Approach to Reference Models for Building Performance Simulation

Sahil-Jai Arora[1,2,*] [a], Clara Ceccolini[1,3,*] [b] and Markus Rabe[2]

[1] *Bosch Thermotechnik GmbH, Junkersstraße 20-24, 73243 Wernau (Neckar), Germany*

[2] *Department IT in Production and Logistics, TU Dortmund University, 44221 Dortmund, Germany*

[3] *INATECH, Department of Sustainable Systems Engineering, Freiburg University, 79110 Freiburg, Germany*

Keywords: Reference Model, Conceptual Architecture, Procedure Model, Model-based Engineering, Design by Reuse, Building Performance Simulation, Building Energy Systems.

Abstract: In the fields of business process modeling, logistics, and information model development, Reference Models (RMs) have shown to enhance standardization, support the common understanding of terminology and procedures, reduce the modeling efforts and cost through the paradigm "Design by Reuse", and enable knowledge transfer. The use of RMs in Building Performance Simulation (BPS) shows potential to achieve similar benefits. Firstly, to clarify the terminology adopted in the different fields, this paper presents a comprehensive overview of the diversely interpreted definitions, benefits, and attributes of RMs and related terms, including classification into common and uncommon understanding. Secondly, the paper transfers the approach of RMs to BPS. A definition for RMs applicable to BPS is provided, the identified RM qualities are matched with BPS's challenges, and finally an example of an RM for simulation-based test benches is presented.

1 INTRODUCTION

Modeling and simulation of buildings and Heating, Ventilation, and Air Conditioning (HVAC) systems have become an established practice, both in the research and industry, to manage the increasing complexity of Building Energy System (BES) interactions and tackle the global targets to their decarbonization (Hasan et al., 2015). These applications are designated with the term Building Performance Simulation (BPS). The use of simulation and computational models can support the BES life cycle (Hensen and Lamberts, 2019), from the design process until the commissioning and maintenance phases.

In general, model-based engineering, which adopts models instead of directly realizing a solution (van Beek et al., 2014), leads to frontloading efforts during the development process. Therefore, it supports an early-stage concept verification and, hence, faster and more efficient time-to-market, improving the chances to detect errors early.

Nevertheless, BPS and likewise model-based engineering induce several challenges. The design of reliable and accurate mathematical models is time-consuming and compels experts and cost; therefore, there is a need for model re-usability (Wetter, 2011). Moreover, besides the intrinsic multi-disciplinary approach to BES (Singaravel, 2020), the increase in system complexity (e.g., integration of elements of the so-called Internet of Things) has resulted in a closer interaction of various disciplines (Wetter, 2011) – architecture, engineering, as well as IT and data science. Consequently, the models' transparency, their ease of share, and common understanding among different experts become fundamental. Furthermore, facilitating knowledge transfer of BPS processes and procedures would further spur its adoption across the whole BES life-cycle (Tucker and Bleil de Souza, 2016). Eventually, a higher model abstraction and modular approach helps reducing the comprehension efforts as well as enhance simulation program debugging and, additionally, model maintenance and portability (Wetter, 2011).

This study aims to illustrate the potential of Reference Models (RMs) in facing the BPS challenges named. An RM is a conceptual framework "for understanding the significant concepts, entities, and relationships of some domain, and therefore a "foundation" for the considered area" (Camarinha-Matos and Afsarmanesh, 2008, p. 1).

[a] https://orcid.org/0000-0002-6877-1480

[b] https://orcid.org/0000-0002-0238-8796

[*] These authors contributed equally to this work.

Arora, S., Ceccolini, C. and Rabe, M.
Approach to Reference Models for Building Performance Simulation.
DOI: 10.5220/0010888800003119
In *Proceedings of the 10th International Conference on Model-Driven Engineering and Software Development (MODELSWARD 2022)*, pages 271-278
ISBN: 978-989-758-550-0; ISSN: 2184-4348

