.org/specifications/ifc-releases [Accessed November 28, 2015].

Delmotte, C. et al., 2014. *Rapport 15: Berekening van drukverliezen en dimensionering van luchtdistributienetwerken*,

Duncan, A., 2014. Autodesk University - Integrated and Automated Duct and Pipe System Calculations in Revit MEP. Available at: http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2014/revit-for-mep-engineers/mp6329#chapter=0 [Accessed April 25, 2016].

Howieson, S., Sharpe, T. & Farren, P., 2013. Building tight - ventilating right? How are new air tightness standards affecting indoor air quality in dwellings? *Building Services Engineering Research and Technology*, 35(5), pp.475–487.

Indigne, L., 2012. *Introductie van BIM als tool : een samenwerking tussen architect en ingenieur technieken*. KAHO Sint-Lieven. Technologiecampus Gent.

Kilkelly, M., 2015. 4 Easy Ways to Link Revit to Excel - Arch Smarter. Available at: http://archsmarter.com/link-revit-to-excel/ [Accessed December 18, 2015].

Kron, Z., 2013. Autodesk University - Dynamo : Visual Programming for Design.

Kulkul & Venkov, D., 2016. Read Revit Key Parameter value + set new Key parameter value. Available at: http://dynamobim.org/forums/topic/read-revit-key-parameter-value-set-new-key-parameter-value/ [Accessed March 27, 2016].

Leenknegt, S. et al., 2011. Towards a more reliable modelling of night-time ventilation with building energy simulation models. *Roomvent 2011*, (1), pp.1–8.

Lenihan, R., 2015. Taking a return trip from Revit to Excel using Dynamo. Available at: http://www.revit.com.au/?p=1564 [Accessed March 20, 2016].

Leving, H., 2003. Indoor Air Pollutants Part 1: general description of pollutants, levels and standards. *Ventilation Information Paper*, 2, p.12. Available at: http://www.aivc.org/resource/vip-02-indoor-air-pollutants-part-1-general-description-pollutants-levels-and-standards.

Marynissen, V. & Moons, B., 2015. *Modelling a building in ArchiCAD and Revit - State Office Building of Seinäjoki*. Thomas More, Associatie KU Leuven.

Munkholm, 2011. Revit - Inconsistent Units and how to neutralize them. Available at: http://www.revitforum.org/tutorials-tips-tricks/1138-revit-inconsistent-units-how-neutralize-them.html [Accessed March 23, 2016].

National BIM Standard-United-States, 2016. Frequently Asked Questions About the National BIM Standard-United States™ | National BIM Standard - United States. Available at: https://www.nationalbimstandard.org/faqs#faq1 [Accessed April 25, 2016].

Sgambelluri, M., 2014. Autodesk University - Practically Dynamo: Practical Uses for Dynamo Within Revit. Available at: http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2014/revit-for-architects/ab6557#chapter=0 [Accessed December 18, 2015].

Sobon, K.K., 2015. bumblebee - dynamo and excel interop. Available at: http://archi-lab.net/bumblebee-dynamo-and-excel-interop/ [Accessed March 25, 2016].

Succar, B., 2013. 3. BIM Stages. Available at: http://www.bimframework.info/2013/12/bim-stages.html [Accessed April 26, 2016].

Succar, B., 2010. Building Information Modelling Maturity Matrix. *Handbook of research on Building Information Modelling and construction informatics: concepts and technologies*, pp.65–103. Available at: https://www.academia.edu/186259/Building_Information_Modelling_Maturity_Matrix [Accessed April 25, 2016].

Teirlinck, S., 2011. Europese normering - Weerstand tegen brand en reactie bij brand. Available at: http://www.brandweervlaanderen.be/Portals/BVV/Documenten/Wie zijn we/KAPB/KAPB Europese normering.pdf.

Varga, Z., 2015. Concrete beam - representation in plan views. Available at: https://knowledge.autodesk.com/community/screencast/aefc4a06-5ac6-4115-b241-6df290fae305 [Accessed March 20, 2016].

VEA & WTCB, 2015. *Ventilatiedocument : niet-residentieel*, Belgium.

VENG, 2016. Warning message when linking CAD files to Revit. Available at: http://learning-revit.com/warning-message-when-linking-cad-files-to-revit/ [Accessed March 27, 2016].

Venkov, D., 2016. dimven / SpringNodes. Available at: https://github.com/dimven/SpringNodes [Accessed March 27, 2016].

LIST OF PICTURES

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Appendix 1. Process maps set 1 – pre-BIM status

(Excluded from publication)

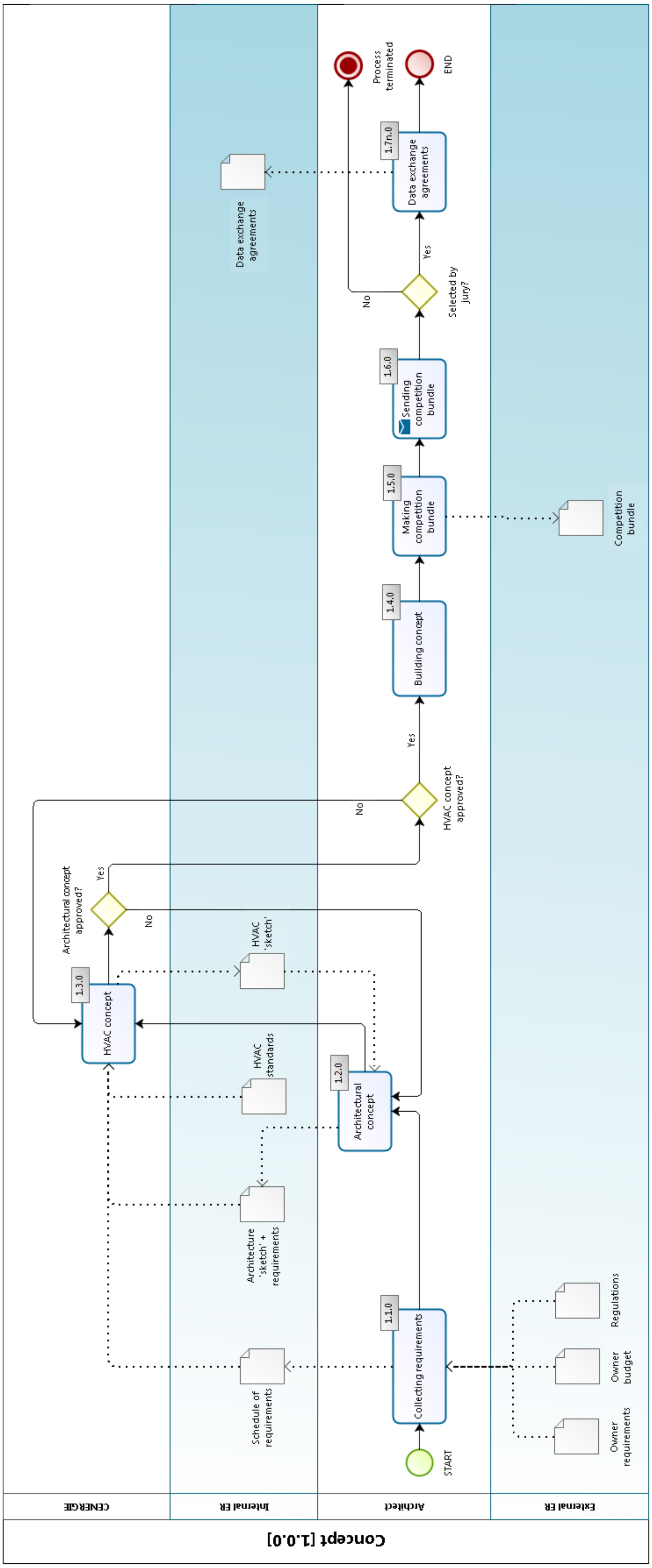
(continues)

Appendix 2. Process maps set 1 – pre-BIM status: documentation

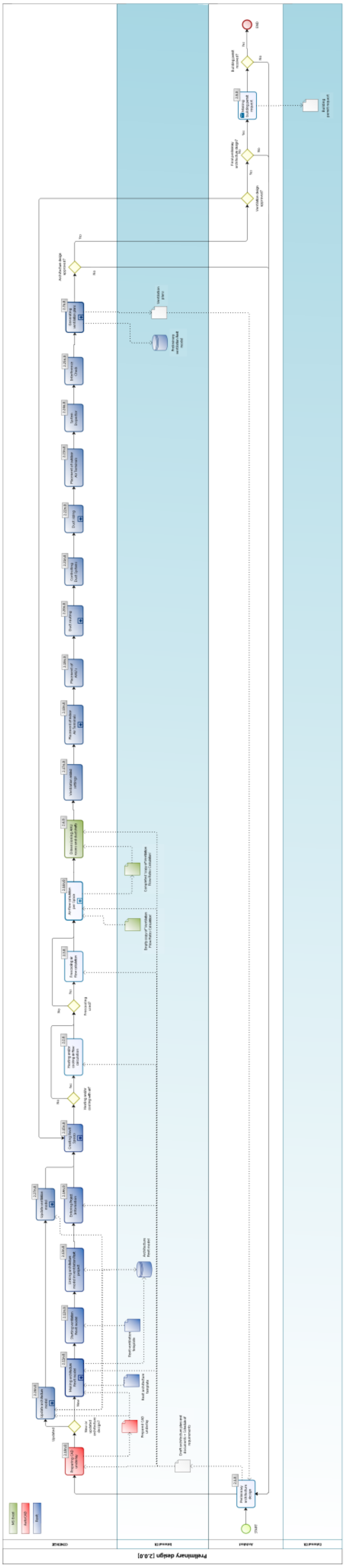
(Excluded from publication)

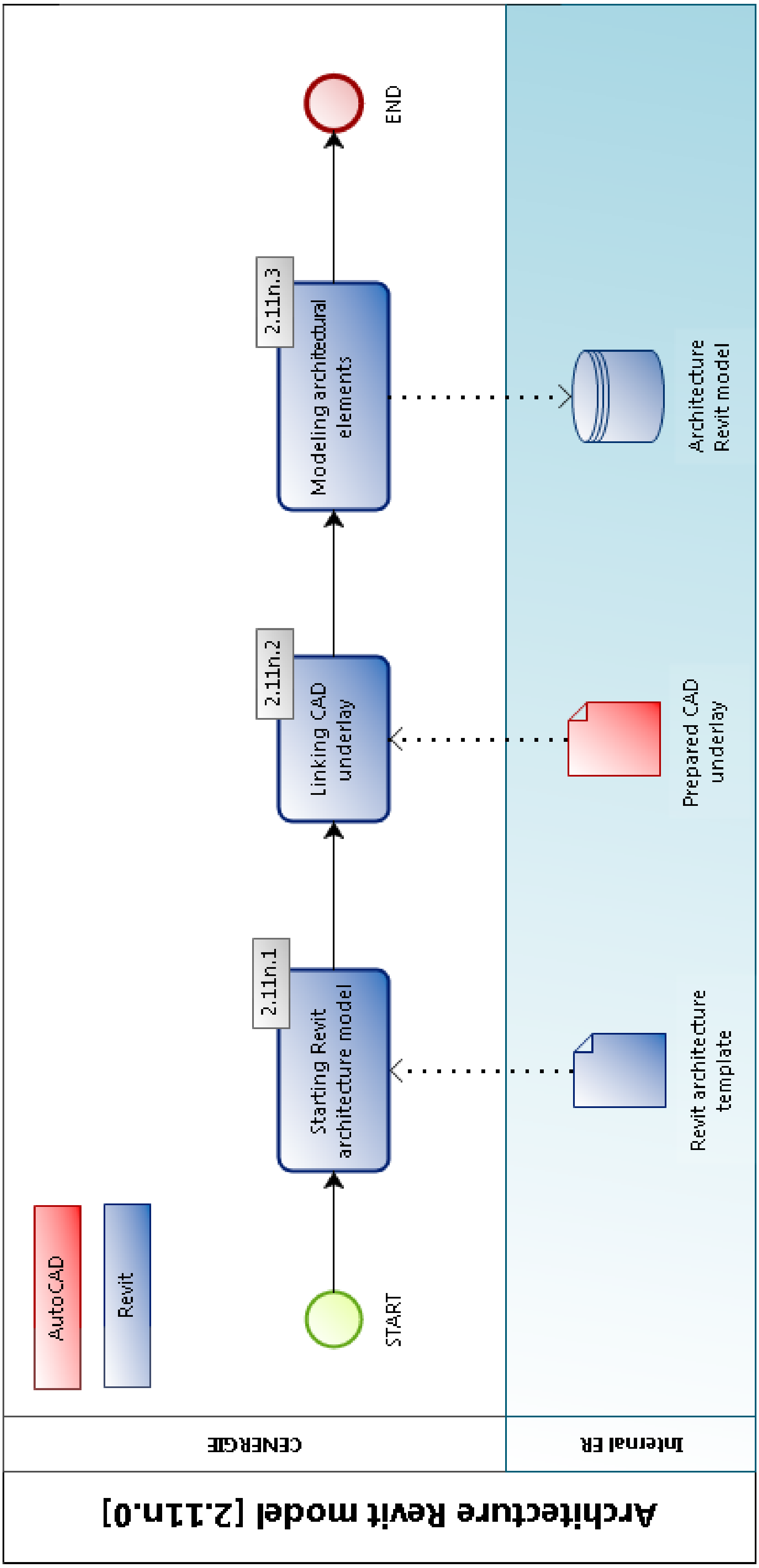
(continues)

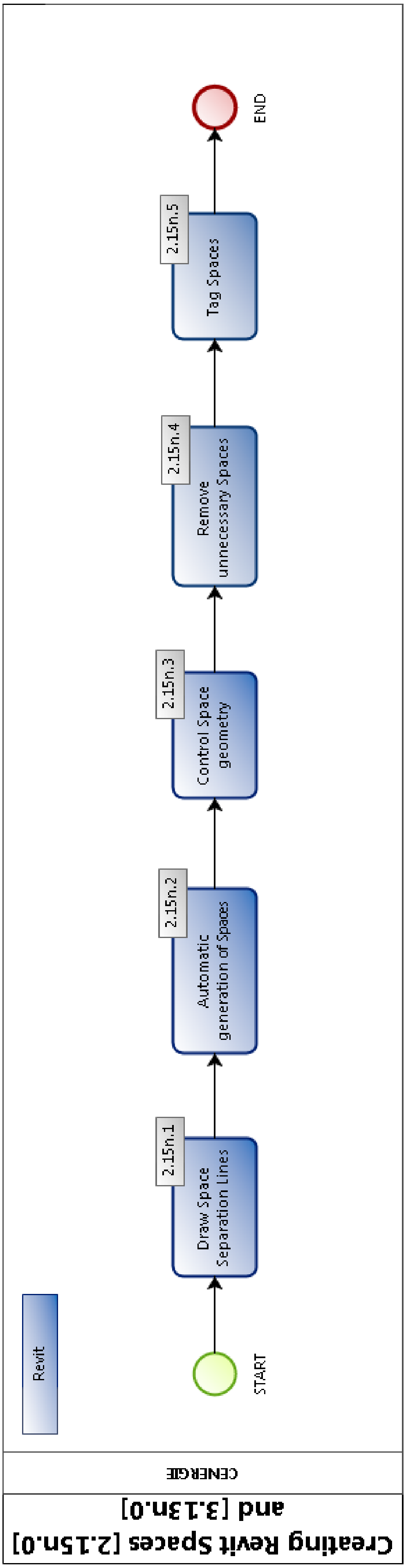
Appendix 3. Process maps set 2 – BIM stage 1

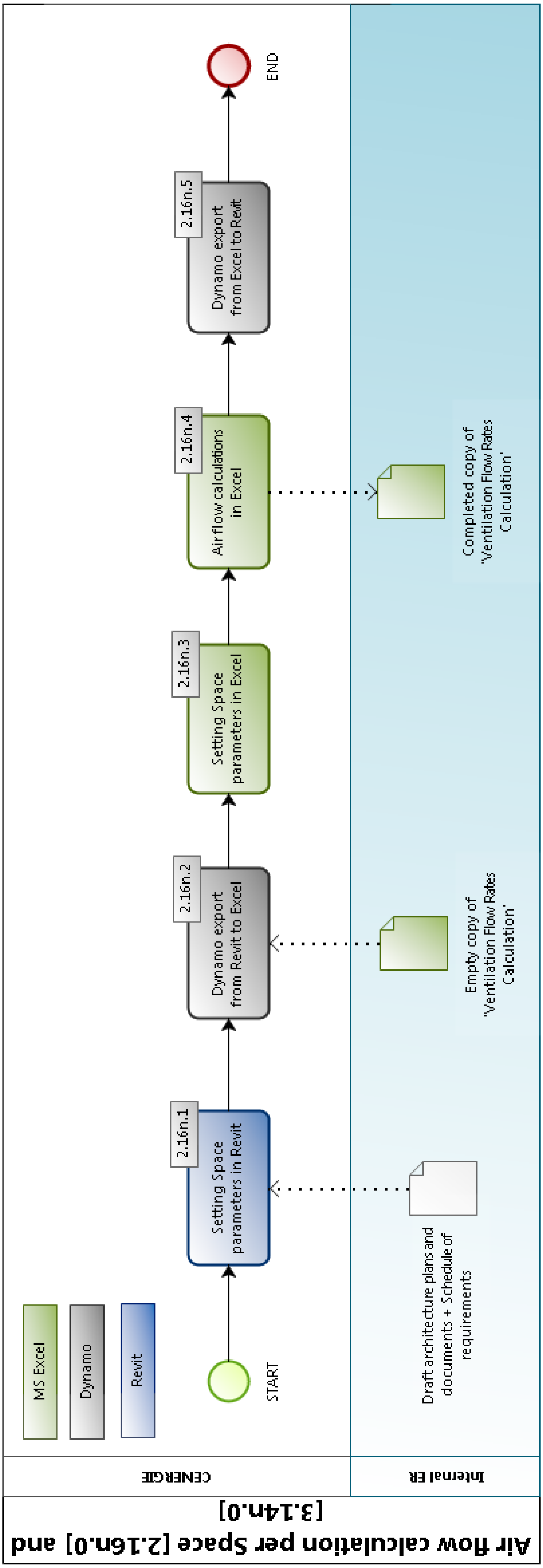


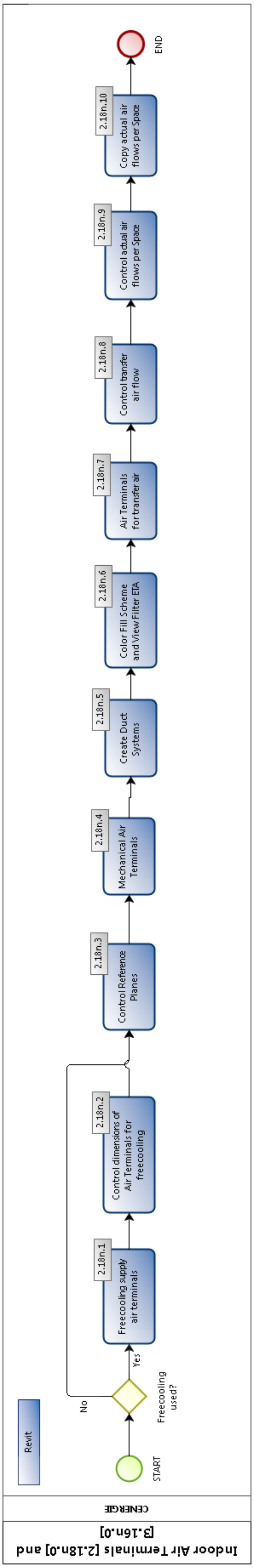
(continues)

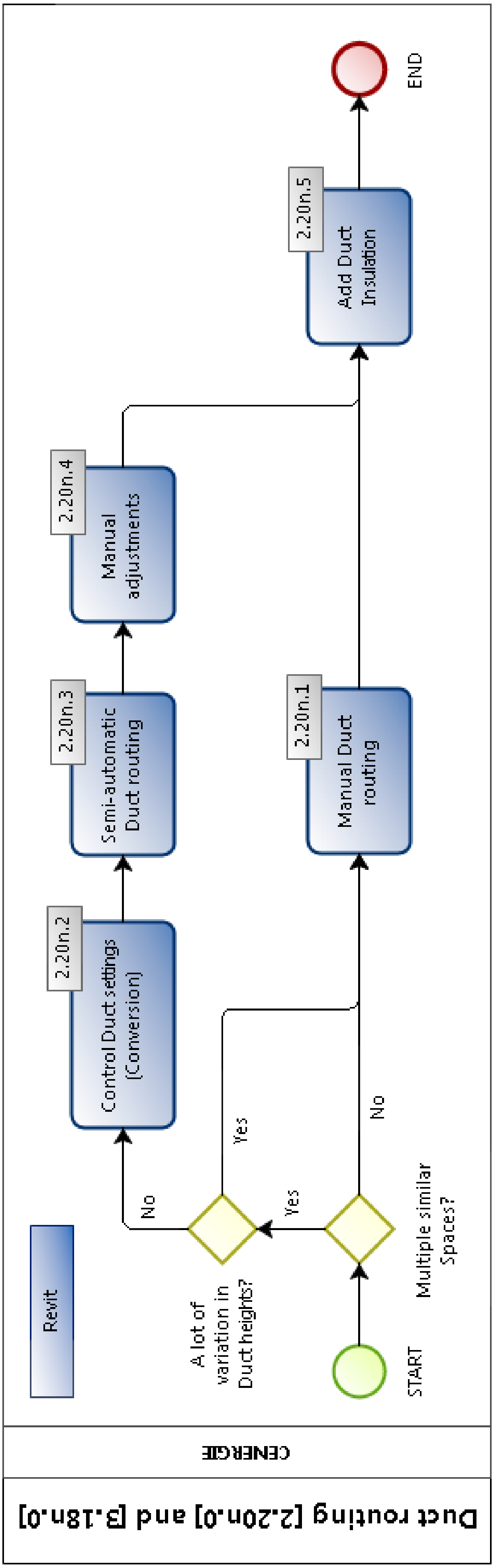


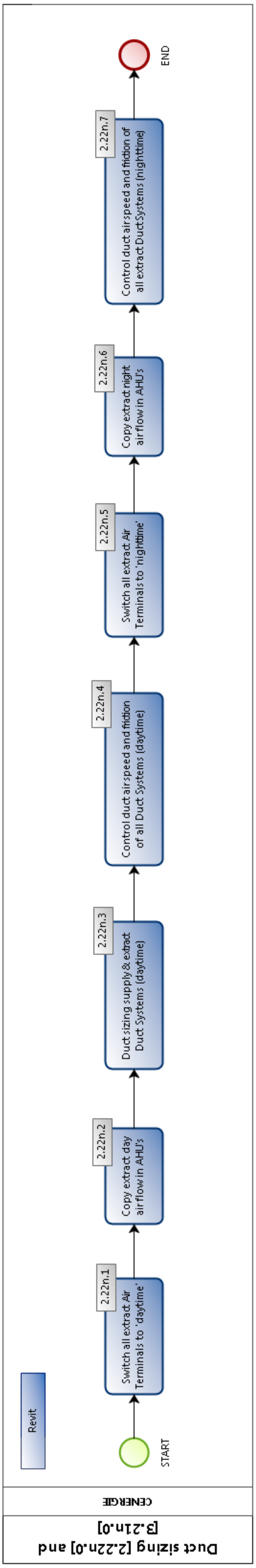

Architecture Revit model [2.11n.0]
CENERGIE
Internal ER
AutoCAD
Revit
START
2.11n.1
Starting Revit architecture model
2.11n.2
Linking CAD underlay
2.11n.3
Modeling architectural elements
END
Revit architecture template
Prepared CAD underlay
Architecture Revit model

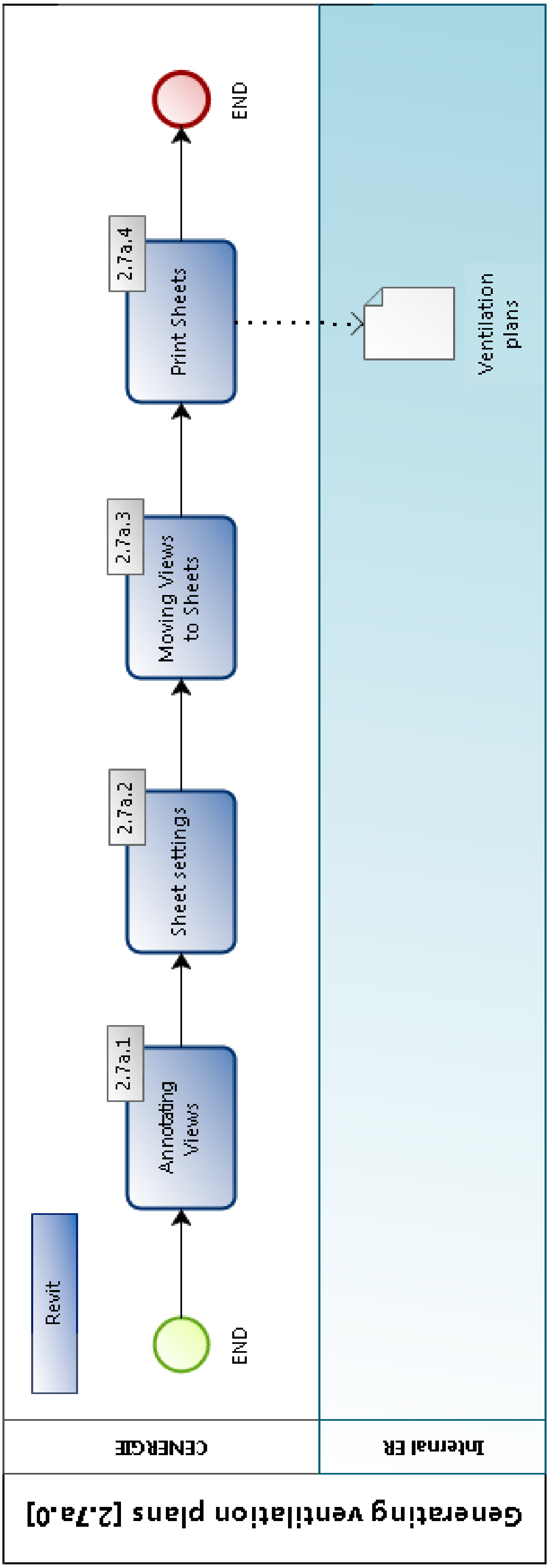

Creating Revit Spaces [2.15n.0] and [3.13n.0]
CENERGIE
Revit
START
Draw Space Separation Lines
2.15n.1
Automatic generation of Spaces
2.15n.2
Control Space geometry
2.15n.3
Remove unnecessary Spaces
2.15n.4
Tag Spaces
2.15n.5
END

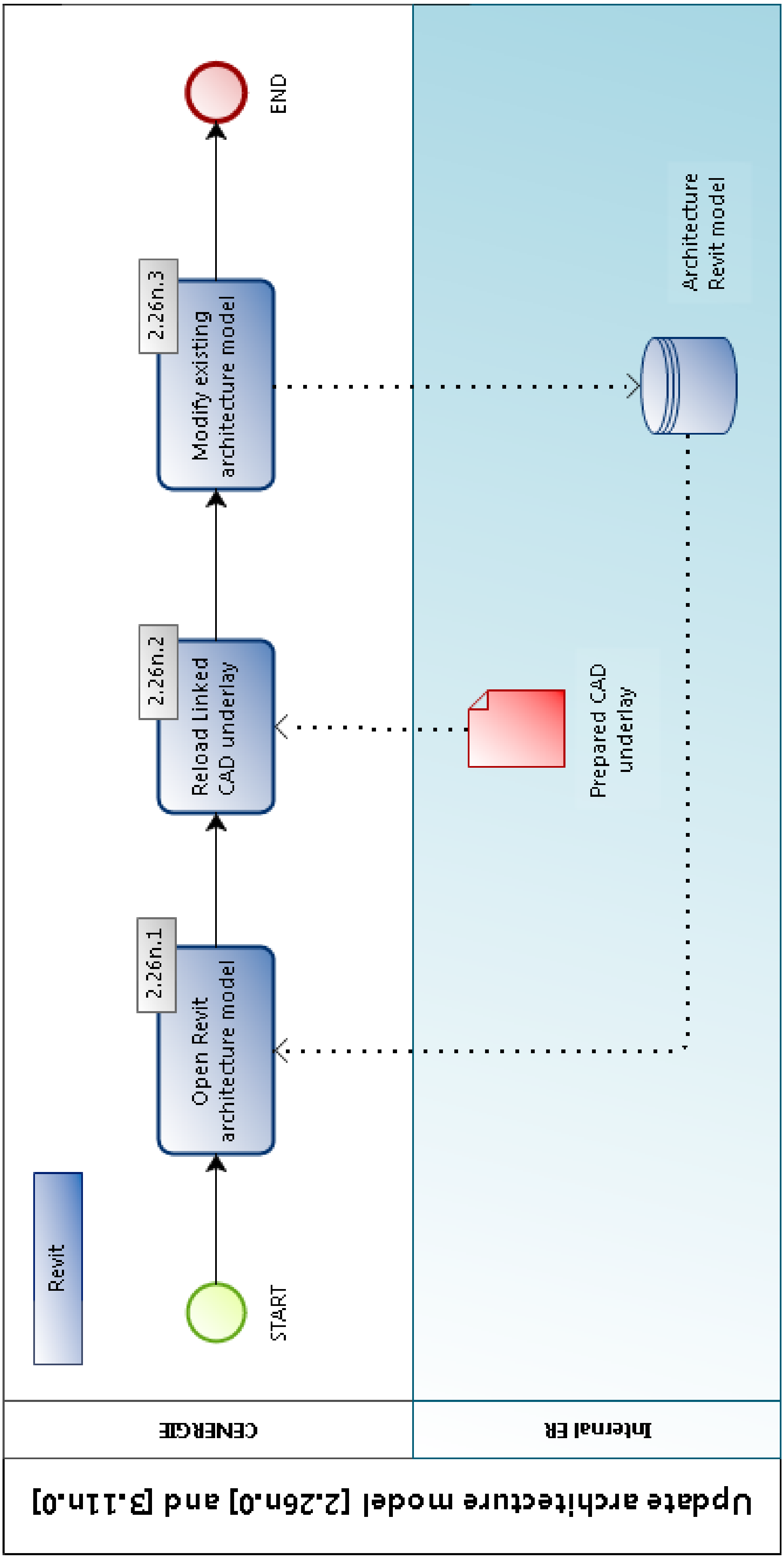

Air flow calculation per Space [2.16n.0] and [3.14n.0]
CENERGIE
Internal ER
MS Excel
Dynamo
Revit
START
2.16n.1
Setting Space parameters in Revit
2.16n.2
Dynamo export from Revit to Excel
2.16n.3
Setting Space parameters in Excel
2.16n.4
Air flow calculations in Excel
2.16n.5
Dynamo export from Excel to Revit
END
Draft architecture plans and documents + Schedule of requirements
Empty copy of 'Ventilation Flow Rates Calculation'
Completed copy of 'Ventilation Flow Rates Calculation'

