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AI Eats Building-Performance Simulation for Breakfast

Manuel Frey
Gruner Roschi AG, Switzerland

Learning Objectives

- Further develop visions for the long-term orientation of business models, including IoT, ML, AI, and simulations
- Learn how to design strategies to implement new processes for the integration of building performance simulations into everyday work
- Discover concrete measures to improve existing processes and methods of energy analysis in HVAC engineering
- Learn how to formulate skills and requirements for future employees to develop or build a specialist team in your company

Description

These days, you can use software like Revit MEP software, Dynamo, Python, Forge, and Insight360 to create highly detailed analytical simulation models as the basis for high-quality MEP planning. However, oftentimes the simulation results and operation profiles aren't transferred to building operation, which leads to a significant performance gap. This industry talk will provide insight into the evolution of building performance simulations for practical use and as a basis for training AI-based HVAC controllers using pattern recognition—which will revolutionize the way building engineering is planned—in BIM2Field (building automation and building performance simulation) and in BIM2FM, using digital twins and linked IoT (Internet of Things).

Speaker(s)

Manuel Frey is a digital leader and pioneer of BIM/VDC within the European HVAC Industry. He brings 18 years of experience and a passion for model-based planning and performance simulations to his current roles as head of the Digital Engineering & Simulations Department at the Gruner Group, President of the Swiss Chapter of The International Building Performance Simulation Association (IBPSA CH), and co-lead of the BIM2FM working group of buildingSMART Switzerland. Manuel and his team of specialists are at the forefront of model-based planning workflow, digital strategy, change management, and process optimization. He shares his knowledge with students as a lecturer at ETH Zurich, UAS Luzern, UAS NW Switzerland, Man and Machine – BIM Management Program, and at his alma mater, UAS Biberach. Manuel continues to present his published works based on applied research of best practice experience in building performance simulation and HVAC engineering at leading energy efficiency conferences.

Vision

Vision enables me to offer my employees, colleagues and project partners guidance and help them determine long-term goals for their own further development. In addition, the decisive question for our continued existence and raison d'être is, of course, whether our current business model, with its underlying work processes, still works.

Credit: Unsplash / Marc-Olivier Jodoin

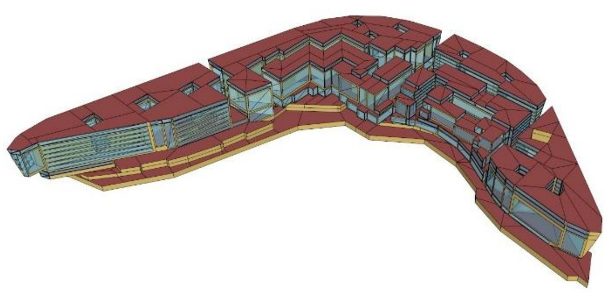
It is my belief that in the near future desirable and profitable digital construction and building operation models will generate the majority of their value based on data. How can we participate? How can we anticipate the development? Additionally, how can we structure and further develop our existing business models and work processes in such a way that we will continue to contribute to the construction industry of the future?
The example of optimized HVAC engineering already shows us that new methods, processes and tools can be used to generate more data with less effort. Since the first simulation applications for commercial use, development in recent years has made great strides, especially in the pre- and post-processing of simulations. It has been shown that the decisive success factor for a broad application with simultaneously increased economic attractiveness is reflected in the further development towards an integral component of the planning process chain.

Tools for equation-based building abstractions and their use to predict their future behaviour have been available since the 1970s. We have been utilizing these tools at Gruner Roschi since 2010.