RMs have been applied primarily in the fields of information systems (Thomas, 2006; Becker and Knackstedt, 2002), virtual enterprises (Camarinha-Matos and Afsarmanesh, 2008), production and logistics simulations (Altendorfer-Kaiser, 2016; Rabe et al., 2006), business administration, and informatics (Bartsch, 2015). In these sectors, the most recurring benefit is the future time and cost efforts saving during the development phase of new models, because an RM enables the ”Design by Reuse” paradigm (van der Aalst et al., 2006; Altendorfer-Kaiser, 2016; Rixe and Augustin, 2020). Moreover, by standardizing and systematizing best practices (Müller et al., 2019), they have proven to increase the quality of the to-be-realized model (Thomas, 2006; Rabe et al., 2006). Another recognized benefit is that the use of RMs leads to recommendations for actions to derive measures for improvements (Altendorfer-Kaiser, 2016; Rabe et al., 2020). In addition, an RM fosters the communication between different experts by bringing together the subjective views (Bartsch, 2015); it builds a foundation for a common terminology and common procedures (Camarinha-Matos and Afsarmanesh, 2008; Rabe et al., 2006). Less noted but still relevant is that RMs guide simulation of logistic processes allowing easier interaction with the simulation models (Müller et al., 2019). RMs enable knowledge transfer (Dietzsch and Esswein, 1998) and serve educational purposes, such as employee training (Becker and Knackstedt, 2002). Therefore, RMs for BPS have the potential to achieve similar benefits.

The authors present a comprehensive overview of the diversely interpreted definitions, benefits, and attributes of RMs and the related terms. This investigation is necessary to clarify the terminology before transferring the term RM to BPS. As discussed by Bartsch (2015), Thomas (2006), and Camarinha-Matos and Afsarmanesh (2008), a generally accepted understanding of the term RM cannot be found.

This paper is structured as follows: Section 2 presents the state of the art in understanding the term RM. Section 3 documents the authors' suggested definition for the term RM in the field of BPS as well as the related attributes, showing the benefits of RMs. The understanding of RM is supported by an application example in Section 4. In Section 5, conclusions are drawn with an outlook for future scientific work.

2 UNDERSTANDING OF RMs

The term Reference Model (RM) emerged in the literature at the end of the 1980ies for the development of industrial enterprise models and pertains to a class of words that are often used but seldom clearly understood (Thomas, 2006). Reference modeling is the process of developing an RM to be used for different applications (Becker and Knackstedt, 2002). From a pure etymological perspective, the term reference model consists of the words *reference* and *model*. These have respectively the meaning of ”quoting something” and ”remarkably good example that can be imitated” (Cambridge Dictionary, 2021c; Cambridge Dictionary, 2021b). Nonetheless, an agreed understanding of RMs is lacking, and diverse definitions are offered, depending also on the application field. Actually, the denomination RM is sometimes used without any well-founded qualification (Braun and Esswein, 2006).

A model itself is an abstract formal representation of a portion of the real world (Dietzsch and Esswein, 1998). A model can be used to understand, explain, design, and implement a system (Becker et al., 1995; Camarinha-Matos and Afsarmanesh, 2008).

Van der Aalst et al. (2006) report that RMs provide generic solutions for developing specific models. Bartsch (2015) adds that RMs are understood as a specific manifestation of a general type of abstract model having certain characteristics. Furthermore, Pajk et al. (2012) declare that RMs ”are generic conceptual models that formalize recommended practices for a certain domain”. Accordingly, Rabe et al. (2006) define an RM to be a conceptual framework that includes a standard description of processes and best-in-class practices. In Camarinha-Matos and Afsarmanesh (2008) the authors state an RM to be an ”abstract representation of a large number of possible systems” (Camarinha-Matos and Afsarmanesh, 2008). Eventually, Thomas (2006) offers a user-centered definition: An RM is a user-accepted model that can be exploited (and re-used) in supporting the construction of another model. Based on this definition, an RM requires that at least one application of it can be found.

It can be noted that while there is no universally agreed definition, there are nonetheless commonalities to be found regarding their characteristics and benefits. Based on the investigated contributions, the application of an RM is generically illustrated in Figure 1. First, the required elements of the RM are selected. At the same time, also the required elements of the model to be created are to be identified. These two steps support each other iteratively, hence they already represent an initial application of the RM. Subsequently, the latter is to be applied profoundly by substituting already developed elements from the RM into the model to be created. Possibly, not all required elements are covered by the RM. These, there-