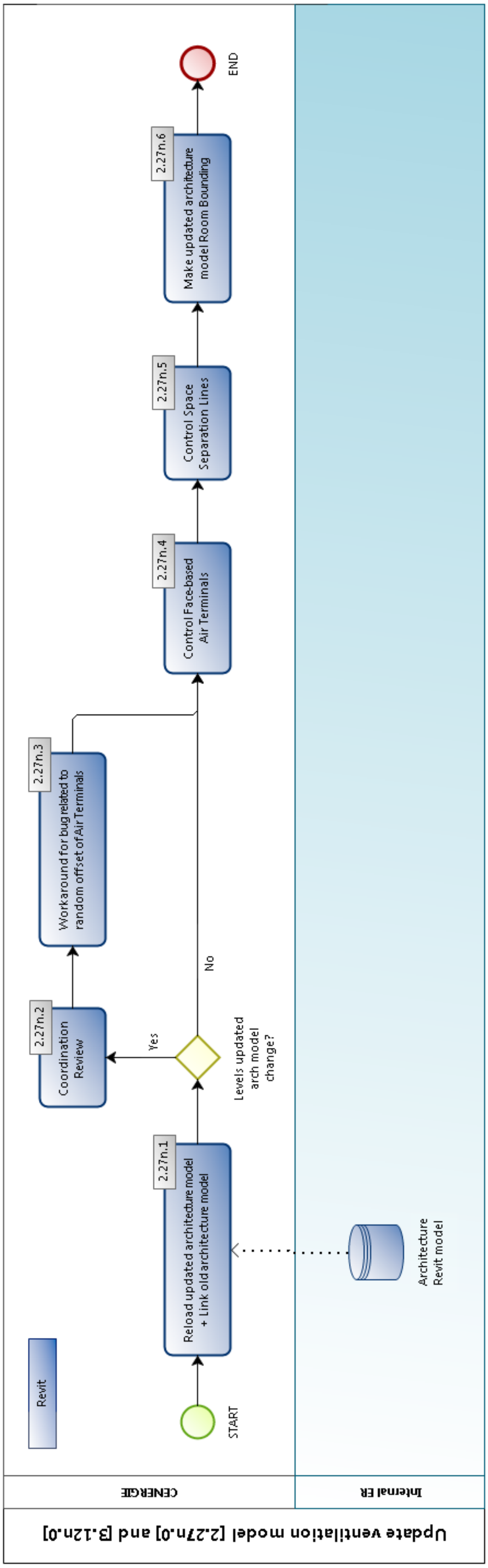

Indoor Air Terminals [2.18n.0] and [3.16n.0]
CENERGIE
Revit
START
Freecooling used?
No
Yes
2.18n.1
Freecooling supply air terminals
2.18n.2
Control dimensions of Air Terminals for freecooling
2.18n.3
Control Reference Planes
2.18n.4
Mechanical Air Terminals
2.18n.5
Create Duct Systems
2.18n.6
Color Fill Scheme and View Filter ETA
2.18n.7
Air Terminals for transfer air
2.18n.8
Control transfer air flow
2.18n.9
Control actual air flows per Space
2.18n.10
Copy actual air flows per Space
END

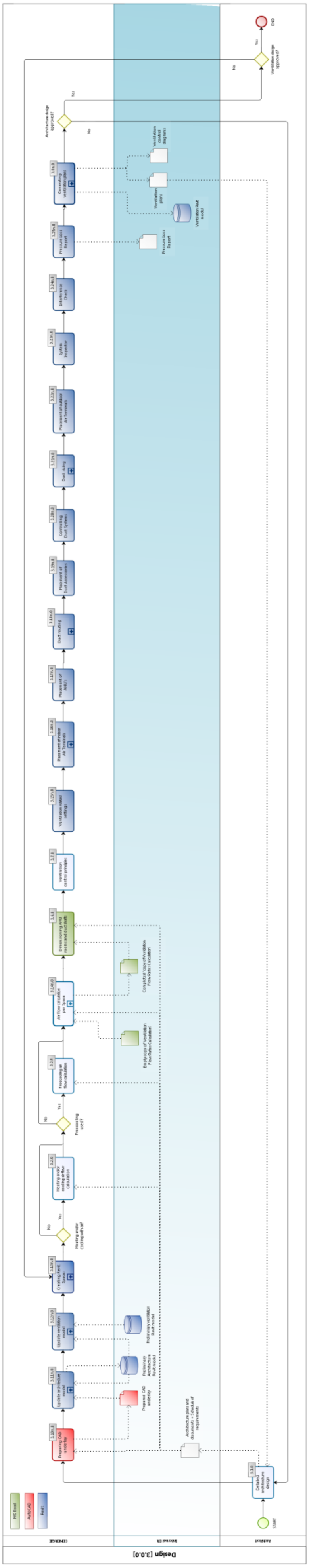

Duct routing [2.20n.0] and [3.18n.0]
CENERGIE
Revit
START
Multiple similar Spaces?
Yes
No
A lot of variation in Duct heights?
No
Yes
2.20n.2
Control Duct settings (Conversion)
2.20n.3
Semi-automatic Duct routing
2.20n.4
Manual adjustments
2.20n.1
Manual Duct routing
2.20n.5
Add Duct Insulation
END

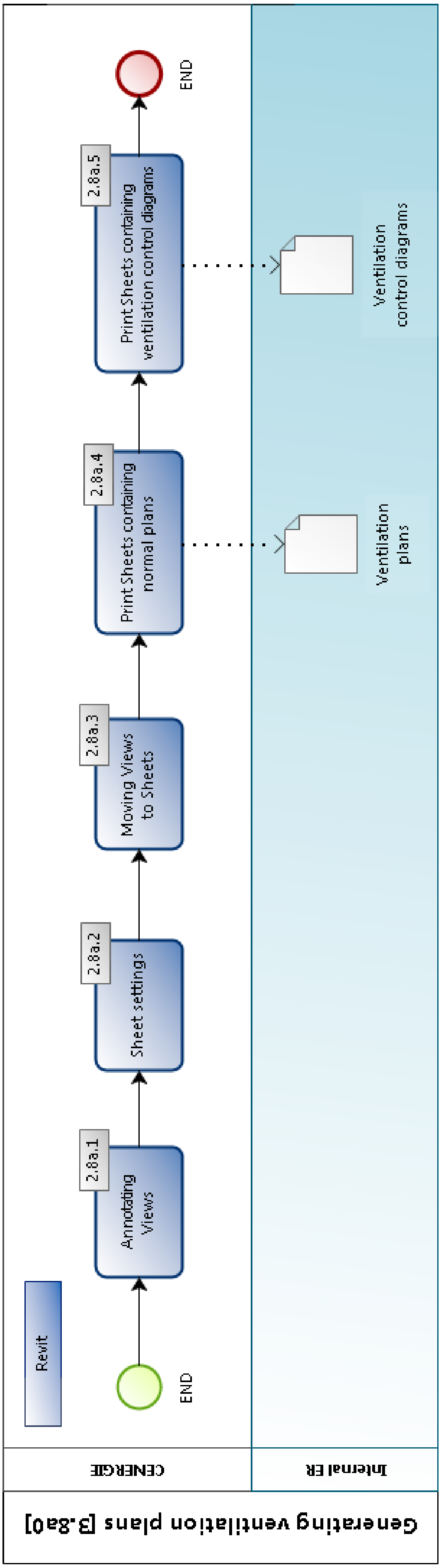

Duct sizing [2.22n.0] and [3.21n.0]
CENERGIE
Revit
START
2.22n.1
Switch all extract Air Terminals to 'daytime'
2.22n.2
Copy extract day air flow in AHU's
2.22n.3
Duct sizing supply & extract Duct Systems (daytime)
2.22n.4
Control duct air speed and friction of all Duct Systems (daytime)
2.22n.5
Switch all extract Air Terminals to 'nighttime'
2.22n.6
Copy extract night air flow in AHU's
2.22n.7
Control duct air speed and friction of all extract Duct Systems (nighttime)
END

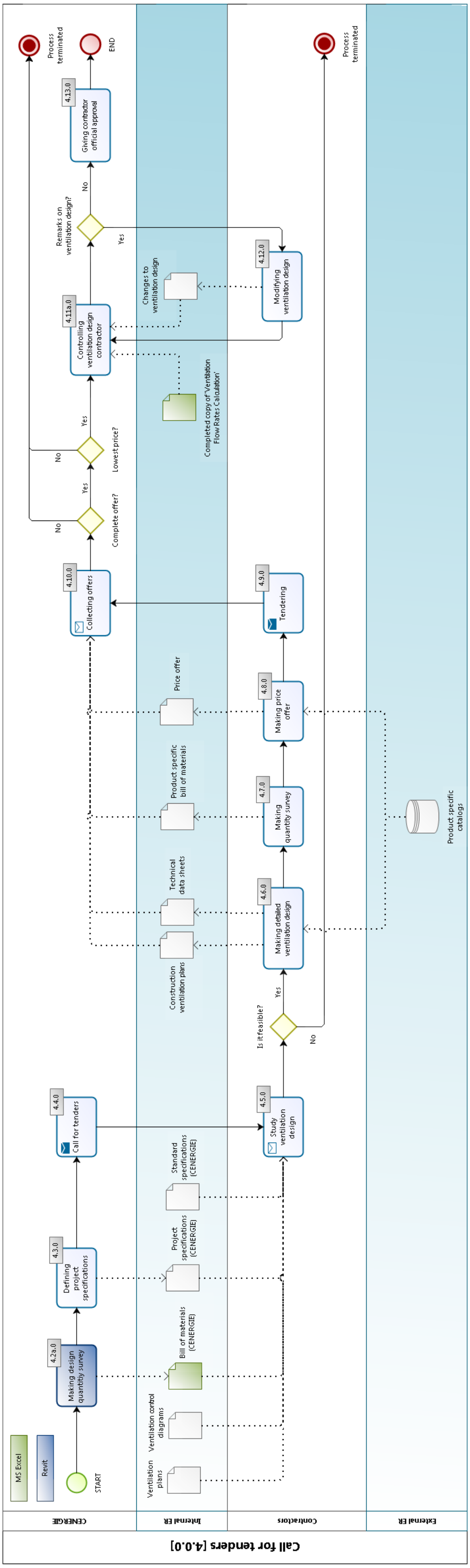

Generating ventilation plans [2.7a.0]
CENERGIE
Internal ER
Revit
END
2.7a.1
Annotating Views
2.7a.2
Sheet settings
2.7a.3
Moving Views to Sheets
2.7a.4
Print Sheets
END
Ventilation plans


Update architecture model [2.26n.0] and [3.11n.0]
CENERGIE
Internal ER
Revit
START
2.26n.1
Open Revit architecture model
2.26n.2
Reload Linked CAD underlay
2.26n.3
Modify existing architecture model
END
Prepared CAD underlay
Architecture Revit model


Update ventilation model [2.27n.0] and [3.12n.0]
CENERGIE
Internal ER
Revit
START
2.27n.1
Reload updated architecture model + Link old architecture model
Architecture Revit model
Levels updated arch model change?
Yes
No
2.27n.2
Coordination Review
2.27n.3
Workaround for bug related to random offset of Air Terminals
2.27n.4
Control Face-based Air Terminals
2.27n.5
Control Space Separation Lines
2.27n.6
Make updated architecture model Room Bounding
END




Generating ventilation plans [3.8a0]
CENERGIE
Internal ER
Revit
END
2.8a.1
Annotating Views
2.8a.2
Sheet settings
2.8a.3
Moving Views to Sheets
2.8a.4
Print Sheets containing normal plans
2.8a.5
Print Sheets containing ventilation control diagrams
END
Ventilation plans
Ventilation control diagrams


Call for tenders [4.0.0]
CENERGIE
Internal ER
Contractors
External ER
MS Excel
Revit
START
4.2a.0 Making design quantity survey
4.3.0 Defining project specifications
4.4.0 Call for tenders
Ventilation plans
Ventilation control diagrams
Bill of materials (CENERGIE)
Project specifications (CENERGIE)
Standard specifications (CENERGIE)
4.5.0 Study ventilation design
Is it feasible?
Yes
No
4.6.0 Making detailed ventilation design
Construction ventilation plans
Technical data sheets
4.7.0 Making quantity survey
Product specific bill of materials
Product specific catalogs
4.8.0 Making price offer
Price offer
4.9.0 Tendering
4.10.0 Collecting offers
Complete offer?
Lowest price?
4.11a.0 Controlling ventilation design contractor
Completed copy of "Ventilation Flow Rates Calculation"
Changes to ventilation design
4.12.0 Modifying ventilation design
Remarks on ventilation design?
4.13.0 Giving contractor official approval
END
Process terminated

Appendix 4. Process maps set 2 – BIM stage 1: documentation

<table>
<tr><th colspan="3">Ventilation design [0.0.0]</th></tr>
<tr><th colspan="3">Concept [1.0.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[1.7n.0]</td><td>Data exchange agreements: A document that contains all exchange requirements during the design, exchanged between CENERGIE and the architect. This includes information about the moments of data exchange, file formats, data sharing platforms, used CAD/BIM software, CAD drawing and/or BIM model structure. (data types: text, tables, etc.)</td><td>Data exchange agreements: Beside the normal agreements about the collaboration between the actors in the building design team, it is advisable to make extra agreements on the exchange requirements during the design process. The efficiency of the BIM workflow is dependent on a consistent data transfer. The main data exchange is via the architect, who collects design data from the different building disciplines.</td></tr>
<tr><th colspan="3">Preliminary design [2.0.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[2.10n.0]</td><td>Draft architecture plans and documents + schedule of requirements: drafting plans and update of the schedule of requirements. (variable data types: ‘.dwg’ plans, tables, text)
Prepared CAD underlay: a separate folder which contains the prepared ‘.dwg’ floor plans, sections and elevations of the architect. (data type: ‘.dwg’)</td><td>Preparing CAD underlay: The received architecture draft plans must be controlled in AutoCAD if they are not made according to the proposed recommendations. When this is done, the AutoCAD file can be controlled automatically for errors and all redundant data can be removed.</td></tr>
<tr><td colspan="3">• First the following changes and checks in AutoCAD should be performed:
  ○ Each plan (floor plan, elevation, section) should be saved as a separate ‘.dwg’ file. Give the different drawings a recognizable name that includes the drawing date.
  ○ The floor plans should all have the same drawing origin.
  ○ Control the used drawing units and change these to millimeters [Units]
  ○ Delete all elements that are only located in Paper Space (delete all layouts)
  ○ Check if no drawing elements are located far from the origin [Zoom Extend]
• Let AutoCAD control the drawing and solve the errors it finds [Audit]
• Delete all unused layers, blocks, line styles and dimension styles automatically in AutoCAD [Purge]</td></tr>
<tr><td>[2.11n.0]</td><td>Draft architecture plans and documents + schedule of requirements: see [2.10n.0]</td><td>Making architecture Revit model: Starting from the template ‘CN_Template Architecture.rte’,</td></tr>
</table>

(continues)

<table>
<tr>
<td></td>
<td><u>Prepared CAD underlay</u>: see [2.10n.0]
<u>Revit architecture template</u>: The template that is prepared for this workflow. It contains all necessary settings, Views, architecture System (Walls, Roofs, Floors, Ceilings, Stairs) and loaded Families (Doors, Windows, elevator). See appendix 6. (data type: ‘.rte’ Revit template)
<u>Architecture Revit model</u>: The 171pdate171ctture model that is created during this task. (data type: ‘.rvt’ Revit model)</td>
<td>a simple architecture Revit model is created. First the ‘.dwg’ plan documents are Linked in the architecture model. When this is done, the important layers can get a visual override to increase the visibility. Next, the architecture elements are modeled, based on the ‘.dwg’ underlay plans.</td>
</tr>
<tr>
<td>[2.12n.0]</td>
<td><u>Revit ventilation template</u>: The template that is prepared for this workflow. It contains all necessary settings, Views, ventilation System (Duct Types, Duct Insulation Types, Duct System Types) and loaded Families (Air Terminals and Mechanical Equipment). See appendix 5. (data type: Revit template)</td>
<td><u>Starting ventilation Revit model</u>: Start a new model from the template ‘CN_Template Ventilation.rte’. The project units settings should be controlled.</td>
</tr>
<tr>
<td colspan="3">

Start a new Revit file, by opening the prepared Revit ventilation template ‘CN_Template Ventilation.rte’
Control the used Project Units settings [Manage tab > Settings > Project Units]

</td>
</tr>
<tr>
<td>[2.13n.0]</td>
<td><u>Revit architecture model</u>: see [2.11n.0]</td>
<td><u>Linking architecture model in ventilation Revit project</u>: The architecture model prepared in the last step, is now Linked in the new ventilation model. The Levels are monitored to the Levels of the architecture model.</td>
</tr>
<tr>
<td colspan="3">

Link the architecture model in the host model [Insert tab > Link > Link Revit]
‘Positioning’: ‘Auto – Origin to Origin’
Set the following Type Properties of the Linked model by selecting the Link or via [Manage tab > Manage Project > Manage Links]:

‘Room Bounding’: ‘Yes’
‘Reference type’: ‘Overlay’
‘Path Type’: ‘Relative’ (only via Manage Links)

Pin the Linked architecture model after selecting it [Modify | RVT Links tab > Modify > Pin]
Monitor the Levels of the ventilation model to the corresponding Levels of the Linked architecture model [Collaborate tab > Coordinate > Copy/Monitor > Select Link]
The corresponding Level already exists in the ventilation model:
Make sure that both Levels are aligned, so they have the same height. Do this before activating the Copy/Monitor tab.

</td>
</tr>
</table>

<table>
<tr><td colspan="3">▪ Select Copy/Monitor and select the Linked Model.
▪ Click Monitor [Copy/Monitor tab > Tools > Monitor]. Select the Level of the ventilation Model followed by the Level of the Linked Model. If a Level is monitored correctly, a sign will appear above it.
▪ Finish the Copy/Monitor action [Copy/Monitor tab > Copy/Monitor > Finish]
o The corresponding Level does not exist:
▪ Select Copy/Monitor and select the right Linked Model.
▪ Click Copy [Copy/Monitor tab > Tools > Copy]. Select the Level of the Hosted Model. The created ventilation Level is monitored automatically.
▪ Finish the Copy/Monitor action [Copy/Monitor tab > Copy/Monitor > Finish]
▪ Make new Floor Plan Views for this Level.</td></tr>
<tr><td>[2.14n.0]</td><td><u>Draft architecture plans and documents + schedule of requirements</u>: see [2.10n.0]</td><td><u>Entering Project Information</u>: The details about the project and building partners are entered in the Project Information parameters of the ventilation model.</td></tr>
<tr><td colspan="3">• Fill in the Project Information parameters that will appear on the Sheets. Only the custom-made parameters of the parameter group Text should be changed [Manage tab > Settings > Project Information]</td></tr>
<tr><td>[2.15n.0]</td><td>/</td><td><u>Creating Revit Spaces</u>: In this task, the Spaces are generated in the ventilation model, after the necessary Space Separator Lines are drawn.</td></tr>
<tr><td>[2.16n.0]</td><td><u>Draft architecture plans and documents + schedule of requirements</u>: see [2.10n.0]
<u>Empty copy of ‘Ventilation Flow Rates Calculation’</u> (data type: ‘.xlsx’ Excel workbook)
<u>Completed copy of ‘Ventilation Flow Rates Calculation</u>: The Space lists contains all Spaces, relevant parameter values and calculation information. (data type: ‘.xlsx’ Excel workbook)</td><td><u>Air flow calculation per Space</u>: First, the Space settings are entered in Revit. The Space data is exported via Dynamo to the prepared Excel file ‘Ventilation Flow Rates Calculation.xlsx’. Some parameters can be adjusted here too. The data from Excel is then exported back to the corresponding Spaces in Revit via Dynamo.</td></tr>
<tr><td>[2.17n.0]</td><td>/</td><td><u>Ventilation related settings</u>: The settings that are saved in the ventilation template should be checked before starting with modeling ventilation elements.</td></tr>
<tr><td colspan="3">• Control the Mechanical Settings [Manage tab > Settings > MEP Settings > Mechanical Settings]
• Control the Duct System Types [Project Browser > Families > Duct Systems > Duct System]. Control the Type Properties by right clicking a Duct System Type from the list.</td></tr>
</table>

<table>
<tr><td colspan="3">

• Control the Duct Types *[Project Browser > Families > Ducts > Rectangular Duct]* and *[Project Browser > Families > Ducts > Round Duct]*. Control the Type Properties by right clicking a Duct Type from the list.
• Control the Flex Duct Types *[Project Browser > Families > Flex Ducts > Flex Duct Rectangular]* and *[Project Browser > Families > Flex Ducts > Flex Duct Round]*. Control the Type Properties by right clicking a Flex Duct Type from the list.
• Control the Duct Insulation Types *[Project Browser > Families > Duct Insulations > Duct Insulation]*. Control the Type Properties by right clicking a Duct Insulation Type from the list.
</td></tr>
<tr><td>[2.18n.0]</td><td>/</td><td><u>Placement of indoor Air Terminals</u>: The necessary Air Terminals for freecooling supply air, transfer air and mechanical supply and extract air are placed in the ventilation model. They should provide enough air change for every Space.</td></tr>
<tr><td colspan="3">

• <u>General note</u>: an Air Terminal will only appear in Space Schedules if it is located inside a Space, what means that the Room Calculation Point must be located inside a Space. The location of this point can be controlled by selecting an Air Terminal in any View.
</td></tr>
<tr><td>[2.19n.0]</td><td>/</td><td><u>Placement of AHU's</u>: When all indoor Air Terminals are modeled, the AHU can be placed in the model. After placement, the AHU parameters can be filled in.</td></tr>
<tr><td colspan="3">

• Go to a Floor Plan View of the Sub-Category 'Ventilation – Work Views'
• Select the correct AHU *[Systems* tab > *Mechanical Equipment]* and place it in the Floor Plan View
• Change the side of the Clearance zone ('CN_Clearance Zone Left' or 'CN_Clearance Zone Right') and try to locate the AHU in such a way that it does not interfere with a Wall or other element.
• Enter the AHU name ('CN_V_AHU Name'). It is possible to control in the Schedule 'Work – V_Duct Systems AHU Name' if the correct Duct Systems are connected to this AHU. Both values for 'CN_V_AHU Name' should match.
</td></tr>
<tr><td>[2.20n.0]</td><td>/</td><td><u>Duct routing</u>: Two duct routing methods are explained: the manual and the semi-automatic method. The last method is not discussed in detail, because it has little practical use. Ducts will connect the indoor Air Terminals with the AHU. When this is done, the total The other Ducts will be modeled starting from the Outdoor Air and Exhaust Air Connectors of the indoor AHU towards the location of the still unplaced outside Air Terminals. The roof extractor AHU only has a Connector for 'Extract Air'. When the Ducts are modeled, the Duct Insulation is added.</td></tr>
<tr><td>[2.21n.0]</td><td>/</td><td><u>Controlling Duct Systems</u>: The Duct Systems used in the project are controlled for unconnected parts of the same Duct System. At the same time, it is possible to check if there are open Duct Connectors from unassigned Mechanical Equipment, Air Terminals, Ducts, Duct Fittings and Duct Accessory.</td></tr>
</table>

<table>
<tr><td colspan="3">• Control via the System Browser of all Air Terminals and Mechanical Equipment (AHU) are connected to the correct Duct System [View tab > Windows > User Interface > System Browser].
• Control in each Floor Plan View of the Sub-Category ‘Ventilation – Work Views’ if there are any Ducts Systems with parts that are not connected [Analyze tab > Check Systems > Check Duct Systems]. Switch off the Check Duct Systems tool when everything is controlled.
• Control in each Floor Plan View of the Sub-Category ‘Ventilation – Work Views’ if there are any Ducts, Duct Fittings, Duct Accessory or Mechanical Equipment elements with open Duct Connectors [Analyze tab > Check Systems > Show Disconnects > Duct]. The last check should be in the ‘3D – Vent – Work View’ of the same Sub-Category. Switch off the Show Disconnects tool when everything is controlled.
• Check if there are still any warnings that are unsolved [Manage tab > Inquiry > Review Warnings]. Each Air Terminal should have a pressure loss defined</td></tr>
<tr><td>[2.22n.0]</td><td>/</td><td><u>Duct Sizing:</u> The Duct runs of all Duct Systems are sized be limiting the linear pressure loss per meter to 1 Pa/m and the duct air velocity according to the demands regarding ventilation noise of each Space (2, 4 or 6 m/s).</td></tr>
<tr><td>[2.23n.0]</td><td>/</td><td><u>Placement of outdoor Air Terminals</u>: The outdoor Air Terminals (‘Outdoor Air’ and ‘Exhaust Air’ Duct Systems) can be placed directly on the sized Ducts that are modeled starting from the AHU.</td></tr>
<tr><td colspan="3">• Control the size of the Ducts leaving the AHU. Check if the Air Terminal grille has the same Duct Connector size via its Type Properties. If not, make an extra Air Terminal Type with the correct Duct Connector size and change the name of the Type accordingly.
• Open the 3D View of the Sub-Category ‘Ventilation – Work Views’ and select the correct Air Terminal [Systems tab > HVAC > Air Terminal]
• Place the outdoor or exhaust Air Terminal on the Duct by hovering over the Duct end while tapping the spacebar until the Air Terminal is rotated in the correct position.
• In the case of a grille that is located in a Wall, move the Air Terminal that is connected to the Duct towards the Wall Face and do this in a Floor Plan View. The Air Terminal is well connected if the Duct moves along.</td></tr>
<tr><td>[2.24n.0]</td><td>/</td><td><u>System Inspector</u>: Correct connected and sized Duct Systems can be analyzed via the System Inspector (flow direction, flow, critical path, pressure). All local pressure losses must be correctly defined before this tool becomes useful.</td></tr>
<tr><td colspan="3">• Select a piece of correctly connected and sized ductwork and open the System Inspector tool [Modify | Multi-Select tab > Analysis > System Inspector].
• Select ‘Inspect’ of the floating System Inspector ribbon and move over the Ducts, Air Terminals and Mechanical Equipment to get information. Close to tool by selecting ‘Finish’ or ‘Cancel’.</td></tr>
</table>

<table>
<tr><td>[2.25n.0]</td><td>/</td><td><u>Interference Check</u>: It is possible to control if there are any unwanted geometric interferences between 175pdate175ctture elements from the Linked model and the ventilation related elements. It can also be used to control interferences between ventilation related objects.</td></tr>
<tr><td colspan="3">

- Open the *Interference Check* dialog [Collaborate tab > Coordinate > Interference Check > Run Interference Check]
- Select the elements that should be checked from the ventilation model or the Linked model and click on 'OK'.
- The Interference Report opens directly. Each listed interference can be investigated.

</td></tr>
<tr><td>[2.7a.0]</td><td><u>Preliminary ventilation Revit model</u>: At the end of this task, the ventilation model is finished for the preliminary design phase. (data type: '.rvt' Revit model)
<u>Ventilation plans</u>: The plans can be exported to '.pdf' or printed. These plans are typically Floor Plans with the ventilation related elements visible. (data types: '.pdf' or printed plan documents)</td><td><u>Generating ventilation plans</u>: This task is a modified version of the existing pre-BIM task where ventilation drawings are made in CAD software. The drawings are Views of one central model. It is possible to add annotation elements to the Views that will be exported to '.pdf' or printed. The Views can be placed on prepared Sheets.</td></tr>
<tr><td>[2.26n.0]</td><td><u>Prepared CAD underlay</u>:
see [2.10n.0]
<u>Architecture Revit model</u>: The architecture model that is updated during this task. (data type: '.rvt' Revit model)</td><td><u>Update architecture model</u>: By changing the visibility options of the Linked underlay '.dwg' plan documents and the existing architecture elements in Revit, it is possible to quickly modify the 175pdate175ctture model according to the new 175pdate175ctture design.</td></tr>
<tr><td>[2.27n.0]</td><td>/</td><td><u>Update ventilation model</u>: The updated architecture model is reloaded and replaces the first architecture model. The old model is Linked separately to make it easier to compare between the two versions. When this is done, the normal model workflow can be followed again.</td></tr>
<tr><th colspan="3">Architecture Revit model [2.11n.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[2.11n.1]</td><td><u>Revit architecture template</u>: see [2.11n.0]</td><td><u>Starting Revit architecture model</u></td></tr>
<tr><td colspan="3">

- Start a new Revit project file by opening 'CN_Template Architecture.rte'

</td></tr>
<tr><td>[2.12n.1]</td><td><u>Prepared CAD underlay</u>: see [2.11n.0]</td><td><u>Linking CAD underlay</u></td></tr>
<tr><td colspan="3">

- Link the '.dwg' file containing the ground floor plan, in the architecture model while the corresponding Floor Plan View is open in Revit *[Insert* tab > *Link* > *Link CAD]*.
    - In the dialog window, choose the following settings:

</td></tr>
</table>

  - Current view only: off
  - Colors: Preserve
  - Layers: All
  - Import units: fill in manually
  - Correct lines that are slightly off axis: off
  - Positioning: Auto – Origin to Origin
  - Place at: corresponding level
  - Orient to View: on
 - Leave the Linked CAD drawing pinned, so it cannot be moved accidently.
- Model the Gridlines according to the ones of the architecture drawing *[Architecture tab > Datum > Grid]*.
- Model the outer Walls of the building *[Architecture tab > Build > Walls]*.
- Use the Walls from the last step to place extra Elevation Views in the floor plan if necessary *[View tab > Create > Elevation > Elevation]*. When the Elevation symbol is moved near a Revit Wall, the Elevation view will rotate towards this Wall.
- Make Section Views in the same Floor Plan View where needed *[View tab > Create > Section]*.
- Link an elevation or section '.dwg' drawing in the project while the correct Elevation/Section View is active *[Insert* tab *> Link > Link CAD]*. Use the same settings as the Linked '.dwg' floor plans. The Linked drawing should be unpinned *[Modify | "Linked CAD file name" tab > Modify > Unpin]*.
- Move the Linked elevation/section CAD file horizontally, by using the Gridlines *[Modify | "Linked CAD file name" tab > Modify > Move]*. Align the Linked drawing vertically to the ground Level *[Modify | "Linked CAD file name" tab > Modify > Align]*. Pin the Linked drawing. Repeat these last two steps for every elevation and section.
- Go to an Elevation/Section View, and align the other Revit Levels to the levels that are drawn by the architect in the '.dwg' elevation/section. Change the names of the Revit Levels so they correspond with the names of the levels drawn by the architect. Add extra Levels (and their corresponding Views) if needed *[Architecture tab > Datum > Level]*.
- Link the other floor plans and roof plan '.dwg' drawings, after setting the corresponding Floor Plan View active. Use the same settings as for the ground floor plan.
- In each View, the linked CAD files that should not appear, can turned off to keep the Views clear *[View tab > Graphics > Visibility/Graphics > Imported Categories]*. In the same tab, it is possible to use different line colors for the different layers in the '.dwg' file.