Simulation Engine	Developer	First Release
DOE-2	James J. Hirsch & Associates, US	1978
Energy+	Lawrence Berkeley National Laboratory, US	2001
ESP-r	University of Strathclyde, UK	1974
IDA ICE	EQUA Simulation AB, SE	1998
SPARK	Lawrence Berkeley National Laboratory, US	1986
TRNSYS	University of Wisconsin-Madison, US	1975

Source: Wikipedia (https://en.wikipedia.org/wiki/Building_performance_simulation)

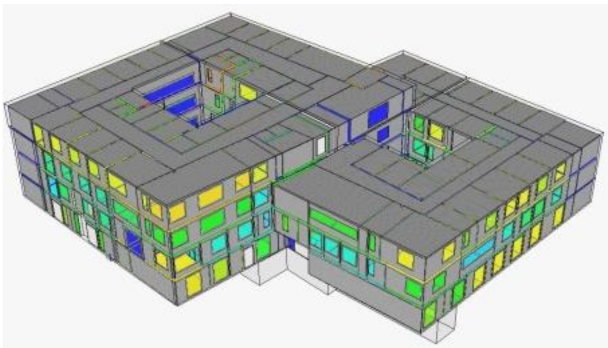
Our experience from recent years has established that the building simulation tool is becoming an increasingly integral part of optimized building technology planning. By using new tools (SketchUp, Revit) for the geometric modelling of building models, a large cost factor could be significantly reduced. In addition, the simulation tools have also developed considerably so that today, a very large amount of data can not only be generated with little effort, but also visualized, analyzed, evaluated and ultimately documented. My team is on the threshold of our own development process to transition from Microsoft Excel-based data evaluation to more advanced tools such as Python Bokeh, MS Power BI or QlikSense.



- 230'000 m2 / 2'480'000 sqft
- 113 simulated rooms
- 7 Use profiles
- Analyzed variables: 452
- Visualized data points: 1.6 Mio.
- Cost $ 50'000.-
- Cost per variable: $ 110.-
- Cost per room: $ 3'800.-

Building Performance Simulation in 2013 with Sketchup and Energy Plus

For example, in 2013 we used an amalgamation of SketchUp (geometry), EnergyPlus (simulation) and MS Excel (analysis) as well as MS Word (documentation). This has been expressed in many manual steps for import and export as well as for PDF-based communication and can be compared with BIM Level 1. In 2015, we received the first usable IFC models (Allplan) and were able to familiarize ourselves with model-based data exchange and collaboration. This has already resulted in a noticeable increase in efficiency through the use of the IFC format (geometry) with the simulation tool IDA ICE (simulation) and MS Excel (analysis) as well as MS Word (documentation). The greatest increase in efficiency was achieved in the area of geometry creation. After the initial findings in model-based work, we launched Revit in 2016, the software for general data management in pre- and post-processing, which not only revolutionized the quality assurance of simulation boundary conditions, but also further developed a substantial step towards the integration of simulations as an integral part of optimized HVAC engineering. This development can be equated with BIM Level 2.



- 5'600 m2 / 60'300 sqft
- 280 simulated rooms
- 12 Use profiles
- Analyzed variables: 560
- Visualized data points: 2.0 million
- Cost $ 8'000.-
- Cost per variable: $ 14.-
- Cost per room: $ 29.-

Building Performance Simulation in 2016 with IFC and IDA ICE

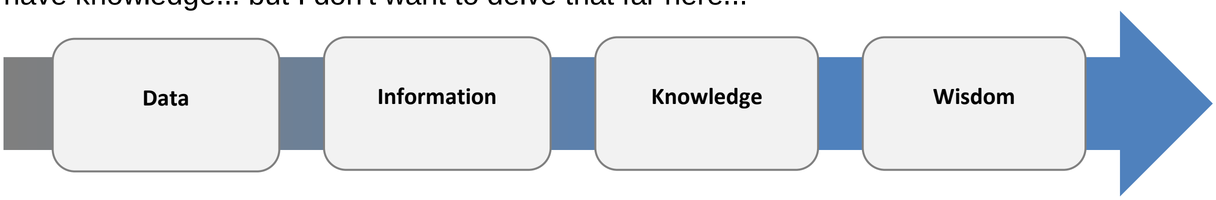
Today, the entire data management for building simulation is performed in Autodesk Revit. This enabled us to reduce the cost of creating large simulation models from $3,800 to just $12 per room. We expect a further reduction to a range of $5-8 per room in 2022, when BIM Level 3, e.g. with Autodesk BIM360 Next Generation, is widely used in the construction industry.

