METATGA: A CHANCE FOR BIM IN THE FIELD OF MEP

S. Hauer[1], J. Murschetz[2], A. Bres[1], A. Sporr[1], M. Schöny[1] and M. Monsberger[2]
[1]Austrian Institute of Technology GmbH, Center for Energy, Thermal Energy Systems, Vienna, Austria
[2]Graz University of Technology, Institute of Building Construction, Graz, Austria

ABSTRACT

The use of Building Information Modeling (BIM) is becoming more and more state-of-the-art in the construction and real estate industries. Mechanical, electrical, and plumbing (MEP) has a major part in this field. The quality of MEP in the planning and the construction phase of a building is crucial for energy consumption and human comfort within the building. To benefit from the advantages of the BIM methodology, a high-quality data model is needed to ensure the availability of necessary information of a complete life cycle of a building. The Austrian research project metaTGA provides solutions for high-qualtiy data models. The paper will provide information about: how do MEP openBIM data models need to look like? What are the major development steps of this models? How they are applied in a BIM project including first practical feedback? How does the process support quality measures for BIM projects?

INTRODUCTION

The use of Building Information Modeling (BIM) represents a fundamental technological leap in the construction and real estate industries and has medium- to long-term implications for all stakeholders in the value chain of the construction sector. Mechanical, electrical, and plumbing (MEP) has a major part in this field. The quality of MEP planning and coordination is one of the central and most resource-intensive tasks in the construction process and it is crucial for energy consumption and human comfort within the building (Boktor et al., 2014; Wang and Leite, 2016). Studies show that open data interfaces such as Industry Foundation Classes (IFC) and interoperability between software environments are of great importance, especially in the area of MEP (Both et al., 2013; Kovacic et al., 2013). Uniform data models and modeling standards are important pre-requisites for open data exchange via openBIM. openBIM is a universal approach to the collaborative design, realization and operation of buildings based on open standards and workflows (buildingSMART-International, 2014). Current activities at national and international level are trying to further advance and establish openBIM. At the level of buildingSMART International[1], the International Property Server *buildingSMART Data Dictionary*[2] (bsDD), its Framework of Dictionaries (IFD) and the specifications of IFC4.3 are currently under development, which can be found at the international level in the current ISO 16739 standard (IFC) and the existing ISO 12006 standard (IFD). This activity is supported by the upcoming ISO 23386 standard (methodology for the description, creation and maintenance of properties in interconnected data catalogs), which also includes the necessary link to the international property server (bsDD/IFD). ISO 19650-Part 1/2/3 and the planned extensions Part 4/5/6 (information exchange, security-minded approach to information management) are the basis for project-related (PIM) and company-related (AIM) data management. The requirements of ISO 23386 and ISO 19650 are essential and will therefore be adopted in the upcoming CEN TC442 EU BIM standard. The results from the CEN TC442 subsequently lead to national standards such as ÖN A6241-2: 20XX and will have a significant impact on the practical project organization. buildingSMART International works continuously on the IFC standard, which in the long term will also include the complete data structure for transport infrastructure within IFC 5 and will subsequently result in the next update of the ISO 16739 standard (Eichler, 2020).

Nevertheless, the current development stage especially of MEP BIM models shows that a comprehensive and consistent usage in different BIM applications is currently limited. Mainly because of information losses within MEP models using the openBIM approach, re-modeling is often part of reality (Castell-Codesal, Javier and Frantzen, Jürgen, 2015). On the one hand, one of the main reasons is, that current available standards for openBIM MEP models are not sufficient in terms of available information about which parameters need to be specified and provided (Hauer et al., 2019). Initiatives like bimobject[3], MEPcontent[4], BIM&CO[5], NBS National BIM Library[6] etc. provide online platforms and several plug-ins to facilitate pre-defined BIM objects from various manufacterors for BIM projects.