[2.13n.1]	Revit architecture model: see [2.11n.0]	Modeling architectural elements

- Make a simple architecture model, using the provided Revit Walls, Floors, Roofs, Ceilings, Stairs, elevators (Generic Models), Windows (two types: normal and Skylight) and Doors. If necessary, the Topography can be modeled to. See appendix 6 and 7 for more details about the prepared System and Loadable Families.
- If the location of beams and columns is known, model them in Floor Plan Views

- *[Structure* tab > *Structure* > *Beam*]. If the beam does not appear after modeling, try to check its instance parameter 'CN_Length Invisible Height'. The lowest point of this invisible line should be under the Cut Plane of the Floor Plan View, so the hidden lines of the above beams will appear. If the beam-ends are not on the same height, the hidden lines marking the location of the beam will not appear.
- Make shaft openings (elevator and building systems) according the proposal of the architect by drawing the borders in the lowest floor plan *[Architecture tab > Opening > Shaft]*. Adjust the Top Constraint to the top level of the shaft. Shaft annotation can be added *[Modify | Shaft Openings* tab > *Edit Sketch > Symbolic Line]* and they will appear in every Floor Plan View. Do not add annotation for the elevator shaft, because these are already included in the elevator Family.
- Adjust the following parameters:
  - Walls, Floors, Ceilings, Roofs: 'Room Bounding' (by default 'Yes')
  - Walls, Floors and Roofs: 'CN_Wall Fire Resistance (R)EI'/'CN_Floor Fire Resistance REI'/'CN_Roof Fire Resistance REI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing'. This can be done in the Schedules 'Work – Walls', 'Work – Floors' and 'Work – Roofs'.
  - Some Walls, Floors, Ceilings and Roofs that are first drawn as one, will need to be separated in two or more elements, so different values for the above parameters can be set:
    - Walls: *[Modify |Walls tab > Mode > Edit Profile]* and *[Modify |Walls tab > Modify > Split Element]*
    - Floors: *[Modify |Floors tab > Mode > Edit Boundary]*
    - Ceilings: *[Modify |Ceilings tab > Mode > Edit Boundary]*
    - Roofs: [*Modify |Roofs tab > Mode > Edit Footprint]*
  - Do not draw Room or Space Separation Lines as this can be done later in the ventilation model. Control the built-in 'Room Bounding' parameter and let the Dynamo graph 'Tool – Room Bounding' copy the values to the custom parameter 'CN_Room Bounding', which is used in the prepared View Filter 'Not Room Bounding' to give those elements that are not room bounding a blue color fill.
- Save the architecture model and close the file.

Creating Revit Spaces [2.15n.0] and [3.13n.0]		
Task code	Exchange requirements	Task explanation
[2.15n.1]	/	Draw Space Separation Lines

- Place Space Separator Lines around elevator Instances and, if necessary, in Spaces *[Analyze* tab > *Spaces & Zones* > *Space Separator]*

Task code	Exchange requirements	Task explanation
[2.15n.2]	/	Automatic generation of Spaces

- Go to each Level Floor Plan View and generate Spaces *[Analyze* tab > *Spaces & Zones > Space]*
  - Set the right values in the Option Bar: Upper Limit to the next Level and the Offset to 0.
  - Generate the Spaces *[Modify | Place Space* tab > *Place Spaces Automatically]*

<table>
<tr><td colspan="3">• If the crosshairs of the Spaces are not within the floor area, they should be moved until they are in the correct location. (this can occur for L-shaped Spaces, as Revit automatically places them in the geometric center, which can be located outside the floor area).</td></tr>
<tr><td>[2.15n.3]</td><td>/</td><td><u>Control Space geometry</u></td></tr>
<tr><td colspan="3">• Control the Space geometry in Section Views or by exporting the model as an IFC file:
o *[R > Export > IFC > Export…]*
o Open a IFC Viewer (e.g. Solibri Model Viewer) and control the Spaces in 3D</td></tr>
<tr><td>[2.15n.4]</td><td>/</td><td><u>Remove unnecessary Spaces</u></td></tr>
<tr><td colspan="3">• Unnecessary Spaces can be found when controlling the Warning dialog *[Manage > Inquiry > Review Warnings]*
• Remove unnecessary Spaces (control the ‘Area’ field) in the warning dialog or in the Schedule ‘Work – Spaces_General’ *[Modify Schedule/Quantities* tab > *Rows > Delete]*:
o ‘Not Placed’ (Space is deleted, but not in a Space Schedule)
o ‘Not Enclosed’ (Space has not enough Room Boundaries)
o ‘Redundant Space’ (double Space)</td></tr>
<tr><td>[2.15n.5]</td><td>/</td><td><u>Tag Spaces</u></td></tr>
<tr><td colspan="3">• Tag Spaces in each Floor Plan View of the Sub-Category ‘Ventilation – Work Views’ *[Annotate* tab > *Tag > Tag All]* and select Category Space Tags.</td></tr>
<tr><td colspan="3">Air flow calculation per Space [2.16n.0] and [3.14n.0]</td></tr>
<tr><td>Task code</td><td>Exchange requirements</td><td>Task explanation</td></tr>
<tr><td>[2.16n.1]</td><td><u>Draft architecture plans and documents + Schedule of Requirements</u>: see [2.10n.0]</td><td><u>Setting Space parameters in Revit</u></td></tr>
<tr><td colspan="3">• Fill in the Space parameters via the following Space Schedules while the corresponding Floor Plan is opened:
o General notes:
▪ Cells with a light red fill should never be edited in Revit.
▪ Extra combinations regarding air quality control can be made, by adding new rows in the Key Schedule ‘Key – V_Air Quality Control’ *[Modify Schedule/Quantities > Rows > Insert Data Row]*
▪ Some parameter values can also be entered in the next phase in Excel, after the export via Dynamo (Excel columns with a red colored fill in the header).
▪ More information about each Space parameter can be found in appendix 5.
o Schedule ‘Work – Spaces General’:
▪ Fill in Space ‘Number’ and Space ‘Name’
▪ Control the Space Lower and Upper Boundaries; adapt them if necessary. This can also be done in Floor Plan Views via Properties or in Section Views, by moving the handles.
▪ Measure additional floor area that is not measured correctly by Revit for</td></tr>
</table>

each Space (e.g. stairwell). Draw Filled Regions in the Floor Plan Views *[Annotate tab > Region > Filled Region]* and control the 'Area' parameter of it. Add this value manually in 'CN_V_Additional Floor Area'. Simple formulas with numbers can be used (e.g. '=50+30'). This value can also be negative.

- Measure additional Volume that is not measured correctly by Revit for each Space (e.g. sloping Walls away from Space center). Add it to the parameter 'CN_V_Additional Volume'. Simple formulas with numbers can be used (e.g. '=50+30'). This value can also be negative.

- Schedule 'Work – V_Spaces General':
  - Choose the right Space type regarding ventilation via 'CN_V_Space Type'. This automatically sets the following parameters accordingly (not visible in this Schedule):
    - 'CN_V_Building Sector'
    - 'CN_V_AHU Name'
    - 'CN_V_D_Air Flow Per Floor Area ($m^3/(h.m^2)$)'
    - 'CN_V_D_Floor Area Per Person (m^2/pers)'
    - 'CN_V_Min Supply Air Quality'
    - 'CN_V_Extract Air Quality'
  - Set the following parameters:
    - 'CN_V_AHU Name'
    - 'CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers))'
    - 'CN_V_Max Air Velocity Day (m/s)'
    - 'CN_V_Max Air Velocity Night (m/s)'
    - 'CN_V_Smokers'
    - 'CN_V_IDA Class': Key parameter (Key Schedule: 'Key – V_IDA Class')
    - 'CN_V_Air Quality Control': Key parameter (Key Schedule: 'Key – V_Air Quality Control')
- Schedule 'Work – V_Spaces Occupancy':
  - Set the following parameters:
    - 'CN_V_D_#Occupants'
    - 'CN_V_D_#Employees'
    - 'CN_V_D_#Toilets'
    - 'CN_V_D_#Showers'
- Schedule 'Work – V_Special Spaces':
  - Set the following parameters:
    - 'CN_V_Special Space'
    - 'CN_V_D_Special Space Air Flow (m^3/h)'
- Schedule 'Work – V_Spaces Freecooling':
  - Set the following parameters:
    - 'CN_V_Freecooling Day'
    - 'CN_V_D_Freecooling Day Air Change (1/h)'

    - ‘CN_V_Freecooling Night’
    - ‘CN_V_D_Freecooling Night Air Change (1/h)’
- Schedule ‘Work – V_Spaces Heating And Cooling With Air’:
  - Set the following parameters:
    - ‘CN_V_Heating With Air’
    - ‘CN_V_D_Heating Air Flow (m^3/h)’
    - ‘CN_V_Cooling With Air’
    - ‘CN_V_D_Cooling Air Flow (m^3/h)’
- Schedule ‘Work – V_Spaces Comments’:
  - Add information to the ‘Comments’ parameter if necessary

[2.16n.2]	<u>Empty copy of ‘Ventilation Flow Rates Calculation’</u>: see [2.16n.0]	<u>Dynamo export from Revit to Excel</u>

- Make a copy of ‘Ventilation Flow Rates Calculation.xlsx’
- Start Dynamo *[Add-Ins* tab > *Visual Programming* > *Dynamo 0.9]*
- Click on ‘Open’ and select the graph ‘Tool – Link Revit-Excel.dyn’
- Control if Dynamo is set to run ‘Manual’ instead of ‘Automatic’, by checking the lower left corner.
- Go to the first input named ‘File Path’. Click on ‘Browse’ and select the copy of the Excel file ‘Ventilation Flow Rates Calculation.xlsx’
- Set the second input ‘Boolean’ to ‘True’
- Click on ‘Run’ in the lower left corner of the screen.
- The Excel file should open automatically. Check if the export is complete by checking the ‘IMPORT’ worksheet in Excel.
- Check in Dynamo if the export was OK: The highest ‘Watch’ node should display a list.
- Sometimes, the link between Dynamo and the Excel file can be broken (e.g. if between two exports from Revit the open Excel file has been edited). It is advisable to check if a changed value in Revit also changed in Excel after a second export. If not, go again to the File Path node and reselect the Excel file again. Run the graph again to export the data from Revit to Excel.
  - If this does not solve the problem, close Dynamo and Excel. Reopen Dynamo again and select the correct File Path for the Excel file. Run the graph again.

[2.16n.3]	/	<u>Setting Space parameters in Excel</u>

Add all necessary values to the parameter values that are not entered in Revit in the ‘IMPORT’ Excel sheet:

- <u>Note</u>: Change only the values of parameters with a red colored cell in the header. Parameters with a blue cell in the header are only for reading values from Revit and should not be changed.
- The rows with Space parameters can be sorted in Excel. Select each time the whole row to make sure that no data is mixed.

[2.16n.4]	<u>Completed copy of ‘Ventilation Flow Rates Calculation’</u>: see [2.16n.0]	<u>Air flow calculations in Excel</u>

Control the values in the 'CALCULATIONS' Excel sheet:

- <u>Note</u>: This worksheet is locked (without password) to prevent users from accidently changing values.
- Add layout to the Excel cells, columns and rows if necessary.
- Add conditional formatting in Excel if necessary.
- Control the calculated parameters (parameters with a green cell in the header)

[2.16n.5]	/	<u>Dynamo export from Excel to Revit</u>

Export the Space parameters back to Revit by using the same Dynamo graph:

- <u>Note</u>: The worksheet 'EXPORT' is locked (without password) to prevent users from accidently changing values. Dynamo will read the data from this sheet, that is linked to the cells of the 'CALCULATION' sheet.
- Save the Excel file.
- Go back to Dynamo and switch the 'Boolean' input node to 'False'
- Click on 'Run' in the lower left corner of the screen.
- Sometimes, the link between Dynamo and the Excel file can be broken (e.g. if between two exports from Excel the open Revit project has been edited).
    - Because this is not directly visible in Dynamo, it is advisable to check if a changed value in Excel also changed in Revit after a second export. If not, go again to the File Path node and reselect the Excel file again. Run the graph again to export the data from Revit to Excel.
    - If this does not solve the problem, close Dynamo and Excel. Reopen Dynamo and select the correct File Path for the Excel file. Run the graph.

Placement of indoor Air Terminals [2.18n.0] and [3.16n.0]

Task code	Exchange requirements	Task explanation
[2.18n.1]	/	<u>Freecooling supply Air Terminals</u>

- Place the supply Air Terminals for freecooling ('CN_V_Freecooling Air Supply – Face Linked Window') in a Mechanical Floor Plan View. Place the Air Terminal on the Face of the Window from the Linked architecture model.
- Go to a parallel Section View and adjust the size of the Air Terminal to the size of the Window.
- Enter the actual air flow values for freecooling in the Schedule 'Work – V_Spaces Actual Air Flows – Not Checked'

[2.18n.2]	/	<u>Control dimensions of Air Terminals for freecooling</u>

- Control the following settings:
    - 'CN_Single Awning' or 'CN_Single Hopper': Window type (also in Family Type name)
    - 'CN_Window Angle': Window opening angle (also in Family Type name)
    - 'CN_Outdoor Wind Speed': value used for calculation of the maximum air flow (also in Family Type name)
- Control in Schedule 'Control – V_Air Terminals Freecooling' if the actual air flow per Air Terminal is lower than the maximum possible air flow.

[2.18n.3]	/	<u>Control Reference Planes</u>

- Go to the View ‘Front – Vent – Reference Planes’ under the Sub-Category ‘Ventilation – Reference Planes’.
- Move the existing Reference Planes if needed
- Make new Reference Planes if necessary *[Architecture* tab > *Work Plane* > *Ref Plane]*
  - Draw the Reference Planes from left to right for Air Terminals located in against the ceiling of the Space. Draw them from right to left for Air Terminals located in the floor of the Space.
  - Give the Reference Plane a name via its Properties: ‘RP_Level xx_Air Terminals – description’
- Place dimension lines between each Reference Plane and the Level below it *[Annotate* tab > *Dimension* > *Aligned]*

[2.18n.4]	/	Mechanical Air Terminals

- Go to a Floor Plan View of the Sub-Category ‘Ventilation – Work Views’ and select the correct mechanical Air Terminal *[Systems* tab > *HVAC* > *Air Terminal]*
- Select Place on Work Plane *[Modify | Place Air Terminal* tab > *Placement* > *Place on Work Plane]*
- Select Placement Plane and choose the right Reference Plane.

[2.18n.5]	/	Create Duct Systems

- Add all mechanical Air Terminals to the correct Duct System with the correct Duct System Type after selecting them *[Modify | Air Terminals* tab > *Create Systems]*.
- It is possible to change the Duct System Type later, but the Duct System Name will not change automatically. Because some View Filters and Schedules filter on this name that is based on the ‘Abbreviation’ parameter of the Duct System Type, it is very important to change the name if you change the Duct System Type.
- Every Duct System (except ‘Transfer Air’ Duct System Types) must have the ‘CN_V_AHU Name’ parameter filled in. This can be done in the Schedule ‘Work – V_Duct Systems AHU Name’.

[2.18n.6]	/	Color Fill Scheme and View Filter ETA

- Go to the Mechanical Floor Plan Views under the Sub-Category ‘Ventilation – Color Fill – ETA’. The Color Fill Scheme ‘ETA Classes’ and the View Filter ‘Spaces – Min Supply Air Quality’ are already active.
- Place a Color Fill Legend *[Analyze* tab > *Color Fill* > *Color Fill Legend]*.

[2.18n.7]	/	Air Terminals for transfer air

Place the Air Terminals for transfer air in the Floor Plan Views of the Sub-Category ‘Ventilation – Color Fill – ETA’:

- Transfer air grille and door gap:
  - Select the extract Air Terminal *[Systems* tab > *HVAC* > *Air Terminal]*
  - Select Place on Work Plane *[Modify | Place Air Terminal* tab > *Placement* > *Place on Work Plane]*

  - Select Placement Plane and choose the right Reference Plane. Place the element against a Wall or Door and place it in the correct orientation by tapping the spacebar.
  - Draw a piece of Duct starting from the extract Air Terminal through the Door or Wall.
  - Select the supply Air Terminal counterpart *[Systems* tab > *HVAC > Air Terminal]*
  - Place the supply Air Terminal on the Duct by hovering over the Duct end while tapping the spacebar until the Air Terminal is rotated in the correct position.
  - Move the supply Air Terminal that is connected to the Duct towards the Door or Wall Face. It is connected to the extract Air terminal if it moves along.
- Transfer air in open plan:
  - Select the extract Air Terminal *[Systems* tab > *HVAC > Air Terminal]*
  - Select Place on Work Plane *[Modify | Place Air Terminal* tab > *Placement > Place on Work Plane]*
  - Select Placement Plane and choose the right Reference Plane. Place the element against a Space Separation Line and place it in the correct orientation by tapping the spacebar. Make a Constraint between the Air Terminal and the Space Separation Line.
  - Draw a piece of Duct starting from the extract Air Terminal. The Air Terminal is now a part of a 'Transfer Air' Duct System (the View Filter recognizes it and colors the lines in fuchsia). Remove the Duct.
  - Select the supply Air Terminal counterpart *[Systems* tab > *HVAC > Air Terminal]*
  - Place the supply Air Terminal also perpendicular on the Space Separation Line, but not against the extract Air Terminal.
  - Select the supply Air Terminal and move it by selecting Connector (the start of the flow arrow). Place it above the Connector of the extract Air Terminal and a small purple square icon should appear around it. Both Air Terminals are now connected without Duct.

[2.18n.8]	/	Control transfer air flow

- Enter the air flow values for the extract Air Terminals in Schedule 'Work – V_Spaces Actual Air Flows – Not Checked'. The supply Air Terminals will receive the air flow value during the daytime from the connected extract Air Terminal, but the value during the nighttime must be copied manually. This last air flow value can be entered in Schedule 'Control – V_Air Terminals Transfer Air', where all Air Terminals are grouped in pairs.
- In the case of transfer air via a door gap: control the minimum door gap height in Schedule 'Control – V_Air Terminals Door Gap Height' after the air flow values are filled in.

<table>
<tr><td>[2.18n.9]</td><td>/</td><td><u>Control actual air flow per Space</u></td></tr>
<tr><td colspan="3">• Control if each Space receives enough air by checking the Schedule ‘Work – V_Spaces Actual Air Flows – Not Checked’. If this is enough and the air flows are balanced for the Space, the parameter ‘CN_V_Controlled Actual Air Flow’ can be</td></tr>
<tr><td colspan="3">• set to ‘Yes’. The Space is then removed from the Schedule and will appear in the Schedule ‘Work – V_Spaces Actual Air Flows – Checked’.</td></tr>
<tr><td>[2.18n.10]</td><td>/</td><td><u>Copy actual air flow per Space</u></td></tr>
<tr><td colspan="3">• In the Schedule ‘Work – V_Spaces Actual Air Flows – Checked’, the sum of the actual air flow values of the Air Terminals must be manually copied to the corresponding actual air flow parameters of the Space. These values will be shown by the Space Tags.
• If the necessary air flows would change (e.g. a new calculation is executed), it is possible to control if every Space still receives enough air in the Schedule ‘Control – V_Spaces Air Flow Summary’.</td></tr>
<tr><th colspan="3">Duct routing [2.20n.0] and [3.18n.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[2.20n.1]</td><td>/</td><td><u>Manual Duct routing</u></td></tr>
<tr><td colspan="3">• Model Ducts in a Mechanical Floor Plan View of the Sub-Category ‘Ventilation – Work Views’ and control the result in a 3D mechanical View of the same Sub-Category.
• Draw Ducts manually, starting from the mechanical Air Terminal.
    o Right click on a selected Air Terminal. Select ‘Draw Duct’ from the options to model a Duct that starts from the Air Terminal Connector. In this way, the Duct inherits the size and shape of the Connector, but also the Duct System where the Air Terminal is a part from.
• Draw Ducts manually, starting from the AHU
    o Right click on a selected Air Terminal. Select ‘Draw Duct’ from the options to model a Duct that starts from the Air Terminal Connector. In this way, the Duct inherits the size and shape of the Connector.
    o Select the correct Duct System Type for each Duct leaving a certain Connector. This is either Extract/Exhaust Air or Supply/Outdoor Air. This can be seen be controlling the AHU Connector Description or by zooming in on the AHU in a Floor Plan View and reading the text on both sides of the AHU.
• Make sure to connect the correct Duct System Type with the correct Connector of the AHU.</td></tr>
<tr><td>[2.20n.2]</td><td>/</td><td><u>Control Duct settings (Conversion)</u>: The semi-automatic Duct routing tool cannot be used in a lot of practical cases and is therefore not explained here.</td></tr>
<tr><td>[2.20n.3]</td><td>/</td><td><u>Semi-automatic Duct routing</u>: The semi-automatic Duct routing tool cannot be used in a lot of practical cases and is therefore not explained here.</td></tr>
</table>

<table>
<tr><td>[2.20n.4]</td><td>/</td><td>Manual adjustments: The semi-automatic Duct routing tool cannot be used in a lot of practical cases and is therefore not explained here.</td></tr>
<tr><td>[2.20n.5]</td><td>/</td><td>Add Duct Insulation</td></tr>
<tr><td colspan="3">Model the Duct Insulation by selecting the Ducts and Duct Fittings [Modify | Multi-Select tab > Duct Insulation > Add Insulation]. The Duct Accessory elements placed in the design phase, can also be insulated.</td></tr>
<tr><th colspan="3">Duct sizing [2.22n.0] and [3.21n.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[2.22n.1]</td><td>/</td><td>Switch all extract Air Terminals to ‘daytime’</td></tr>
<tr><td colspan="3">Activate the Schedule ‘Work – V_Air Terminals Switch Daytime’ and set the parameter ‘CN_Daytime’ to ‘Yes’ (black colored ticked box).</td></tr>
<tr><td>[2.22n.2]</td><td>/</td><td>Copy extract day air flow in AHU’s</td></tr>
<tr><td colspan="3">Copy for every AHU, the value of ‘CN_Mechanical AHU Extract Air Flow’ to ‘CN_Mechanical AHU Extract Day Air Flow’</td></tr>
<tr><td>[2.22n.3]</td><td>/</td><td>Duct sizing supply & extract Duct Systems (daytime)</td></tr>
<tr><td colspan="3">Open the Floor Plan Views of the Sub-Category ‘Ventilation – Color Fill – Duct Air Velocity’. The Color Scheme ‘Max Duct Air Velocity Day’ is already visible. Place a Color Fill Legend on each of the above Floor Plan Views [Analyze tab > Color Fill > Color Fill Legend] Divide long Ducts, that go through different Spaces with different limits to the duct air velocity, in smaller parts [Modify | Ducts tab > Modify > Split Element]. A union Duct Fitting will be placed automatically between the two parts, so they are still connected. Select a duct run (including Duct Fittings) that has maximum one open Connector towards away from the Air Terminals and that goes through one or more Spaces with the same limitation to the duct air velocity. Size the Ducts while they are selected [Modify | Multi-Select tab > Analysis > Duct/Pipe Sizing]. In the dialog window the ‘Friction’ must be set to 1 Pa/m and the ‘Velocity’ according to the limits of the Space(s). Select ‘Calculated Size Only’. If necessary, it is possible to restrict the height and/or the width of the selected duct run. Repeat this last step for every part of all Duct Systems (also ‘Outdoor Air’ and ‘Exhaust Air’ Duct Systems).</td></tr>
<tr><td>[2.22n.4]</td><td>/</td><td>Control duct air speed and friction of all Duct Systems (daytime)</td></tr>
<tr><td colspan="3">Control in Schedule ‘Control – V_Ducts Friction And Velocity’ if the friction is below 1 Pa/m for every Duct. The Schedule will flag all Ducts that have a Friction value that is higher than 1 Pa/m.
Control in the same Floor Plan Views visually if every Duct has a duct air velocity lower than the maximum allowed in each Space, by activating the Duct System Color Scheme ‘Duct Color Fill – Velocity’ [Floor Plan Properties > System Color Schemes > Ducts]. The vertical Ducts cannot be controlled in this way, and need to be controlled manually in 3D or Section Views, in combination with Schedule ‘Control – V_Ducts Friction And Velocity’.</td></tr>
</table>

[2.22n.5]	/	Switch all extract Air Terminals to 'nighttime'
• Open the Schedule 'Work – V_Air Terminals Switch Daytime' and set the parameter 'CN_Daytime' to 'No' (black colored non-ticked box).		
[2.22n.6]	/	Copy extract night air flow in AHU's
• Copy for every AHU, the value of 'CN_Mechanical AHU Extract Air Flow' to 'CN_Mechanical AHU Extract Night Air Flow'		
[2.22n.7]	/	Control duct air speed and friction of all Duct Systems (nighttime)
• Control in Schedule 'Control – V_Ducts Friction And Velocity' if the friction is below 1 Pa/m for every Duct. The Schedule will flag all Ducts that have a Friction value that is higher than 1 Pa/m. • Go back to the Floor Plan Views and change the Space Color Fill to 'Max Duct Air Velocity Night' *[Floor Plan Properties > Color Scheme > Category: Spaces > Max Duct Air Velocity Day]*. It is possible to turn off the 'Supply Air' and 'Outdoor Air' Duct Systems via the View Filters *[Visibility/Graphics Overrides > Filters]*. The vertical Ducts cannot be controlled in this way, and need to be controlled manually in 3D or Section Views, in combination with Schedule 'Control – V_Ducts Friction And Velocity'.		