- 45'00 m2 / 480'00 sqft
- 1'700 simulated rooms
- 52 Use profiles
- Analyzed variables: 34'000
- Visualized data points: 122.0 million
- Cost $ 20'000.-
- Cost per variable: $ 0.6
- Cost per room: $ 12.-

Building Performance Simulation in 2019 with Revit and IDA ICE

A similar development made data analysis possible and thus yielded the evaluation of concepts and variants. To date, the majority of commercially used building simulations have been analysed and visualised using MS Excel. The advantage there is that many employees can process a large amount of data with comparatively simple tools. However, since model-based work (IFC, RVT, Dynamo, Grasshopper) and the use of optimization tools such as GenOpt and Refinery make it possible to create very large buildings (>>2,000 rooms) with many variants (>> 100 variants) and allow the number of variables to simultaneously be analyzed (>> 50 per room) in a very economical way, inevitably leads to higher demands on the analysis and visualization tools that we use going forward. If a digital twin is used (not only in the planning, but over the entire life cycle of the order, from planning through to the operating phase of a building) and a possibility of a serious performance gap analysis exists, the demands to the temporal resolution of simulation results, simulation boundary conditions and their measured equivalent from the real enterprise are substantially increased. This means that we have to increase our current time step size from one value per hour (hourly average) to 12 values per hour (5 minute time step) or even 60 values per hour (minute values).

In my opinion, this realization inevitably reveals previously unknown amounts of data in optimized HVAC engineering and presents us with both new challenges and new opportunities. Then only those who have the data can obtain information from the data itself and its context. Only those who have information can gain knowledge from its context... and well, those who have knowledge... but I don't want to delve that far here...



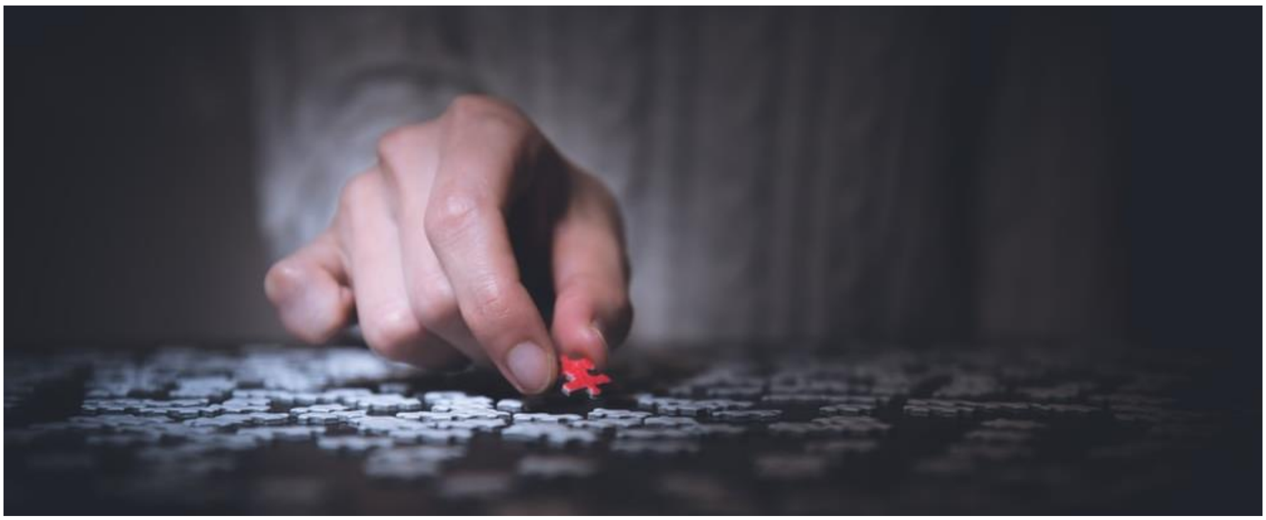
My vision is the complete model-based mapping of all possible operating scenarios of a building including the associated use (human), building technology and the higher-level building automation using a digital twin over the entire life cycle of a building. If we can now map every imaginable usage scenario in every room of a building and link this to both the underlying building technology and the connecting building automation, as well as model it in a commercially attractive way in the context of changing environmental influences (global warming & local microclimate), we have taken an important first step towards greater sustainability (ecologically & economically). If we can keep this digital twin consistent from ordering through planning to the construction site and track every change and optimization, we have achieved the second important step. Due to the large amount of data that we generate in the planning phase, we can use pattern recognition to program the room, plant and building automation of our buildings in such a way that the predicted behaviour of a building can actually be implemented in the programming on the construction site and then the optimum operating mode (ecological & economic) of a building can be set during operation using increasing (artificial) intelligence. Through the already existing IoT-based measuring devices, we get exactly the data of the operating mode of a building, which we need for the performance gap analysis and reduction.