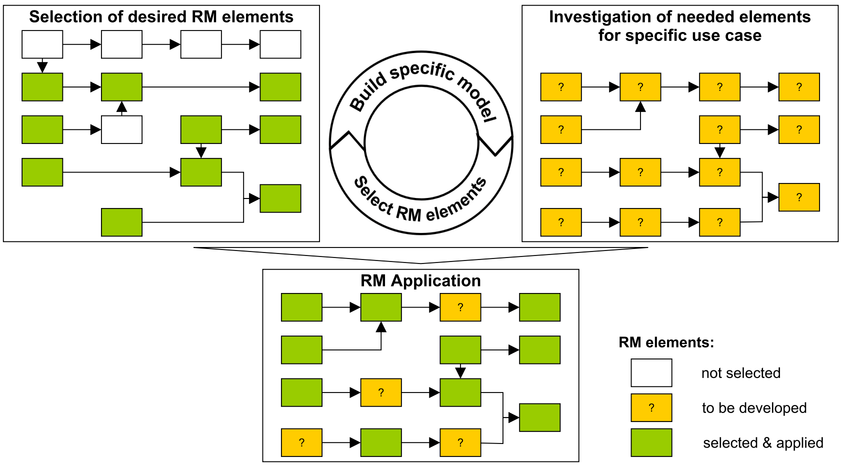

Figure 1: Exemplary application of a reference model.

fore, may need to be developed afterwards, but with an overall significantly lower effort.

Nevertheless, in order to use the full potentials of RMs in the field of Building Performance Simulation (BPS), a deep understanding of RMs and their conception is required. To meet the need for more transparency and to later guide the identification of an RM definition applicable to the field of BPS, in the following the authors collect the RMs' attributes and present the clustering process that leads to their synthesis into qualities.

2.1 RM Attributes and Qualities

By investigating seventeen relevant contributions, a total of forty-one attributes of RMs are identified and clustered to nine qualities (Figure 2). These qualities, providing a profound understanding of RMs' characteristics, are *reusable*, *flexible*, *reliable*, *designed systematically*, *generally valid*, *required*, *user-centered*, *comprehensive*, and *educative*.

The attributes adaptable, applicable, customizable, and configurable enable the RM to its quality of *reusability* (Q1). On the one hand, there is a need for a high abstraction level – abstract from specific features – (Bartsch, 2015; Pescholl, 2020; Becker and Knackstedt, 2002), as the RM should be applicable to various homogeneous fields. On the other hand, a high level of detail is required (Becker et al., 1997) to offer guidelines to ensure the RM's ease of use (Pescholl, 2020; Dietzsch and Esswein, 1998). This conflict of goals goes together with the inconsistency in literature about whether an RM should be tool-independent – only referring to them (Rabe and Friedland, 2000) – or tool-related (Becker et al., 1997).

A modular and hierarchical structure consisting of a composition of submodels, allowing a wide range of choices (van der Aalst et al., 2006), leads to *flexibility* (Q2) (Müller et al., 2019; Rixe and Augustin, 2020).

The quality of *generally valid* (Q3) consists of the attributes universal, transferable, and valid in a specific field when meeting corresponding specified conditions (Dietzsch and Esswein, 1998; Rabe et al., 2020; Pescholl, 2020). Therefore, there is no claim to an absolute universal validity, but to a general validity in a class of applications (Thomas, 2006).

Noteworthy, qualities Q1, Q2, Q3 present fuzzy boundaries as their attributes overlap. This is the case, e.g., for the attribute customizable, which can be entirely associated neither to the quality flexible, nor reusable, nor generally valid. Moreover, there is a strong interrelation of the quality Q3 with Q1 as being generally valid is necessary for the RM to be reusable.

In order for the user to be confident in applying an RM, the quality of *reliability* (Q4) has to be ensured (Dietzsch and Esswein, 1998). Accordingly, an RM should be credible, e.g., by observing best practices (Becker et al., 1997; Becker and Knackstedt, 2002; Dietzsch and Esswein, 1998), as well as disclosing the sources cited and the authorship (Camarinha-Matos and Afsarmanesh, 2008). It should, in the best case, already be validated or at least validateable (Pescholl, 2020; Bartsch, 2015). Finally, it is necessary that the user accepts the model as a reference and that the RM is applied at least in one case (Thomas, 2006).

Another identified quality is *designed systematically* (Q5) (Rabe et al., 2020). The RM should feature a structured, compact (Pescholl, 2020; Rixe and Augustin, 2020), and methodical design (Müller et al., 2019; Pescholl, 2020; Bartsch, 2015).

