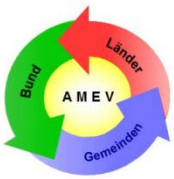
Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Mechanical and Electrical
Engineering Working Party



of National, Regional
and Local Authorities

Technical Monitoring 2017

Technical Monitoring as an Instrument for Quality Assurance

Recommendation No.: 135e

AMEV

Mechanical and Electrical Engineering Working Party of National, Regional and Local Authorities

Technical Monitoring
as an Instrument
for Quality Assurance

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FOREWORD

Rising user demand, increasingly complex legal frameworks and the resulting higher degree of building mechanisation are associated with mounting challenges for the economical, functional and needs-based operation of buildings. Therefore, requirements for these elements must be established in the planning and building phases.

This AMEV Recommendation on Technical Monitoring will contribute to quality assurance, especially in terms of building technology, for the interfaces between the planning and building phases and the first use phase. An additional goal will be to establish requirements for energy-efficient, functional and needs-oriented building operations. This recommendation draws on findings from a research project on monitoring in federal construction as well as on the state of Baden-Württemberg's prior experiences with the application of monitoring in projects.

The BNB evaluation system for sustainable building, which was introduced for federal construction, was based on regulations placed on monitoring and on the involvement of independent third parties for performance- and functional testing. Along these lines, the following AMEV recommendation contains practical notes for the implementation of monitoring arrangements. One component of the recommendation is a performance profile for the implementation of technical monitoring, as a basis for the commissioning of an independent third party. Additionally, the recommendation contains notes on important services to be rendered by participating planners; boilerplates for service specifications; and statements on cost frameworks and possible financing. Selected services to support the commissioning management are also taken into account.

The recommendation is especially appropriate for the owners and operators of public buildings, and includes the areas of planning and building as well as operation.

In addition, this recommendation offers notes on the use of measuring devices, thereby serving in substantial part as a replacement for the AMEV Recommendation EnMess 2001. It thus establishes a basis for the role of energy control, as discussed in the AMEV Recommendation "Energy," among others.

Berlin, August 2017

Torsten Wenisch / President of the AMEV Ralf-Dieter Person / Chairman

1 INTRODUCTION

For private and public construction projects, it is often the case that, even in the first use period, buildings do not achieve economical and needs-oriented operation. The very conditions for such operation are, in many cases, unavailable. The same usually holds true for construction projects as well, since in many cases the participating companies and planners are no longer responsible for operations after the approval and handover of the building.

Between the planning and building phase and the use phase, one frequently comes to a “break in the system.” Often, even in the first use phase, building technology installations encounter major errors and perform at a suboptimal level. In addition to economic disadvantages, like high operations costs, this state of affairs can also lead to a disruption in building use and associated user dissatisfaction.

This issue was identified by the Evaluation System for Sustainable Building (BNB), a system introduced for federal construction (as well as state construction in a few federal states). Monitoring arrangements implemented early in the planning phase as well as functional and performance tests administered by independent third parties are integral parts of BNB performance profiles.

For the construction of public buildings, the following recommendations for the implementation of technical monitoring (TMon) are hereby issued, to ensure the desired quality, especially of building technology, at the interfaces between the planning and building phase and the first use phase, and to establish requirements for energy-efficient, functional and needs-oriented building operations.

These recommendations supplement existing AMEV recommendations for planning and realisation of technical systems (e.g. Heating, Ventilation, Air conditioning (HVAC) installations, building automation) as well as for operations (heating operations, HVAC service, energy). On the basis of relevant technical regulations (e.g. VDI 6041[1]), these recommendations offer practical notes on the launch and implementation of technical monitoring, especially for the construction of public buildings.

[1] VDI 6041:2017-07 Facility Management; Technical monitoring of buildings and building-technology installations

Figure 1 locates TMon in the planning, building and use phases of a building and distinguishes it from other AMEV recommendations.

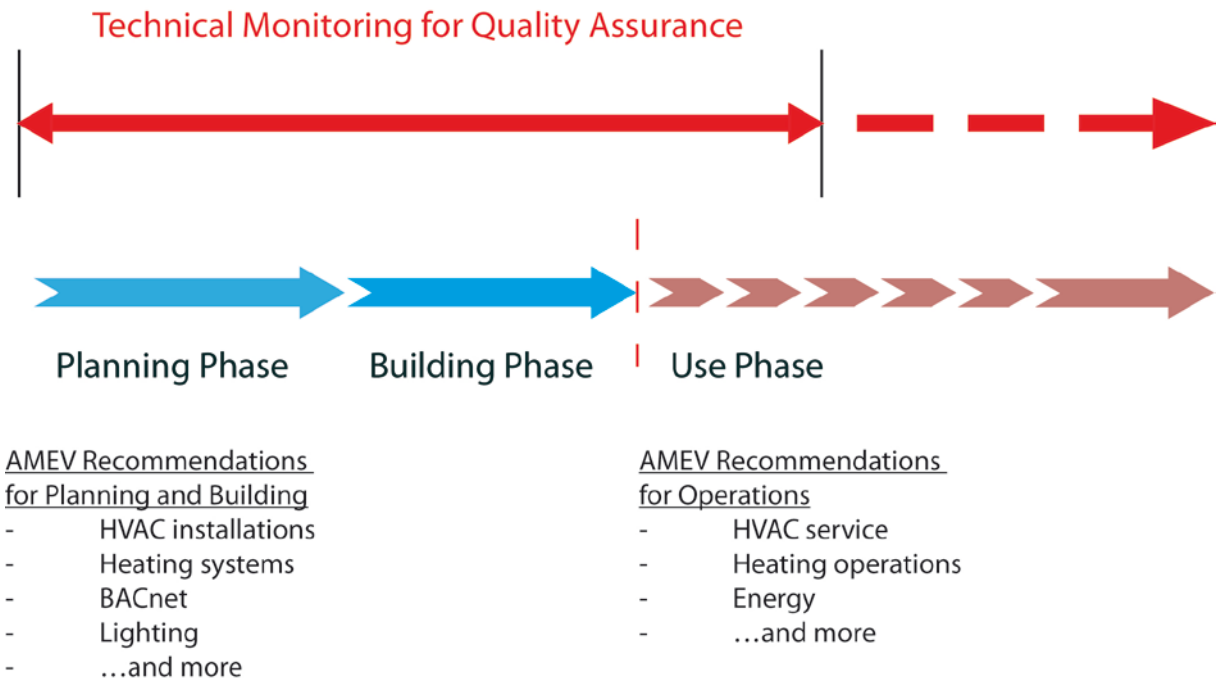


Figure 1: Fig. 1 Distinguishing TMon from other AMEV Recommendations

Figure 2 describes TMon as an instrument for ensuring building performance. It supplements the existing control loops through a general process for guaranteeing the quality achieved in operations in relation to the original goals of the project.