I assume that in the upcoming optimized, automated and rationalized HVAC engineering, today’s common processing steps will be obsolete or, at the very least, significantly different.

The Next Big Thing?

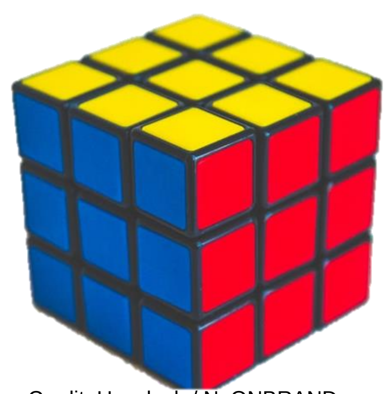
What does the current situation look like at your company? Do you have a vision? Where should the journey take us? What could challenge your current business model in the future? How can you prepare for tomorrow's changes today?

Looking for the "next big thing", the unique piece of the puzzle that will complete your big picture and make it a reality? Is it really about the next big thing? About the one piece of the puzzle that changes everything? I don't think so.



Credit: Unsplash / Ryoji Iwata

In my opinion, the final success of a project or a strategy depends on the interaction of multiple factors. The recipe for succes requires a vision, the right skills and the right incentive. In addition, it goes without saying that the right resources and the right plan of action for upcoming innovations are needed. Imagine a Rubics Cube. All cooresponding tiles need to line up to achieve success. I think this also applies to the implementation of new methods, processes and tools in daily work; especially if this change has a substantial impact on the current manner in which we collaborate with colleagues. We have a great responsibility to accompany and support our employees on the path of change. Special attention should be paid to this change management.



Credit: Unsplash / NeONBRAND

On one hand, I believe strategic development means focusing on our core competence and the current basis of our business model. On the other hand, this business model should be supplemented with the ideal additional processes and operational steps in order to achieve greater added value holistically. Building performance simulation plays an important role in this. It influences the entire planning and construction process and, increasingly, also the operating phase of buildings. It is, therefore, an essential component of our current and future business model.

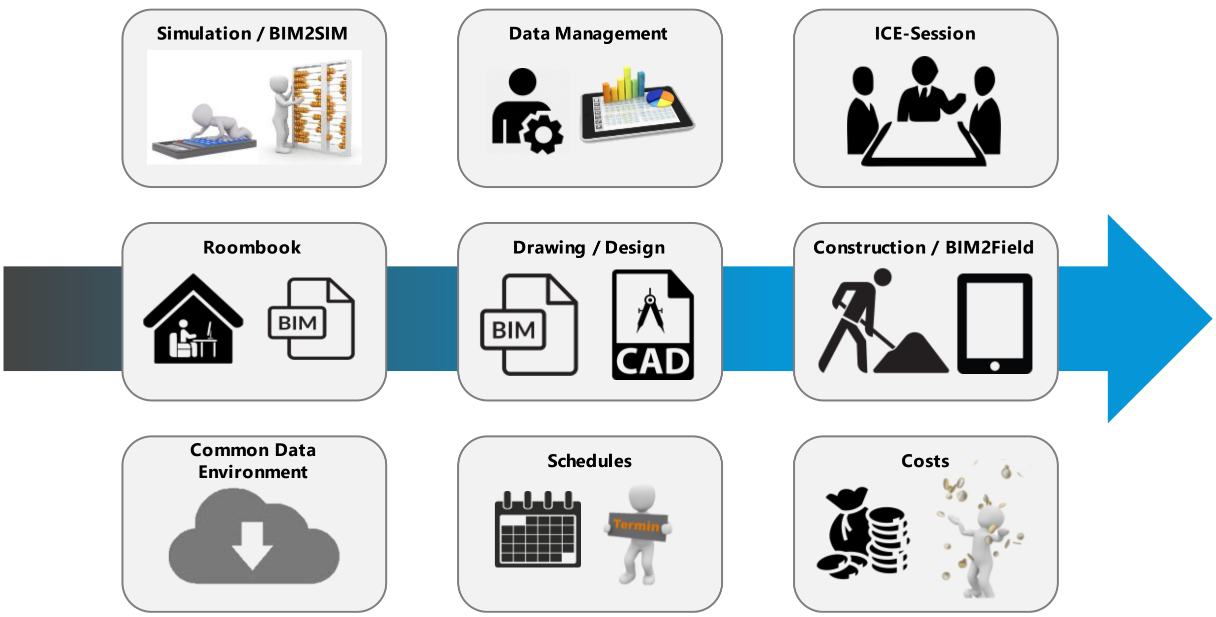
What if...?