To justify the RM use, the quality of *required* (Q6) is crucial. Attributes of this quality are the usefulness and utility of the RM (Bartsch, 2015; Becker et al., 1997) and, if applicable, its innovativeness (Bartsch,

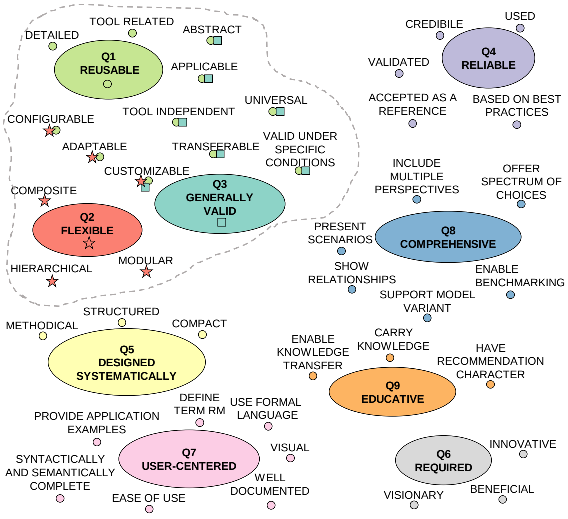

Figure 2: RM's attributes clustering. Line marks overlapping qualities: Reusable ●, Generally valid ■, Flexible ★.

2015; Becker and Knackstedt, 2002).

Being *user-centered* (Q7) is a fundamental quality of RMs. This quality implies ease of use (Müller et al., 2019), visualization character (Becker et al., 1997; Bartsch, 2015), and providing a definition of the meaning and the purpose of the RM (Dietzsch and Esswein, 1998) together with its correct and efficient use (Rabe et al., 2006). Ultimately, there is a need for syntactic (well defined linking and combination of elements) and semantic (well defined content) completeness (Rabe et al., 2020; Becker et al., 1997). This semantic completeness is often supported by a formal description technique (Becker and Knackstedt, 2002; Schubel et al., 2015; Rixe and Augustin, 2020).

An RM should include the quality of being *comprehensive* (Q8), both in its development and application (Becker et al., 1997). By showing relationships between activities and entities (Becker and Knackstedt, 2002), an RM can provide multiple perspectives and scenarios of application depending on the current boundary conditions (Becker et al., 1997; van der Aalst et al., 2006). Q8 also enables a continuous improvement by allowing the benchmark of the as-is and target status (Altendorfer-Kaiser, 2016; Becker et al., 1997; Camarinha-Matos and Afsarmanesh, 2008).

The last identified quality is *educative* (Q9). RMs are knowledge carriers (Becker et al., 1997; Becker and Knackstedt, 2002; Dietzsch and Esswein, 1998) and, therefore, provide recommendations by presenting a default solution (Altendorfer-Kaiser, 2016; Bartsch, 2015; Pescholl, 2020; Thomas, 2006).

2.2 Prioritizing the Compiled Qualities

The occurrence of the detected qualities in the respective contributions is counted to determine their prevalence, hence allowing for ranking them. Table 1 reports in each line all the qualities that emerge within the investigated contributions (i.e., also in their state of the art chapters).

In particular, each row is intended as a summary of several referenced publications, which are not presented individually in this study because of space constraints. However, the inclusion of several works both by Becker et al. and Rabe et al. is justified because of the evolutions in the authors' opinion over time.

Within this investigation, there seems to be a particular consensus regarding the qualities *reusable* (Q1, 94%), *generally valid* (Q3, 76%), *user-centered* (Q7, 71%), *educative* (Q9, 71%), *flexible* (59%), and *comprehensive* (53%). These qualities, which reach prevalences above 50%, are, therefore, classified as common perception of RMs. At this point, it should be pointed out again that some qualities have fuzzy boundaries (see Section 2.1). The quality *flexible*, for example, shows a high attribute overlap with *reusable* and *generally valid.*

The remaining identified qualities are not shared by the majority and are, thus, seen as additionally annotated qualities. Regardless, a model should be *reliable* (Q4, 35%) and *systematic* (Q5, 24%), thus supporting trustworthiness, reusability, and user-centricity. Increased reliability, for example, can be achieved by an initial application or even validation of the developed RM. The lowest-weighted quality is *required* (Q6, 18%). This result is to be questioned critically, as the requirement itself might already be expressed by the creation of the RM. The detection and occurence of these qualities is intended to show the common and uncommon perception of the investigated contributions, but by no means to exclude uncommon perceptions. Instead, the goal is to provide the fundamentals for a viable definition and general understanding of RMs in order to integrate them to the field of BPS.

3 TRANSFERRING THE RM APPROACH TO BPS

As stated in Section 2, a model is "something that a copy can be based on because it is an extremely good example of its type" (Cambridge Dictionary, 2021b); it is an abstract formal representation of the investigated portion of the world (Dietzsch and Esswein, 1998). Consequently, as a premise to this chapter, the

Table 1: Perspectives on the qualities of a reference model.