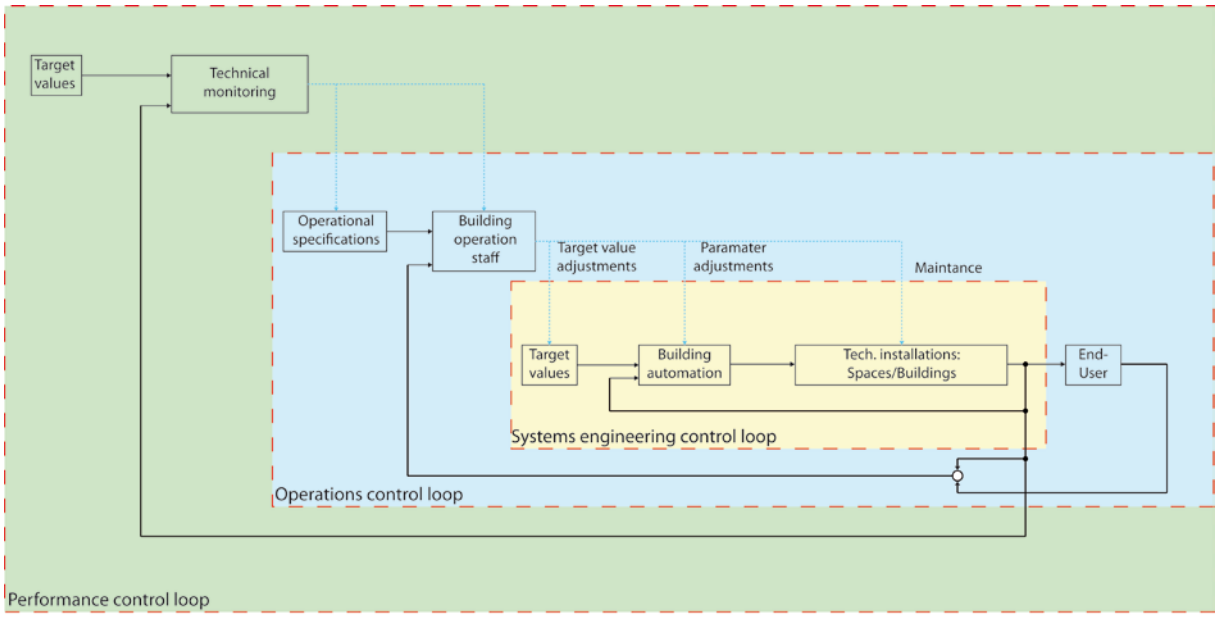


Figure 2: TMon as Primary Control Loop

For definitions of concepts, refer to VDI 6041 as well as to Chapter 6 (Glossary).

2 GOALS AND TASKS OF TECHNICAL MONITORING

TMon is an instrument for the direct support of project success in new buildings as well as a wide range of conversions and renovations. The function of TMon is to test the performance capacity of buildings and systems. Its goal is to achieve and maintain economical and efficient as well as functional and needs-oriented building operation, utilising findings from a variety of disciplines.

It is important to differentiate between TMon in the building phase and the first use phase (including approvals and adjustment), as well as TMon in regular operation (existing buildings).

1. **TMon in the planning, building, and first use phase**
   The goal is to test whether the building achieves the target performance capacity. In the building and first use phases (including in the course of approvals and during adjustments), TMon occurs as a test of the operation of the building and its individual systems in relation to the target capacities specified in the planning stage, or promised by the builders. This test has succeeded in trial runs over a limited time frame (e.g. one week), under conditions as defined as possible and without the correcting interference of the building operator.

   In the course of adjustment in the first two years of the building operations, characteristic values will additionally be determined on the basis of the planning (among other foundations); these will serve as comparative values for further operations optimisation.

2. **TMon in regular operation (existing buildings)**
   The goal is regular and/or continuous oversight as to whether the building maintains the target capacities in the long term. In regular operation, changes in usage and interference by the management can occur, both of which have an influence on the performance capacity of the building. In regular operation, TMon tests the building's functions without special preparations in terms of the building's structure, its use or its management. These tests usually happen in wide intervals (e.g. yearly), or they can be initiated by technical alarms or user complaints.

TMon's essential tasks include:

- Retrieving the necessary target figures for economical as well as functional and needs-oriented building operations,
- Retrieving or capturing and documentation of the targets, starting in the planning stage, in the form of testable target values (e.g. "21ºC") for individual test parameters (e.g. "Air temperature in room"),
- Defining suitable methods and appropriate technical and organisational precedents for testing of target achievement,
- Capturing or receiving operational values from building operations (from building automation or from other measuring systems),
- Meaningfully comparing target values and operations data for defined test parameters, to assess target achievement
- Communicating evaluations with building contractors, specialist planners, builders and operators as appropriate, as a point of departure for operations optimisation as well as to provide insights for future projects.

TMon supports project success when test results and insights are rendered transparently and communicated constructively. The planners, builders, operators and project leaders involved use this information to achieve the objectives owed within the framework of their contractual obligations.

Limitations of TMon for Commissioning Management

Commissioning management services, both as basic services as defined by the HOAI, and as special services as outlined in VDI 6039[2], are important planning services from the early project phases up to handover and subsequent problem tracking. TMon is neither a planning nor a building service, but rather a service for the testing of functional objectives in buildings and systems.

As a basic HOAI service, the preparation and organisation of commissioning is the task of specialist planners. For larger construction projects, a commissioning management in accordance with VDI 6039 can be arranged as a special service of specialist planners.