- ... all those involved in the planning process worked in a Common Data Environment?
- ... repetitive work steps were no longer necessary?
- ... the exchange of data, information and knowledge worked without manual I/O?

Yes, what would happen if future building performance simulation were simply a by-product of model-based collaboration between architects, structural engineers, HVAC engineers, clients and, of course, the future users of a building?

Yes, what if the analysis and optimization of the visual and thermal comfort, as well as the expected energy demand, could be carried out as an integral part of every project without additional effort and thus, not only improved, but also more sustainable buildings could be planned and built?

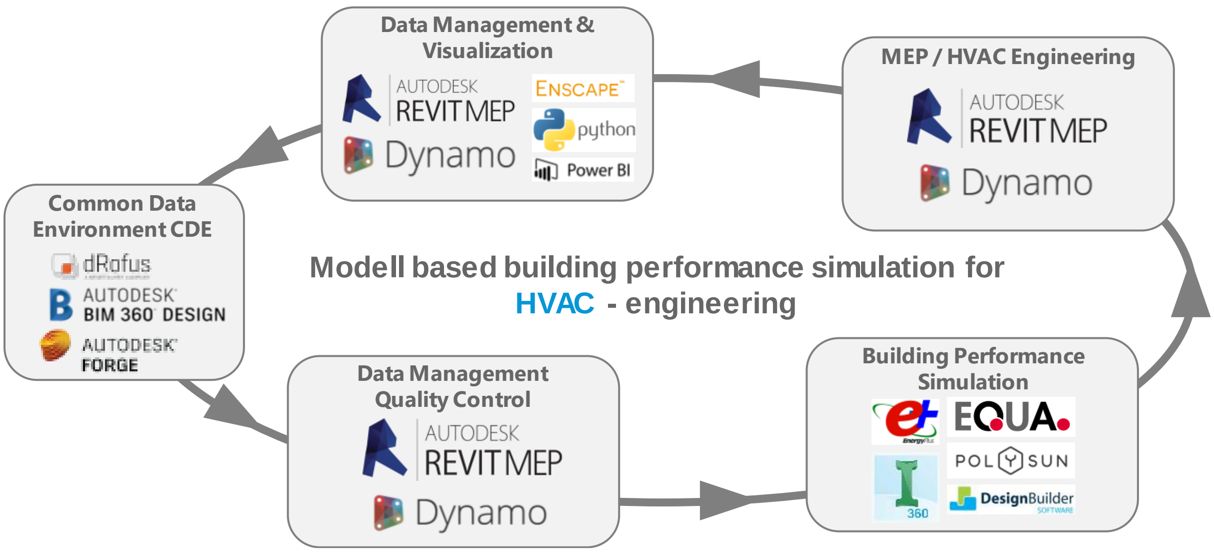
Since an engineering office for building technology planning is primarily concerned with (1) mapping the needs of the customer or their specifications, (2) carrying out the actual building technology planning from the resulting specifications, (3) obtaining the basis for the construction of the building and (4) ensuring an optimal building operation over the entire life cycle.