[1] https://www.buildingsmart.org
[2] http://bsdd.buildingsmart.org
[3] https://www.bimobject.com/en/product
[4] https://www.mepcontent.com/en/
[5] https://www.bimandco.com/de
[6] www.nationalbimlibrary.com/en/

 DOI: 10.3217/978-3-85125-786-1-60

Manufacturers can use these platforms for publishing their products as BIM models for further use. Mostly the models can be downloaded in various formats e.g. *.rvt*, *.dwg*, *.ifc*, *.dfx*, etc. In the authors opinion the main problem lies in the different quality of the properties, which depend on the respective manufacturer. Critical spoken, in terms of geometry- and basic information, the models are good to be used in the design phase of a building, but in terms of technical properties necessary for MEP design, the content of the models show that they can not be used for this purpose.

buildup Schweiz[7] tries to close these gaps although they also depend on manufacturer information. In the authors opinien, the platform offers more technical properties compared to the others. Buildup offers a neutral structure of technical information provided by manufacturers, which allows BIM modelers to search, filter and compare based on properties. For a better connection customers can use an open API for further use. Moreover, additional technical information e.g. manuals, data sheets and in many cases generic ifc-files, which contain all information in IFC langueage, are available for customers (buildup, n.d.).

On the other hand, the import/export functionality of state-of-the-art BIM applications need to be improved as well, because often they cause errors in openBIM MEP models. Based on stakeholder feedback from the building domain, (Hauer et al., 2018a) confirms, that missing parameters in IFC especially in MEP represent one of the biggest obstacles for a continuous use of the openBIM approach. The Austrian research project metaTGA[8] deals exactly with those challenges and provides solutions avoiding such situations. Based on the results of the project, the paper investigates following questions: how do MEP openBIM data models need to look like? What are the major development steps of this models? How they are applied in a BIM project including first practical feedback? How does the process support quality measures for BIM projects?

METHODOLOGY

Developed processes

The first step in the development process was to generate high-quality metadata (chapter data harvesting) as a basis for all upcoming developments. The second step (chapter data processing) was to process the data in terms of usability, practical use and structuring the parameters, to be able to finally specify MEP models. Finally, a practical example of how these models can be applied in BIM based MEP planning is introduced in chapter data usage.

MEP BIM model requirements

To ensure a strong practical relevance of the developed solution of the research project metaTGA, an intense stakeholder involvement from the building industry was established (see *Figure*- step1). Hence, feedback (based on interviews, workshops and classical desk research) from real BIM projects and consequently of the BIM real-world problems were collected and investigated. Among others, the following challenges have been identified (Hauer et al., 2018b):

- the reusability of IFC models or in other words an error-free transfer between different software environments is often not possible. Mostly due to missing attributes in the IFC structure or based on insufficient export capability.
- BIM models from manufacturers are often too detailed in terms of geometrical information. On the other hand, mandatory metadata is often missing. The provided models should be made more manageable and have an adequate storage size by e.g., simplifying the geometry.
- New parameters should be specified uniquely and correctly, that there is no room for interpretation. Currently this is not guaranteed due to e.g. translation errors between different languages.

Further requests from the metaTGA stakeholder feedback for MEP models were, e.g.:

- the developed models, in particular the specified attributes and metadata, should have a strong practical relevance and should consider the entire life cycle of a building, especially planning and operation.
- the developed models should be validated by experts to guarantee a strong practical use.

To meet above requirements an universal concept was developed introduced by (Hauer et al., 2019). This concept was further developed within the scope of the project metaTGA and will be described in the following sections.

Data harvesting

For each MEP component to be developed e.g. heat pump, different sources of information (e.g. individual sheets from VDI-3805, manufacturing data sheets, IFC4 Add2TC1, Austrian standardized specification for building services (in German language: Standardisierte Leistungsbeschreibung Haustechnik[9]), experience values from HVAC experts, etc.) were analysed in detail, resulting in parameter lists of available metadata.