[2] VDI 6039: 2011-06 Facility Management; Operational management for buildings; Methods and approaches for building-technology systems.

Multiple committees are currently discussing development of full performance profiles for commissioning management as a whole, beyond the basic services of the HOAI outlined previously. In anticipation of future regulations, individual services for the support of commissioning management are delineated in the context of this recommendation.

3 IMPLEMENTATION OF A MONITORING PROJECT

3.1 Preparation

Whenever possible, TMon for construction projects should begin to define the expected performance capacity of the building and its systems in the design-planning phase, or at the latest in the execution-planning phase. Important technical and organisational prerequisites should be defined as additional tasks for the specialist planner.

The essential services of the special planner that are fundamental to TMon should already be taken into account in the specialist planners' bids, if they surpass the basic HOAI services that would already be yielded.

3.1.1 Needs Assessment for TMon

TMon is recommended for building projects with net total costs (DIN 276[3], cost group 200 – 700) of more than 2 million EUR. The following will therefore give recommendations on this scale. The expenses for TMon can be adjusted to the size of the project.

In addition to energy management in the context of normal operating tasks, TMon can also be employed as an instrument for oversight and optimisation in regular operations for existing buildings, not just construction projects.

3.1.2 Organisation of the Monitoring Project

TMon must be commissioned directly from and work directly for the client. It must thus be independent from the participating specialist planners, the builders and/or an external operator.

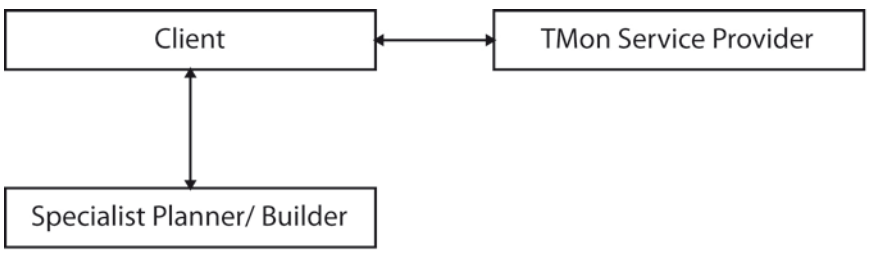


Figure 3: Participants in the Monitoring Project

[3] DIN 276-1: 2008-12 Costs in the Building Industry – Part 1: Engineering

The following possibilities exist for the implementation of TMon services:

- Suitable third parties who have specialised in these services and are not involved in the conventional planning process
- In-house personnel (e.g. representatives of the client, expert management staff of the user/building operator)

Appropriate expertise and sufficient personnel resources are essential prerequisites for the implementation of monitoring tasks by in-house personnel.

3.2 TMon Services

As a rule, TMon begins in the design-planning phase (HOAI Phase 3), in which the testable technical functions and objectives (defined in the planning phase) and the execution guidelines of TMon can be defined. Monitoring in construction projects then proceeds through the planning and building phase, into the first use phase. In the first use phase, TMon monitors adjustment in operations and tests the target values from the planning phase.

Whenever TMon in the construction project is not commissioned in the design planning phase, but rather first in later service phases, the services to be commissioned should adapt accordingly, while always maintaining the monitoring functions. This is also true of TMon in regular operation.

3.2.1 Development of the Monitoring Arrangement (HOAI Phase 3)

For the building and the systems under consideration, the test parameters as well as the appropriate target values are to be defined by the specialist planners, or agreed with the planners and documented appropriately. On this basis, a monitoring arrangement usually describes measuring and metering systems of individual works and standards for data collection.

For the following, a flow chart is established for the project phases to be considered, as a part of the monitoring. This chart describes the services of TMon: specifically, the quantity, timing and duration of the trial operations as well as necessary preparatory work by other project participants, where appropriate. The data is supplied to the appropriate specialist planners for their consideration. TMon coordinates the responsibilities and liabilities for the individual steps with the remaining project participants.

3.2.2 Implementation of the Monitoring Arrangement (HOAI Phase 5)

The TMon service provider considers the data from the execution planning phase and updates the monitoring arrangement. Changes in target values, the measuring and assessment arrangements and other updates are tracked within the monitoring arrangement.

The TMon service provider generates the necessary specifications for implementation in later phases for consideration of the performance descriptions, e.g. in relation to data preparation and data transfer from the building automation and/or other measuring systems.

In particular, TMon requirements for launch, as well as for functional testing and trial operations, must be defined. It is important to note that trial operations and functional measurements, according to the VOB/C, are to be described as “special services,” if they are not already included as additional services to be rendered.

In the end, the TMon service provider transfers the TMon specifications to the specialist planners.

The specialists take these requirements into account in the service descriptions, so that when commissioned, achievement of the target values and the proving thereof will correspond to the monitoring-arrangement part of the services due in the VOB contract (HOAI Phases 6-7).

3.2.3 Building Equipment/Plant/Services Surveillance (HOAI Phase 8)

With regard to building surveillance, trial operations are to be carried out before approval and handover, as appropriate to the pertinent regulations on technology and the monitoring arrangement. A trial operation serves, among other purposes, as a test of the automatic MSR functions and always covers the limited-time operation of individual systems without corrective manual interference in the operation of the system.

During trial operation, certain load conditions can be generated (e.g. heightened CO_2 levels in a room, or a temporarily heightened index value for supply air temperature), to test the corresponding system functions. The particular load conditions should be defined in the monitoring arrangement in advance.

Operations data from the building are the basis for testing the target values in trial operations. These data should be transferred from the builder for each system for the time period of the trial operations arranged according to the monitoring arrangement.

Should further changes in relation to TMon arise in the context of the construction documentation and planning, they should be agreed with the TMon service provider in advance. If appropriate changes are agreed by the specialist planners, the monitoring arrangement should adjust accordingly.

Prior to launch, the work schedule for the individual trial operations is calibrated in detail (prerequisites, dates, participants, etc.) in coordination with the specialist planners and the appropriate construction firms, and amended or clarified in the monitoring arrangement. Before the trial operations, the target values for all trial sizes that will be used in the ensuing tests, as well as particular load conditions, are to be determined and confirmed by the participants. TMon should be coordinated with the procedures of conventional launches, approvals, handovers and adjustments. However, it may not be restricted by such.