Generating ventilation plans [2.7a.0] and [3.8a.0]		
Task code	Exchange requirements	Task explanation
[2.7a.1]	/	Annotating Views
• Open the Views of the Sub-Category 'Ventilation – Sheet Views' that will be printed or exported to '.pdf' • Annotate the Views if necessary: ○ Place dimensions *[Annotate* tab > *Dimension]* ○ Place text *[Annotate* tab > *Text]* ○ Place Revision Clouds: ▪ Make a new Revision *[View* tab > *Sheet Composition > Sheet Issues/Revisions]*. Add information about the Revision under 'Date' and 'Description'. ▪ Place the Revision Cloud in the View *[Annotate* tab > *Detail > Revision Cloud]* ▪ Assign the Revision Cloud to the correct Revision via the parameters of the Revision Cloud. Add some description in the 'Comments' parameter of the Revision Cloud. This last parameter can be shown on Views by selecting the Tag 'CN_Revision Cloud Tag' and Type 'Revision Number – Comments'. ○ Place Tags: ▪ Tag all elements or all elements of one Category that are visible in the View *[Annotate* tab > *Tag > Tag All]*. In the dialog window, the Loaded Tags and Tag Types that should be used, can be selected. ▪ Tag one element at a time by Category, according to the settings in the previous dialog window *[Annotate* tab > *Tag > Tag by Category]* ▪ Move the Tags to the right position if they would hide something else. ○ Place symbols [Annotate tab > Symbol]		

<table>
<tr><td>[2.7a.2]</td><td>/</td><td>Sheet settings</td></tr>
<tr><td colspan="3">Make new Sheets, if necessary [View tab > Sheet Composition > Sheet]. Select the correct titleblock (‘CN_Titleblock A0 metric’ or ‘CN_Titleblock A1 metric’)
Copy the Sheet parameters ‘CN_Sheet Size’, ‘CN_Sheet Discipline’ and ‘CN_Sheet Sub-Discipline’ manually from the existing Sheets.
Control the Revisions, Sheet settings and Project Information. This parameter values will appear automatically in the Titleblock.</td></tr>
<tr><td>[2.7a.3]</td><td>/</td><td>Move Views to Sheets</td></tr>
<tr><td colspan="3">Place the Views on the correct Sheets by dragging them from the Project Browser.</td></tr>
<tr><td>[2.7a.4]</td><td>Ventilation plans: see [2.7a.0]</td><td>Print Sheets</td></tr>
<tr><td colspan="3">Export the Sheets to ‘.pdf’ or print them [R > Print > Print]</td></tr>
<tr><th colspan="3">Update architecture model [2.26n.0] and [3.11n0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[2.26n.1]</td><td>Architecture Revit model: see [2.26n.1]</td><td>Open Revit architecture model</td></tr>
<tr><td colspan="3">In the ventilation model, go to the Elevation View ‘Front – Vent – Reference Planes’ of the Sub-Category ‘Ventilation – Reference Planes’ and lock all dimensions between the Reference Planes and the Levels below, by clicking on the Lock symbol (‘Create or remove a length or alignment constraint’).
Make a copy of the architecture model and rename so it is clear that this is the architecture model that will be updated.
Open the Revit architecture model that will be updated.</td></tr>
<tr><td>[2.26n.2]</td><td>Prepared CAD underlay: see [2.10n.1]</td><td>Reload Linked CAD underlay</td></tr>
<tr><td colspan="3">Reload the existing with the new ‘.dwg’ plan documents [Manage tab > Manage Project > Manage Links > CAD Formats > Reload From…]. Control if the new CAD sections and elevations of the architect are positioned on the same location.
Change the color of the important layers of the ‘.dwg’ files in the Floor Plan Views of the Sub-Category ‘Filter – Updated Architecture Elements’, to increase the visibility of the different layers [Visibility/Graphics Overrides > Imported Categories > FileName.dwg]</td></tr>
<tr><td>[2.26n.3]</td><td>Architecture Revit model: see [2.26n.1]</td><td>Modify existing architecture model</td></tr>
<tr><td colspan="3">Modify the existing architecture Revit elements (including Levels and Grids) and add or remove other Revit elements.
Control the built-in ‘Room Bounding’ parameter and let the Dynamo graph ‘Tool – Room Bounding’ copy the values to the custom parameter ‘CN_Room Bounding’ that is used by the View Filter ‘Not Room Bounding’.
If an element is in the right place and has the correct parameters, its parameter ‘CN_Updated Architecture Element’ can be changed to ‘Yes’. The updated elements now have a red color fill. An overview of all updated and non-updated elements can be found in the Schedule ‘Control – Multicategory – ‘CN_Updated Architecture Element’’. If the architecture model was already updated before, it is possible to reset the parameter ‘CN_Updated Architecture Elements’ for all elements via the Schedule ‘Work – Multicategory – Reset ‘CN_Updated Architecture Element’’.</td></tr>
</table>

<table>
<tr><th colspan="3">Update ventilation model [2.27n.0] and [3.12n.0]</th></tr>
<tr><td>Task code</td><td>Exchange requirements</td><td>Task explanation</td></tr>
<tr><td>[2.27n.1]</td><td><u>Architecture Revit model</u>: see [2.26n.1]</td><td><u>Reload updated architecture model + Link old architecture model</u></td></tr>
<tr><td colspan="3">Reload the existing architecture model with the new, updated one [Manage tab > Manage Project > Manage Links > Revit > Reload From…].
Link the old architecture model again, in the same dialog via ‘Add…’. Change the ‘Room Bounding’ Type parameter of both models to ‘No’.
Open Floor Plan Views of the Sub-Category ‘Coordination’ and change the visibility of the old architecture model to move it to the background [Visibility/Graphics Overrides > Revit Links > Underlay]</td></tr>
<tr><td>[2.26n.2]</td><td>/</td><td><u>Coordination Review</u></td></tr>
<tr><td colspan="3">If the Levels of the updated architecture model have been changed, Revit will show a Warning (‘Instance of link needs Coordination Review’) when the new architecture model is loaded.
Open the Coordination Review and select as Action ‘Move Level ‘LevelName’’ [Collaborate tab > Coordinate > Coordination Review > Select Link]. The Monitored Level of the ventilation model will now move to its new position.</td></tr>
<tr><td>[2.26n.3]</td><td>/</td><td><u>Workaround for bug related to random offset of Air Terminals</u></td></tr>
<tr><td colspan="3">The relative height of the Reference Planes above the lower Level will remain the same, because this dimension was locked during task [2.26n.0]. A strange bug makes that all Air Terminals get a random value for their ‘Offset’ parameter (offset from the Reference Plane). To reset this value, follow this workaround: Go to the 3D View of Sub-Category ‘Ventilation – Work Views’ and select all modeled elements by dragging a window. Filter the Ducts out [Modify | Multi-Select tab > Selection > Filter > Category: Ducts]. Move all Ducts one step to the front and one step back to reset the offset of the Air Terminals. This workaround works for most cases, but not always. It is considered good practice to control the Offset parameter of every Air Terminal. It is not possible to Schedule this built-in parameter, but it can be copied automatically with the Dynamo graph ‘Tool – Air Terminals Location.dyn’ to the custom parameter ‘CN_V_Offset From Face Or Level’. In the Schedule ‘Control – V_Air Terminals Location’ a list with all Air Terminals and their location is given. Note that if the element is Face-based hosted, the Offset is always the offset perpendicular on the Face.</td></tr>
<tr><td>[2.26n.4]</td><td>/</td><td><u>Control Face-based Air Terminals</u></td></tr>
<tr><td colspan="3">Control the location of the Air Terminals for freecooling that were Face-based hosted on Windows of the Linked architecture model. If the Window is moved in the 188pdateed model, the Air Terminal will move along. Update the size of the Air Terminal. All other ventilation elements are generic placed and will therefore stay at their initial position.</td></tr>
</table>

[2.26n.5]	/	Control Space Separation Lines	
• Control the location of the Space Separation Lines and make new ones if necessary.			
[2.26n.6]	/	Make updated architecture model Room Bounding	
• Change the Type parameter 'Room Bounding' of the updated architecture model to 'Yes'.			
Design [3.0.0]			
Task code	Exchange requirements	Task explanation	
[3.10n.0]	Architecture plans and documents + schedule of requirements: Final architecture plans and update of the schedule of requirements. (variable data types: '.dwg' plans, tables, text) Prepared CAD underlay: see [2.10n.0]	Preparing CAD underlay: see [2.10n.0]	
[3.11n.0]	Architecture Revit model: see [2.11n.0] Prepared CAD underlay: see [2.10n.0]	Update architecture model: see [2.26n.0]	
[3.12n.0]	Architecture Revit model: see [2.11n.0]	Update ventilation model: see [2.27n.0]	
[3.13n.0]	/	Creating Revit Spaces: see [2.15n.0]	
[3.14n.0]	/	Air flow calculation per Space: see [2.16n.0]	
[3.15n.0]	/	Ventilation related settings: see [2.17n.0]	
[3.16n.0]	/	Placement of indoor Air Terminals: see [2.18n.0]	
[3.17n.0]	/	Placement of AHU's: see [2.19n.0]	
[3.18n.0]	/	Duct routing: see [2.20n.0]	
[3.19n.0]	/	Placement of Duct Accessories: Silencers, fire valves, control valves, heating and/or cooling coils, cleaning covers, etc. can be placed when the Ducts are modeled.	
• Open a Floor Plan View of the Sub-Category 'Ventilation – Work Views'. • Select the correct Duct Accessory Family and load it in the Project *[Systems* tab > *HVAC > Duct Accessory > Load Family]*. Navigate to the out-of-the-box Revit library *[RVT 2016 > Libraries > Belgium > Duct > Accessories]* • Place the Duct Accessory element by moving it to the middle of a Duct • Normally, the Duct Accessory has also Duct Insulation if the Duct where it is placed in already has Duct Insulation. If not, Duct Insulation can be added *[Modify | Duct Accessories* tab > *Duct Insulation > Add Insulation]*			
[3.20n.0]	/	Controlling Duct Systems: see [2.21n.0]	
[3.21n.0]	/	Duct sizing: see [2.22n.0]	
[3.22n.0]	/	Placement of outdoor Air Terminals: see [2.23n.0]	
[3.23n.0]	/	System Inspector: see [2.24n.0]	
[3.24n.0]	/	Interference Check: see [2.25n.0]	
[3.25n.0]	Pressure Loss Report (data type: '.html' file)	Pressure Loss Report: When all local and linear pressure losses are defined correctly, it is possible to generate a Pressure Loss Report that gives an overview of all pressure losses of the selected Duct Systems.	

<table>
<tr><td colspan="3">

- Generate a Pressure Loss Report of the selected Duct Systems
    - *[Analyze* tab > *Reports & Schedules > Duct Pressure Loss Report]*
    - Select the Duct System(s)
    - Select the parameters that should be displayed in the report ('Report Fields')
    - Select Generate and study the exported Pressure Loss Report.

</td></tr>
<tr><td>[3.8a.0]</td><td>Ventilation plans: see [2.7a.0]
Ventilation control diagrams: Printed or exported Floor Plan Views that are modified to represent a ventilation control diagram (data types: '.pdf' or printed plan documents)
Ventilation Revit model: The final version of the ventilation model. (data type: '.rvt' Revit model)</td><td>Generating ventilation plans: see [2.7a.0]. Ventilation control diagrams can now be generated. Place all Floor Plan Views of the Sub-Category 'Ventilation – Control Diagram' on one Sheet (change the View Scales) and add annotation lines to show the connections between the different Floor Plans (duct shafts).</td></tr>
<tr><td colspan="3">

- Export or print the ventilation control diagrams:
    - Open the Floor Plan Views of the Sub-Category 'Ventilation – Control Diagram'
    - Add all necessary annotation elements to these Views (Tags, text, symbols and Revision Clouds) as described in task [2.7a.1]
    - Drop these Views on a Sheet and change the View Scale of the Floor Plan Views until they all fit the Sheet.
    - Add annotation lines on the Sheet to display the connections between the different Floor Plans (the duct shafts).
    - Print or export the Sheets as described in task [2.7a.4]

</td></tr>
<tr><th colspan="3">Generating ventilation plans [3.8a.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[3.8a.1]</td><td>/</td><td>Annotating Views: see [2.7a.1]. Also Floor Plan Views of the Sub-Category 'Ventilation – Control Diagram' can be annotated. Add for example annotation lines to connect the different control diagrams of each Floor Plan.</td></tr>
<tr><td>[3.8a.2]</td><td>/</td><td>Sheet settings: see [2.7a.2]</td></tr>
<tr><td>[3.8a.3]</td><td>/</td><td>Moving Views to Sheets: see [2.7a.3]. It is possible that the View Scale of the Views that represent the control diagrams must be changed in order to get every View on a Sheet.</td></tr>
<tr><td>[3.8a.4]</td><td>Ventilation plans: see [2.7a.0]</td><td>Print Sheets containing normal plans: see [2.7a.4]</td></tr>
<tr><td>[3.8a.5]</td><td>Ventilation control diagrams: see [3.8a.0]</td><td>Print Sheets containing ventilation control diagrams: similar as [2.7a.4]</td></tr>
<tr><th colspan="3">Call for tenders [4.0.0]</th></tr>
<tr><th>Task code</th><th>Exchange requirements</th><th>Task explanation</th></tr>
<tr><td>[4.2a.0]</td><td>Bill of materials: A final bill of materials is produced, based on the</td><td>Making design quantity survey: Seven Schedules contain all physical</td></tr>
</table>

	BoQ Schedules from the Revit model. (data type: Excel file)	ventilation-related objects that are placed in the model. The values listed in the Schedules can be manually entered in the complete bill of quantities file. It is also possible to export the Schedules as a CSV '.txt' file.

- Schedule 'BoQ – V_Air Terminals – Freecooling Supply Window'
  - This Schedule contains all 'CN_V_Freecooling Air Supply – Face Linked Window' Air Terminals that are placed in the model.
  - Information about the different dimensions of the Window (height, width, opening angle, opening area for the contractor) can be extracted.
- Schedule 'BoQ – V_Air Terminals – Mechanical'
  - This Schedule contains all mechanical Air Terminals that are placed in the model. They are sorted according to their Duct System, Air Terminal type ('CN_V_Air Terminal Type') and their Family Type.
- Schedule 'BoQ – V_Air Terminals – Transfer Air'
  - All door gaps and transfer air grilles are listed. Because these Air Terminals are modeled in pairs, but actually are one physical element, only the extract Air Terminals are listed in the Schedule.
  - Extra information such as door gap height and grille dimensions can be listed.
- Schedule 'BoQ – V_Duct Accessories'
  - All Duct Accessories that are part of a Duct System are listed and grouped per Duct System.
  - If the elements are insulated, the Duct Insulation Type and thickness can be extracted.
- Schedule 'BoQ – V_Duct Fittings'
  - Only Duct Fittings from the Duct System Types 'Supply Air', 'Extract Air', 'Outdoor Air' and 'Exhaust Air' are listed.
  - No Union Duct Fittings are measured. These are Duct Fittings that connect two identical Ducts that lie on a line.
  - The Duct Fittings are counted per Duct System and a grand total is given at the bottom of the list.
  - If the Duct Fittings are insulated, the Duct Insulation Type and thickness can be extracted.
- Schedule 'BoQ – V_Ducts'
  - Only Ducts from the Duct System Types 'Supply Air', 'Extract Air', 'Outdoor Air' and 'Exhaust Air' are listed.
  - The Ducts are sorted per Duct System.
  - If the Ducts are insulated, the Duct Insulation Type and thickness can be extracted.
- Schedule 'BoQ – V_Mechanical Equipment – AHU'
  - All AHU's that are prepared for this workflow are listed.

○ The maximum air flow values that pass through the AHU are shown ('CN_Mechanical AHU Outdoor Air Flow' and 'CN_Mechanical Exhaust Air Flow') ○ Additional information can be presented via parameter fields in the Schedule.		
[4.11a.0]	Completed copy of 'Ventilation Flow Rates Calculation': The Excel file that contains the final calculation data about the air flows per Space after task [3.14n.0]. (data type: Excel file) Changes to ventilation design: These documents contain the proposed solutions of the contractor for the remarks made by CENERGIE after the first control (data types: '.pdf' or '.dwg' drawings, tables, text)	Controlling ventilation design contractor: The Excel file with the calculations of the air flows per Space can be used to control the design of the contractor. The model can be used to quickly verify possible coordination issues in 3D (e.g. structural walls or beams in combination with ventilation ductwork). Alternative designs proposed by the contractor can be studied by using the BIM model that was made by CENERGIE during phase [2.0.0] and [3.0.0]
Construction [5.0.0]		

Appendix 5. Documentation of Revit template 'CN_Template Ventilation'

Parameter code legend		
How is the parameter entered?		
M	Manually	
A	Automatically by Revit (direct or via Key parameter)	
C	Calculated by Revit (only loaded Families)	
IV	Invisible parameter	
CE	Calculated in Excel (calculation) and entered via Dynamo	
D	Dynamo copied parameter	
Template Name		
CN_Template Ventilation.rte		
Base Template		
Mechanical-Default_Metric.rte	Source: Out-of-the-box Revit library: RVT 2016 > Templates > Belgium	
Starting View		
00 - Coord		
Project Units		
Discipline: HVAC	All calculations by Revit are executed with non-rounded values	
Air Flow	m³/h instead of l/s	
Dynamic Viscosity	8 digits after the decimal mark	
Decimal Symbol/Digit Grouping	123 456 789,00	
Power	kW instead of W, 2 digits after the decimal mark	
Slope	Decimal degrees instead of percentage	
Mechanical Settings		
Hidden Line		
Hidden Line	Draw MEP Hidden Lines	Yes
	Line Style	MEP Hidden
Duct Settings		
Duct Settings: Duct Settings	Air Density	1,204 kg/m³
	Air Dynamic Viscosity	Air Kinetic Viscosity x Air Density = 1,5.10-5 m²/s x 1,2040 kg/m³ = 0,00001806 Pa.s
Duct Settings: Angles	Use Specific Angles	90° / 60° / 45° / 30°
Duct Settings: Conversion (Supply Air & Exhaust Air)	Main: Duct Type	Round Duct : Taps / Short Radius
	Main: Offset	2750
	Branch: Duct Type	Round Duct : Taps / Short Radius
	Branch: Offset	2750
	Branch: Flex Duct Type	Flex Duct Round : Flex - Round
	Branch: Maximum Flex Duct Length	1000
Duct Settings: Rectangular	Used in Size Lists	100 / 150 / 200 / 250 / 300 / 400 / 500 / 600 / 800 / 1000 / 1200 / 1400 / 1600 / 1800 / 2000 mm
	Used in Sizing	150 / 200 / 250 / 300 / 400 / 500 / 600 / 800 / 1000 / 1200 / 1400 / 1600 / 1800 / 2000 mm
Duct Settings: Round	Used in Size Lists	80 / 100 / 125 / 150 / 160 / 200 / 250 / 300 / 315 / 355 / 400 / 450 / 500 / 560 / 630 / 710 / 800 / 900 / 1000 / 1120 / 1250 mm
	Used in Sizing	80 / 100 / 125 / 160 / 200 / 250 / 315 / 400 / 500 / 630 / 800 / 1000 / 1250 mm
Duct Settings: Calculation	Calculation Method	Colebrook Equation
Levels		
Level 00		
Elevation: 0 mm		
Building Story	Yes	
Reference Planes	Elevation: 400 mm	Name: RP_Level 00_Air Terminals - Transfer Air
	Elevation: 3000 mm	Name: RP_Level 00_Air Terminals - Ceiling
Level 10		
Elevation: 4000 mm		
Building Story	Yes	
Reference Planes	Elevation: 4400 mm	Name: RP_Level 10_Air Terminals - Transfer Air
	Elevation: 7000 mm	Name: RP_Level 10_Air Terminals - Ceiling
Level 20		
Elevation: 8000 mm		
Building Story	Yes	
Reference Planes	Elevation: 8400 mm	Name: RP_Level 20_Air Terminals - Transfer Air
	Elevation: 11000 mm	Name: RP_Level 20_Air Terminals - Ceiling
Level 30		
Elevation: 12000 mm		
Building Story	Yes	
Reference Planes	Elevation: 12400 mm	Name: RP_Level 30_Air Terminals - Transfer Air
	Elevation: 15000 mm	Name: RP_Level 30_Air Terminals - Ceiling
Level 40 Roof		
Elevation: 16000 mm		
Building Story	No	
Roof Overview		
Elevation: 22000		
Building Story	No	
Project Browser (Browser Organization)		
Views		
Discipline > Sub-Discipline > Family and Type (Floor Plans > Ceiling Plans > 3D Views > Elevations (Building Elevation) > Section) > View Name		
Schedules/Quantities		
Not possible (alphabetic order)		
Sheets		
CN_Sheet Discipline > CN_Sheet Sub-Discipline > CN_Sheet Size > Sheet Number		
Families		
Category > Family > Type		
System Browser (Browser Organization)		
View	Systems > Mechanical	
Revit System Families		
Category: Spaces	Family: Spaces	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type) - Parameter Data Type	Description

(continues)

Element UniqueID	(Not Visible) - IV - Built-In (Instance) - Element UniqueID	Used by Dynamo to assign the Space data in Excel back to the right Spaces.
Level	Constraints - A - Built-In (Instance) - Level	Level where the Space is located. Depends on the Floor Plan View where the Space is placed.
Area	Dimensions - A - Built-In (Instance) - Area	Area of the Space, measured at 'Calculation Height' (Level parameter)
Volume	Dimensions - A - Built-In (Instance) - Volume	Volume of the Space, measured between 'Level' with 'Base Offset' to 'Upper Limit' with 'Limit Offset'.
CN_V_Additional Floor Area	Dimensions - M - Project (Instance) - Area	Additional floor area per Space can contain for example horizontal areas of stairs, landings and above Floors in stairwells. This can be measured manually with Filled Regions (Detail Items) and needs to be entered manually in this parameter. It is also possible to add a negative correction to the Space 'Area' calculated by Revit.
CN_V_Additional Volume	Dimensions - M - Project (Instance) - Volume	Additional volume per Space. This parameter should be used if a correct Space volume in Revit is not possible. It is also possible to add a negative correction to the Space 'Volume' calculated by Revit.
Comments	Identity Data - M - Built-In (Instance) - Text	Extra information about calculation/values/... can be added here by the user.
Name	Identity Data - M - Built-In (Instance) - Text	Space name
Number	Identity Data - M - Built-In (Instance) - Text	Space number
CN_V_Air Quality Control	Identity Data - M - Key (Instance) - Key Value	The designer can choose how the air quality will be controlled according to NBN EN 13779. Extra combinations can be made by adding new rows in the Key Schedule 'Key - V_Air Quality Control'.
CN_V_IDA Class	Identity Data - M - Key (Instance) - Key Value	IDA class 1, 2 or 3 can be selected according to standard NBN EN 13779. This parameter has no influence on the parameter 'CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers))', but can be used in Excel to flag this parameter with conditional formatting if it does not meets the values of the IDA class. See Key Schedule 'Key - V_IDA Class'.
CN_V_Space Type	Identity Data - M - Key (Instance) - Key Value	Space type according to standard NBN EN 13779, needed for ventilation air flow calculations. A serie of parameters are dependent on this Key parameter (see Key Schedule 'Key - V_Space Type').
CN_V_Max Air Velocity Day (m/s)	Identity Data - M - Project (Instance) - Number	The maximum air speed in Ducts going through the Space during daytime. This value typically depends on the use of the Space and the ventilation noise limitations.
CN_V_Max Air Velocity Night (m/s)	Identity Data - M - Project (Instance) - Number	The maximum air speed in Ducts going through the Space during nighttime. This value typically depends on the use of the Space and the ventilation noise limitations.
CN_V_Cooling With Air	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected, the ventilation system is used for cooling of the Space (cooling battery)
CN_V_Freecooling Day	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected, there is freecooling during daytime, used to cool the Space.
CN_V_Freecooling Night	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected, there is freecooling during nighttime, used to cool the Space.
CN_V_Heating With Air	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected, the ventilation system is used for heating of the Space (cooling battery)
CN_V_Smokers	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected, smoking is allowed in this Space.
CN_V_Special Space	Identity Data - M - Project (Instance) - Yes/No	If 'Yes' is selected this Space is marked as a "special space" according to NBN EN 13779. Extra calculations can be necessary; the resulting air flow needs to be entered in 'CN_V_D_Special Space Air Flow (m^3/h)', besides normal calculation for hygienic ventilation.
CN_V_AHU Name	Identity Data - M - Shared (Instance) - Text	The name of the AHU that will bring air to this Space can be entered (early design phase). The same Shared Project parameter is also made active for Duct Systems and Mechanical Equipment (e.g. AHU).
CN_V_Building Sector	Identity Data - M/A (key) - Project (Instance) - Text	According to standard NBN EN 13779. Changes with key parameter 'CN_V_Space Type'.
CN_V_Extract Air Quality	Identity Data - M/A (key) - Project (Instance) - Text	Worst possible air quality after use in this Space (ETA Classes). According to standard NBN EN 13779. Changes with key parameter 'CN_V_Space Type'.
CN_V_Min Supply Air Quality	Identity Data - M/A (key) - Project (Instance) - Text	Minimum needed supply air quality (Outdoor Air or ETA Classes). According to standard NBN EN 13779. Changes with key parameter 'CN_V_Space Type'.
CN_Controlled Actual Air Flow	Mechanical-Flow - M - Project (Instance) - Yes/No	Parameter used in Schedules for actual air flow design. If the Space has enough air flow, the modeler can set this parameter from '(none)' or grey ticked box to 'Yes' (black ticked box) to mark it as ready.
CN_V_D_Actual Freecooling Supply Day Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of freecooling supply air flow during daytime
CN_V_D_Actual Freecooling Supply Night Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of freecooling supply air flow during nighttime
CN_V_D_Actual Mechanical Extract Day Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of mechanical extract air flow during daytime
CN_V_D_Actual Mechanical Extract Night Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of mechanical extract air flow during nighttime
CN_V_D_Actual Mechanical Supply Day Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of mechanical supply air flow during daytime
CN_V_D_Actual Mechanical Supply Night Air Flow (m^3/h)	Mechanical-Flow - M - Shared (Instance) - Number	This parameter can be used to store manually the total amount of mechanical supply air flow during nighttime
CN_V_R_Total Freecooling Supply Day Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter. Flow value calculated in Excel.
Excel formula: =**CN_V_D_Freecooling Day Air Change (1/h)*(Volume + CN_Additional Volume)**		
CN_V_R_Total Freecooling Supply Night Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter. Flow value calculated in Excel.
Excel formula: =**CN_V_D_Freecooling Night Air Change (1/h)*(Volume + CN_Additional Volume)**		
CN_V_R_Total Mechanical Extract Day Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter.
Excel formula: = Max('CN_V_R_Total Mechanical Supply Day Air Flow (m^3/h)' ; 'CN_V_R_Total Freecooling Supply Day Air Flow (m^3/h)')		
CN_V_R_Total Mechanical Extract Night Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter.
Excel formula: = Max('CN_V_R_Total Mechanical Supply Night Air Flow (m^3/h)' ; 'CN_V_R_Total Freecooling Supply Night Air Flow (m^3/h)')		
CN_V_R_Total Mechanical Supply Day Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter.
Excel formula: = MAX('CN_V_D_Cooling Air Flow (m^3/h)' ; 'CN_V_D_Heating Air Flow (m^3/h)' ; 'CN_V_R_Hygienic Air Flow (m^3/h)' ; 'CN_V_D_Special Space Air Flow (m^3/h)')		
CN_V_R_Total Mechanical Supply Night Air Flow (m^3/h)	Mechanical-Flow - CE - Project (Instance) - Number	Final result parameter. This parameter is equal to the maximum of 'CN_V_D_Heating Air Flow (m^3/h)' and 'CN_V_D_Special Air Flow (m^3/h)'. For complex buildings where there are different Spaces without and with occupation during the night, the following value is calculated as the maximum of 'CN_V_D_Special Air Flow (m^3/h)', 'CN_V_D_Heating Air Flow (m^3/h)', 'CN_V_D_Cooling Air Flow (m^3/h)' and 'CN_V_R_Hygienic Air Flow (m^3/h)'. This common exception is set for the following Space types: 'Cell, dayroom', 'Watch post', 'Bedroom' and 'Dormitory'. The user can change the used formula in Excel, if there would be a specific exception in the project.
Excel formula: =IF((OR('CN_V_Space Type'="Cell, dayroom" ; 'CN_V_Space Type'="Watch post" ; 'CN_V_Space Type'="Bedroom" ; 'CN_V_Space Type'="Dormitory")) ; MAX('CN_V_D_Special Air Flow (m^3/h)' ; 'CN_V_D_Heating Air Flow (m^3/h)' ; 'CN_V_D_Cooling Air Flow (m^3/h)' ; 'CN_V_R_Hygienic Air Flow (m^3/h)') ; MAX('CN_V_D_Heating Air Flow (m^3/h)' ; 'CN_V_D_Special Air Flow (m^3/h)'))		

CN_V_R_#Occupants	Other - CE - Project (Instance) - Integer	Number of occupants as maximum from the value entered by the design team and the calculated occupancy (including employees). This value is always rounded to the next integer.
Excel formula: =ROUNDUP(MAX(CN_V_D_#Occupants;IFERROR((Area+CN_V_Additional Floor Area)/CN_V_D_Floor Area Per Person (m^2/pers);0));0)		
CN_V_R_Hygienic Air Flow (m^3/h)	Other - CE - Project (Instance) - Number	Hygienic air flow of occupied or non-occupied spaces according to standard NBN EN 13779.
Excel formula: =MAX((Area+CN_V_Additional Floor Area)*CN_V_D_Air Flow Per Floor Area (m^3/(h.m^2));CN_V_D_#Toilets*25+CN_V_D_#Showers*50;IF(CN_V_Smokers=1;43*CN_V_R_#Occupants;IF(CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers))<=30;((CN_V_R_#Occupants-CN_V_D_#Employees)*CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers)))+(CN_V_D_#Employees*30);CN_V_R_#Occupants*CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers)))))		
CN_V_D_#Employees	Other - M - Project (Instance) - Integer	Number of employees as part of the total number of calculated occupants ('CN_V_R_#Occupants').
CN_V_D_#Occupants	Other - M - Project (Instance) - Integer	Number of occupants entered by design team (including employees).
CN_V_D_#Showers	Other - M - Project (Instance) - Integer	Number of showers in the Space.
CN_V_D_#Toilets	Other - M - Project (Instance) - Integer	Number of toilets (including urinals) in the Space.
CN_V_D_Cooling Air Flow (m^3/h)	Other - M - Project (Instance) - Number	Necessary air flow to cool the Space. This value is the result of calculations outside this described workflow and needs to be entered manually here.
CN_V_D_Freecooling Day Air Change (1/h)	Other - M - Project (Instance) - number	The design value for the air change for freecooling during the day. This value is typically the result of third party simulation software and needs to be entered manually here.
CN_V_D_Freecooling Night Air Change (1/h)	Other - M - Project (Instance) - number	The design value for the air change for freecooling during the night. This value is typically the result of third party simulation software and needs to be entered manually here.
CN_V_D_Heating Air Flow (m^3/h)	Other - M - Project (Instance) - Number	Necessary air flow to heat the Space. This value is the result of calculations outside this described workflow and needs to be entered manually here.
CN_V_D_Hygienic Air Flow Per Person (m^3/(h.pers))	Other - M - Project (Instance) - Number	Value for each person that is no employee if the value is lower than 30 m^3/(h.person). If the parameter value is higher, this value also counts for employees.
CN_V_D_Special Space Air Flow (m^3/h)	Other - M - Project (Instance) - Number	The calculated air flow for the 'special space' according to other standards. The result needs to be entered here manually.
CN_V_D_Air Flow Per Floor Area (m^3/(h.m^2))	Other - M/A (key) - Project (Instance) - Text	According to standard NBN EN 13779. Changes with key parameter 'CN_V_Space Type'.
CN_V_D_Floor Area Per Person (m^2/pers)	Other - M/A (key) - Project (Instance) - Text	According to standard NBN EN 13779. Changes with key parameter 'CN_V_Space Type'.
Category: Walls	Family: Basic Wall	
Type	CN_Generic Wall - 100 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Width	Construction - M - Built-In (Type, 100 mm) - Distance	The thickness of the Wall. This value can be changed by editing the 'Structure' parameter of the Wall Type.
CN_Wall Fire Resistance (R)EI	Identity Data - M - Key (Instance) - Text	Values to indicate the fire resistance characteristics of the Wall according to standard EN 13502-2.
CN_Bearing	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Wall is bearing.
CN_Fire Compartment Part	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Wall is part of a fire compartment.
CN_Thermal Insulation	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Wall is part of the building thermal insulation layer.
Structural Material	Material and Finished - M - Built-In (Type, Default Wall) - Material	The material of the Wall.
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
CN_Room Bounding	Constraints - D - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a Wall, Floor, Roof or Ceiling is Room Bounding of not. The built-in Revit parameter 'Room Bounding' cannot be used in Schedules and View Filters, so this value is copied with a Dynamo graph 'Tool - Room Bounding' to this parameter.
Type	CN_Generic Wall - 200 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type) - Parameter Data Type	Description
Width	Construction - M - Built-In (Type, 200 mm) - Distance	The thickness of the Wall. This value can be changed by editing the 'Structure' parameter of the Wall Type.
Type	CN_Generic Wall - 300 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type) - Parameter Data Type	Description
Width	Construction - M - Built-In (Type, 300 mm) - Distance	The thickness of the Wall. This value can be changed by editing the 'Structure' parameter of the Wall Type.
Category: Floors	Family: Floor	
Type	CN_Generic Floor - 300 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Default Thickness	Construction - M - Built-In (Type, 300 mm) - Distance	The thickness of the Floor. This value can be changed by editing the 'Structure' parameter of the Floor Type.
CN_Floor Fire Resistance REI	Identity Data - M - Key (Instance) - Text	Values to indicate the fire resistance characteristics of the Floor according to standard EN 13502-2.
CN_Bearing	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Floor is bearing (always 'Yes')
CN_Fire Compartment Part	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Floor is part of a fire compartment.
CN_Thermal Insulation	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Floor is part of the building thermal insulation layer.
Structural Material	Material and Finished - M - Built-In (Type, Default Floor) - Material	The material of the Floor.
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
CN_Room Bounding	Constraints - D - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a Wall, Floor, Roof or Ceiling is Room Bounding of not. The built-in Revit parameter 'Room Bounding' cannot be used in Schedules and View Filters, so this value is copied with a Dynamo graph 'Tool - Room Bounding' to this parameter.
Category: Stairs		
Type	CN_Generic Roof - 400 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.