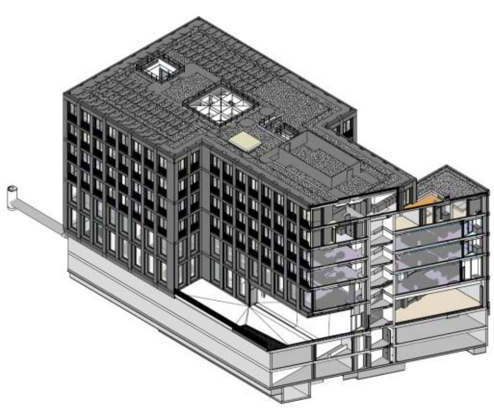
Which basic components does your business model use to build? Which additional processes will sufficiently prepare your current business model for the future?

How does it work?

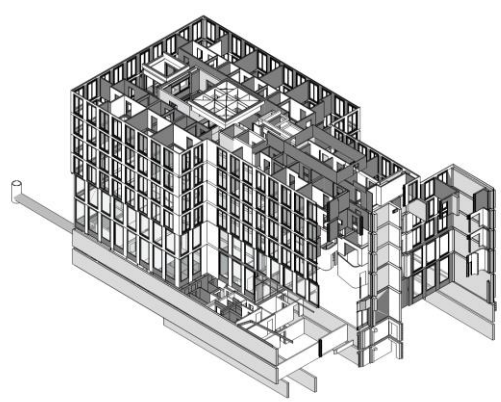
I believe the basis for good work is having quality control of the data which is being processed. It is important that you fully understand your own building simulation process and can describe it both qualitatively and quantitatively. From this you can then determine concrete requirements for other project participants (e.g. architecture or building physics) and communicate them using the Information Delivery Manual (IDM) and Model View Definitions (MVD).



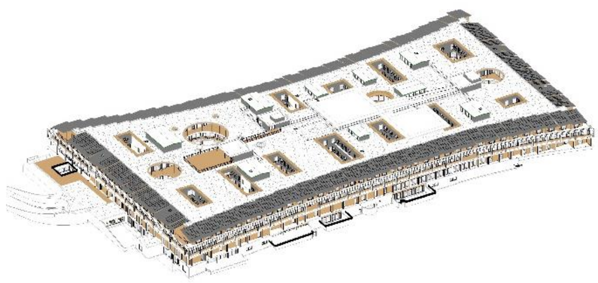
Starting from the provision of data and information via Common Data Environment (CDE), e.g. with BIM360 Next Generation, you can create simulation boundary conditions for your internal quality assurance measures. For this we use verification scripts which can, for example, check the architectural model for completeness. After quality control, the digital twin is further parameterized to prepare the respective simulation. After the simulation is completed, the simulation results are saved back into the Revit model using Dynamo & Python. Finally, the tested simulation results are then used as the basis for the next planning step.