[7] https://ch.buildup.group
[8] www.metatga.org
[9] https://www.bmdw.gv.at/KulturellesErbe/Bauservice/Seiten/LB-Haustechnik.aspx

 DOI: 10.3217/978-3-85125-786-1-60

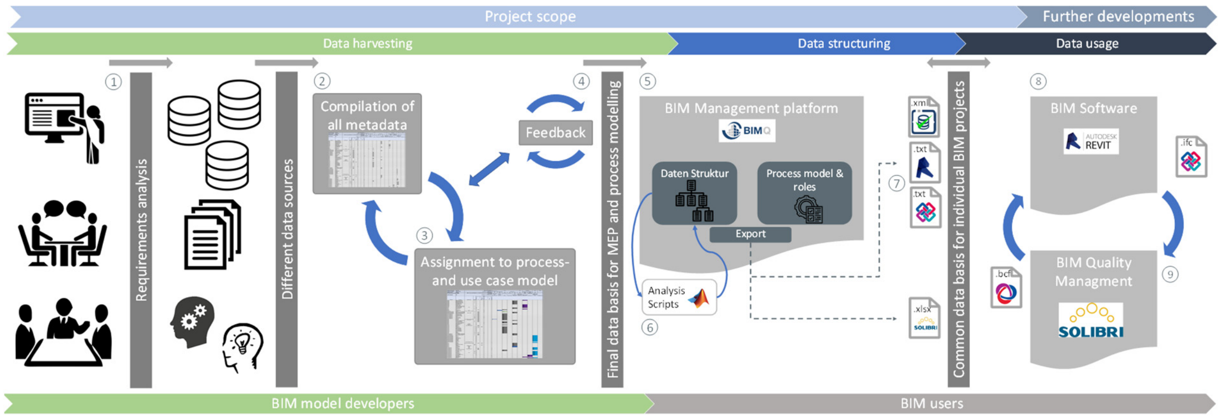

Figure 1: Process overview of the metaTGA approach of developing MEP BIM models

These parameters were investigated for their practical relevance, reduced to the essential ones and extended with corresponding SI-Units (Figure 1- step 1-2). Next step (Figure 1- step 3) was to investigate which data out of this set of metadata, is needed from whom and when, for BIM to be able to deliver its benefits over the entire building life cycle. Therefore, all necessary metadata were associated to different involved stakeholders (e.g. client, architect, technical sub-domain planner, facility manager, etc.) and building life cycle phases according to the Austrian Standard ÖNORM A 6241 Part 2- Appendix B[10] and the Austrian scale of fee structures for architects and engineers (in German language: Leistungsmodell-Technische Ausrüstung LM.TA- 2014[11]). As side effect, the results can be further used for process models e.g. sizing of HVAC components, using standardized languages like business process model and notation (BPMN). To ensure practical relevance of the developed results, a cross-check by experts was performed on a regular basis (see Figure 1- step 4).

Data processing and structuring

After the definition of mandatory metadata and their responsible technician (e.g. technical sub-domain planner, architect, facility manager, etc.) for different MEP components, these definitions must be transferred into a BIM collaboration and management platform which enables different users to apply them according to their role in a BIM project with different BIM applications. The collaboration software BIMQ[12] was chosen for this purpose.