Category: Roofs	Family: Basic Roof	
Type	CN_Generic Roof - 400 mm	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Default Thickness	Construction - M - Built-In (Type, 400 mm) - Distance	The thickness of the Roof. This value can be changed by editing the 'Structure' parameter of the Roof Type.
CN_Roof Fire Resistance REI	Identity Data - M - Key (Instance) - Text	Values to indicate the fire resistance characteristics of the Floor according to standard EN 13502-2.
CN_Bearing	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Roof is bearing (always 'Yes')
CN_Fire Compartment Part	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Roof is part of a fire compartment.
CN_Thermal Insulation	Identity Data - M/A (key) - Project (Instance) - Yes/No	Parameter to indicate if this Roof is part of the building thermal insulation layer.
Structural Material	Material and Finished - M - Built-In (Type, Default Roof) - Material	The material of the Roof.
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
CN_Room Bounding	Constraints - D - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a Wall, Floor, Roof or Ceiling is Room Bounding of not. The built-in Revit parameter 'Room Bounding' cannot be used in Schedules and View Filters, so this value is copied with a Dynamo graph 'Tool - Room Bounding' to this parameter.
Category: Ceilings	Family: Compound Ceiling	
Type	CN_Plain	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Thickness	Construction - M - Built-In (Type, 50 mm) - Distance	The thickness of the Ceiling. This value can be changed by editing the 'Structure' parameter of the Ceiling Type.
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
CN_Room Bounding	Constraints - D - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a Wall, Floor, Roof or Ceiling is Room Bounding of not. The built-in Revit parameter 'Room Bounding' cannot be used in Schedules and View Filters, so this value is copied with a Dynamo graph 'Tool - Room Bounding' to this parameter.
Category: Ducts	Family: Rectangular Ducts	
Type	Mittered Elbows / Taps	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Roughness	Construction - M - Built-In (Type, 0,09 mm) - Roughness	Parameter used by Revit to calculate the linear pressure losses per meter.
Routing Preferences: Union	Fittings - M - Built-In (Type, 'CN_V_Duct Fitting - Rectangular Union: Standard') - Family (Category: Duct Fittings)	This Family replaces the out-of-the-box Union, because this one has a parameter to 'CN_Union Not In BoQ' to make it possible to filter this Duct Fitting out of the bill of quantities.
Type	Mittered Elbows / Tees	
Type	Radius Elbows / Taps	
Type	Radius Elbows / Tees	
Category: Ducts	Family: Round Ducts	
Type	Taps	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Roughness	Construction - M - Built-In (Type, 0,09 mm) - Roughness	Parameter used by Revit to calculate the linear pressure losses per meter.
Routing Preferences: Union	Fittings - M - Built-In (Type, 'CN_V_Duct Fitting - Round Union: Standard') - Family (Category: Duct Fittings)	This Family replaces the out-of-the-box Union, because this one has a parameter to 'CN_Union Not In BoQ' to make it possible to filter this Duct Fitting out of the bill of quantities.
Type	Taps / Short Radius	
Type	Tees	
Category: Flex Ducts	Family: Flex Duct Rectangular	
Type	Flex - Rectangular	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Roughness	Construction - M - Built-In (Type, 0,09 mm) - Roughness	Parameter used by Revit to calculate the linear pressure losses per meter.
Fittings (Tee / Tap / Transition / Multi Shape Transition Rect to Round / Multi Shape Transition Rect to Oval / Multi Shape Transition Oval to Round / Union)	Fittings - M - Built-In (Type, all 'None') - Family (Category: Duct Fittings)	No Duct Fittings are filled in, so it is not possible to use flexible duct anywhere else except between a branch and an Air Terminal.
Category: Flex Ducts	Family: Flex Duct Round	
Type	Flex - Round	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Roughness	Construction - M - Built-In (Type, 0,09 mm) - Roughness	Parameter used by Revit to calculate the linear pressure losses per meter.
Fittings (Tee / Tap / Transition / Multi Shape Transition Rect to Round / Multi Shape Transition Rect to Oval / Multi Shape Transition Oval to Round / Union)	Fittings - M - Built-In (Type, all 'None') - Family (Category: Duct Fittings)	No Duct Fittings are filled in, so it is not possible to use flexible duct anywhere else except between a branch and an Air Terminal.
Category: Duct Systems	Family: Duct System	
Type	Exhaust Air	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Graphic Overrides	Graphics - M - Built-In (Type, Weight: No Override - Color: Brown - Pattern: No Override) - Line Graphics	Visual settings for the Lines according to NBN EN 13779:2010. View Filters can be used for changing View Settings of Surfaces.
Abbreviation	Identity Data - M - Built-In (Type, 'EHA -') - Text	This abbreviation will become the first part of the System Name and is based on standard NBN EN 13779: 2010.
CN_V_AHU Name	Identity Data - M - Shared (Instance) - Text	The name of the AHU. The same shared project parameter is also made active for Spaces and Mechanical Equipment (e.g. AHU)
System Classification	Mechanical - A - Built-In (Instance, 'Exhaust Air') - System Classification	This parameter cannot be changed. A new Duct System Type based on a different Duct System Classification can be made by duplicating an existing Ducst System Type from a certain Duct System Classification.
Calculations	Mechanical - M - Built-In (Type, 'All') - (Setting)	Flows and linear pressure losses are calculated. This can be changed temporarily to 'None' when working in complex MEP models to improve the model performance.

Type	Extract Air	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Graphic Overrides	Graphics - M - Built-In (Type, Weight: No Override - Color: (dark) Yellow - Pattern: No Override) - Line Graphics	Visual settings for the Lines according to NBN EN 13779:2010. View Filters can be used for changing View Settings of Surfaces.
Abbreviation	Identity Data - M - Built-In (Type, 'ETA -') - Text	This abbreviation will become the first part of the System Name and is based on standard NBN EN 13779: 2010.
System Classification	Mechanical - A - Built-In (Instance, 'Exhaust Air') - System Classification	This parameter cannot be changed. A new Duct System Type based on a different Duct System Classification can be made by duplicating an existing Ducst System Type from a certain Duct System Classification.
Type	Outdoor Air	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Graphic Overrides	Graphics - M - Built-In (Type, Weight: No Override - Color: Green - Pattern: No Override) - Line Graphics	Visual settings for the Lines according to NBN EN 13779:2010. View Filters can be used for changing View Settings of Surfaces.
Abbreviation	Identity Data - M - Built-In (Type, 'ODA -') - Text	This abbreviation will become the first part of the System Name and is based on standard NBN EN 13779: 2010.
System Classification	Mechanical - A - Built-In (Instance, 'Supply Air') - System Classification	This parameter cannot be changed. A new Duct System Type based on a different Duct System Classification can be made by duplicating an existing Ducst System Type from a certain Duct System Classification.
Type	Supply Air	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Graphic Overrides	Graphics - M - Built-In (Type, Weight: No Override - Color: Blue - Pattern: No Override) - Line Graphics	Visual settings for the Lines according to NBN EN 13779:2010. View Filters can be used for changing View Settings of Surfaces.
Abbreviation	Identity Data - M - Built-In (Type, 'SUP -') - Text	This abbreviation will become the first part of the System Name and is based on standard NBN EN 13779: 2010.
System Classification	Mechanical - A - Built-In (Instance, 'Supply Air') - System Classification	This parameter cannot be changed. A new Duct System Type based on a different Duct System Classification can be made by duplicating an existing Ducst System Type from a certain Duct System Classification.
Type	Transfer Air	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Graphic Overrides	Graphics - M - Built-In (Type, Weight: No Override - Color: Grey - Pattern: No Override) - Line Graphics	Visual settings for the Lines according to NBN EN 13779:2010. View Filters can be used for changing View Settings of Surfaces.
Abbreviation	Identity Data - M - Built-In (Type, 'TRA -') - Text	This abbreviation will become the first part of the System Name and is based on standard NBN EN 13779: 2010.
System Classification	Mechanical - A - Built-In (Instance, 'Return Air') - System Classification	This parameter cannot be changed. A new Duct System Type based on a different Duct System Classification can be made by duplicating an existing Ducst System Type from a certain Duct System Classification.

Loaded Families In Template

Category: Air Terminals	Family: CN_V_Freecooling Air Supply - Face Linked Window
Type	Single Awning Window - 20° Opening - 1 m/s
Type	Single Hopper Window - 20° Opening - 1 m/s
Category: Air Terminals	Family: CN_V_Mech Air Terminal Exhaust - Generic - Rectangular Face & Rectangular Horizontal Duct
Type	600x400 Duct
Type	1000x500 Duct
Category: Air Terminals	Family: CN_V_Mech Air Terminal Extract - RP Ceiling Or Floor - Square Face & Round Duct
Type	300x300 Face - Ø100 Duct
Type	375x375 Face - Ø125 Duct
Type	480x480 Face - Ø160 Duct
Type	480x480 Face - Ø160 Duct
Category: Air Terminals	Family: CN_V_Mech Air Terminal Outdoor - Generic - Rectangular Face & Rectangular Horizontal Duct
Type	600x400 Duct
Type	1000x500 Duct
Category: Air Terminals	Family: CN_V_Mech Air Terminal Supply - Generic (On Duct) - Curved Face & Round Duct
Type	252x102 Face - Ø250 Duct
Type	352x152 Face - Ø600 Duct
Type	452x252 Face - Ø1000 Duct
Category: Air Terminals	Family: CN_V_Mech Air Terminal Supply - Generic (On Duct) - Rectangular Face & Rectangular Duct
Type	252x102 Face - 210x60 Duct
Type	352x152 Face - 310x110 Duct
Type	452x102 Face - 410x60 Duct
Type	452x252 Face - 410x210 Duct
Category: Air Terminals	Family: CN_V_Mech Air Terminal Supply - RP Ceiling Or Floor - Square Face & Round Duct
Type	300x300 Face - Ø100 Duct
Type	375x375 Face - Ø125 Duct
Type	480x480 Face - Ø160 Duct
Type	600x600 Face - Ø200 Duct
Category: Air Terminals	Family: CN_V_Transfer Air Door Gap Extract - RP Transfer Air - Rectangular Duct
Type	(400x100 Duct) - 2 Pa - Door Gap 900x20
Type	(400x100 Duct) - 10 Pa - Door Gap 900x20
Category: Air Terminals	Family: CN_V_Transfer Air Door Gap Supply - Generic - Rectangular Duct
Type	(400x100 Duct)
Category: Air Terminals	Family: CN_V_Transfer Air Grille Extract - RP Transfer Air - Rectangular Face & Recangular Duct
Type	Acoustic - 400x100 Duct
Type	Normal - 400x100 Duct
Category: Air Terminals	Family: CN_V_Transfer Air Grille Supply - Generic - Rectangular Face & Recangular Duct
Type	400x100 Duct
Category: Air Terminals	Family: CN_V_Transfer Air Open Plan Extract - RP Transfer Air - Rectangular Duct
Type	(400x100 Duct)
Category: Annotation Symbols	Family: CN_Air Terminal Tag
Type	Freecooling Supply Air Flow
Type	System
Type	System - Mechanical Exhaust Air Flow
Type	System - Mechanical Extract Air Flow
Type	System - Mechanical Outdoor Air Flow
Type	System - Mechanical Supply Air Flow
Category: Annotation Symbols	Family: CN_Duct Tag
Type	CN_Duct Tag

Category: Annotation Symbols	Family: CN_Revision Cloud Tag	
Type	Revision Number	
Type	Revision Number - Comments	
Category: Annotation Symbols	Family: CN_Space Tag	
Type	Number - Name	
Type	Number - Name - Actual Air Flow Day	
Type	Number - Name - Actual Air Flow Day & Night	
Type	Number - Name - Actual Air Flow Night	
Type	System - Mechanical Outdoor Air Flow	
Category: Duct Fittings	Family: CN_V_Duct Fitting - Rectangular Union	
Type	Standard	
Category: Duct Fittings	Family: CN_V_Duct Fitting - Round Union	
Type	Standard	
Category: Mechanical Equipment	Family: CN_V_AHU - Indoor - Recuperator - Rectangular Duct	
Type	600x400 Duct	
Category: Mechanical Equipment	Family: CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	
Type	1000x500 Duct	
Category: Mechanical Equipment	Family: CN_V_AHU - Roof Extractor - Rectangular Duct	
Type	500x500 Duct	
Project Parameters (except System Families)		
Category: Project Information Parameters		
Parameter name	Parameter Group - Code - Parameter Type - Parameter Data Type	Description
CN_PI_Architect Adress Municipality Code And Name	Text - M - Shared - Text	
CN_PI_Architect Adress Street And Street Number	Text - M - Shared - Text	
CN_PI_Architect Name	Text - M - Shared - Text	
CN_PI_Architect Telephone	Text - M - Shared - Text	
CN_PI_Client Adress Street And Street Number	Text - M - Shared - Text	
CN_PI_Client Municipality Code And Name	Text - M - Shared - Text	
CN_PI_Client Name	Text - M - Shared - Text	Replaces the Built-In Project Information Parameter 'Client Name'
CN_PI_Master Phase	Text - M - Shared - Text	Code according to CENERGIE file project folder structure
CN_PI_Master Step	Text - M - Shared - Text	Code according to CENERGIE file project folder structure
CN_PI_Project Adress Municipality Code And Name	Text - M - Shared - Text	Replaces the Built-In Project Information Parameter 'Project Adress'
CN_PI_Project Adress Street And Number	Text - M - Shared - Text	Replaces the Built-In Project Information Parameter 'Project Adress'
CN_PI_Project Name	Text - M - Shared - Text	Replaces the Built-In Project Information Parameter 'Project Name'
CN_PI_Project Number	Text - M - Shared - Text	Replaces the Built-In Project Information Parameter 'Project Number'
CN_PI_Project Phase	Text - M - Shared - Text	Status or phase of the project e.g. (pre) Design, Revision, Tendering, Construction, ... Replaces the Built-In Project Information Parameter 'Project Status'
Category: Sheets		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
Scale	Graphics - A - Built-In - Text	Scale of the Plan Views on the sheet; if there are Plans with different scale, it shows 'As indicated'
Sheet Name	Identity Data - M - Built-In (Instance) - Text	
Sheet Number	Identity Data - M - Built-In (Instance) - Text	
File Path	Other - A - Built-In (Instance) - File Path	The file path of the model.
CN_Sheet Size	Other - M - Project (Instance) - Text	Paper sizes (e.g. A0, A1, ...) used to filter the Sheet list. Not linked to Titleblock, because a Titleblock has always a specific paper size.
CN_Sheet Discipline	Other - M - Shared (Instance, '5- HVAC') - Text	Not the Revit Discipline (Coordination, Architecture, Mechanical, Structural) but according to Sfb code.
CN_Sheet Sub-Discipline	Other - M - Shared (Instance, '57 Ventilation') - Text	Not the Built-In Sub-Discipline for Views. Parameter value according to Sfb code.
CN_Sheet Set	Other - M - Shared (Instance, 'Final') - Text	Use this parameter if the Sheet is part of a set of plans that need to be printed all toghether.
Category: Air Terminals		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_V_Offset From Face Or Level	Identity Data - D - Project (Instance) - Distance	The Dynamo graph 'Tool - Air Terminals Location' reads the Built-In 'Offset' parameter of the Air Terminals, which can be an offset from a Reference Plane or a Level, depending on the hosting method. For an Air Terminal hosted on a Reference Plane, this offset is not the distance between the Air Terminal and the 'Schedule Level', but the distance between the Reference Plane and the Air Terminal. This value should normally be equal to zero.
CN_V_Face	Identity Data - D - Project (Instance) - Text	If the Air Terminal is Face (Work Plane) based, the Dynamo graph 'Tool - Air Terminals Location' reads the Built-In 'Work Plane' parameter and pastes it in this custom made Project parameter.
CN_V_Level	Identity Data - D - Project (Instance) - Text	The Dynamo graph 'Tool - Air Terminals Location' reads either the Built-In 'Level' parameter for generic hosted or 'Schedule Level' parameter for Face (Work Plane) based Air Terminals and pastes this values to this custom made Project parameter. The Built-In parameter 'Schedule Level' can be changed for Face based hosted Air Terminals, if they are hosted by a Reference Plane.
CN_V_Air Terminal Type	Identity Data - M - Key - Text Key Value	With this Key parameter, the Air Terminal Type can be selected. Extra values can be added to specify the Type more precise.
Category: Windows		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
Category: Doors		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
Category: Generic Models		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description

CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
Category: Structural Framing		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
Category: Structural Columns		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_Updated Architecture Element	Constraints - M - Shared (Instance, '(none)') - Yes/No	This parameter is used to flag if a certain architecture element (Wall, Floor, Roof, Ceiling, Window, Door, Generic Models (elevator), Stairs, Structural Columns, Structural Framing (beam)) is controlled during an update of the architecture model.
Category: Mechanical Equipment		
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, Default Value) - Parameter Data Type	Description
CN_V_AHU Name	Identity Data - M - Shared (Instance) - Text	The name of the AHU. The same shared project parameter is also made active for Spaces and Duct Systems.
Color fill schemes for Spaces		
Max Duct Air Velocity Night		
Parameter	CN_V_Max Air Velocity Night	
Max Duct Air Velocity Day		
Parameter	CN_V_Max Air Velocity Day	
ETA Classes		
Parameter	CN_V_Extract Air Quality	
View Filters		
Beams/Columns		
Categories	Structural Columns	
	Structural Framing	
Filter Rule 1	(none)	
Duct Insulation - Exhaust		
Categories	Duct Insulation	
Filter Rule 1	'System Type' equals 'Exhaust Air'	
Duct Insulation - Extract		
Categories	Duct Insulation	
Filter Rule 1	'System Type' equals 'Extract Air'	
Duct Insulation - Outdoor		
Categories	Duct Insulation	
Filter Rule 1	'System Type' equals 'Outdoor Air'	
Duct Insulation - Supply		
Categories	Duct Insulation	
Filter Rule 1	'System Type' equals 'Supply Air'	
Duct System - Exhaust		
Categories	Air Terminals	
	Duct Accessories	
	Duct Fittings	
	Duct Insulation	
	Ducts	
	Flex Ducts	
Filter Rule 1	'System Type' equals 'Exhaust Air'	
Duct System - Extract		
Categories	Air Terminals	
	Duct Accessories	
	Duct Fittings	
	Duct Insulation	
	Ducts	
	Flex Ducts	
Filter Rule 1	'System Type' equals 'Extract Air'	
Duct System - No Duct System Classification		
Categories	Air Terminals	
Filter Rule 1	'System Classification' does not equal 'Exhaust Air'	
Filter Rule 2	'System Classification' does not equal 'Return Air'	
Filter Rule 3	'System Classification' does not equal 'Supply Air'	
Duct System - Outdoor		
Categories	Air Terminals	
	Duct Accessories	
	Duct Fittings	
	Duct Insulation	
	Ducts	
	Flex Ducts	
Filter Rule 1	'System Type' equals 'Outdoor Air'	
Duct System - Supply		
Categories	Air Terminals	
	Duct Accessories	
	Duct Fittings	
	Duct Insulation	
	Ducts	
	Flex Ducts	
Filter Rule 1	'System Type' equals 'Supply Air'	
Duct System - Transfer		
Categories	Air Terminals	
	Duct Accessories	
	Duct Fittings	
	Duct Insulation	
	Ducts	
	Flex Ducts	
Filter Rule 1	'System Type' equals 'Transfer Air'	
Floors/Roofs/Walls - Bearing		

Categories	Floors	
	Roofs	
	Walls	
Filter Rule 1	'CN_Bearing' equals 'Yes'	
Floors/Roofs/Walls - Fire Compartments		
Categories	Floors	
	Roofs	
	Walls	
Filter Rule 1	'CN_Fire Compartment Part' equals 'Yes'	
Floors/Roofs/Walls - Thermal Insulation		
Categories	Floors	
	Roofs	
	Walls	
Filter Rule 1	'CN_Thermal Insulation' equals 'Yes'	
Not Room Bounding		
Categories	Ceilings	
	Floors	
	Roofs	
	Walls	
Filter Rule 1	'CN_Room Bounding' equals 'No'	
Spaces - Min Supply Air Quality ETA2		
Categories	Spaces	
Filter Rule 1	'CN_V_Min Supply Air Quality' equals 'ETA2'	
Updated Architecture Element		
Categories	Ceilings	
	Doors	
	Floors	
	Generic Models	
	Roofs	
	Stairs	
	Structural Columns	
	Structural Framing	
	Walls	
	Windows	
Filter Rule 1	'CN_Updated Architecture Element' equals 'Yes'	
View Templates		
Coordination_Coordination_3D View		
Visibility/Graphics Model	Everything visible	
	Duct Insulation: 70% transparancy	
Sub-Discipline	Coordination	
Coordination_Coordination_Ceiling Plan		
Sub-Discipline	Coordination	
Coordination_Coordination_Elevation		
Sub-Discipline	Coordination	
Coordination_Coordination_Floor Plan		
Sub-Discipline	Coordination	
Coordination_Coordination_Section		
Sub-Discipline	Coordination	
Coordination_Filter - Bearing Elements_Floor Plan		
Visibility/Graphics Filters	Floors/Roofs/Walls - Bearing	light green color fill
	Beams/Columns	dasher light green lines / light green color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Filter - Bearing Element	
Coordination_Filter - Bearing Elements_Section		
Visibility/Graphics Filters	Floors/Roofs/Walls - Bearing	light green color fill
	Beams/Columns	light green color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Filter - Bearing Element	
Coordination_Filter - Fire Compartments_Floor Plan		
Visibility/Graphics Filters	Floors/Roofs/Walls - Fire Compartments	orange color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Filter - Fire Compartments	
Coordination_Filter - Fire Compartments_Section		
Visibility/Graphics Filters	Floors/Roofs/Walls - Fire Compartments	orange color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Filter - Fire Compartments	
Coordination_Filter - Thermal Insulation_Floor Plan		
Visibility/Graphics Filters	Floors/Roofs/Walls - Thermal Insulation	yellow color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Filter - Thermal Insulation	
Coordination_Filter - Thermal Insulation_Section		
Visibility/Graphics Filters	Floors/Roofs/Walls - Thermal Insulation	yellow color fill
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Filter - Thermal Insulation	
Coordination_Filter - Updated Architecture Elements_Floor Plan		
Visibility/Graphics Model	Everything visible	
	Duct Insulation: 70% transparancy	
	Ceilings, Doors, Floors, Generic Models, Roofs, Stairs, Walls, Windows : 70% transparancy	
Visibility/Graphics Filters	Updated Architecture Element	red color fill (projection and cut)
	Not Room Bounding	blue color fill (cut)
Model Display	Shaded	
Color Scheme Location	Background	

Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Filter - Updated Architecture Element	
Coordination_Filter - Updated Architecure Elements_Section		
Visibility/Graphics Model	Everything visible	
	Duct Insulation: 70% transparancy	
	Ceilings, Doors, Floors, Generic Models, Roofs, Stairs, Walls, Windows : 70% transparancy	
Visibility/Graphics Filters	Updated Architecture Element	red color fill (projection and cut)
	Not Room Bounding	blue color fill (cut)
Model Display	Shaded	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Filter - Updated Architecture Element	
Mechanical_Ventilation - Color Fill - Duct Air Velocity_Floor Plan		
Visibility/Graphics Model	Everything visible (except electricity-related)	
	Duct Insulation: 70% transparancy	
Model Display	Shaded	
Sub-Discipline	Ventilation - Color Fill - Duct Air Velocity	
Mechanical_Ventilation - Color Fill - ETA_Floor Plan		
Visibility/Graphics Model	Everything visible (except electricity-related)	
	Duct Insulation: 70% transparancy	
Visibility/Graphics Filters	Duct System - Transfer	Not visible
	Spaces - Min Supply Air Quality	70% transparancy
	Duct System - No Duct System Classification	Not visible
Model Display	Shaded	
Color Scheme Location	Background	
Color Scheme	ETA Classes	
System Color Schemes	None	
Sub-Discipline	Ventilation - Color Fill - ETA	
Mechanical_Ventilation - Control Diagram_Floor Plan		
Visibility/Graphics Model	Visible: Air Terminals, Detail Items, Duct Fittings, Duct Placeholders, Ducts, Flex Ducts, Mechanical Equipment, Shaft Openings,	
	Duct Insulation: 70% transparancy	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Transfer	Fuchsia lines
	Duct System - No Duct System Classification	Cyan lines
Model Display	Shaded	
Color Scheme Location	Background	
Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Ventilation - Control Diagram	
Mechanical_Ventilation - Reference Planes_Elevation		
Visibility/Graphics Model	Nothing visible	
Visibility/Graphics Import		
Visibility/Graphics Filters	None	
Model Display	Shaded	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Ventilation - Reference Planes	
Mechanical_Ventilation - Sheet Views_3D View		
Visibility/Graphics Model	Everything visible	
	Duct Insulation: 70% transparancy	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Supply	Black lines / dark blue color fill
	Duct System - Outdoor	Black lines / green color fill
	Duct System - Extract	Black lines / yellow color fill
	Duct System - Exhaust	Black lines / orange color fill
	Duct System - Transfer	Fuchsia lines / light grey color fill
	Duct System - No Duct System Classification	Cyan lines / no color fill
Model Display	Hidden Line	
Sub-Discipline	Ventilation - Sheet Views	
Mechanical_Ventilation - Sheet Views_Ceiling Plan		
Visibility/Graphics Model	Everything visible (except electricity-related)	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Supply	Black lines / dark blue color fill
	Duct System - Outdoor	Black lines / green color fill
	Duct System - Extract	Black lines / yellow color fill
	Duct System - Exhaust	Black lines / orange color fill
	Duct System - Transfer	Fuchsia lines / light grey color fill
	Duct System - No Duct System Classification	Cyan lines / no color fill
	Duct Insulation - Supply	Dark blue color fill / 30% transparancy
	Duct Insulation - Outdoor	Green color fill / 30% transparancy
	Duct Insulation - Extract	Yellow color fill / 30% transparancy
	Duct Insulation - Exhaust	Orange color fill / 30% transparancy
Model Display	Hidden Line	
Sub-Discipline	Ventilation - Sheet Views	
Mechanical_Ventilation - Sheet Views_Elevation		
Visibility/Graphics Model	Everything visible (except electricity-related)	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Supply	Black lines / dark blue color fill
	Duct System - Outdoor	Black lines / green color fill
	Duct System - Extract	Black lines / yellow color fill
	Duct System - Exhaust	Black lines / orange color fill
	Duct System - Transfer	Fuchsia lines / light grey color fill
	Duct System - No Duct System Classification	Cyan lines / no color fill
	Duct Insulation - Supply	Dark blue color fill / 30% transparancy
	Duct Insulation - Outdoor	Green color fill / 30% transparancy
	Duct Insulation - Extract	Yellow color fill / 30% transparancy
	Duct Insulation - Exhaust	Orange color fill / 30% transparancy
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Ventilation - Sheet Views	
Mechanical_Ventilation - Sheet Views_Floor Plan		
Visibility/Graphics Model	Everything visible (except electricity-related)	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Supply	Black lines / dark blue color fill
	Duct System - Outdoor	Black lines / green color fill
	Duct System - Extract	Black lines / yellow color fill