	Common perception						Uncommon perception		
	Reusable	*Generally valid*	*User-centered*	*Educative*	*Flexible*	*Comprehensive*	*Reliable*	*Systematic*	*Required*
van der Aalst et al., 2006	•		•		•	•			
Altendorfer-Kaiser, 2016	•			•		•		•	
Bartsch, 2015	•	•	•	•	•	•			
Becker et al., 1997	•	•	•	•	•	•	•	•	
Becker and Knackstedt, 2002	•	•	•	•	•	•			•
Camarinha-Matos and Afsarmanesh, 2008	•	•	•	•		•	•		
Dietzsch and Esswein, 1998	•	•	•	•		•	•		
Müller et al., 2019	•	•	•		•				
Pajk et al., 2012 (Pajk et al., 2012)	•	•		•					
Peschooll, 2010	•	•	•	•	•			•	•
Rabe and Friedland, 2000	•	•			•				
Rabe et al., 2006	•	•	•	•		•			
Rabe et al., 2009 (Rabe et al., 2009)					•	•	•		
Rabe et al., 2020	•	•		•				•	
Schubel et al., 2015	•		•				•		
Thomas, 2006	•	•	•	•	•		•		•
Rixe and Augustin, 2020	•	•	•	•	•				
Occurrence (%)	94	76	71	71	59	53	35	24	18

authors underline that it should not be misunderstood as a building or HVAC simulation model, which represents a digital counterpart of physical phenomena and is used for predicting and understanding their dynamics.

The investigation on the qualities of RMs (see Table 1) indicates the presence of ambivalent perspectives, which is partly the result of different needs of different application fields. Consequently, Section 3.1 presents the author's general definition of RMs (based on the state of the art), which is applicable likewise to BPS and is essential for transferring the RM methodology to the latter field.

3.1 RM Definition Proposal

An RM is a holistic collection of methodologies systematically structured in an architecture in which every element (e.g., guidelines, methods, procedures, and entities, ...) is made transparent and outlined as a generic solution based on both best practices and innovative approaches.

The main objective of such an RM in the field of BPS is empowering flexible reuse of existing knowledge and practices, spurring the adoption of model-based engineering, in turn, leading to efficient development of high-quality solutions.

Based on this definition, RMs require a conceptual architecture (synonym: framework) that itself is an organized view of the RM (Figure 3).

As reported in Camarinha-Matos and Afsarmanesh (2008), an architecture defines a specific system in an abstract way. This architecture is a logical collection of elements that should be described with the help of a modeling language, which emerges to meta models. A meta model is a model of a model "describing the syntax of the model and generalizing the semantic" (Rabe et al., 2020, p. 7) with the help of a meta language (Bartsch, 2015) (e.g., Unified Modeling Language (UML), System Modeling Language (SysML), programming languages, ...). As depicted in Figure 3, meta models can be regarded as the architecture's foundation. There may be different meta models needed for various purposes depending on the described element.

Typical architecture's elements are guidelines (Camarinha-Matos and Afsarmanesh, 2008), which suggest predetermined procedures or good practice methods that can be adopted to ease a particular process (Cambridge Dictionary, 2021a). Other common elements of the architecture are maturity models, which are usually linked to a process. They are perceived as benchmark tools to evaluate weaknesses and strengths of the as-is status that later can be used to guide optimization or better lead to recommendations for actions. Exemplary tools can be part of the architecture, supporting the understanding and applicability of the RM as well as allowing the RM valida-

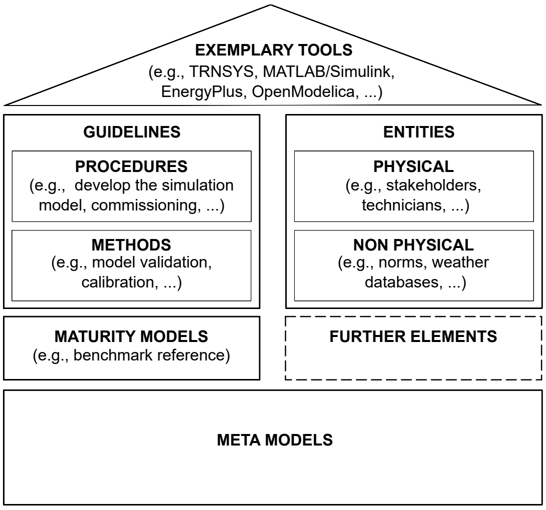

Figure 3: Reference architecture overview.

tion. Noteworthy, Figure 3 shows that elements can have different abstraction levels; this is the case, for example, of the element entities and its sub-elements physical and non-physical.