The features of BIMQ perfectly match the requirements of the metaTGA project and support the idea of the openBIM approach (see Figure 1- step 5). Additionally to other features, BIMQ offers the possibility to define individual roles, meaning responsible persons, project phases and use cases (see further information e.g. Baldwin et al., 2019, p. 180; Liebich, 2018; Wirz and Frey, 2019). This means with BIMQ one of the main requirements – specify which parameters are needed (and when) to fully describe a MEP component over the entire building life cycle phases – can be fulfilled using BIMQ. From a project point of view, among others BIMQ interacts as kind of an individual or company specific "property server" for MEP BIM model definitions. From a management point of view in the role of a MEP planner, BIMQ allows both to define Level of Information (LOI) requirements as parts of employer information requests (EIRs) (in German: Auftraggeber-Informations-Anforderung (AIA)) or apply them for BIM projects. In order to ensure that EIRs and BIM models meet the quality standards, BIMQ offers export files for model checking software such as Solibri Model checker (SMC)[13] or simplebim[14], which can be used to automatically check whether the requirements have been met. Thus, it can be guaranteed that every involved technician within a BIM project has the same MEP model standards especially in terms of model quality and clear responsibilities (same number of parameters, unique responsibility of parameters to be defined in different project phases, etc.). One challenge of the definition process was, that every parameter of all MEP models to be specified, must not exist more than once in the system. This means a parameter for e.g. pressure drop, can be defined only once in BIMQ but can be assigned to other MEP components if necessary. For a few MEP components, this can be done of course manually, but during the metaTGA project 56 MEP components for heating and mechanical ventilation (from categories generation, distribution and delivery like: heat pumps, air handling units, valves, pipes, fittings, actuators, etc.) have been defined resulting in ~840 individual parameters. Therefore, analysis scripts in MATLAB were developed supporting the following necessary

[10] https://shop.austrian-standards.at/action/en/public/details/514168/OENORM_A_6241-2_2015_03_15

[11] https://www.ingenieurbueros.at/media/Kwc_Basic_DownloadTag_Component/161-4730-5986-downloadTag/default/903380cc/1496768149/technische-ausruestung.pdf

[12] https://bim-plattform.com/de/bimq/

[13] https://www.graphisoft.at/solibri/

[14] https://simplebim.com

 DOI: 10.3217/978-3-85125-786-1-60

tasks to have a good data structure for each MEP model (see Figure 1- step 6): In the first step, all data from different MEP components were combined and sorted. The data were automatically investigated in terms of typical typing errors and similar meanings but different names. Errors were corrected automatically with the help of histograms to increase the number of similar parameters. These corrected parameters were checked for similarities between them in order to allow unifying. After the unifying process, the parameters were checked for grouping them in similar categories for an easier implementation into BIMQ. According to the 56 MEP models, following main categories were specified: general parameters, domain heating and ventilation, and each of them were additionally subdivided into generation, distribution and delivery. As practical example parameters like AKS number (in German: "Anlagenkennzeichnungs-system"), warranty period, warranty terms were grouped into the category "general_properties _metatga", parameters like type of air, pressure drop and air flowrate range were assigned to the category "general_ventilation _properties_metatga". One of the most important steps in this definition phase was the assignment of each MEP component and their parameters to the corresponding (if available) IFC4 entity and properties. This is crucial because this guarantees a functional openBIM approach using IFC as collaboration format. Unfortunately, due to a lack of IFC properties – especially in the field of MEP – this mapping was not easy to fulfil. Only ~20% of all unique parameters could be mapped to IFC properties directly. Therefore user-defined property sets, so called "M-sets", were specified in order to transfer all necessary parameters within an IFC file. Finally, after all definition steps in BIMQ were done, the platform is ready to export the results in the corresponding BIM application (see Figure 1- step 7). Depending on the chosen software for MEP modeling (currently available for Revit, Allplan, ArchiCAD, ProVi) or model checking, the export type of files varies between simple text (specifically formatted), mvdXML[15] or xlsx/.csv. For the actual project setting, this means a *.txt* Revit mapping file for IFC, a *.txt* and *.xml* Revit import file and a *.xlsx* model checking file.

Data usage

After the sets of metadata for MEP components were structured by using the data management platform BIMQ, all participants within a collaborative BIM project are "compelled" to use them according to their responsibilities and roles along the whole project life cycle. This guarantees clear responsibilities and a high quality in the MEP planning process.