	Duct System - Exhaust	Black lines / orange color fill
	Duct System - Transfer	Fuchsia lines / light grey color fill
	Duct System - No Duct System Classification	Cyan lines / no color fill
	Duct Insulation - Supply	Dark blue color fill / 30% transparancy
	Duct Insulation - Outdoor	Green color fill / 30% transparancy
	Duct Insulation - Extract	Yellow color fill / 30% transparancy
	Duct Insulation - Exhaust	Orange color fill / 30% transparancy
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
System Color Schemes	None	
Sub-Discipline	Ventilation - Sheet Views	
Mechanical_Ventilation - Sheet Views_Section		
Visibility/Graphics Model	Everything visible (except electricity-related)	
Visibility/Graphics Import		
Visibility/Graphics Filters	Duct System - Supply	Black lines / dark blue color fill
	Duct System - Outdoor	Black lines / green color fill
	Duct System - Extract	Black lines / yellow color fill
	Duct System - Exhaust	Black lines / orange color fill
	Duct System - Transfer	Fuchsia lines / light grey color fill
	Duct System - No Duct System Classification	Cyan lines / no color fill
	Duct Insulation - Supply	Dark blue color fill / 30% transparancy
	Duct Insulation - Outdoor	Green color fill / 30% transparancy
	Duct Insulation - Extract	Yellow color fill / 30% transparancy
	Duct Insulation - Exhaust	Orange color fill / 30% transparancy
Model Display	Hidden Line	
Color Scheme Location	Background	
Color Scheme	None	
Sub-Discipline	Ventilation - Sheet Views	
Mechanical_Ventilation - Work Views_3D View		
Sub-Discipline	Ventilation - Work Views	
Mechanical_Ventilation - Work Views_Ceiling Plan		
Sub-Discipline	Ventilation - Work Views	
Mechanical_Ventilation - Work Views_Elevation		
Sub-Discipline	Ventilation - Work Views	
Mechanical_Ventilation - Work Views_Floor Plan		
Sub-Discipline	Ventilation - Work Views	
Mechanical_Ventilation - Work Views_Section		
Sub-Discipline	Ventilation - Work Views	
Views		
Discipline: Coordination	**Sub-Discipline: Coordination**	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord	Associated Level: Level 00
	10 - Coord	Associated Level: Level 10
	20 - Coord	Associated Level: Level 20
	30 - Coord	Associated Level: Level 30
	40 Roof - Coord	Associated Level: Level 40 Roof
	Roof Overview - Coord	Associated Level: Level Roof Overview
View Template	Coordination_Coordination_Floor Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Ceiling Plan	Type: Ceiling Plan	
View Names	00 (Ceiling) - Coord	Associated Level: Level 00
	10 (Ceiling) - Coord	Associated Level: Level 10
	20 (Ceiling) - Coord	Associated Level: Level 20
	30 (Ceiling) - Coord	Associated Level: Level 30
View Template	Coordination_Coordination_Ceiling Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
Family: 3D View	Type: 3D View	
View Names	3D - Coord	
View Template	Coordination_Coordination_3D View	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
Family: Elevation	Type: Building Elevation	
View Names	Back - Coord	
	Front - Coord	
	Left - Coord	
	Right - Coord	
View Template	Coordination_Coordination_Elevation	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Color Scheme Location	
	Color Scheme	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord)	
View Template	(New Section: Coordination_Coordination_Section)	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Color Scheme Location	
	Color Scheme	
Discipline: Coordination	**Sub-Discipline: Filter - Bearing Elements**	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Bearing	Associated Level: Level 00
	10 - Coord - Bearing	Associated Level: Level 10
	20 - Coord - Bearing	Associated Level: Level 20
	30 - Coord - Bearing	Associated Level: Level 30
View Template	Coordination_Filter - Bearing_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	

View Names	none (New Section: AA - Coord - Bearing)	
View Template	(New Section: Coordination_Filter - Bearing_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Fire Compartments	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Fire Compartments	Associated Level: Level 00
	10 - Coord - Fire Compartments	Associated Level: Level 10
	20 - Coord - Fire Compartments	Associated Level: Level 20
	30 - Coord - Fire Compartments	Associated Level: Level 30
View Template	Coordination_Filter - Fire Compartments_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Fire Compartments)	
View Template	(New Section: Coordination_Filter - Fire Compartments_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Thermal Insulation	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Thermal Insulation	Associated Level: Level 00
	10 - Coord - Thermal Insulation	Associated Level: Level 10
	20 - Coord - Thermal Insulation	Associated Level: Level 20
	30 - Coord - Thermal Insulation	Associated Level: Level 30
View Template	Coordination_Filter - Thermal Insulation_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Thermal Insulation)	
View Template	(New Section: Coordination_Filter - Thermal Insulation_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Updated Architecture Elements	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Updated Architecture Elements	Associated Level: Level 00
	10 - Coord - Updated Architecture Elements	Associated Level: Level 10
	20 - Coord - Updated Architecture Elements	Associated Level: Level 20
	30 - Coord - Updated Architecture Elements	Associated Level: Level 30
View Template	Coordination_Filter - Updated Architecture Elements_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Model and Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Updated Architecture Elements)	
View Template	(New Section: Coordination_Filter - Updated Architecture_Section)	
View Settings independent of View Template	V/G Overrides (all except Model and Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Mechanical	Sub-Discipline: Ventilation - Color Fill - Duct Air Velocity	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Vent - Color Fill - Duct Air Velocity	Associated Level: Level 00
	10 - Vent - Color Fill - Duct Air Velocity	Associated Level: Level 10
	20 - Vent - Color Fill - Duct Air Velocity	Associated Level: Level 20
	30 - Vent - Color Fill - Duct Air Velocity	Associated Level: Level 30
View Template	Mechanical_Ventilation - Color Fill - Duct Air Velocity_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Mechanical	Sub-Discipline: Ventilation - Color Fill - ETA	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Vent - Color Fill - ETA	Associated Level: Level 00
	10 - Vent - Color Fill - ETA	Associated Level: Level 10
	20 - Vent - Color Fill - ETA	Associated Level: Level 20
	30 - Vent - Color Fill - ETA	Associated Level: Level 30
View Template	Mechanical_Ventilation - Color Fill - ETA_Floor Plan	
View Settings independent of View Template	Underlay Orientation	
	Color Scheme Location	
Discipline: Mechanical	Sub-Discipline: Ventilation - Control Diagram	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Vent - Control Diagram	Associated Level: Level 00
	10 - Vent - Control Diagram	Associated Level: Level 10
	20 - Vent - Control Diagram	Associated Level: Level 20
	30 - Vent - Control Diagram	Associated Level: Level 30
	40 Roof - Vent - Control Diagram	Associated Level: Level 40 Roof
View Template	Mechanical_Ventilation - Control Diagram_Floor Plan	
View Settings independent of View Template	View Scale	
Discipline: Mechanical	Sub-Discipline: Ventilation - Reference Planes	

Family: Elevation	Type: Building Elevation	
View Names	Front - Vent - Reference Planes	
View Template	Mechanical_Ventilation - Reference Planes_Elevation	
View Settings independent of View Template	None	
Discipline: Mechanical	Sub-Discipline: Ventilation - Sheet Views	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Vent - Sheet View	Associated Level: Level 00
	10 - Vent - Sheet View	Associated Level: Level 10
	20 - Vent - Sheet View	Associated Level: Level 20
	30 - Vent - Sheet View	Associated Level: Level 30
	40 Roof - Vent - Sheet View	Associated Level: Level 40 Roof
View Template	Mechanical_Ventilation - Sheet Views_Floor Plan	
View Settings independent of View Template	None	
Family: Ceiling Plan	Type: Ceiling Plan	
View Names	00 (Ceiling) - Vent - Sheet View	Associated Level: Level 00
	10 (Ceiling) - Vent - Sheet View	Associated Level: Level 10
	20 (Ceiling) - Vent - Sheet View	Associated Level: Level 20
	30 (Ceiling) - Vent - Sheet View	Associated Level: Level 30
View Template	Mechanical_Ventilation - Sheet Views_Ceiling Plan	
View Settings independent of View Template	None	
Family: 3D View	Type: 3D View	
View Names	3D - Vent - Sheet View	
View Template	Mechanical_Ventilation - Sheet Views_3D View	
View Settings independent of View Template	None	
Family: Elevation	Type: Building Elevation	
View Names	Back - Vent - Sheet View	
	Front - Vent - Sheet View	
	Left - Vent - Sheet View	
	Right - Vent - Sheet View	
View Template	Mechanical_Ventilation - Sheet Views_Elevation	
View Settings independent of View Template	None	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Vent - Sheet View)	
View Template	(New Section: Mechanical_Ventilation - Sheet Views_Section)	
View Settings independent of View Template	None	
Discipline: Mechanical	Sub-Discipline: Ventilation - Work Views	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Vent - Work View	Associated Level: Level 00
	10 - Vent - Work View	Associated Level: Level 10
	20 - Vent - Work View	Associated Level: Level 20
	30 - Vent - Work View	Associated Level: Level 30
	40 Roof - Vent - Work View	Associated Level: Level 40 Roof
View Template	Mechanical_Ventilation - Work Views_Floor Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
Family: Ceiling Plan	Type: Ceiling Plan	
View Names	00 (Ceiling) - Vent - Work View	Associated Level: Level 00
	10 (Ceiling) - Vent - Work View	Associated Level: Level 10
	20 (Ceiling) - Vent - Work View	Associated Level: Level 20
	30 (Ceiling) - Vent - Work View	Associated Level: Level 30
View Template	Mechanical_Ventilation - Work Views_Ceiling Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
Family: 3D View	Type: 3D View	
View Names	3D - Vent - Work View	
View Template	Mechanical_Ventilation - Work Views_3D View	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
Family: Elevation	Type: Building Elevation	
View Names	Back - Vent - Work View	
	Front - Vent - Work View	
	Left - Vent - Work View	
	Right - Vent - Work View	
View Template	Mechanical_Ventilation - Work Views_Elevation	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Color Scheme Location	
	Color Scheme	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Vent - Work View)	
View Template	(New Section: Mechanical_Ventilation - Work Views_Section)	
View Settings independent of View Template	None	

Schedules/Quantities	
BoQ - V_Air Terminals - Freecooling Supply Window	
Practical use	Bill of quantity: contains all windows (Air Terminals) that will be used for freecooling.
Filtered elements	'CN_Window Width' parameter exists (all Air Terminals for freecooling supply)
BoQ - V_Air Terminals - Mechanical	
Practical use	Bill of quantity: contains all mechanical Air Terminals
Filtered elements	'System Name' does not contain 'TRA' (no Air Terminals from the Duct System Type 'Transfer Air')
	'System Name' contains '-' (all Air Terminals that are connected to a Duct System)
BoQ - V_Air Terminals - Transfer Air	
Practical use	Bill of quantity: contains all extract Air Terminals for transfer air with a geometric representation (grille or door gap) that are part of a Duct System
Filtered elements	'System Name' contains 'TRA' (all Air Terminals of the Duct System Type 'Transfer Air')
	'CN_Geometric Extract Transfer Air Terminal' equals 'Yes' (no Air Terminals for transfer air in open plan + only extract Air Terminals)
BoQ - V_Duct Accessories	
Practical use	Bill of quantity: contains all Duct Accessory elements that are connected to a Duct System (except 'Transfer Air'). Information about Duct Insulation is also listed.
Filtered elements	'System Name' does not contain 'TRA' (no Duct Accessories from the Duct System Type 'Transfer Air')
	'System Name' contains '-' (all Duct Accessories that are connected to a Duct System)
BoQ - V_Duct Fittings	
Practical use	Bill of quantity: contains all Duct Fittings except unions, that are connected to a Duct System (except 'Transfer Air '). Information about Duct Insulation is also listed.

Filtered elements	'System Name' does not contain 'TRA' (no Duct Fittings from the Duct System Type 'Transfer Air')
	'System Name' contains '-' (all Duct Fittings that are connected to a Duct System)
	'CN_Union Not In BoQ' does not equal 'Yes' (no union Duct Fittings)
BoQ - V_Ducts	
Practical use	Bill of quantity: contains all Ducts that are connected to a Duct System (except 'Transfer Air'). Information about Duct Insulation is also listed.
Filtered elements	'System Name' does not contain 'TRA' (no Duct Accessories from the Duct System Type 'Transfer Air')
	'System Name' contains '-' (all Duct Accessories that are connected to a Duct System)
BoQ - V_Mechanical equipment - AHU	
Practical use	Bill of quantity: contains all custom AHU's
Filtered elements	'CN_Mechanical AHU Exhaust Air Flow' parameter exists (no other Mechanical Equipment)
Control - Multicategory - 'CN_Updated Architecture Element'	
Practical use	List with all updated and not updated architectural and structural elements to get an overview if all elements are updated (moved or modified) or removed
Filtered elements	'CN_Updated Architecture Element' parameter exists (no other Families/Categories)
Control - V_Air Terminals - Not In Space	
Practical use	List with all Air Terminals except the ones that are part of Duct Systems Types 'Exhaust Air' and 'Outdoor Air'. The Schedule can be used to control if every other Air Terminal is located inside a Space.
Filtered elements	'CN_Updated Architecture Element' parameter exists (no other Families/Categories)
Control - V_Air Terminals Door Gap Height	
Practical use	List with all extract door gap Air Terminals for transfer air. In this Schedule, the selected height of the door gap can be compared with the minimum calculated door gap height.
Filtered elements	'CN_Door Gap Height' parameter exists (only extract door gap Air Terminals)
Control - V_Air Terminals Freecooling	
Practical use	List with all Air Terminals for freecooling supply air. The Schedule can be used to control if the selected air flows are lower than the maximum calculated air flow.
Filtered elements	'CN_Window Height' parameter exists (all Air Terminals for freecooling supply)
Control - V_Air Terminals Location	
Practical use	List of all Air Terminals that are placed in the Project. When the Dynamo graph 'Tool - Air Terminlas Location' has runned, these parameters will be filled in automatically (copy of the built-in parameters). When the Levels of the ventilation model are updated, it can be that several Air Terminals get a randow offset from their Reference Plane. The 'CN_V_OFfset From Face Or Level' parameter depends on the hosting method of the Air Terminal.
Filtered elements	none
Control - V_Air Terminals Transfer Air	
Practical use	Every transfer air representation consists of two Air Terminals (supply and mechanical) that form one pair. The air flow values of both Air Terminals should be the same and this can be controlled here.
Filtered elements	'System Name' begins with 'TRA' (only Air Terminals of Duct System Type 'Transfer Air')
Control - V_Ducts Duct Insulation	
Practical use	List of all Ducts (except Transfer Air) to control if every Duct is insulated.
Filtered elements	'System Name' does not contain 'TRA' (no Ducts of Duct System Type 'Transfer Air')
Control - V_Ducts Friction And Velocity	
Practical use	List of all Ducts (except Transfer Air) to control if the 'Friction' (pressure loss per meter) and 'Velocity' is acceptable for the air flows during the daytime or the nighttime.
Filtered elements	'System Name' does not contain 'TRA' (no Ducts of Duct System Type 'Transfer Air')
Control - V_Spaces Air Flow Summary	
Practical use	List of all Spaces, their calculated necessary air flows (via Dynamo) and the actual air flows per Space (copied in Schedule 'Work - V_Spaces Actual Air Flows - Checked'. This Schedule can be used to control if every Space receives enough air and if the supply and extract air flows are balanced.
Filtered elements	none
Key - Fire Resistance Floor	
Practical use	Key Schedule that contains the possible values for the 'CN_Floor Fire Resistance REI' Key parameter and the depending parameters.
Key - Fire Resistance Roof	
Practical use	Key Schedule that contains the possible values for the 'CN_Roof Fire Resistance REI' Key parameter and the depending parameters.
Key - Fire Resistance Wall	
Practical use	Key Schedule that contains the possible values for the 'CN_Wall Fire Resistance (R)EI' Key parameter and the depending parameters.
Key - V_Air Quality Control	
Practical use	Key Schedule that contains the possible values for the 'CN_V_Air Quality Control' Key parameter
Key - V_Air Terminal Type	
Practical use	Key Schedule that contains the possible values for the 'CN_V_Air Terminal Type' Key parameter
Key - V_IDA Class	
Practical use	Key Schedule that contains the possible values for the 'CN_V_IDA Class' Key parameter
Key - V_Space Type	
Practical use	Key Schedule that contains the possible values for the 'CN_V_Space Type' Key parameter and the depending parameters.
Work - Ceilings	
Practical use	Schedule that lists all Ceilings, to control if certain Ceilings are Room Bounding. The Dynamo graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled.
Filtered elements	none
Work - Floors	
Practical use	Schedule that lists all Floors, to control if a certain Floor is Room Bounding. The Dynamo graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Floor Fire Resistance REI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters
Filtered elements	none
Work - Multicategory - Reset 'CN_Updated Architecture Element'	
Practical use	When an architecture model is updated for the second time, the 'CN_Updated Architecture Element' parameter of all elements can be reset to 'No' with one click.
Filtered elements	'CN_Updated Architecture Element' parameter exists
Work - Roofs	
Practical use	Schedule that lists all Roofs, to control if a certain Roof is Room Bounding. The Dynamo graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Roof Fire Resistance REI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters
Filtered elements	none
Work - Spaces Comments	
Practical use	Space Schedule that can be used to add additional information about a Space in the 'Comments' parameter
Filtered elements	none
Work - Spaces General	
Practical use	Space Schedule that can be used add additional floor area and/or volume. The dimensions of the Space can be controlled.
Filtered elements	none
Work - V_Air Terminals - Switch Daytime	
Practical use	This Schedule can be used to switch the parameter 'CN_Daytime' of all mechanical extract Air Terminals at once.

Filtered elements	'CN_Daytime' parameter exists
Work - V_Duct Systems AHU Name	
Practical use	A Duct System Schedule with a Mechanical Equipment Embedded Schedule. This Schedule can be used to control if the correct Duct Systems are connected to the right AHU. It can also be used to fill in the parameter 'CN_V_AHU Name' for the AHU and/or the Duct Systems.
Filtered elements	'System Name' does not begin with 'TRA' (no 'Transfer Air' Duct System Types)
Filtered elements (Embedded Schedule)	'CN_Extract Fan Type' parameter exists (all custom AHU's)
Work - V_Mechanical Equipment AHU Settings	
Practical use	Schedule to fill in the parameters of the AHU's.
Filtered elements	'CN_Extract Fan Type' parameter exists (all custom AHU's)
Work - V_Spaces Actual Air Flows - Checked	
Practical use	Space Schedule with an Embedded Air Terminal Schedule. It should be used to copy the total air flows of all Air Terminals located in the Space to the actual air flow parameters of the Space. These last values can appear in Schedule 'Control - V_Spaces Air Flow Summary' and in the custom Space Tag. Only the Spaces that were controlled in the Schedule 'Work - V_Spaces Actual Air Flows - Not Checked' are listed here.
Filtered elements	'CN_V_Controlled Actual Air Flow' equals 'Yes' (all Spaces that were controlled on actual air flows in the Schedule 'Work - V_Spaces Actual Air Flows - Not Checked')
Work - V_Spaces Actual Air Flows - Not Checked	
Practical use	Space Schedule with an Embedded Air Terminal Schedule. It should be used to control the total air flows of all Air Terminals located in the Space with the calculated necessary air flow values of the Space. The air flows for supply and extraction should be balanced during the daytime and the nighttime. If a Space has enough actual air flows, the parameter 'CN_V_Controlled Actual Air Flow' can be switched to 'Yes' in order to move the Space to the Schedule 'Work - V_Spaces Actual Air Flows - Checked'
Filtered elements	'CN_V_Controlled Actual Air Flow' does not equal 'Yes' (all Spaces that were not yet controlled on actual air flows in the Schedule 'Work - V_Spaces Actual Air Flows - Not Checked')
Work - V_Spaces Actual Air Flows - Switch All	
Practical use	If the calculation of the necessary air flows is updated, it will be necessary to control every Space again for its actual air flows. To change the parameter 'CN_V_Controlled Actual Air Flow' of all Spaces to 'No' this Schedule can be used.
Filtered elements	none
Work - V_Spaces Calculated Air Flow Summary	
Practical use	This Space Schedule gives an overview on all calculated necessary air flow values. Air flow values for heating, cooling and special Spaces can be entered if a new calculation via Dynamo will be started.
Filtered elements	none
Work - V_Spaces Freecooling	
Practical use	This Space Schedule can be used to indicate if freecooling is used and what the air change values during the day-/nighttime
Filtered elements	none
Work - V_Spaces General	
Practical use	This Space Schedule should be used to fill in general ventilation related parameters such as 'CN_V_Space Type', 'CN_V_AHU Name', ...
Filtered elements	none
Work - V_Spaces Heating And Cooling With Air	
Practical use	This Space Schedule can be used to indicate if heating and/or cooling with air is used for a certain Space and what the air flow values should be.
Filtered elements	none
Work - V_Spaces Occupancy	
Practical use	This Space Schedule should be used to fill in the number of occupants according to the design team (including employees). The number of employees as a part of the number of occupants can be given, followed by the number of toillets and showers
Filtered elements	none
Work - V_Special Spaces	
Practical use	This Space Schedule should be used to indicate if a Space should be treated as a Special Space with an air flow that is determined according to other standards or methods.
Filtered elements	none
Work - Walls	
Practical use	Schedule that lists all Walls, to control if a certain Wall is Room Bounding. The Dynamo graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Wall Fire Resistance (R)EI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters.
Filtered elements	none
Sheets	
Sheet Discipline: 5- HVAC	Sheet Sub-Discipline: 57 Ventilation
Sheet Size: A0	Sheet Name: A101
Titleblock	CN_Titleblock A0 metric
Sheet Size: A1	Sheet Name: A102
Titleblock	CN_Titleblock A1 metric

Appendix 6. Documentation of Revit template ‘CN_Template Architecture’

Only differences (removed or added elements/settings) with 'CN_Template Ventilation.rte' are mentioned		
General changes		
No sheets (no printing)		
No reference Planes		
Template name		
CN_Template Architecture.rte	Source: Out-of-the-box Revit library: RVT 2016 > Templates > Belgium	
Loaded Families In Template		
Category: Doors	Family: CN_Generic Door	
Type	Double Door	
Type	Single Door	
Category: Windows	Family: CN_Generic Window	
Type	CN_Generic Window	
Views		
Discipline: Coordination	Sub-Discipline: Coordination	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord	Associated Level: Level 00
	10 - Coord	Associated Level: Level 10
	20 - Coord	Associated Level: Level 20
	30 - Coord	Associated Level: Level 30
	40 Roof - Coord	Associated Level: Level 40 Roof
	Roof Overview - Coord	Associated Level: Level Roof Overview
View Template	Coordination_Coordination_Floor Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Ceiling Plan	Type: Ceiling Plan	
View Names	00 (Ceiling) - Coord	Associated Level: Level 00
	10 (Ceiling) - Coord	Associated Level: Level 10
	20 (Ceiling) - Coord	Associated Level: Level 20
	30 (Ceiling) - Coord	Associated Level: Level 30
View Template	Coordination_Coordination_Ceiling Plan	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Underlay Orientation	
Family: 3D View	Type: 3D View	
View Names	3D - Coord	
View Template	Coordination_Coordination_3D View	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
Family: Elevation	Type: Building Elevation	
View Names	Back - Coord	
	Front - Coord	
	Left - Coord	
	Right - Coord	
View Template	Coordination_Coordination_Elevation	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Color Scheme Location	
	Color Scheme	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord)	
View Template	(New Section: Coordination_Coordination_Section)	
View Settings independent of View Template	V/G Overrides (all)	
	Model Display	
	Color Scheme Location	
	Color Scheme	
Discipline: Coordination	Sub-Discipline: Filter - Bearing Elements	
Family: Floor Plan	Type: Floor Plan	

View Names	00 - Coord - Bearing	Associated Level: Level 00
	10 - Coord - Bearing	Associated Level: Level 10
	20 - Coord - Bearing	Associated Level: Level 20
	30 - Coord - Bearing	Associated Level: Level 30
View Template	Coordination_Filter - Bearing_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Bearing)	
View Template	(New Section: Coordination_Filter - Bearing_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Fire Compartments	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Fire Compartments	Associated Level: Level 00
	10 - Coord - Fire Compartments	Associated Level: Level 10
	20 - Coord - Fire Compartments	Associated Level: Level 20
	30 - Coord - Fire Compartments	Associated Level: Level 30
View Template	Coordination_Filter - Fire Compartments_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Fire Compartments)	
View Template	(New Section: Coordination_Filter - Fire Compartments_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Thermal Insulation	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Thermal Insulation	Associated Level: Level 00
	10 - Coord - Thermal Insulation	Associated Level: Level 10
	20 - Coord - Thermal Insulation	Associated Level: Level 20
	30 - Coord - Thermal Insulation	Associated Level: Level 30
View Template	Coordination_Filter - Thermal Insulation_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Thermal Insulation)	
View Template	(New Section: Coordination_Filter - Thermal Insulation_Section)	
View Settings independent of View Template	V/G Overrides (all except Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Discipline: Coordination	Sub-Discipline: Filter - Updated Architecture Elements	
Family: Floor Plan	Type: Floor Plan	
View Names	00 - Coord - Updated Architecture Elements	Associated Level: Level 00
	10 - Coord - Updated Architecture Elements	Associated Level: Level 10

	20 - Coord - Updated Architecture Elements	Associated Level: Level 20
	30 - Coord - Updated Architecture Elements	Associated Level: Level 30
View Template	Coordination_Filter - Updated Architecture Elements_Floor Plan	
View Settings independent of View Template	V/G Overrides (all except Model and Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	
Family: Section	Type: Building Section	
View Names	none (New Section: AA - Coord - Updated Architecture Elements)	
View Template	(New Section: Coordination_Filter - Updated Architecture_Section)	
View Settings independent of View Template	V/G Overrides (all except Model and Filters)	
	Underlay Orientation	
	Color Scheme Location	
	Color Scheme	
	System Color Schemes	

Schedules/Quantities	
Control - Multicategory - 'CN_Updated Architecture Element'	
Practical use	List with all updated and not updated architectural and structural elements to get an overview if all elements are updated (moved or modified) or removed
Filtered elements	'CN_Updated Architecture Element' parameter exists (no other Families/Categories)
Key - Fire Resistance Floor	
Practical use	Key Schedule that contains the possible values for the 'CN_Floor Fire Resistance REI' Key parameter and the depending parameters.
Key - Fire Resistance Roof	
Practical use	Key Schedule that contains the possible values for the 'CN_Roof Fire Resistance REI' Key parameter and the depending parameters.
Key - Fire Resistance Wall	
Practical use	Key Schedule that contains the possible values for the 'CN_Wall Fire Resistance (R)EI' Key parameter and the depending parameters.
Work - Ceilings	
Practical use	graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled.
Filtered elements	none
Work - Floors	
Practical use	graph 'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Floor Fire Resistance REI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters
Filtered elements	none
Work - Multicategory - Reset 'CN_Updated Architecture Element'	
Practical use	When an architecture model is updated for the second time, the 'CN_Updated Architecture Element' parameter of all elements can be reset to 'No' with one click.
Filtered elements	'CN_Updated Architecture Element' parameter exists
Work - Roofs	
Practical use	'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Roof Fire Resistance REI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters
Filtered elements	none
Work - Walls	
Practical use	'Tool - Room Bounding' can be used to copy all 'Room Bounding' values of the built-in parameter to this custom paramater that can be Scheduled. Additional, the parameters 'CN_Wall Fire Resistance (R)EI', 'CN_Fire Compartment Part', 'CN_Thermal Insulation' and 'CN_Bearing' can be seen and used to fill in these parameters.
Filtered elements	none

Appendix 7. Documentation of developed loadable Revit Families

Type	Double Door	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Height	Dimensions - M - Built-In (Instance, 2100) - Length	Height of the door opening and panel.
Width	Dimensions - M - Built-In (Instance, 900) - Length	Witdh of the door opening and panel.
Thickness	Dimensions - M - Built-In (Type, 80) - Length	Thickness of the door panel.
CN_DoubleDoor	Other - C - Family (Type, Yes) - Yes/No	If this parameter is equal to 'Yes' a double door panel and symbol lines (plan swing) are shown
CN_SingleDoor	Other - M - Family (Type, No) - Yes/No	If this parameter is equal to 'Yes' a single door panel and symbol lines (plan swing) are shown
Type	Single Door	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_DoubleDoor	Other - C - Family (Type, No) - Yes/No	If this parameter is equal to 'Yes' a double door panel and symbol lines (plan swing) are shown
CN_SingleDoor	Other - M - Family (Type, Yes) - Yes/No	If this parameter is equal to 'Yes' a single door panel and symbol lines (plan swing) are shown
Category	**Generic Models**	
Family	CN_Generic Elevator	
Family Template	Metric Generic Model two level based.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
General Note	Place one Instance per Level. Per Level the number of doors can be choosen (0, 1 or 2).	
Type	CN_Generic Elevator	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Void Thickness_DoorBack	Dimensions - C - Family (Instance, 100) - Length	Thickness of the void extrusion that cuts the elevator extrusion. If this value is 100 mm, the void does not cut the elevator and no opening is created). It reacts on the chosen number of doors (0, 1 or 2) via the parameter 'CN_#Doors'.
CN_Void Thickness_DoorFront	Dimensions - C - Family (Instance, 260) - Length	Thickness of the void extrusion that cuts the elevator extrusion. If this value is 100 mm, the void does not cut the elevator and no opening is created). It reacts on the chosen number of doors (0, 1 or 2) via the parameter 'CN_#Doors'.
CN_Elevator Depth	Dimensions - M - Family (Instance, 2000) - Length	Outside depth of the elevator (with elevator shaft walls)
CN_Elevator Width	Dimensions - M - Family (Instance, 2000) - Length	Outside width of the elevator (with elevator shaft walls)
CN_Door Height	Dimensions - M - Family (Type, 2100) - Length	Height of the door opening and panel, and height of the opening in front of the door (in the case of two doors: both door openings, panels and opening in front of doors).
CN_Door Thickness	Dimensions - M - Family (Type, 80) - Length	Thickness of the door opening and panel, and depth of the opening in front of the door (in the case of two doors: both door openings, panels and opening in front of doors).
CN_Door Width	Dimensions - M - Family (Type, 900) - Length	Width of the door opening and panel, and width of opening in front of the door (in the case of two doors: both door openings, panels and opening in front of doors).
CN_DoorBackVisible	Other - C - Family (Instance, No) - Yes/No	If this parameter is equal to 'Yes', a double door panel appears at the back of the elevator.
CN_DoorFrontVisible	Other - C - Family (Instance, Yes) - Yes/No	If this parameter is equal to 'Yes', a double door panel appears at the front of the elevator.
CN_#Doors	Other - M - Family (Instance, 1) - Integer	Give number of doors for the elevator instance, located on a certain Level. Only 0, 1 and 2 will cause a change in the number of doors. The second door appears at the backside of the elevator
Category	**Windows**	
Family	CN_Generic Skylight	
Family Template	Metric Generic Model roof based.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Type	CN_Generic Skylight	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Glass Thickness	Dimensions - M - Family (Type, 50) - Length	Glass thickness
Height	Dimensions - M - Built-In (Instance, 1000) - Length	Height dimension of skylight (parallel with Roof surface)
Width	Dimensions - M - Built-In (Instance, 1200) - Length	Width of the skylight (parallel with the Roof surface)
Family	CN_Generic Window	
Family Template	Metric Window.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Type	CN_Generic Window	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description

(continues)

Width	Dimensions - M - Built-In (Instance, 1000) - Length	Width of the window
Height	Dimensions - M - Built-In (Instance, 1200) - Length	Height of the window
CN_Glass Thickness	Dimensions - M - Family (Type, 50) - Length	Glass thickness
Default Sill Height	Other - M - Family (Type, 900) - Length	Defines the default sill height when the family is placed. The used sill height can (Instance parameter) be changed in the project
Category	**Annotation Symbols**	
Family	CN_Air Terminal Tag	
Family Template	Metric Generic Tag.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English > Annotations
Type	Freecooling Supply Window	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_System	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
Type	System	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_System	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
Type	System - Mechanical Exhaust Air Flow	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_System	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
Type	System - Mechanical Extract Air Flow	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.