To ensure that data collection proceeds as planned, the correct data transfer before trial operation should be ensured by the builder, by transferring the operations data for the required measurements to the TMon service provider in the intended format.

The TMon service provider evaluates the received operations data in comparison to the achievement of the target values in the time frame of the test operation and prepares a corresponding monitoring report. For each target value, a transparent evaluation is to be provided (examples for which are presented in Section 4).

Missing a target value in a trial operation should be described by TMon informally as a defect. Possible causes are to be named (e.g. faulty data, apparent malfunctions, etc.) and, if applicable, notes on remedies should be given. Defects are to be communicated to the specialist planner and the client, and should then be identified by the specialist planner to the builder as a defect.

In a trial operation, if the functions owed or the achievement of the target values cannot be proven in the manner described in the monitoring arrangement, the trial operation should be repeated.

If trial operations cannot be carried out before the approval of a system, they should be carried out in the adjustment phase, under real load conditions if possible. In order to guarantee that they are carried out, any missing trial operations are to be recorded as defects and are to be ensured with sufficient withholdings or guarantees, in accordance with the contractual agreement.

3.2.4 Services in the First Use Phase

TMon supports the optimisation of the system operation by the builder and the building operator in the first use phase. As a rule, this spans a time frame of two years. In this phase, usage adaptations and the intervention of the operator are possible and even necessary. Resulting changes in the target values are to be tracked in the monitoring arrangement and documented in the monitoring reports.

The operations data of the systems are to be recorded, analysed and evaluated according to the monitoring arrangement. Reports should be generated in the same format as after a trial operation, and supplemented, if applicable, with key figures (e.g. degree of utilisation, operating hours, etc.) over a longer time frame. The reports should be communicated to the client or owner, the builder and the operator. The TMon service provider thereby supports the operator especially during the first use and adjustment phases and, if applicable, in building management and energy management as well as in maintenance and repair management.

The cycles are to be defined contingent upon the goals for the project. The following report cycles are recommended for TMon:
1st year of operation: monthly
2nd year of operation: quarterly

After completion of the adjustment phase and first use phase, the TMon service provider creates a final report. This report documents the achievement of the targets in the adjustment phase, the defects identified in the course of monitoring, and the resulting adaptations of the target values where applicable.

Finally, a customised monitoring arrangement will be pursued as part of the operational tasks in the context of regular energy management (long-term monitoring).

3.2.5 TMon in Regular Operation in Existing Buildings

In regular operation, the operators must meet requirements that include elements of the monitoring arrangement, in the context of regular energy management.

Additionally, TMon in regular operation for existing buildings can be performed for the optimisation of operations and for the support of operational requirements. The deliverables of TMon service providers are thus adapted to the deliverables described in the construction documents.

Report cycles should be adjusted accordingly. All the required operations data for the original monitoring should be recorded thereafter in the same way.

In regular operation, interventions in the system operations (e.g. manual operation) as well as adjustments of target values (e.g. to customise the system operation for adapted usage) are permissible. These should be documented by the operator and communicated to the TMon service provider. The resulting changes in target values are to be tracked in the monitoring arrangement and documented in the Monitoring Reports.

The TMon service provider evaluates the remaining operations data according to the monitoring arrangement, with respect to the achievement of target values, and generates the appropriate reports. Possible defects, for example target values not achieved, or faulty operations data, are documented and communicated to the contractors and operators. This prompts corrective action according to each contractual situation, e.g. preexisting warranty claims, with the participation of the specialist planners, builders and the maintenance and repair companies.

3.3 Bidding and Allocation

3.3.1 Services of TMon Service Providers

A TMon performance profile is included in Appendix 1: Modular Illustration of Performance Profiles for Technical Monitoring**.** It can be used as a basis to assist with bidding and final commissioning of external service providers. If TMon is performed by in-house personnel, the performance profile should be used as appropriate.

The performance profile can be adjusted according to the project size and the planned performance phases. Basic services should always be written out. Additional services, e.g. for quality assurance or for the support of the operation management, can be assigned if

necessitated by the building requirements (e.g. those of higher complexity) or the project situation (e.g. a lack of technical capacity on the side of the client).

3.3.2 Services of the TGA Planning Specialists (Incorporation into Contracts)

In addition to preexisting contractual obligations, contracts with TGA specialist planners, with companies that render these services or parts thereof (e.g. general contractors, general transferees, operations managers), or with project leaders should include appropriate services that result from TMon implementation in a building project.

These include, among others:

- Presentation and explanation of the desired technical functions and goals with respect to TMon
- Consideration of anticipated technical and organisational specifications of TMon
- Agreement and coordination of the tests (e.g. test operations) set by TMon
- Consideration of TMon's test results in the course of approvals and in defect tracking

Services that should be considered in the relevant contracts are listed in

Appendix 2: Services of the TGA Planning Specialists.

3.3.3 Specifications for Executing Companies/Builders

The specialist planners must record the essential services for TMon implementation in the performance specifications. These especially include:

- The technical target values to be achieved and documented in trial operations
- The requirements for executing trial operations and of subsequently continuous monitoring (e.g. measuring and data technology) as well as
- The execution of trial operations
- The transfer of the operations data arranged for the verification of objective achievement
- Regulations in case of non-achievement of individual goals in the context of the contractual arrangements (e.g. acceptance relevance, security deposits)

The builder must support TMon. TMon test results are part of the evidence of its functional success.

Example templates for performance specifications are compiled in Appendix 3: Services in VOB Contracts (Boilerplates for Service Specifications).