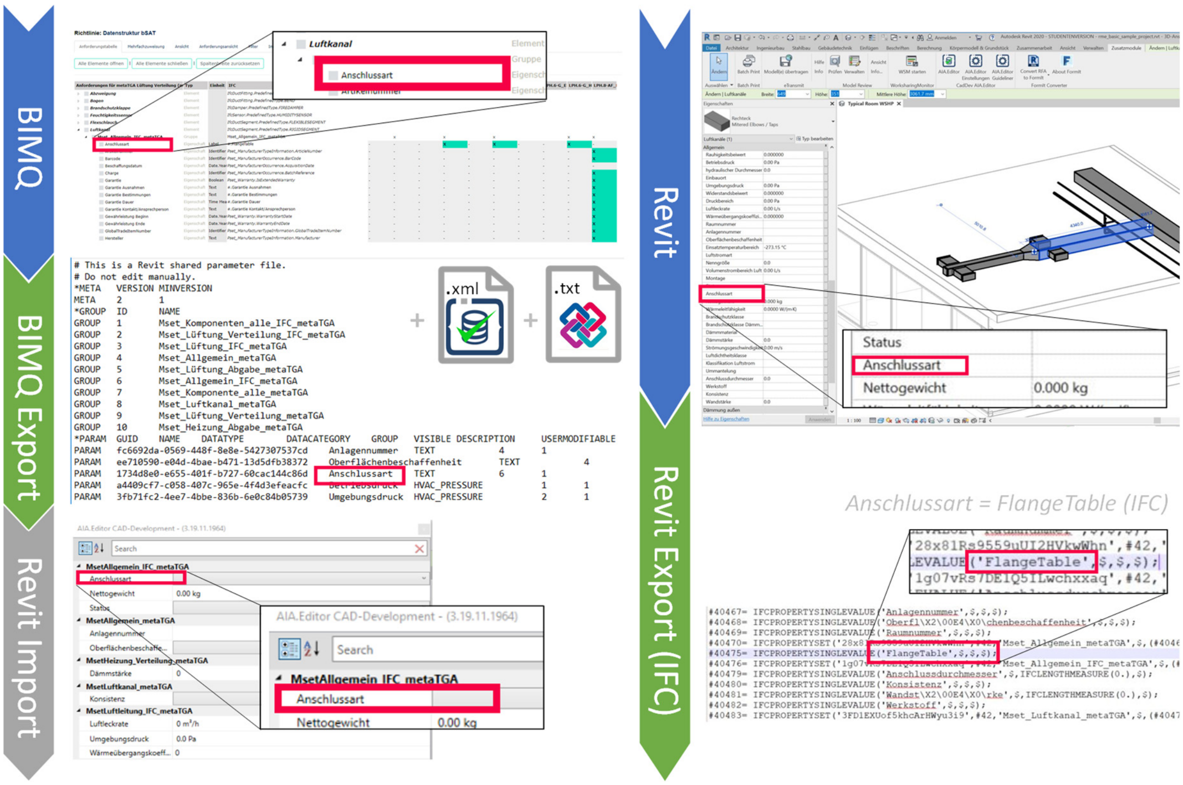

Figure 2: Example of data transfer (from left to right and from top to bottom) from BIMQ (upper left) into the authoring Software Autodesk Revit (upper right) and the export as IFC file (lower right) for the parameter connection type (in German: Anschlussart) of a duct segment

[15] https://technical.buildingsmart.org/standards/mvd/mvdxml/

To finally enable the use of these MEP components in the planning process of a building, each component can be transferred depending on their project phase into the chosen BIM software and model checking software (see Figure 1- step 7/8). Figure 2 shows the export steps in more detail, focusing on the parameter connection type (in German: Anschlussart) of a duct segment. BIMQ exports two Revit-readable *.txt*-files including the mapping information for IFC and Revit (how they appear in Revit after import for further use) and one *.xml*-file for the following add-on. With the support of the RVT.AIAEditor[16] the parameters can be easily imported and mapped correctly to the Revit structure. After the successful import in Revit, the parameters can be parametrized as always. Based on the openBIM approach, Revit can now export an *.ifc*-file for further use (e.g. model checking or combining IFC sub-models to an overall model). From a practical point of view, planning processes are iterative, thus model checking against metadata-requirements should be executed in each planning phase of the building Figure 1- step 8 and 9). That's why this transfer process will be repeated in every stage of the planning process as new parameters must be defined due to the increasing level of detail (LOD) of the model. With a model-checking software like Solibri Model checker each transfer process, respectively the question "was each parameter specified correctly and completely in the corresponding planning phase", can be verified with these tools semi-automatically. For that, SMC imports both the *.ifc*-file (Revit) and the automatically created *.xlsx*-file (BIMQ) to perform the quality check of the model (Figure 1- step 9).