CN_System	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
Type	System - Mechanical Outdoor Air Flow	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_System	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
Type	System - Mechanical Supply Air Flow	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Freecooling Supply Day Air Flow' and 'CN_Freecooling Supply Night Air Flow'.
CN_Mechanical Exhaust Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Exhaust Air Flow'.
CN_Mechanical Extract Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Extract Day Air Flow' and 'CN_Mechanical Extract Night Air Flow'.
CN_Mechanical Outdoor Air Flow	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'CN_Mechanical Outdoor Air Flow'.
CN_Mechanical Supply Air Flow	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameters 'CN_Mechanical Supply Day Air Flow' and 'CN_Mechanical Supply Night Air Flow'.
CN_System	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'System Name'.
Labels	Parameter Name	
	CN_Freecooling Supply Day Air Flow	
	CN_Freecooling Supply Night Air Flow	
	CN_Mechanical Exhaust Air Flow	
	CN_Mechanical Extract Day Air Flow	
	CN_Mechanical Extract Night Air Flow	
	CN_Mechanical Outdoor Air Flow	
	CN_Mechanical Supply Day Air Flow	
	CN_Mechanical Supply Night Air Flow	
	System Name	
Family	CN_Duct Tag	
Existing Family	M_Duct Size Tag.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Annotations > Mechanical > Duct
Type	CN_Duct Tag	
Labels	Parameter Name	
	Size	
Family	CN_Revision Cloud Tag	
Existing Family	M_Revision Tag	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Annotations
Type	Revision Number	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Comment	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the label containing the parameter 'Comments'.
Type	Revision Number - Comment	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Comment	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the label containing the parameter 'Comments'.
Labels	Parameter Name	
	Comments	
Family	CN_Space Tag	
Existing Family	M_Space Tag	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Annotations > Mechanical
Type	Number - Name	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description

CN_Actual Air Flow Day & Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the labels controlled by parameter 'CN_Actual Air Flow Day'.
CN_Actual Air Flow Day Or Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control the heading above the labels with parameters of air flows during day- or nighttime.
CN_Actual Air Flow Only Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the heading.
CN_Actual Air Flow Not Day	Graphics - C - Project (Type, Yes) - Yes/No	Parameter used in the formula of parameter 'CN_Actual Air Flow Only Night'
CN_Actual Air Flow Day	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the labels containing the parameters 'CN_V_D_Actual Freecooling Supply Day Air Flow (m³/h)'
CN_Actual Air Flow Night	Graphics - M - Project (Type, No) - Yes/No	The parameter is used in the formulas of the next three parameters.
Type	Number - Name - Actual Air Flow Day	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Actual Air Flow Day & Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the labels controlled by parameter 'CN_Actual Air Flow Day'.
CN_Actual Air Flow Not Day	Graphics - C - Project (Type, No) - Yes/No	Parameter used in the formula of parameter 'CN_Actual Air Flow Only Night'
CN_Actual Air Flow Only Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the heading.
CN_Actual Air Flow Day Or Night	Graphics - C - Project (Type, Yes) - Yes/No	Visibility parameter to control the heading above the labels with parameters of air flows during day- or nighttime.
CN_Actual Air Flow Night	Graphics - M - Project (Type, No) - Yes/No	The parameter is used in the formulas of the next three parameters.
CN_Actual Air Flow Day	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the labels containing the parameters 'CN_V_D_Actual Freecooling Supply Day Air Flow (m³/h)'
Type	Number - Name - Actual Air Flow Day & Night	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Actual Air Flow Not Day	Graphics - C - Project (Type, No) - Yes/No	Parameter used in the formula of parameter 'CN_Actual Air Flow Only Night'
CN_Actual Air Flow Only Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the heading.
CN_Actual Air Flow Day & Night	Graphics - C - Project (Type, Yes) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the labels controlled by parameter 'CN_Actual Air Flow Day'.
CN_Actual Air Flow Day Or Night	Graphics - C - Project (Type, Yes) - Yes/No	Visibility parameter to control the heading above the labels with parameters of air flows during day- or nighttime.
CN_Actual Air Flow Day	Graphics - M - Project (Type, Yes) - Yes/No	Visibility parameter to control the labels containing the parameters 'CN_V_D_Actual Freecooling Supply Day Air Flow (m³/h)'
CN_Actual Air Flow Night	Graphics - M - Project (Type, Yes) - Yes/No	The parameter is used in the formulas of the next three parameters.
Type	Number - Name - Actual Air Flow Night	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Actual Air Flow Day & Night	Graphics - C - Project (Type, No) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the labels controlled by parameter 'CN_Actual Air Flow Day'.
CN_Actual Air Flow Day Or Night	Graphics - C - Project (Type, Yes) - Yes/No	Visibility parameter to control the heading above the labels with parameters of air flows during day- or nighttime.

CN_Actual Air Flow Not Day	Graphics - C - Project (Type, Yes) - Yes/No	Parameter used in the formula of parameter 'CN_Actual Air Flow Only Night'
CN_Actual Air Flow Only Night	Graphics - C - Project (Type, Yes) - Yes/No	Visibility parameter to control labels with 'CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)', 'CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)' and 'CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)' directly placed under the heading.
CN_Actual Air Flow Day	Graphics - M - Project (Type, No) - Yes/No	Visibility parameter to control the labels containing the parameters 'CN_V_D_Actual Freecooling Supply Day Air Flow (m³/h)'
CN_Actual Air Flow Night	Graphics - M - Project (Type, Yes) - Yes/No	The parameter is used in the formulas of the next three parameters.
Labels	Parameter Name	
	CN_V_D_Actual Freecooling Supply Day Air Flow (m³/h)	
	CN_V_D_Actual Freecooling Supply Night Air Flow (m³/h)	
	CN_V_D_Actual Mechanical Supply Day Air Flow (m³/h)	
	CN_V_D_Actual Mechanical Supply Night Air Flow (m³/h)	
	CN_V_D_Actual Mechanical Extract Day Air Flow (m³/h)	
	CN_V_D_Actual Mechanical Extract Night Air Flow (m³/h)	
Family	CN_Titleblock A0 metric	
Family Template	A0 metric.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English > Titleblocks
Loaded Families	CN_CENERGIE Logo Annotation Family	In Family Editor set to not visibe (Visibility/Graphics); Category: Annotation Symbols
Revision Schedule		
Type	CN_Titleblock_A0 metric	
Labels	Parameter Name	
	CN_PI_Architect Adress Municipality Code And Name	
	CN_PI_Architect Adress Street And Street Number	
	CN_PI_Architect Name	
	CN_PI_Architect Telephone	
	CN_PI_Client Adress Street And Street Number	
	CN_PI_Client Municipality Code And Name	
	CN_PI_Client Name	
	CN_PI_Master Phase	
	CN_PI_Master Step	
	CN_PI_Project Adress Municipality Code And Name	
	CN_PI_Project Adress Street And Number	
	CN_PI_Project Name	
	CN_PI_Project Number	
	CN_PI_Project Phase	
	CN_Sheet Discipline	
	CN_Sheet Sub-Discipline	
	File Path	
	Scale	
	Sheet Name	
	Sheet Number	
	Sheet Set	
Family	CN_Titleblock A1 metric	
Family Template	A1 metric.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English > Titleblocks
Loaded Families	CN_CENERGIE Logo Annotation Family	In Family Editor set to not visibe (Visibility/Graphics); Category: Annotation Symbols
Revision Schedule		
Type	CN_Titleblock A1 metric	
Labels	Parameter Name	
Discipline	**STRUCTURAL LOADABLE FAMILIES**	
Category	**Structural Framing**	
Family	CN_IPE Beam	
Existing Family	IPE-Beams.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Structural Framing > Steel > Belgium Specific
Type	Loaded from Type Catalog 'CN_IPE Beam.txt'	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Length Invisible Line	Graphics - M - Family (Instance, 3000 mm) - Length	This parameter regulates the length of a model line (Subcategory: Invisible Lines). This line starts from the top of a beam and goes down perpendicular at the span direction. This line should go past the Cut Plane Height of the floor Plan View, to make the Symbolic Lines (Subcategory: Hidden Lines) visible in this View.
Family	CN_H-Wide Flange Beam	
Modified existing Family	H-Wide Flange Beams.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Structural Framing > Steel > Belgium Specific
Type	Loaded from Type Catalog 'CN_IPE Beam.txt'	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description

CN_Length Invisible Line	Graphics - M - Family (Instance, 3000 mm) - Length	This parameter regulates the length of a model line (Subcategory: Invisible Lines). This line starts from the top of a beam and goes down perpendicular at the span direction. This line should go past the Cut Plane Height of the floor Plan View, to make the Symbolic Lines (Subcategory: Hidden Lines) visible in this View.
Family	CN_Concrete Beam	
Modified existing Family	M_Concrete-Rectangular Beam.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Structural Framing > Concrete
Type	300 x 600mm	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Length Invisible Line	M - Family (Instance, 3000 mm) - Length	This parameter regulates the length of a model line (Subcategory: Invisible Lines). This line starts from the top of a beam and goes down perpendicular at the span direction. This line should go past the Cut Plane Height of the floor Plan View, to make the Symbolic Lines (Subcategory: Hidden Lines) visible in this View.
Type	400 x 800mm	
Discipline	**MECHANICAL LOADABLE FAMILIES**	
Category	**Air Terminals**	
Family	CN_V_Transfer Air Grille Extract - RP Transfer Air - Rectangular Face & Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	Yes	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Connector Description	Transfer Air Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter
Flow Direction	Mechanical - Out	Air is flowing out of the connector into the connected duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Pressure Drop	Mechanical - 0 Pa	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Extract Day Air Flow')	This value is will populate the 'CN_Mechanical Supply Day Air Flow' parameter of the connected Air Terminal for supply transfer air
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	Normal - 400x100 Duct	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Vertical Offset	Constraints - M - Shared (Instance, 300 mm) - Length	This parameter defines the vertical offset (distance between the middle of the grille and the lower Level)
CN_Mechanical Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 120 mm) - Length	Height of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 420 mm) - Length	Width of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 50 mm) - Length	Parameter used to distribute the Model Lines representing the grille
CN_Visibility Flow Arrow	Graphics - M - Family (Instance, Yes) - Yes/No	This boolean parameter regulates the visibility of the transfer air direction arrow (only visible in Plan Views)
CN_Flow Arrow Length	Graphics - M - Family (Type, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
CN_Geometric Extract Transfer Air Terminal	Other - M - Family (Type, Yes) - Yes/No	Parameter to flag this Family as an extract Air Terminal with geometric representation
Type	Acoustic - 400x100 Duct	
Parameter Name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Acoustic	General - M - Shared (Type, Yes) - Yes/No	Boolean parameter to determine if this is an acoustic transfer air grille or not
Family	CN_V_Transfer Air Grille Supply - Generic - Rectangular Face & Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	

Connector Description	Transfer Air Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The flow set in the extract transfer grille, propagates through the connecting Duct to this Connector if the flow configuration is set to Calculated
Flow Direction	Mechanical - In	Air is flowing in the connector from the connected Duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Flow	Mechanical-Flow - (Linked to 'CN_Mechanical Supply Day Air Flow')	The air flow value 'CN_Mechanical Extracct Day Air Flow' goes through the Duct to this Connecter and gives this parameter to 'CN_Mechanical Supply Day Air Flow'.
Pressure Drop	Mechanical - 0 Pa	
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	400x100 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m). This value is brought through the Duct Connector.
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m). This value must be filled in manually.
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 120 mm) - Length	Height of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 420 mm) - Length	Width of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 50 mm) - Length	Parameter used to distribute the Model Lines representing the grille
CN_Visibility Flow Direction	Graphics - M - Family (Instance, Yes) - Yes/No	This boolean parameter regulates the visibility of the transfer air direction arrow (only visible in Plan Views)
CN_Flow Arrow Length	Graphics - M - Family (Instance, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
Family	CN_V_Transfer Air Door Gap Extract - RP Transfer Air - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	Yes	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Connector Description	Transfer Air Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter
Flow Direction	Mechanical - Out	Air is flowing out of the connector into the connected duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Pressure Drop	Mechanical-Flow - 0 Pa	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Extract Day Air Flow')	This value is will populate the 'CN_Mechanical Supply Day Air Flow' parameter of the connected Air Terminal for supply transfer air
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	(400x100 Duct) - 10 Pa - 900x20 Door Gap	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Connector. This dimension is not important for any graphical representation.
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Connector. This dimension is not important for any graphical representation.
CN_Door Gap Height	Dimensions - M - Shared (Type, 20 mm) - Length	Not important for any graphical representation
CN_Door Gap Width	Dimensions - M - Shared (Type, 900 mm) - Length	Not important for any graphical representation.

CN_Pressure Difference (2 or 10 Pa)	Dimensions - M - Family (Type, 10) - Integer	Pressure difference between Spaces connected with by the Door; if another value than 2 or 10 Pa is entered an extreme big value will be generated for the 'CN_Min Door Gap Height' parameter. This indicates that a wrong value is entered here.
CN_Min Door Gap Height	Dimensions - C - Shared (Instance, 5 mm) - Length	This parameter calculates the minimum height of the door gap, given 'CN_Pressure Difference (2 or 10 Pa)', 'CN_Air Flow' and 'CN_Door Gap Width'. The calculation is done according to the rules described in 'Ventilatiedocument : niet-residentieel'
CN_Flow Arrow Length	Graphics - M - Family (Type, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
CN_Geometric Extract Transfer Air Terminal	Other - M - Family (Type, Yes) - Yes/No	Parameter to flag this Family as an extract Air Terminal with geometric representation
Type	(400x100 Duct) - 2 Pa - Door Gap 900x20	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Pressure Difference (2 or 10 Pa)	Dimensions - M - Family (Type, 2) - Integer	Pressure difference between Spaces connected with by the Door; if another value than 2 or 10 Pa is entered an extreme big value will be generated for the 'CN_Min Door Gap Height' parameter. This indicates that a wrong value is entered here.
Family	CN_V_Transfer Air Door Gap Supply - Generic - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Connector Description	Transfer Air Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The flow set in the extract transfer grille, propagates through the connecting Duct to this Connector if the flow configuration is set to Calculated
Flow Direction	Mechanical - In	Air is flowing in the connector from the connected Duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Pressure Drop	Mechanical-Flow - 0 Pa	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Supply Day Air Flow')	This value is will populate the 'CN_Mechanical Supply Day Air Flow' parameter of the connected Air Terminal for supply transfer air
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	(400x100 Duct)	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Connector. This dimension is not important for any graphical representation.
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Connector. This dimension is not important for any graphical representation.
CN_Flow Arrow Length	Graphics - M - Family (Instance, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
Family	CN_V_Transfer Air Open Plan Extract - RP Transfer Air - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	Yes	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Connector Description	Transfer Air Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's Flow' parameter
Flow Direction	Mechanical - Out	Air is flowing out of the connector into the connected duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Pressure Drop	Mechanical-Flow - 0 Pa	

Flow	Mechanical-Flow - (linked to 'CN_Mechanical Extract Day Air Flow')	This value is will populate the 'CN_Mechanical Supply Day Air Flow' parameter of the connected Air Terminal for supply transfer air
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	(400x100 Duct)	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Connector. This dimension is not important for any graphical representation.
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Connector. This dimension is not important for any graphical representation.
CN_Flow Arrow Length	Graphics - M - Family (Type, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
Family	CN_V_Transfer Air Open Plan Supply - Generic - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Connector Description	Transfer Air Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The 'Flow', set in the extract transfer grille, propagates through the connecting Duct to this Connector if the flow configuration is set to Calculated
Flow Direction	Mechanical - In	Air is flowing in the connector from the connected Duct
System Classification	Mechanical - Return Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Return Air.
Loss Method	Mechanical - Specific Loss	No value is needed but if it remains on 'Not Defined' Revit will show a warning
Pressure Drop	Mechanical-Flow - 0 Pa	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Supply Day Air Flow')	This value is will populate the 'CN_Mechanical Supply Day Air Flow' parameter of the connected Air Terminal for supply transfer air
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	(400x100 Duct)	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Duct Height	Dimensions - M - Family (Type, 100 mm) - Length	Height of the Connector. This dimension is not important for any graphical representation.
CN_Duct Width	Dimensions - M - Family (Type, 400 mm) - Length	Width of the Connector. This dimension is not important for any graphical representation.
CN_Flow Arrow Length	Graphics - M - Family (Type, 360 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
Family	CN_V_Freecooling Air Supply - Face Linked Window	
Family template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	Yes	
Always vertical	No	
Room Calculation Point	Yes (located 300 mm away from 'Center (Front/Back)')	
Type	Single Awning Window - 20° Opening - 1 m/s	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Freecooling Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Freecooling Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Flow Arrow Length	Graphics - M - Family (Type, 300 mm) - Length	The length of the arrow line that indicates the flow direction (only visible in Plan Views)
CN_Single Awning	Graphics - M - Family (Type, Yes) - Yes/No	This parameter defines the type of window

CN_Single Awning Swing Visibility	Graphics - C - Family (Instance, Yes) - Yes/No	This visibility parameter controls the visibility of the swing Model Lines. This parameter value becomes 'Yes' if both 'CN_Single Awning' and 'CN_Window Swing & Frame Visibility' are set to 'Yes'.
CN_Single Hopper	Graphics - M - Family (Type, No) - Yes/No	This parameter defines the type of window
CN_Single Hopper Swing Visibility	Graphics - C - Family (Instance, No) - Yes/No	This visibility parameter controls the swing Model Lines. If both 'CN_Single Hopper' and 'CN_Window Swing & Frame Visibility' are set to 'Yes', this parameter value is also 'Yes'.
CN_Window Swing & Frame Visibility	Graphics - M - Family (Instance, Yes) - Yes/No	This instance parameter can be used to switch of the visibility of the Model Lines representing the window frame and swing, independent of the type of window.
CN_Outdoor Wind Speed	Other - M - Family (Type, 1 m/s) - Velocity	Typical outdoor wind speed that is used for a control calculation of the entering freecooling air flow.
CN_Window Angle	Other - M - Family (Type, 20°) - Angle	Opening angle of the window used for freecooling
CN_Window Height	Other - M - Shared (Instance, 500 mm) - Length	Height of the window that is used for freecooling. The Model Lines representing the frame of the window are depend on this parameter
CN_Window Width	Other - M - Shared (Instance, 1000 mm) - Length	Width of the window that is used for freecooling. The Model Lines representing the frame of the window are depend on this parameter
CN_Window Opening Area	Other - C - Family (Instance, 0.171 m²) - Area	Opening area of the window, measured perpendicular on the open window surface
CN_Window Opening Area Contractor	Other - C - Shared (Instance, 0.182 m²) - Area	Opening area of the window, measured perpendicular on the wall surface.
CN_Window Air Flow	Other - C - Shared (Instance, 615.6 m³/h) - Air Flow	The maximum air flow that can come through the window entering the Space. Calculated by multiplying the opening area and wind speed.
Type	Single Hopper Window - 20° Opening - 1 m/s	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Single Awning	Graphics - M - Family (Type, No) - Yes/No	This parameter defines the type of window
CN_Single Awning Swing Visibility	Graphics - C - Family (Instance, No) - Yes/No	This visibility parameter controls the visibility of the swing Model Lines. This parameter value becomes 'Yes' if both 'CN_Single Awning' and 'CN_Window Swing & Frame Visibility' are set to 'Yes'.
CN_Single Hopper	Graphics - M - Family (Type, Yes) - Yes/No	This parameter defines the type of window
CN_Single Hopper Swing Visibility	Graphics - C - Family (Instance, Yes) - Yes/No	This visibility parameter controls the swing Model Lines. If both 'CN_Single Hopper' and 'CN_Window Swing & Frame Visibility' are set to 'Yes', this parameter value is also 'Yes'.
CN_Window Swing & Frame Visibility	Graphics - M - Family (Instance, Yes) - Yes/No	This instance parameter can be used to switch of the visibility of the Model Lines representing the window frame and swing, independent of the type of window.
Family	CN_V_Mech Air Terminal Supply - RP Ceiling Or Floor - Square Face & Round Duct	
Started from existing Family	M_Supply Diffuser.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Mechanical > MEP > Air-Side Components > Air Terminals
Work Plane-Based	Yes	
Always vertical	No	
Room Calculation Point	Yes (located 300 mm away from Face/Reference Level)	
Connector Description	Mechanical Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - In	Air is flowing out of the connected duct into the connector
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Supply Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Supply Day Air Flow' parameter)	
Shape	Dimensions - Round	Only round Duct Types can be connected
Diameter	Dimensions - (linked to 'CN_Duct Diameter')	
Type	300x300 Face - Ø100 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m). This value is always the maximum of the supply air flow during day- and nighttime and is given directly to the Connector.
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in night conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal.
CN_Duct Diameter	Dimensions - M - Family (Type, 100 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 300 mm) - Length	Width of the Air Terminal Face (three times 'CN_Duct Diameter')

CN_Air Terminal Height	Dimensions - C - Family (Type, 300 mm) - Length	Height of the Air Terminal Face , equal to the width of the Air Terminal
Type	375x375 Face - Ø125 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 125 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 375 mm) - Length	Width of the Air Terminal Face (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 375 mm) - Length	Height of the Air Terminal Face , equal to the width of the Air Terminal
Type	480x480 Face - Ø160 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 160 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 480 mm) - Length	Width of the Air Terminal Face (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 480 mm) - Length	Height of the Air Terminal Face , equal to the width of the Air Terminal
Type	600x600 Face - Ø200 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 200 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 600 mm) - Length	Width of the Air Terminal Face (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 600 mm) - Length	Height of the Air Terminal Face , equal to the width of the Air Terminal
Family	CN_V_Mech Air Terminal Extract - RP Ceiling Or Floor - Square Face & Round Duct	
Started from existing Family	M_Supply Diffuser.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Mechanical > MEP > Air-Side Components > Air Terminals
Work Plane-Based	Yes	
Always vertical	No	
Room Calculation Point	Yes (located 300 mm away from Face/Reference Level)	
Connector Description	Mechanical Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - Out	Air is flowing out of the connector into the Duct
System Classification	Mechanical - Exhaust Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Air Flow' parameter)	
Shape	Dimensions - Round	Only round Duct Types can be connected
Diameter	Dimensions - (linked to 'CN_Duct Diameter')	
Type	300x300 Face - Ø100 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m)
CN_Mechanical Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in night conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Daytime	Mechanical-Flow - M - Shared (Instance, Yes) - Yes/No	If this parameter value is equal to 'Yes', the Air Terminal will send the air flow during daytime through the system. If this is equal to 'No', then the air flow during nighttime will become active.
CN_Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	If 'CN_Daytime' is 'Yes' then the 'CN_Mechancial Extract Day Air Flow' is used; if 'No', then 'CN_Mechancial Extract Night Air Flow' is used. This Air Flow parameter is linked to the Flow parameter of the Duct Connector in the Family
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal.
CN_Duct Diameter	Dimensions - M - Family (Type, 100 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 300 mm) - Length	Width of the Air Terminal (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 300 mm) - Length	Height of the Air Terminal, equal to the width of the Air Terminal
Type	375x375 Face - Ø125 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 125 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct

CN_Air Terminal Width	Dimensions - C - Family (Type, 375 mm) - Length	Width of the Air Terminal (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 375 mm) - Length	Height of the Air Terminal, equal to the width of the Air Terminal
Type	480x480 Face - Ø160 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 160 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 480 mm) - Length	Width of the Air Terminal (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 480 mm) - Length	Height of the Air Terminal, equal to the width of the Air Terminal
Type	600x600 Face - Ø200 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Diameter	Dimensions - M - Family (Type, 200 mm) - Duct Size	Diameter of the connector opening and thus the necessary diameter of the connected Duct
CN_Air Terminal Width	Dimensions - C - Family (Type, 600 mm) - Length	Width of the Air Terminal (three times 'CN_Duct Diameter')
CN_Air Terminal Height	Dimensions - C - Family (Type, 600 mm) - Length	Height of the Air Terminal, equal to the width of the Air Terminal
Family	CN_V_Mech Air Terminal Supply - Generic (On Duct) - Rectangular Face & Rectangular Duct	
Started from existing Family	M_Supply Grille - Single Deflection - Rectangular Face Rectangular Neck.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Mechanical > MEP > Air-Side Components > Air Terminals
Work Plane-Based	No	
Always vertical	No	
Room Calculation Point	Yes (located 300 mm away from Duct)	
Connector Description	Mechanical Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - In	Air is flowing out of the connected duct into the connector
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Supply Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Supply Day Air Flow' parameter)	
Shape	Dimensions - Rectangular	No influence on connected Duct
Height	Dimensions - (linked to 'Duct Height')	No influence on connected Duct
Width	Dimensions - (linked to 'Duct Width')	No influence on connected Duct
Type	252x102 Face	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_ArrowLeft	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the lower side of the Duct
CN_ArrowRight	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the lower side of the Duct
CN_ArrowSide	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the side of the Duct
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m). This value is always the maximum of the supply air flow during day- and nighttime and is given to the Connector.
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air flow used for duct sizing in night conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal.
Grille Width	Dimensions - C - Family (Type, 102 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 252 mm) - Length	External length of the grille (face)
Type	352x152 Face	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Grille Width	Dimensions - C - Family (Type, 152 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 352 mm) - Length	External length of the grille (face)
Type	452x102 Face	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Grille Width	Dimensions - C - Family (Type, 102 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 452 mm) - Length	External length of the grille (face)
Type	452x252 Face	

Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Grille Width	Dimensions - C - Family (Type, 252 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 452 mm) - Length	External length of the grille (face)
Family	**CN_V_Mech Air Terminal Supply - Generic (On Duct) - Curved Face & Round Duct**	
Started from existing Family	M_Supply Grille - Single Deflection - Curve Face Rectangular Neck.rfa	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Mechanical > MEP > Air-Side Components > Air Terminals
Work Plane-Based	No	
Always vertical	No	
Room Calculation Point	Yes (located 300 mm away from Duct)	
Connector Description	Mechanical Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - In	Air is flowing out of the connected duct into the connector
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Supply Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical Supply Day Air Flow' parameter)	
Shape	Dimensions - Rectangular	No influence on connected Duct
Height	Dimensions - (linked to 'Duct Height')	No influence on connected Duct
Width	Dimensions - (linked to 'Duct Width')	No influence on connected Duct
Type	252x102 Face - Ø250 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_ArrowLeft	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the lower side of the Duct
CN_ArrowRight	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the lower side of the Duct
CN_ArrowSide	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the flow arrow by when the Air Terminal is placed at the side of the Duct
CN_Mechanical Supply Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m^3/h) - Air Flow	Air flow used for duct sizing in day conditions ('CN_Max Air Velocity Day (m/s)' and max 1 Pa/m). This value is always the maximum of the supply air flow during day- and nighttime and is given to the Connector.
CN_Mechanical Supply Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m^3/h) - Air Flow	Air flow used for duct sizing in night conditions ('CN_Max Air Velocity Night (m/s)' and max 1 Pa/m)
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal, if this value is known.
Duct Diameter	Dimensions - C - Family (Type, 250 mm) - Duct Size	Diameter of the connected Duct. The curved grille adapts according to the size of the Duct
Grille Width	Dimensions - C - Family (Type, 102 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 252 mm) - Length	External length of the grille (face)
Type	352x152 Face - Ø600 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Duct Diameter	Dimensions - C - Family (Type, 600 mm) - Duct Size	Diameter of the connected Duct. The curved grille adapts according to the size of the Duct
Grille Width	Dimensions - C - Family (Type, 152 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 352 mm) - Length	External length of the grille (face)
Type	452x252 Face - Ø1000 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Duct Diameter	Dimensions - C - Family (Type, 1000 mm) - Duct Size	Diameter of the connected Duct. The curved grille adapts according to the size of the Duct
Grille Width	Dimensions - C - Family (Type, 252 mm) - Length	External width of the grille (face)
Grille Length	Dimensions - C - Family (Type, 452 mm) - Length	External length of the grille (face)
Family	**CN_V_Mech Air Terminal Exhaust - Generic - Rectangular Face & Rectangular Horizontal Duct**	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	No	
Connector Description	Exhaust Air	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The flow set in the extract transfer grille, propagates through the connecting Duct to this Connector if the flow configuration is set to Calculated
Flow Direction	Mechanical - In	Air is flowing in the connector from the connected Duct