4 REQUIREMENTS FOR MONITORING ARRANGEMENTS AND REPORTING

4.1 Minimum Requirements for the Design of TMon System

A monitoring arrangement describes the organisational and substantive functions of TMon. A monitoring arrangement must have at least the following functions and statements:

- TMon objectives
- Monitoring schedule with presentation of the TMon work package, projected trial operations and reporting cycles, tasks of the TMon service provider and the other participants of the project, as well as processing time periods or spaces for the individual services
- List of systems to be tested, along with TMon test parameters and necessary data points (sensor technology, actuator technology, physical and virtual data points, records of measuring points relevant to TMon in planning documents or other appropriate drafts, a list of target values and presentation of assessment

methodology (basis of calculation, e.g. for weather adjustment, for calculation of effectiveness or for the definition of tolerance) as delivered by specialist planners

- Requirements for measurement and data technology for TMon as a specification for the specialist planners
- Presentation of prerequisites for implementation of trial operations (presence of appropriate planning documents, descriptions of functions, operations data from building automation, etc.) as well as specifications for implementation (e.g. the creation of special load situations)

It should be shown whether and, if so, how the continued use of the hard- and software installed for TMon will subsequently be possible for the operator.

In the following, examples are presented for how test parameters can be set (Table 1). The values compiled there must be altered for each building for which a technical monitoring arrangement is performed. As a rule, all values should be recorded as instantaneous every fifteen minutes.

Requirements for monitoring arrangements and reporting

Building, Trial Values	Target value	Measurement	[Unit]	Comment
Electr. energy consumption from network	Max. 450,000 kWh/a	Meter Reading	[kWh]	
	Max. 90 kWel	Active power load	[kW]	
Electr. energy feed into network	Min. 100,000 kWh/a	Meter Reading	[kWh]	Grid export meter
Production of PV electr. current	Min. 180,000 kWh/a	Meter Reading	[kWh]	PV export meter
Gas consumption	Max. 700,000 kWh/a	Meter Reading	[m³]	Thermal equivalent
Heating energy requirement	Max. 70 kWH/m²	Calculation	[kWh/m²]	NRF reference area
Drinking water consumption	Max. 250 m³/a	Meter Reading	[m³]	
Air temperature		Measurement	[°C]	
Gas Condensing Boiler, Trial Values	**Target value**	**Measurement**	**[Unit]**	**Comment**
Gas consumption	Max. 700,000 m³/a	Meter Reading	[m³]	
Generated heat	Max. 700,000 kWh/a	Meter Reading	[kWh]	
Degree of thermal utilization (Min. value)	> 90%	Calculation	[-]	Value per day, assessment in trial
Operation hours	3,500 h/a	Meter Reading	[h]	
Operation launches	5,000 a	Meter Reading	[qty]	
Operation launches per operation hour	< 1.5	Calculation	[-]	Value per day, assessment in trial
Supply temperature	75°C ± 3K	Measurement	[°C]	80% correct values for 96 value measurements per day, assessment in trial operation
Return temperature	< 45°C	Measurement	[°C]	80% correct values for 96 value measurements per day, assessment in trial operation
Outdoor air temperature		Measurement	[°C]	Current outdoor air temperature and adjustable average 24h
Heating Circuit 1, Trial Values	**Target value**	**Measurement**	**[Unit]**	**Comment**
Operating signal for circulation pump	Release criterion T(outdoor)<18°C		[-]	Pump must be switched off if the outdoor air temperature is over the heating threshold temperature, assessment in trial operation
Supply temperature	Characteristic TVL/T(outdoor): (70/-12:30/20); Tolerance: ± 2K		[°C]	
Return temperature	Characteristic TRL/T(outdoor): (50/-12:30/20); Tolerance: ± 5K		[°C]	
Outdoor air temperature			[°C]	

Table 1: Trial Values for Buildings and Systems (Example)

4.2 Minimum Requirements for the Design of Monitoring Reports

Monitoring reports document the results of the application of test parameters in comparison with the target values and operations data of a building and its systems (actual values). The central message of the reports must be whether the target values of the planning have been achieved and/or maintained in operation. Monitoring reports must include the following statements for the respective test periods:

- Information on extent of testing (building, systems…) and on testing procedure (time period, participants, preparatory work, unusual features…)
- List of test parameters to be monitored in a building
- List of systems and components with test parameters for system monitoring, including target values delivered by specialist planners and corresponding actual values
- Quantitative evaluation of the achievement or non-achievement of the target values within the trial period (e.g. “Objective not achieved, shortfall from target value at

47%", "Objective achieved, compliance at 87% of the trial points" with a target value of > 80%)

For the client, it must be explicitly and transparently clear from a monitoring report whether a target value has or has not been achieved. Additionally, a trial report should contain concrete notes on the remediation of qualitative deficits and defects.

In a final report, recommendations for further continuation of monitoring in an adjusted capacity should be included.

Figure 4 gives examples of graphical assessments of testing.