A systematic design (Q4) of the RM is enhanced by an elements' classification, making the latter easier to apply. Because classifications highly depend on a specific use case, they are not detailed further in this paper, which addresses a broad BPS perspective.

3.2 Facing the Challenges of BPS

The RM definition provided in Section 3.1 comprises the qualities identified in Section 2.1. Therefore, applying the approach to an RM in BPS supports facing the challenges outlined in Section 1.

The RM qualities of being reusable (Q1) and flexible (Q2) allow for overcoming the development efforts related to time and cost. It leads, for example, to avoid the development of a new simulation model from scratch. Generally valid (Q3) ensures an easier and wider transfer of the established practices in a certain BPS domain to another, e.g., district and urban or residential and commercial building modeling.

By collecting and systematically presenting methodologies in a conceptual architecture (Q5) and by being reliable (Q4), an RM fosters standardization, which leads to a quality increase of the resulting applications of BPS through the whole BES lifecycle, as well as cross-study benchmarks (e.g., compare modeling assumptions). Additionally, the educative (Q9) and user-centered (Q7) characteristics, thanks to disclosing the adopted methods and procedures, can be used not only to transfer knowledge from experts to non-experts, but also as a teaching instrument for students or inexperienced employees. Q7 combined with comprehensive (Q8) lead to more overall transparency of the simulation models, promoting, in turn, their ease of sharing, understanding, debugging, and conducting maintenance.

4 AN RM FOR SIMULATION-BASED TEST BENCHES

To enhance the understanding of the presented RM benefits and clarify how an RM application in the field of BPS would look like, in the following, the authors present a preliminary example.

The performance of newly developed building control systems can be assessed by the three complementary approaches (a) field-test, (b) emulation, and (c) simulation. The latter relies on a simulation model of the system to compute the Key Performance Indicators (KPIs) and verify as well as benchmark the tested control's quality.

This model-based concept is promising to overcome disadvantages related to approaches (a) and (b), when regarding test coverage as well as time and cost efforts. Nevertheless, since such a simulation-based approach relies on BPS, it faces the challenges outlined in Section 1. Furthermore, there is the need for a higher standardization and systematization of approach (c) to ensure results generalization, fair cross-study comparisons, and high test quality (Stopps et al., 2021). Approaches (a) and (b) are established in the industry, while the potential of (c) tends to be not fully acknowledged.

As presented in Section 3.2, RMs are a viable answer to the stated challenges. Therefore, an RM for implementing virtual test environments to assess the performance of building control systems is conceptualized. To ensure the RM flexibility (Q2), the architecture is modular and consists of four categories and nine classes (Figure 4). These identified elements (of the architecture) result from grouping the procedures and methods required to develop a virtual testing concept. Moreover, to design the RM architecture, the trade-off between the level of model abstraction and granularity has been considered to ensure its reusability (Q1) (Rabe et al., 2006). As depicted in Figure 4, the categories are (1) what-if scenario identification, (2) simulation model design, (3) performance assessment, and (4) results benchmark.

Category (1) describes the methods to identify the parameters and variables required to generate the what-if scenarios to ensure a sufficient test coverage and quality (avoid the "garbage-in, garbage-out" paradigm). In particular, this category contains the classes *test location*, *occupants*, *building*, and *HVAC system*, which identify the representative features of the built environment. Category (2) guides the design of the simulation model. Except for the class *simulation environment*, all the contained classes are covered also by category (1). The design of the simulation model affects the input data that are required to characterize the what-if scenarios. Consequently, the authors recognize that categories (1) and (2) must overlap to ensure the RM comprehensiveness (Q8). Noteworthy, the class *simulation environment* leads the implementation of the virtual test on software. The performance assessment methodologies are present in category (3) that allows defining the *reference control* for the benchmark and the evaluation metrics (*KPI selection*). Category (4) guides the result post-processing and benchmark phases: Once the raw data are available, effective *result visualization* and a *test report* are to be ensured for attracting the stakeholders' interest and supporting the design phase of the control under test.

Each class consists of a set of structured steps, which the user should follow to implement a simulation-based benchmark in a standardized and systematic way. Based on the use case scenarios, flow charts or activity diagrams offer the user a panorama of choices (Q8) and problem solving know-how (Q9).