System Classification	Mechanical - Exhaust Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Flow	Mechanical-Flow - (Linked to 'CN_Mechanical Exhaust Air Flow')	
Pressure Drop	Mechanical-Flow - (Linked to 'CN_Local Pressure Loss')	
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	600x400 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Exhaust Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	The air flow is automatically filled in if the Duct is connected to an AHU.
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal.
CN_Duct Height	Dimensions - M - Family (Type, 400 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 600 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 420 mm) - Length	Width of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 720 mm) - Length	Height of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 200 mm) - Length	Parameter used to distribute the Model Lines representing the grille
CN_Visibility Flow Direction	Graphics - M - Family (Instance, Yes) - Yes/No	This boolean parameter regulates the visibility of the transfer air direction arrow (only visible in Plan Views)
CN_Flow Arrow Length	Graphics - M - Family (Instance, 150 mm) - Length	Distance between the grille and the start point of the flow arrow
Type	1000x500 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Height	Dimensions - M - Family (Type, 500 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 1000 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 520 mm) - Length	Width of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 1120 mm) - Length	Height of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 250 mm) - Length	Parameter used to distribute the Model Lines representing the grille
Family	CN_V_Mech Air Terminal Outdoor - Generic - Rectangular Face & Rectangular Horizontal Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	No	
Connector Description	Outdoor Air	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The flow set in the extract transfer grille, propagates through the connecting Duct to this Connector if the flow configuration is set to Calculated
Flow Direction	Mechanical - Out	Air is flowing in the connected Duct out of the Connector
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Supply Air.
Loss Method	Mechanical - Specific Loss	A value for the local pressure loss can be given via the parameter 'CN_Local Pressure Loss' that is connected to this Connector.
Flow	Mechanical-Flow - (Linked to 'CN_Mechanical Outdoor Air Flow')	
Pressure Drop	Mechanical-Flow - (Linked to 'CN_Local Pressure Loss')	
Shape	Dimensions - Rectangular	Only rectangular ducts can be used to connect the two transfer grilles (supply and extract)
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	700x400 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical Outdoor Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	The air flow is automatically filled in if the Duct is connected to an AHU.
CN_Local Pressure Loss	Mechanical-Flow - M - Shared (Type, 0 Pa) - Pressure	This parameter gives the amount of local pressure loss over the Air Terminal, if this value is known.
CN_Duct Height	Dimensions - M - Family (Type, 400 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 700 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 420 mm) - Length	Width of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 720 mm) - Length	Height of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 200 mm) - Length	Parameter used to distribute the Model Lines representing the grille

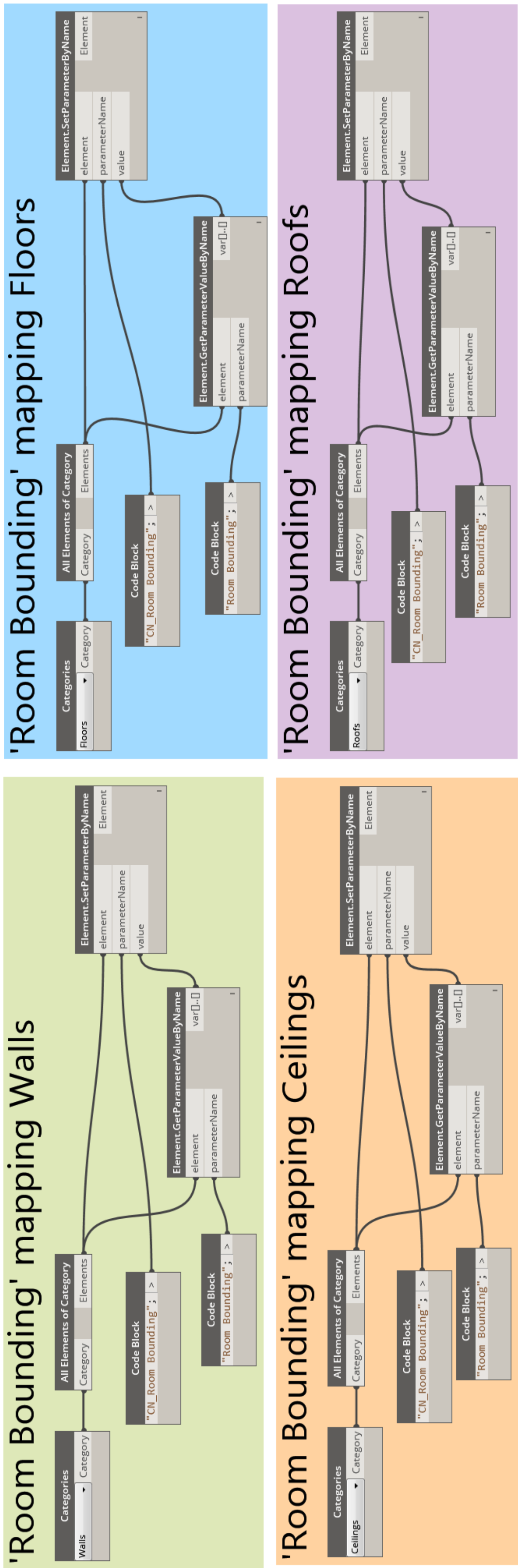
CN_Visibility Flow Direction	Graphics - M - Family (Instance, Yes) - Yes/No	This boolean parameter regulates the visibility of the transfer air direction arrow (only visible in Plan Views)
CN_Flow Arrow Length	Graphics - M - Family (Instance, 450 mm) - Length	Distance between the grille and the start point of the flow arrow
Type	1100x500 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Duct Height	Dimensions - M - Family (Type, 500 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 1100 mm) - Length	Width of the Duct opening and Connector
CN_Air Terminal Width	Dimensions - C - Family (Type, 520 mm) - Length	Width of the grille frame
CN_Air Terminal Height	Dimensions - C - Family (Type, 1120 mm) - Length	Height of the grille frame
CN_Half Duct Height	Dimensions - C - Family (Type, 250 mm) - Length	Parameter used to distribute the Model Lines representing the grille
Category	**Mechanical Equipment**	
Family	CN_V_AHU - Roof Extractor - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	No	
Connector Description	Mechanical Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	The Connector checks the air flow in the Duct System when it enters the Connector and gives this value to the AHU Family.
Flow Direction	Mechanical - In	Air is flowing out of the connected Duct into the Connector
System Classification	Mechanical - Exhaust Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss AHU Extract' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical AHU Extract Air Flow' parameter)	
Shape	Dimensions - Rectangular	Only rectangular ducts can connect to this Connector
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	500x500 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical AHU Extract Air Flow	General - C - Shared (Instance, 0 m³/h) - Air Flow	The air flow received from the connected Extract Duct System.
CN_Local Pressure Loss AHU Extract	General - M - Shared (Instance, 0 Pa) - Pressure	A value for the total pressure loss over the AHU (extract - exhaust air) can be given with the parameter 'CN_Local Pressure Loss AHU Extract'
CN_Mechanical AHU Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air Flow received during daytime (manually copied from 'CN_Mechanical AHU Extract Air Flow').
CN_Mechanical AHU Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air Flow received during nighttime (manually copied from 'CN_Mechanical AHU Extract Air Flow').
CN_Mechanical AHU Exhaust Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	Maximum value of 'CN_Mechanical AHU Extract Day Air Flow' and 'CN_Mechanical AHU Extract Night Air Flow'
CN_AHU Height	Dimensions - M - Family (Instance, 1000 mm) - Length	Heigth of the rooftop extractor AHU
CN_AHU Width	Dimensions - M - Family (Instance, 800 mm) - Length	Width of the rooftop extractor AHU
CN_AHU Length	Dimensions - M - Family (Instance, 800 mm) - Length	Length of the rooftop extractor AHU
CN_Duct Height	Dimensions - M - Family (Type, 500 mm) - Length	Height of the Duct opening and Connector
CN_Duct Width	Dimensions - M - Family (Type, 500 mm) - Length	Width of the Duct opening and Connector
CN_Extract Fan Power	Mechanical - M - Shared (Instance, 0 kW) - Power	The dimensioned fan power.
CN_Extract Fan Type	Mechanical - M - Shared (Instance,) - Text	The type of extract fan can be given
CN_Filter Type	Mechanical - M - Shared (Instance,) - Text	The code for the filter(s) can be given
Family	CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	No	
Connector Description	Mechanical Supply	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - Out	Air is flowing out of the Connector into the connected Duct
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Supply Air.
Loss Method	Mechanical - Specific Loss	A value for the total pressure loss over the AHU (outdoor - supply air) can be given with the parameter 'CN_Local Pressure Loss AHU Supply'

Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss AHU Supply' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical AHU Supply Air Flow')	
Shape	Dimensions - Rectangular	Only rectangular ducts can connect to this Connector
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Connector Description	Mechanical Extract	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Calculated	A value for the flow can be added manually via the connector's 'Flow' parameter, that is linked to another parameter
Flow Direction	Mechanical - In	Air is flowing out of the connected Duct into the Connector
System Classification	Mechanical - Exhaust Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	
Pressure Drop	Mechanical - (linked to 'CN_Local Pressure Loss AHU Extract' parameter)	
Flow	Mechanical-Flow - (linked to 'CN_Mechanical AHU Extract Air Flow')	
Shape	Dimensions - Rectangular	Only rectangular ducts can connect to this Connector
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Connector Description	Mechanical Outdoor	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	The AHU gives the connected Duct System (Type Outdoor) the air flow that it received from the Mechanical Supply Connector (the maximum of day and night air flow).
Flow Direction	Mechanical - In	Air is flowing out of the connected Duct into the Connector
System Classification	Mechanical - Supply Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	
Pressure Drop	Mechanical - 0 Pa	This value is equal to zero because it is already included in the Pressure Drop of the Mechanical Supply Connector
Flow	Mechanical-Flow - (linked to 'CN_Mechanical AHU Outdoor Air Flow')	
Shape	Dimensions - Rectangular	Only rectangular ducts can connect to this Connector
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Connector Description	Mechanical Exhaust	
Parameter name	Parameter Group - Parameter Value	Description
Flow Configuration	Mechanical - Preset	The AHU gives the connected Duct System (Type Exhaust) the air flow that it received from the Mechanical Extract Connector (the maximum of day and night air flow).
Flow Direction	Mechanical - Out	Air is flowing out of the Connector into the connected Duct
System Classification	Mechanical - Exhaust Air	This setting makes sure that Revit recognizes this connector as being a part of a Duct System with Duct System Classification Exhaust Air.
Loss Method	Mechanical - Specific Loss	
Pressure Drop	Mechanical - 0 Pa	This value is equal to zero because it is already included in the Pressure Drop of the Mechanical Supply Connector
Flow	Mechanical-Flow - (linked to 'CN_Mechanical AHU Exhaust Air Flow')	
Shape	Dimensions - Rectangular	Only rectangular ducts can connect to this Connector
Height	Dimensions - (linked to 'CN_Duct Height')	Heigth of the connector opening and thus the necessary height of the connection Duct
Width	Dimensions - (linked to 'CN_Duct Width')	Width of the connector opening and thus the necessary width of the connection Duct
Type	1000x500 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
CN_Mechanical AHU Extract Air Flow	General - C - Shared (Instance, 0 m³/h) - Air Flow	The air flow received from the connected Extract Duct System.
CN_Mechanical AHU Supply Day Air Flow	General - C - Shared (Instance, 0 m³/h) - Air Flow	The air flow received from the connected Supply Duct System. The value during daytime is always the highest supply air flow.
CN_Local Pressure Loss AHU Extract	General - M - Shared (Instance, 0 Pa) - Pressure	A value for the total pressure loss over the AHU (extract - exhaust air) can be given with the parameter 'CN_Local Pressure Loss AHU Extract'
CN_Local Pressure Loss AHU Supply	General - M - Shared (Instance, 0 Pa) - Pressure	A value for the total pressure loss over the AHU (supply - outdoor air)
CN_Mechanical AHU Extract Day Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air Flow received during daytime (manually copied from 'CN_Mechanical AHU Extract Air Flow').

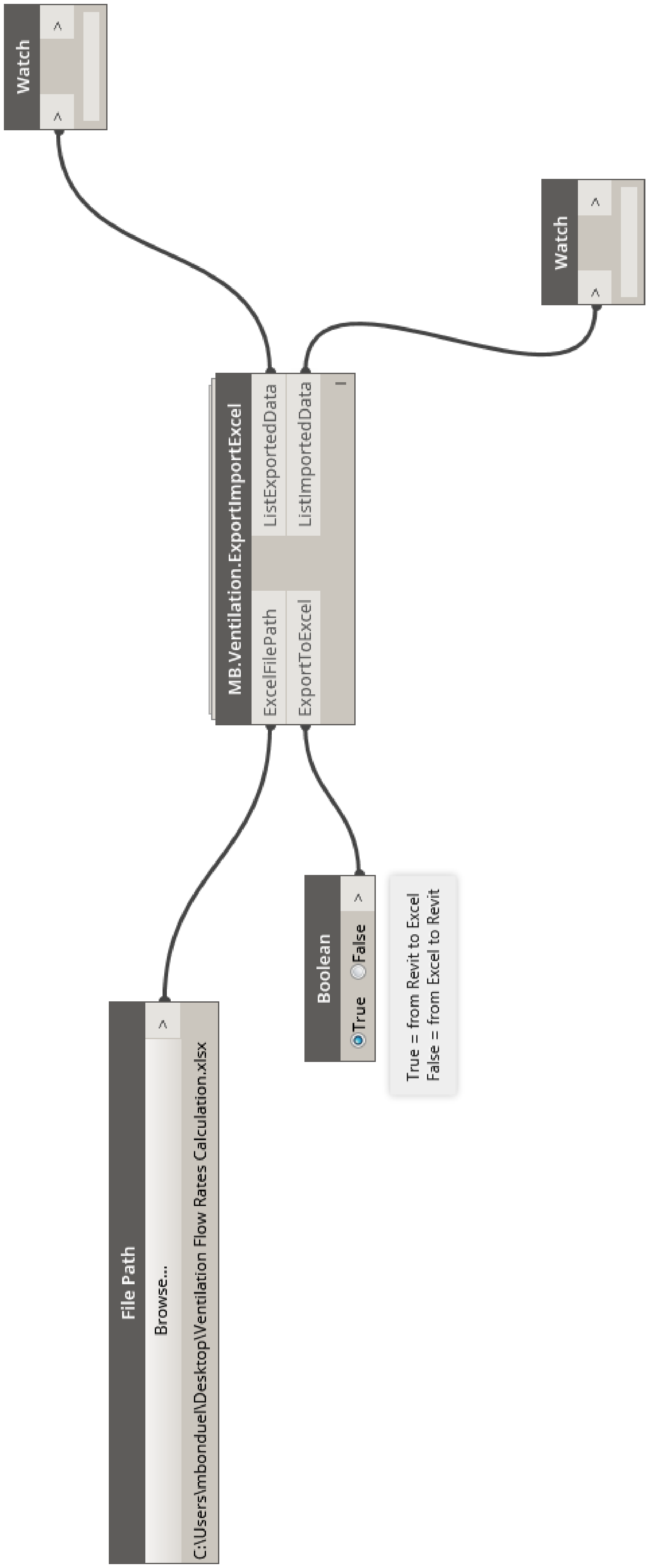
CN_Mechanical AHU Extract Night Air Flow	Mechanical-Flow - M - Shared (Instance, 0 m³/h) - Air Flow	Air Flow received during nighttime (manually copied from 'CN_Mechanical AHU Extract Air Flow').
CN_Mechanical AHU Exhaust Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	Maximum value of 'CN_Mechanical AHU Extract Day Air Flow' and 'CN_Mechanical AHU Extract Night Air Flow'
CN_Mechanical AHU Outdoor Air Flow	Mechanical-Flow - C - Shared (Instance, 0 m³/h) - Air Flow	Equal to 'CN_Mechanical AHU Supply Day Air Flow'
CN_AHU Height	Dimensions - C - Family (Type, 1600 mm) - Length	Heigth of the indoor AHU (exhaust/extract layer and outdoor/supply layer). Depends on parameter 'CN_Duct Height'.
CN_AHU Half Height	Dimensions - C - Family (Type, 800 mm) - Length	Half the total height of the indoor AHU
CN_AHU Width	Dimensions - C - Family (Type, 1300 mm) - Length	Width of the indoor AHU. Depends on parameter 'CN_Duct Width'.
CN_AHU Length Extract Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the extract air flow part of the indoor AHU
CN_AHU Length Exhaust Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the exhaust air flow part of the indoor AHU
CN_AHU Length Supply Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the supply air flow part of the indoor AHU
CN_AHU Length Outdoor Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the outdoor air flow part of the indoor AHU
CN_AHU Length Heat Recovery	Dimensions - M - Family (Type, 450 mm) - Length	Length of the thermal wheel (central part of AHU)
CN_Duct Height	Dimensions - M - Family (Type, 500 mm) - Length	Height of the four Duct openings and Connectors
CN_Duct Width	Dimensions - M - Family (Type, 1000 mm) - Length	Width of the four Duct openings and Connectors
CN_Skid Mounted	Dimensions - M - Family (Instance, No) - Yes/No	This parameter indicates if the AHU is skid mounted or is placed on a concrete base. It also controls the visibility of the skid or base.
CN_Concrete Base	Dimensions - C - Family (Instance, Yes) - Yes/No	This parameter indicates if the AHU is skid mounted or is placed on a concrete base. It also controls the visibility of the skid or base.
CN_ Skid Or Base Height	Dimensions - M - Family (Type, 150 mm) - Distance	The height of the base or skid above the placement Level.
CN_Clearance Zone Horizontal Offset	Dimensions - C - Family (Type, 1300 mm) - Length	The horizontal distance from a side (left and/or right) of the AHU that must remain accesible. This value is the maximum of 1 m and the width of the AHU.
CN_Clearance Zone Vertical Offset	Dimensions - M - Family (Type, 1000 mm) - Length	The vertical distance from the top of the AHU that must remain accesible.
CN_Clearance Zone Total Height	Dimensions - C - Family (Type, 2750 mm) - Length	The sum of 'CN_AHU Height', 'CN_Clearance Zone Vertical Offset' and 'CN_Skid Or Base Height' is the height of the clearance zone next of the AHU.
CN_Clearance Zone Length 1	Dimensions - C - Family (Type, 1000 mm) - Length	The maximum of 'CN_AHU Length Outdoor Part' and 'CN_AHU Length Exhaust Part'
CN_Clearance Zone Length 2	Dimensions - C - Family (Type, 1000 mm) - Length	The maximum of 'CN_AHU Length Supply Part' and 'CN_AHU Length Extract Part'
CN_Extract Fan Power	Mechanical - M - Shared (Instance, 0 kW) - Power	The dimensioned fan power for extract-exhaust air flow
CN_Supply Fan Power	Mechanical - M - Shared (Instance, 0 kW) - Power	The dimensioned fan power for supply-outdoor air flow
CN_Extract Fan Type	Mechanical - M - Shared (Instance,) - Text	The type of extract fan can be given
CN_Supply Fan Type	Mechanical - M - Shared (Instance,) - Text	The type of supply fan can be given
CN_Filter Type	Mechanical - M - Shared (Instance,) - Text	The code for the filter(s) can be given
CN_Heating Battery Type	Mechanical - M - Shared (Instance, 'none') - Text	This parameter can be used to indicate if there is a heating battery in the AHU
CN_Heating Battery Power	Mechanical - M - Shared (Instace, 0 kW) - Power	If there is a heating battery, the calculated needed power can be entered here.
CN_Cooling Battery Type	Mechanical - M - Shared (Instance, 'none') - Text	This parameter can be used to indicate if there is a cooling battery in the AHU
CN_Cooling Battery Power	Mechanical - M - Shared (Instance, 0 kW) - Power	If there is a cooling battery, the calculated needed power can be entered here.
CN_Heat recovery Efficiency	Mechanical - M - Shared (Instance, 0 %) - Factor	The efficiency of the thermal wheel heat recovery system in percent
CN_Clearance Zone Left	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the clearance zone at the left handside of the AHU
CN_Clearance Zone Right	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the clearance zone at the right handside of the AHU
CN_Clearance Zone Top	Graphics - C - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the clearance zone above the AHU
CN_AHU Symbols	Graphics - M - Family (Instance, Yes) - Yes/No	This parameter controls the visibility of the AHU symbols (flow direction, flow text, thermal wheel symbol)
Family	CN_V_AHU - Indoor - Recuperator - Rectangular Duct	
Family Template	Metric Mechanical Equipment.rft	Source: Out-of-the-box Revit library: RVT 2016 > Family Templates > English
Work Plane-Based	No	
Always vertical	Yes	
Room Calculation Point	No	
Connector Description	Mechanical Supply	
Same Connector as 'CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct'		
Connector Description	Mechanical Extract	
Same Connector as 'CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct'		
Connector Description	Mechanical Outdoor	
Same Connector as 'CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct', but switched location with Connector Mechanical Exhaust		
Connector Description	Mechanical Exhaust	
Same Connector as 'CN_V_AHU - Indoor - Thermal Wheel - Rectangular Duct', but switched location with Connector Mechanical Outdoor		
Type	600x400 Duct	
Parameter name	Parameter Group - Code - Parameter Type (Instance/Type, default value) - Parameter Data Type	Description
Same parameters as 'CN_AHU - Indoor - Thermal Wheel - Rectangular Duct' except the following changes in values:		

CN_AHU Height	Dimensions - C - Family (Type, 1000 mm) - Length	Heigth of the indoor AHU (exhaust/extract layer and outdoor/supply layer). Depends on parameter 'CN_Duct Height'.
CN_AHU Half Height	Dimensions - C - Family (Type, 500 mm) - Length	Half the total height of the indoor AHU
CN_AHU Width	Dimensions - C - Family (Type, 700 mm) - Length	Width of the indoor AHU. Depends on parameter 'CN_Duct Width'.
CN_AHU Length Exhaust Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the exhaust air flow part of the indoor AHU. Switched location with 'CN_AHU Length Exhaust Part
CN_AHU Length Outdoor Part	Dimensions - M - Family (Type, 1000 mm) - Length	Length the outdoor air flow part of the indoor AHU
CN_AHU Length Heat Recovery	Dimensions - M - Family (Type, 1000 mm) - Length	Length of the thermal wheel (central part of AHU)
CN_Duct Height	Dimensions - M - Family (Type, 400 mm) - Length	Height of the four Duct openings and Connectors
CN_Duct Width	Dimensions - M - Family (Type, 600 mm) - Length	Width of the four Duct openings and Connectors
CN_Clearance Zone Horizontal Offset	Dimensions - C - Family (Type, 1000 mm) - Length	The horizontal distance from a side (left and/or right) of the AHU that must remain accesible. This value is the maximum of 1 m and the width of the AHU.
CN_Clearance Zone Total Height	Dimensions - C - Family (Type, 2150 mm) - Length	The sum of 'CN_AHU Height', 'CN_Clearance Zone Vertical Offset' and 'CN_Skid Or Base Height' is the height of the clearance zone next of the AHU.
Category	**Duct Fittings**	
Family	CN_V_Duct Fitting - Rectangular Union	
Started from existing Family	M_Rectangular Union	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Duct > Fittings > Rectangular > Unions
Type	Standard	
Parameter name	Parameter Group - Code - Parameter type (Instance/Type, default value) - Parameter data type	Description
CN_Union Not In BoQ	Other - M - Shared (Type, 'Yes') - Yes/No	Added parameter to exclude this Duct Fitting from being Scheduled in a bill of quantities
Family	CN_V_Duct Fitting - Round Union	
Started from existing Family	M_Round Union	Source: Out-of-the-box Revit library: RVT 2016 > Libraries > Belgium > Duct > Fittings > Round > Unions
Type	Standard	
Parameter name	Parameter Group - Code - Parameter type (Instance/Type, default value) - Parameter data type	Description
CN_Union Not In BoQ	Other - M - Shared (Type, 'Yes') - Yes/No	Added parameter to exclude this Duct Fitting from being Scheduled in a bill of quantities

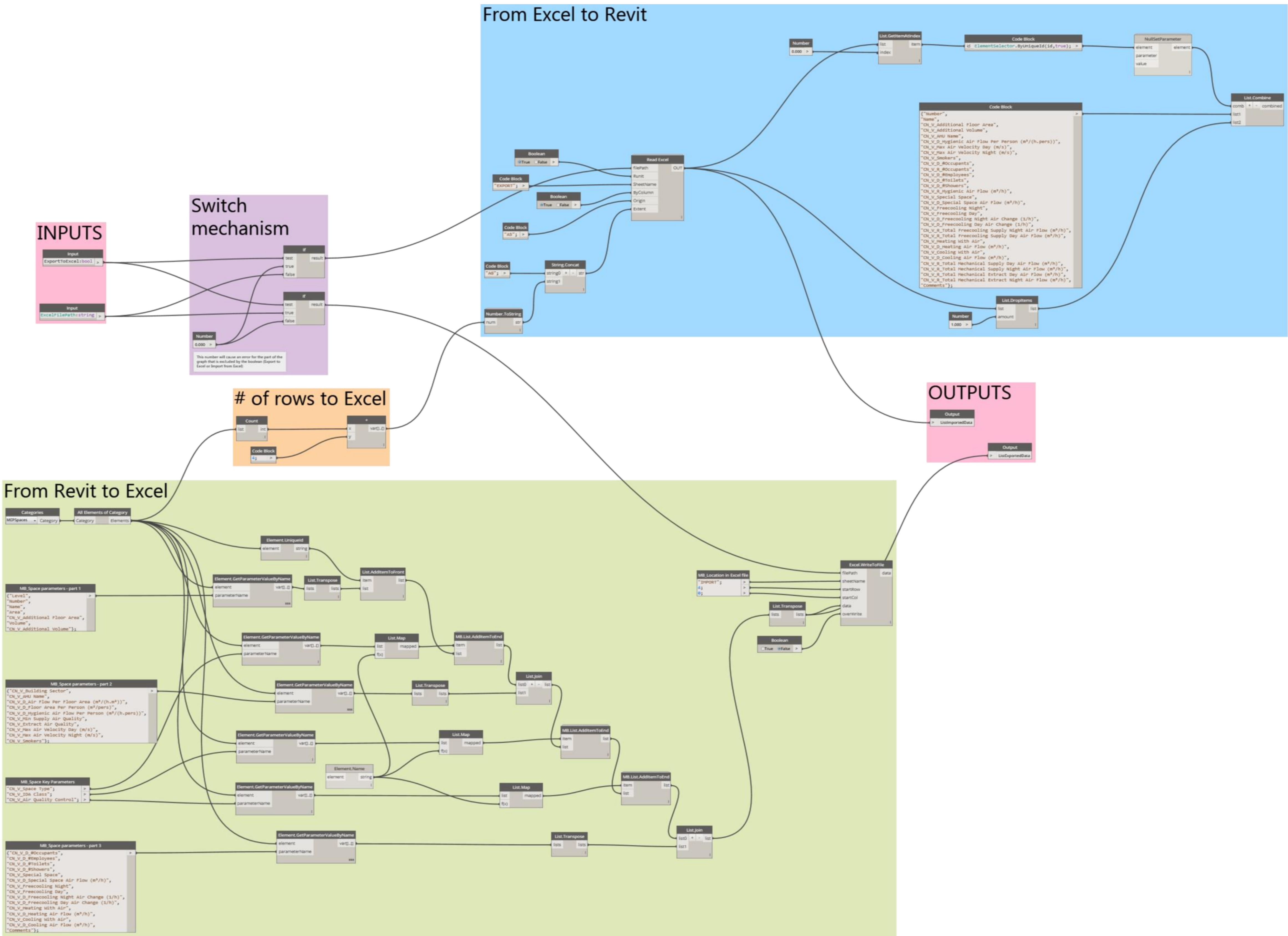
Appendix 8. Dynamo graph ‘Tool – Room Bounding.dyn’



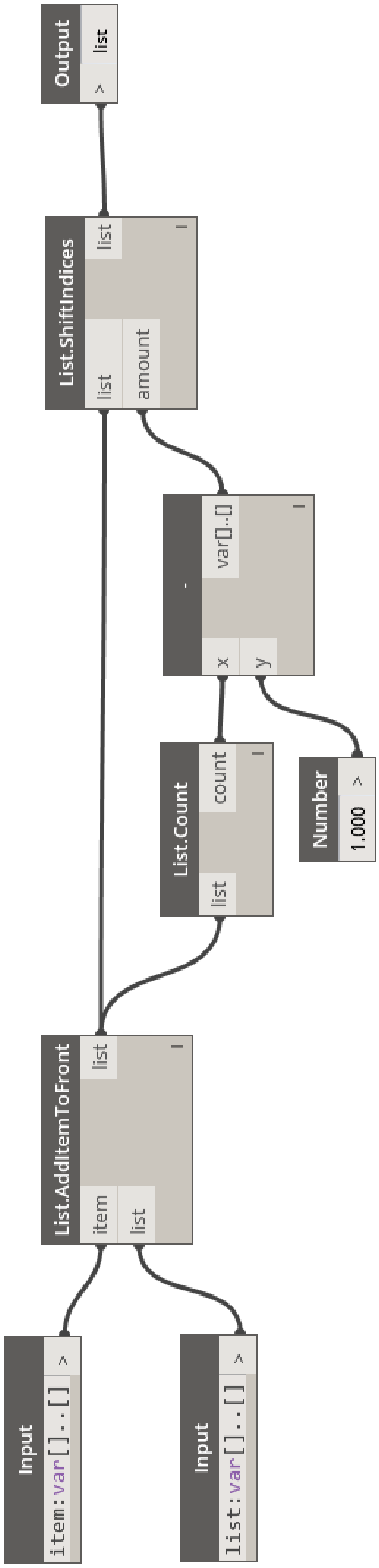
Appendix 9. Dynamo graph ‘Tool – Link Revit-Excel.dyn’



Appendix 10. Dynamo custom node ‘MB.Ventilation.ExportImportExcel.dyf’



Appendix 11. Dynamo custom node ‘MB.ListAddItemToEnd.dyf’



Appendix 12. Dynamo graph ‘Tool – Air Terminals Location.dyn’