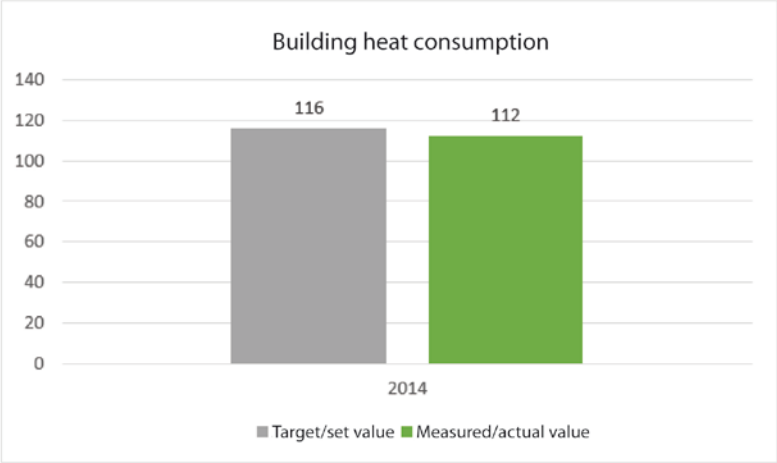
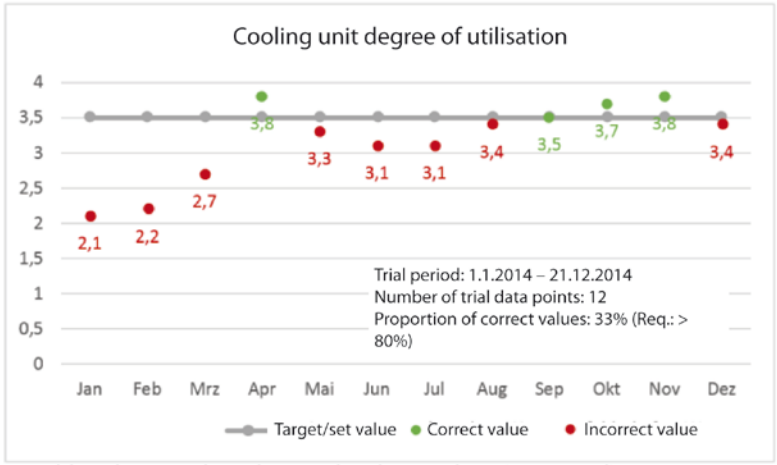
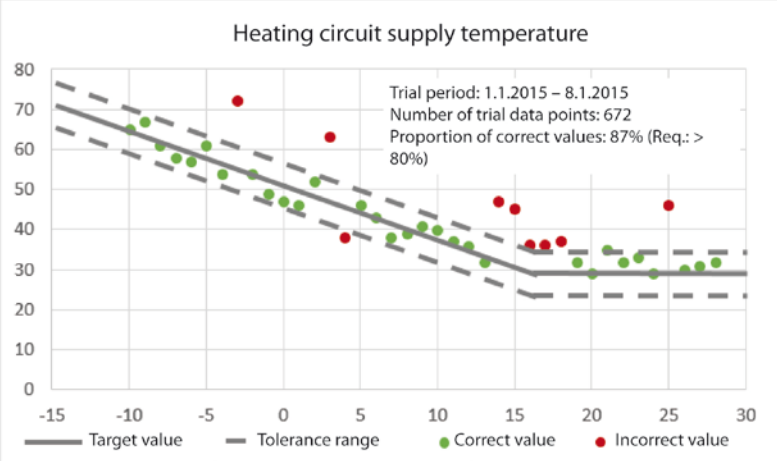
	Explanation
Trial values: Building heat consumption (weather-adjusted 20/15) **Requirement:** Shortfall from yearly maximum target value (Complied with here)	 Yearly value in a bar chart
Trial values: Cooling unit degree of utilisation **Requirement:** Achievement or shortfall of the monthly minimum value for at least 9 months of the year (Not complied with here)	 Monthly values in a line chart with value markers (green/red)
Trial values: Supply temperature for heating/cooling circuits **Requirement:** Compliance of quarter-hourly set values with a tolerance of 2K at 80% of the trial time points (Complied with here)	 Set and measured values in a scatter chart with assessment of the measured values (green/red)

Figure 4: Examples of graphical assessment of testing.

5 FINANCIAL CONSIDERATIONS

5.1 Costs – Expenditures – Uses

Due to commissioning an independent third party, TMon necessitates slightly higher investment costs. In already-realised projects, these account for less than 0.5% of the total building costs. However, a financial benefit in the operations phase runs counter to this higher expenditure, which results mainly from saved operational and energy costs in comparison to defect-ridden, unoptimised operations. Based on available data, a savings of at least 10% of yearly energy costs can be expected. On that basis, one can justify costs of around 3 to 5 times the expected yearly savings (30-50% of the projected yearly energy costs) for TMon services. Certain projects with very high energy requirements (e.g. zero-energy buildings, energy-efficient-plus buildings) will need to deviate from this.

It can be hypothesised from this that the expenditure for monitoring will pay for itself within a few years. Additionally, there are non-monetary advantages, especially in the area of user satisfaction. These advantages result from early error detection and functional building operation.

5.2 Notes on Financing of Monitoring

In the context of building measures, TMon services begin in the planning phase and last through the building and operations phases, up to the first use phase of the building, and should be commissioned all together, as a unit. Since the costs for TMon must be borne in different project phases, from the beginning of the project up to the use phase, clear determination of the payers is necessary.

In principle, this affects phases in which the costs involved are normally borne by different households. For the time period of the planning and building phases, the expenditure is budgeted into the building costs, as a rule. For operational costs after the handover of particular buildings, there are normally separate management titles.

Insofar as external businesses are commissioned to run TMon, the method of payment must be clarified in advance. For this purpose, there are the following possible variations, in principle:

- The total costs for TMon, inclusive of the costs in the first use phase, are budgeted as a part of the total building costs in DIN 276 – cost group 740 (appraisals and consulting). They should be appropriately recorded in the construction documents.
- The incidental costs in the planning and building phases are budgeted into the building costs in DIN 276 – cost group 740 (appraisals and consulting). For services starting from handover (the first use phase), costs are borne as a part of the operating costs.

The budgeting of the total costs as a part of the building costs offers the advantage of a clear responsibility on the side of the client. Additionally, TMon is used as an essential instrument for quality assurance for the building to be constructed, and in this respect it is also a part of the completion of the building. A disadvantage for this variation is that the building title must remain open until monitoring is accounted for.

After the intensive monitoring in the first use phase, the services merge seamlessly into long-term monitoring, or into the preexisting, necessary tasks of energy management. The expenditure here is a part of the operating costs.

It is suggested that the total costs of TMon should be budgeted as a part of the building costs, including for the time period of two years of the first use phase. Should this not be possible, a commission can take place section by section, and the services for monitoring can be accounted for in the building costs, as well as eventually in operating costs in the use phase. Either way, the monitoring services should be rendered by a service provider.

The financing of monitoring in existing buildings complies with budgetary regulations in the relevant administrations.

6 GLOSSARY

6.1 Abbreviations

a	anno (year)
AMEV	Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltungen (Task Force for Mechanical and Electrical Technology, National and Communal Administration)
AMon	adjustment monitoring
BACnet	Building Automation and Control Networks
BCMon	building and comfort-level monitoring
BNB	Bewertungssystem Nachhaltiges Bauen (Evaluation System for Sustainable Building)
cf.	compare
csv	comma separated values (data format)
DIN	Deutsches Institut für Normung (German Institute for Standardisation; cf. BSI)
e.g.	for example
EMon	energy monitoring
etc.	et cetera (and others)
h	hour
HOAI	Honorarordnung für Architekten und Ingenieure (schedule of fees for architects and engineers)
i.e.	in other words
IT	information technology
K	Kelvin
kW	kilowatt (power)
kWh	kilowatt hour (work, energy)
l	litre
LTMon	long-term monitoring
m, m^2, m^3	metre, square metre, cubic metre
Mess EG	Mess-und Eichgesetz (measurement and calibration regulations)
MSR	Mess-, Steuer-, Regelung(stechnik) (measurement, control and regulation technology)
ppm	parts per million
PV	photovoltaic

s	seconds
SMon	systems monitoring
TGA	Technische Gebäudeausrüstung (building infrastructure)
TMon	technical monitoring
TP	total price
UP	unit price
VDI	Verein Deutscher Ingenieure e.V. (Association of German Engineers)
VOB	Vergabe- und Vertragsordnung für Bauleistungen (German Construction Contract Procedures)
W	watt (power)
°C	degrees Celsius

6.2 Terms and Definitions

Actual value

The determined worth of a **test** value determined by measurements during **testing**.