FINDINGS AND FUTURE WORK

The developed processes from Figure 1 were applied in reality, defining the main components which enable modelling heating- and ventilation systems with focus on renewable energy sources. First impressions and practical feedback will be described below:

- The effort to get to all relevant parameters and the definition when and from whom these parameters for a MEP component need to be specified, is immense (in terms of time and relevant information sources) and should not be underestimated for new MEP components.
- Coming from a pool of parameters of different MEP components, the grouping of the parameters to similar datasets is quite a challenge in BIMQ. Moreover, the requirement that each parameter in BIMQ must not exist more than once in the system, is a challenge for itself under the circumstance using BIMQ not from the beginning in the model development process. Avoiding such situations BIMQ would have to be involved early in the design phase of the metaTGA process or in general for BIM projects. Nevertheless, methods of analysing parameters in terms of uniqueness, grouping and assignment to MEP components, need to be developed further: not only for creating a set of metadata from scratch, but also for merging earlier developed or foreign metadata together.
- In order to obtain conclusive datasets for MEP components, it is necessary to compare and assimilate datasets of similar MEP components e.g. pipe and pipe bend. Both components are very similar in function, therefore the datasets should be similar by means of parameters, life cycle information and responsibility for parameters too.
- In order to facilitate a collaborative work with different project participants, an IFC export from BIMQ is essential for an openBIM approach. To get a reliable IFC-export of the model, it is necessary to assign all parameters to IFC-properties. The information which parameter complies with which IFC-property is also a part of the definition in BIMQ. An export enables now a correct usage in the chosen BIM software (modelling or checking). Again, the effort doing that should not be underestimated, since an assignment to an existing IFC parameter is not always clear. The BIMQ designer must know in advance which IFC parameter is in which IFC property set in order to map attributes correctly. This requires a basic knowledge about IFC and its data structure. Language barriers between e.g. English and German and in some cases, the not comprehensible data structure of IFC (where to find parameters from property sets) will increase the effort further.
- The transfer of metadata from BIMQ to MEP-models is also very time consuming (it depends on the used BIM modelling software). Revit without any add-ons for example enables to pick only one attribute at a time. To reduce the effort in terms of time of this migration process, which has to be done for each component in each stage of the planning process, applications like RVT.AIA-Editor should be used.
- The result of the metaTGA process, especially the process model and the unique responsibility of MEP parameters depending on the building life cycle (project phase) increases the planning quality and reducing the effort (time) of coordination between different BIM project participants.

When viewed critically, some processes were described as time-consuming. However, it should be mentioned that these processes usually only have to be done once, namely when defining the model itself. Due to the selected software settings, all models can be used straight away for various BIM projects. The effort of the first implementation should therefore be correctly assessed or not underestimated. However, once these tasks have been completed, the user will

[16] https://cad-development.de/bimloesungen/unsere-bim-loesungen/rvtaiaeditor/

 DOI: 10.3217/978-3-85125-786-1-60

gain a lot of benefits during his work, which means the described approach is expedient. The metaTGA project finally managed to create manufacturer-neutral MEP models (for heating and mechanical ventilation) that can be used generically in BIM projects.