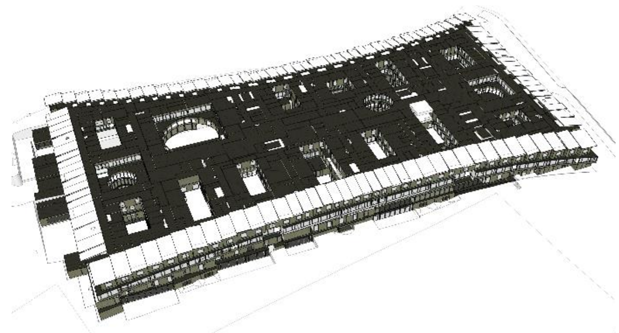


Architectural model in Revit



Revit model striped to necessary parts for simulation





Architectural model in Revit

Building Performance Simulation in IDA ICE

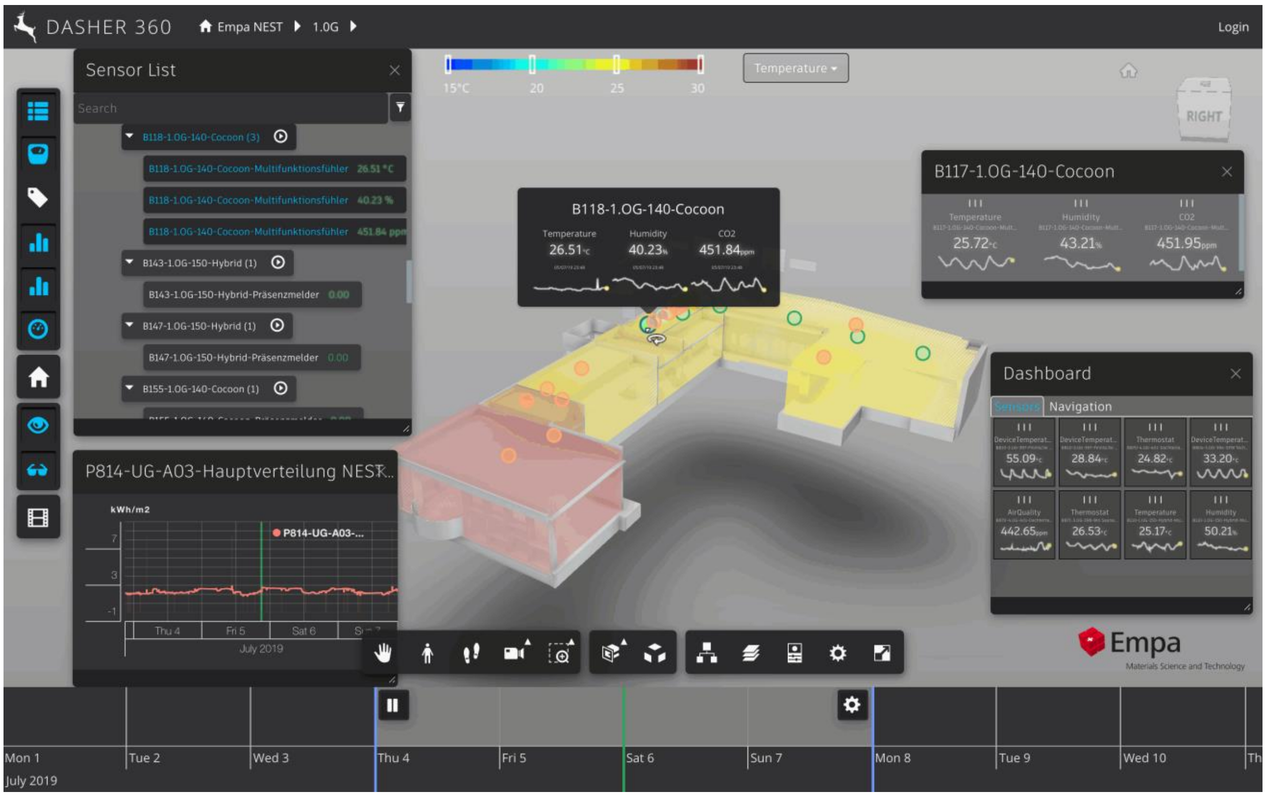
With model-based building performance simulations, the following applications can now be carried out relatively easily.

Modell based use cases BIM2SIM

- Analysis of primary energy demand & CO2 emissions / 2000-Watt
- Calculation of net & final energy demand
- Verification of thermal comfort (ISO 7730)
- Proof of summer thermal protection for application
- Proof of air-conditioning requirements for application
- Heating & cooling load calculation
- Model-based daylight calculations
- Model-based user agreement & roombook

Based on the previously presented application cases, the digital twin can now actually be brought to life. To date, building simulations have been used almost exclusively as a basis for sizing HVAC systems, for predicting the thermal-energetic behaviour of buildings and for convenient analysis. The transfer of control algorithms from simulation to planning and to the construction site takes place very rarely, which is the bottleneck in today's model-based performance gap analysis in the operating phase.

The increasing availability of affordable IoT measuring instruments for the analysis of actual room climate will enable us to reliably compare high-quality simulation results as a prediction of the expected operating behaviour of buildings with the effective operating behaviour. This will bring us to a new level of quality assurance in the virtual design and construction process (VDC), the traceability of design and construction errors as well as optimized HVAC engineering.



Source: Autodesk, Kean Walmsley – Dasher 360 – Empa NEST Switzerland

https://www.keanw.com/2019/09/a-major-update-to-dasher-360-now-showing-the-nest-building.html