Adjustment

Optimisation of the means of operation specified by planning (e.g. set values) of a technical system into an operation coordinated with the real building. For this, the function and service of the technical system will be analysed, as well as the energy needs of the user and the energy consumption. The adjustment phase begins before the acceptance of the building with a trial operation after launch of the engineering systems, and extends over a period of at least two years after the handover of the building.

Note: The adjustment phase principally corresponds to adjustment monitoring (AMon) defined in the VDI 6041. Differently to the VDI 6041, however, the phase already begins before the acceptance of the building. Preferably, a weeklong trial operation is to be carried out that immediately shows possible performance defects of the systems engineering prior to acceptance.

Building and comfort-level monitoring (BCMon)

BCMon essentially considers room conditions and physical supervision of the building, for example of historical building structure [VDI 6041]. User impressions and user behaviour, among other elements, are included as well.

Energy monitoring (EMon)

Ongoing recording, evaluation and presentation of energy- and utilities use [VDI 6041]. EMon creates the foundation for optimisation measures (e.g. in systems operation, for user behaviour, in the building). According to GEFMA 124-1[4], EMon is a component of energy control.

Long-term monitoring (LTMon)

The goal of LTMon is to maintain optimal operations as reached in the adjustment phase over the long term. Unlike the adjustment phase, the time intervals in which the monitoring data are analysed are significantly longer. LTMon begins at the end of the adjustment phase and extends to the end of the use phase of the building.

[4] GEFMA 124-1: 2009-11 Energy management; Foundations and performance profile

Maximum value

Upper-limit value for a test parameter. The actual value determined via monitoring should not (or at the most, only for a specified time) surpass this value, so as to prove the owed success of the work (cf. Appendix 4). Example: yearly heating energy consumption.

Minimum value

Lower-limit value for a test parameter. The actual value determined by monitoring should not (or at the most, only for a specified time) fall below this value, so as to prove the owed success of the work (cf. Appendix 4). Example: degree of utilisation of a cooling system.

Operations data

Measurement values and status information of the building and its technical systems.

Systems monitoring (SMon)

SMon includes the recording and evaluation of existing operations of technical systems through measuring systems and analytical instruments. SMon creates a foundation for functional testing and supervision as well as operations optimisation.

Target value

The target value defines one of the test parameters as an achievable value during the duration of testing. The target value can be a maximum-, minimum- or set value, for which additional time-related conditions (e.g. duration it is permissible to exceed a maximum value) and/or tolerances are specified as needed.

Testing

Procedure to prove the (contractually) guaranteed characteristics of a building and its technical systems. Testing happens during a pre-determined period under specified or known boundary conditions. Example: trial operation.

Tolerance

Tolerance describes a permissible deviation of **measurement values** vis-à-vis the relevant set values.

Trial values

Measurable variables for the description of the behaviour of a building ad its technical systems. The required quality of the building is defined through **target values** for the **test parameters**. Examples: yearly heat energy consumption, room temperatures.

7 APPENDICES

Appendix 1: Modular Illustration of Performance Profiles for Technical Monitoring

The following text can be used as a template for bidding for monitoring services. The specified basic services should be rendered. Extra services can be arranged according to the type and size of the building construction, for quality assurance or for the support of commissioning management.

Note: The performance profiles can also be used for commissioning of TMon in regular operation. In this case, each respective application should be adjusted while preserving the monitoring task.

Design planning [HOAI Phase 3]
Basic services
Preparing the monitoring arrangement: ▪ Screening the supporting documents of design planning. ▪ Deriving the relevant test parameters for the building and the systems being tested, as well as the appropriate target values, from the specialist planners, and/or coordinating and determining them with the specialist planners. ▪ Integrating and, where appropriate, augmenting measurement and metering systems for individual subsections of the system as a whole, including all interfaces and transfer formats. ▪ Developing specifications for data preparation and transfer. ▪ Preparing a procedure for TMon service providers to follow for subsequent project phases. In particular, the procedure should contain the quantity, dates and duration of trial operation as well as necessary preparatory work by other project participants. ▪ Working together with the client and the prospective operator to determine the jurisdiction and responsibilities of TMon service providers for individual steps. ▪ Preparing the monitoring arrangement with all the aforementioned details and transferring it to the specialist planners.
Extra services
o Developing a strategy for the preparation of later information and data transfers to the operators.
o At the beginning of the design planning phase: testing the planning services of the pre-design planning phase (HOAI Phase 2) for completeness, timeliness, consistency and plausibility with respect to the objectives set forth by TMon and

preparing a corresponding protocol. Items to be tested in particular in the planning services: ▪ Exploring and deciding upon possibilities for solutions ▪ Pre-dimensioning of systems ▪ Explaining the essential interdisciplinary processes, boundary conditions and interfaces, and integrating technical systems ▪ As needed, TMon supports the specialist planner or the commissioning management by consulting for foundational development and, as needed, determines the need for extra services (e.g. extra commissioning management services, building automation integration planning, etc.).
o Before the conclusion of design planning: testing the planning services from the design planning phase (HOAI Phase 3) for completeness, timeliness, consistency and plausibility with respect to the objectives set forth by TMon as well as the preparation of an appropriate protocol. Items to be tested in particular are: ▪ Compliance testing for the necessary values determined in design planning with the solutions compiled in the pre-design planning, as well as the general objectives set by the client. ▪ Testing of explanations of the essential interdisciplinary processes, boundary conditions and interfaces, as well as the integration of technical systems. ▪ As needed, TMon supports the specialist planner or the commissioning management by consulting for the development of a foundation and, as needed, determines the need for extra services (e.g. extra commissioning management services, building automation integration planning, b).
o Supporting the creation of an launch plan with time/date scheduled individual measures of the individual measures, integrating the project requirements, while taking into account the planned time for building.
o

<u>Plan of execution [HOAI Phase 5]</u>
Basic services
Updating and creating a detailed report for the monitoring arrangement. ▪ Screening the supporting documents of the plan of execution for how they account for the specifications of TMon and, as necessary, requests for important information from the specialist planners. ▪ Tracking changes in target values as well as the measuring and evaluation

strategies.