In summary, the introduced processes and methods have the potential to increase quality of a BIM project. Using tools like BIMQ, SMC, Revit, etc. in combination with the metaTGA processes, quality measures can be applied almost automatically for every planning phase of a building. Furthermore, the developed MEP models and their mapping to IFC increase the interoperability within BIM projects.
As future work, within the research project metaTGA a final test supporting planning processes of a "real world" project will be done. Feedback from different planning teams will be collected, analysed and if necessary, the metaTGA processes and models will be adapted before they will be finally published.

ACKNOWLEDGEMENT

The work of this paper was created in the course of the project metaTGA (FFG 861729) and promoted in the program line "Stadt der Zukunft" (4th call). "Stadt der Zukunft" is a research and technology program of the Federal Ministry of Transport, Innovation and Technology. It is handled on behalf of the BMVIT by the Österreichische Forschungsförderungsgesellschaft together with Austria Wirtschaftsservice Gesellschaft mbH and the Österreichischen Gesellschaft für Umwelt und Technik (ÖGUT).

REFERENCES

Baldwin, M., V, D.I.N., GmbH, M.M.D., 2019. Der BIM-Manager: Praktische Anleitung für das BIM-Projektmanagement, Beuth Innovation. Beuth Verlag GmbH.

Boktor, J., Hanna, A., C. Menassa, C., 2014. State of Practice of Building Information Modeling in the Mechanical Construction Industry. Journal of Management in Engineering 30, 78–85.

Both, P. von, Koch, V., Kindsvater, A., 2013. BIM - Potentiale, Hemmnisse und Handlungsplan: Analyse der Potentiale und Hemmnisse bei der Umsetzung der integrierten Planungsmethodik Building Information Modeling - BIM - in der deutschen Baubranche und Ableitung eines Handlungsplanes zur Verbesserung der Wettbewerbssituation, Forschungsinitiative ZukunftBau F. Fraunhofer-IRB-Verl, Stuttgart.

buildingSMART-International, 2014. Technical Vision [WWW Document]. Standards. URL https://www.buildingsmart.org/standards/technical-vision/ (accessed 1.30.19).

buildup, n.d. buildup Schweiz [WWW Document]. URL https://ch.buildup.group/static/info/features (accessed 6.23.20).

Castell-Codesal, Javier, Frantzen, Jürgen, 2015. Anforderungen an Produktdaten in der Gebäudetechnik.

Eichler, C., 2020. Overall architecture.

Hauer, S., Bres, A., Partl, R., Monsberger, M., 2019. An approach for the extension of openBIM MEP models with metadata focusing on different use cases, in: Building Simulation 2019. Presented at the Building Simulation 2019, Rom.

Hauer, S., Bres, A., Partl, R., Monsberger, M., 2018a. Einblick in das Forschungsprojekt Metadaten und Prozessmodelle für Open BIM in der TGA (metaTGA). Presented at the enova-internationale Conference, Zukunft der Gebäude?, pp. 253–259.

Hauer, S., Bres, A., Petrushevski, F., Monsberger, M., Fortmüller, P., Partl, R., Eichler, C., Urschler, C., Brandauer, G., 2018b. Deliverable 2.1-Anforderungskatalog für die Entwicklung der TGA-Daten- und Prozessmodelle (internes Deliverable). Wien.

Kovacic, I., Oberwinter, L., Müller, C., Achammer, C., 2013. The "BIM-sustain" experiment – simulation of BIM-supported multi-disciplinary design. Visualization in Engineering 1, 13. https://doi.org/10.1186/2213-7459-1-13

Liebich, T., 2018. Prüfbare Informationsanforderungen aufstellen und im Projekt umsetzen - Informationsmanagement mit BIMQ.

Wang, L., Leite, F., 2016. Formalized knowledge representation for spatial conflict coordination of mechanical, electrical and plumbing (MEP) systems in new building projects. Automation in Construction 64, 20–26. https://doi.org/10.1016/j.autcon.2015.12.020

Wirz, A., Frey, M., 2019. Zusammenarbeit mit der BIM-Methode Erfahrung aus der Praxis.