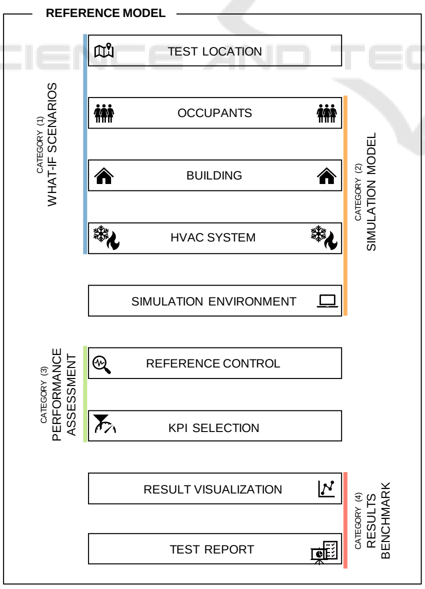

Figure 4: Conceptual architecture of the reference model.

5 CONCLUSIONS

BPS shows optimization potential in terms of modeling effort and costs, practice reusability, and standardization as well as knowledge transfer; this can be tackled by applying RMs. However, due to the diversely interpreted definitions, benefits, and attributes of RMs in different established domains, the prerequisite for transferring RMs to BPS is the creation of terminological transparency.

For this reason, the state of the art regarding the understanding of RMs is shown. Further, RMs' attributes are collected and clustered into nine qualities, which characterize and distinguish them. The eventual transfer of RMs to BPS is achieved by providing a unified definition of RMs, valid also for BPS, based on the identified qualities and by matching the latter with the challenges of BPS.

This study provides a first approach to RMs for BPS, which offer the benefit of collecting both best practices and innovative approaches with a user-centered approach, in a structured and systematic way. However, it shows the need for further scientific work. A main research focus is the pursuit of tangible application of the introduced approach to BPS by developing mature reference models, e.g., for the introduced example and other promising BPS use cases, such as data analytics in reliability prognosis.

REFERENCES

Altendorfer-Kaiser, S. (2016). Referenzmodellierung – Eine Möglichkeit zur Strukturgebung innerhalb der Informationslogistik? In Biedermann, H., editor, *Industrial Engineering und Management*, pages 165–176. Springer Fachmedien, Wiesbaden.

Bartsch, S. (2015). *Ein Referenzmodell zum Wertbeitrag der IT*. Springer Fachmedien, Wiesbaden.

Becker, J. and Knackstedt, R. (2002). *Referenzmodellierung 2002: Methoden–Modelle–Erfahrungen*. Arbeitsberichte des Instituts für Wirtschaftsinformatik, Münster.

Becker, J., Rosemann, M., and Schütte, R. (1995). Grundsätze ordnungsmäßiger Modellierung. *Business & Information Systems Engineering the International Journal of Wirtschaftsinformatik*, 37:435–445.

Becker, J., Rosemann, M., and Schütte, R., editors (1997). *Entwicklungsstand und Entwicklungsperspektiven der Referenzmodellierung: Proceedings zur Veranstaltung*, Münster. 10 March 1997.

Braun, R. and Esswein, W. (2006). Die Qualifizierung der Referenz in der Wirtschaftsinformatik. In *Proceedings of the 30th Annual Conference of the German Classification Society*, pages 401–408, Berlin. 8-10 March 2006.

Camarinha-Matos, L. M. and Afsarmanesh, H. (2008). Reference modeling: Needs and basic terminology. In Camarinha-Matos, L. M. and Afsarmanesh, H., editors, *Collaborative Networks: Reference Modeling*, pages 33–50. Springer, Boston, MA.

Cambridge Dictionary (2021a). Guideline definition. https://dictionary.cambridge.org/de/worterbuch/englisch/guideline, Online access 27.10.2021.

Cambridge Dictionary (2021b). Model definition. https://dictionary.cambridge.org/de/worterbuch/englisch/model, Online access 27.10.2021.

Cambridge Dictionary (2021c). Reference definition. https://dictionary.cambridge.org/de/worterbuch/englisch/reference, Online access 27.10.2021.

Dietzsch, A. and Esswein, W. (1998). Wissensaustausch auf der Grundlage von Referenzmodellen – Anforderungen und Möglichkeiten. In Zimmermann, H. and Schramm, V., editors, *Knowledge Management und Kommuniktationssysteme*, pages 201–209. UKV Universitätsverlag, Konstanz.

Hasan, A., Palonen, M., and Hamdy, M. (2015). Simulation-based optimization for energy and buildings. In *Renewable Energy in the Service of Mankind Vol I: Selected Topics from the World Renewable Energy Congress WREC 2014*, pages 503–513. Springer. London, UK.

Hensen, J. and Lamberts, R. (2019). Building performance simulation – challenges and opportunities. In Hensen, J. L. M. and Lamberts, R., editors, *Building Performance Simulation for Design and Operation*. Routledge. London, UK.

Müller, M., Reggelin, T., and Licht, M. (2019). Referenzmodelle für die Simulation von logistischen Prozessen in Industriewäschereien. In Putz, M. and Schlegel, A., editors, *Simulation in Produktion und Logistik*, pages 531–540. Verlag Wissenschaftliche Skripten.

Pajk, D., Stemberger, M., and Kovačič, A. (2012). Reference model design: An approach and its application. In *Proceedings of the ITI 2012 34th International Conference on Information Technology Interfaces*, pages 455–460. Cavtat / Dubrovnik, Croatia, 25-28 June 2012.

Pescholl, A. (2020). *Adaptive Entwicklung eines Referenzmodells für die Geschäftsprozessunterstützung im technischen Großhandel*. Otto-von-Guericke Universität Magdeburg. Ph.D. Thesis.

Rabe, M. and Friedland (2000). Neutral template libraries for use in globally distributed enterprises. In *The New Simulation in Production and Logistics. Prospects, Views and Attitudes*, pages 385–394. Fraunhofer IRB Verlag, Karlsruhe.

Rabe, M., Jaekel, F.-W., and Weinaug, H. (2006). Reference models for supply chain design and configuration. In Perrone, L. and et al., editors, *Proceedings of the 2006 Winter Simulation Conference*, pages 1143–1150. IEEE, Piscataway.

Rabe, M., Spieckermann, S., and Wenzel, S. (2009). Verification and validation activities within a new procedure model for V&V in production and logistics simulation. In M. D. Rossetti, R. R. Hill, B. J. A. D. and Ingalls, R. G., editors, *Proceedings of the 2009 Winter Simulation Conference*, pages 2509–2519.

Rabe, M., Wincheringer, W., and Sohny, T. (2020). Referenzmodell basierend auf Wertstromsimulation zur Bewertung von Produktionssystemen in der Angebotsphase. In *Proceedings 25. Symposium Simulationstechnik – ASIM 2020*, pages 373–380. Virtual, 14-15 October 2020.

Rixe, C. and Augustin, H. (2020). Referenzmodelle für die Intralogistik: Handlungsempfehlungen für die Konstruktion eines Referenzmodells der Intralogistik. *Zeitschrift für wirtschaftlichen Fabrikbetrieb*, 115(12):894–898.

Schubel, A., Seel, C., and Schneider, M. (2015). Informationsmodelle für die Produktions– und Logistikplanung – Eine Literaturanalyse des aktuellen Referenzmodellbestands. In Thomas, O. and Theuteberg, F., editors, *Proceedings der 12. Internationalen Tagung Wirtschaftsinformatik*, pages 527–541. Osnabrück, 5 March 2015.

Singaravel, S. (2020). *Machine Learning for Energy Performance Prediction in Early Design Stage of Buildings*. Katholieke Universiteit Leuven. Ph.D. Thesis.

Stopps, H., Huchuk, B., Touchie, M. F., and O'Brien, W. (2021). Is anyone home? A critical review of occupant–centric smart HVAC controls implementations in residential buildings. *Building and Environment*, 187:107369.

Thomas, O. (2006). Understanding the term reference model in information systems research: History, literature analysis and explanation. In Bussler, C. J. and Haller, A., editors, *Business Process Management Workshops*, pages 484–496, Berlin, Heidelberg. Springer.

Tucker, S. and Bleil de Souza, C. (2016). Placing user needs at the center of building performance simulation: Transferring knowledge from human computer interaction. In *Proceedings of the 3rd IBPSA – England Conference BSO 2016*, Newcastle University. 12-14 September 2016.

van Beek, D. A., Fokkink, W. J., Hendriks, D., Hofkamp, A., Markovski, J., van de Mortel-Fronczak, J. M., and Reniers, M. A. (2014). Cif 3: Model-based engineering of supervisory controllers. In Ábrahám, E. and Havelund, K., editors, *Tools and Algorithms for the Construction and Analysis of Systems*, pages 575–580, Berlin, Heidelberg, DE. Springer.

van der Aalst, W. M. P., Dreiling, A., Gottschalk, F., Rosemann, M., and Jansen-Vullers, M. H. (2006). Configurable process models as a basis for reference modeling. In Bussler, C. J. and Haller, A., editors, *Business Process Management Workshops*, pages 512–518, Berlin, Heidelberg. Springer.

Wetter, M. (2011). A view on future building system modeling and simulation. In Hensen, J. L. M. and Lamberts, R., editors, *Building Performance Simulation for Design and Operation*. Routledge. London, UK.