- Tracking and, if necessary, itemising the specifications for data preparation and transfer.
- Tracking and, if necessary, itemising the plan of procedure for subsequent project phases.
- Defining the requirements of TMon for start-up implementation as well as for functional testing and trial operations.
    - Note: one should be vigilant that eventual trial operations and functional measurements be described as “special services” according to VOB/C, insofar as they already exceed the additional services to be rendered.
- Supporting the specialist planners with regard to service descriptions, e.g. functional testing, counter calibration and data matching
- Transferring the updated monitoring arrangement to the specialist planner for the integration of the TMon specifications into the service descriptions.

Extra services

- Reviewing the execution plan for accessibility for launch, and later for maintenance.
- Determining and documenting the extent of the installations and systems involved in the launch process, in the form of a detailed description of the technical systems and functional building components.
- Creating a subsection-relationship matrix and developing an interface catalogue in the style of VDI 6039 (in the context of commission management), **or**
- Testing the subsection-relationship matrix and the interface catalogue according to VDI 6039
- Compiling or developing checklists and trial protocols for the support of the executing companies in the commissioning phase, acceptance and handover of documentation of rendered functional evidence and performance measurements.
- Defining requirements for interdisciplinary commissioning.

Preparation and cooperation in allocation [HOAI Phases 6–7]

Basic services

In this phase, no basic services of TMon are defined.

-

Building surveillance [HOAI Phase 8]

Basic services

- Tracking the monitoring arrangement and evaluating the trial operations:
- Adjusting the monitoring arrangement as needed.
- Adjusting and, if needed, detailing the procedure.
- Coordinating the monitoring arrangement for individual trial operations with the specialist planners and the construction firms (prerequisites, dates, participants, etc.) before commissioning.
- Testing to determine whether the conditions for a trial operation are given, especially that:
    - Target values are confirmed by the specialist planners and builders.
    - Data collection and data transmission are functional (transfer of test data on a predefined path).
    - Systems can run automatically.
    - For trial operation, predefined load scenarios can be manufactured.
- Communicating approval for implementation of the trial operations appropriate to the monitoring arrangement to the client or builder.
- Accepting the operations data from the trial operations.
- Analysing and evaluating the operational data retained from trial operations with respect to achievement of the target values.
- Preparing a monitoring report, documenting of all test parameters with the appropriate target values and the measured actual values and creating a comparative evaluation. Deviations from the actual value from the target value, along with notes on possible causes or defects (e.g. faulty operational data, faulty parametrisation or poor adjustment) should be communicated to the client or specialist planner, builder and/or building operator.
- In the event that trial operations are repeated, the appropriate services of TMon service providers should likewise be repeated. Repetitions of the services for additional trial operations are to be paid for separately at cost.
- Preparing a final report as a summary of the services of technical monitoring and all results, especially the target values for the test parameters and the actual values reached in trial operations.
- Conducting a final debriefing with the client.

Additional Services

- Verifying the contents of checklists and testing protocols after document return, with

respect to completeness and plausibility.
o Supporting trial operations on site, especially for adjustment of particular load conditions.
o Supporting interdisciplinary functional and performance testing in cooperation with executing companies and specialist planners. Verifying conformity to project requirements.
o Supporting formal acceptance according to VOB and consulting with the client for acceptance according to VOB as well as regulatory acceptances.
o

Building surveillance / First Use Phase [HOAI Phase 9]
Regular preparation of monitoring reports o Weekly o Monthly o Quarterly o Every 6 months o Annually over a period of ___ years. ▪ Tracking the monitoring arrangement, e.g. with consideration for adjustments in use by the building management, in cooperation with the operator. ▪ Recording, analysing and evaluating the received operations data with respect to the achievement of the goal values relevant to the monitoring arrangement. ▪ Preparing monitoring reports. Documenting all test parameters with the appropriate target values and the measured actual values as well as creating a comparative evaluation. The reports should be represented in accordance with the trial reports for the trial operations. They each evaluate the preceding time period, up to the last trial report. The long-term test parameters specified in the monitoring concept are represented over the entire time period of monitoring. ▪ Deviations of the actual values from the test parameters, along with notes about possible causes (e.g. faulty operations data, faulty parametrisation or poor adjustment) must be communicated to the client or specialist planner, builder and/or operator. ▪ Preparing a final report as a summary of the services of technical monitoring and all results, especially the target values for the test parameters and the actual values reached in trial operations.

Additional services
o Supporting the building operator in optimising system operation, e.g. by providing notes for the adjustment of the system parameters for real operations behaviour. Time period: Quantity/Frequency: *Note: The planned extent of support should be designated a basis for calculation, e.g. 1x per week, monthly, etc.*
o Transferring the installed software of the monitoring system to the client for independent use, along with an introduction to its use.
o Providing an extra monitoring report before the expiration of deficiency claims.
o

Appendix 2: Services of the TGA Planning Specialists

The following text can be used for service specifications of the specialist planners that are necessary for the implementation of TMon. The services are to be specified as *special services.*

Design planning [HOAI Phase 3]
▪ Transferring a current schedule status for the pre-design and design planning, respectively, to the TMon service provider. ▪ Coordinating and determining the contents of the monitoring arrangement with the TMon service provider, including test parameters, target values, data preparation and transfer and procedural planning of trial operations, among others. ▪ Adoption of the monitoring arrangement and training in its requirements by the specialist planners.

Execution planning [HOAI Phase 5]
▪ Transferring a current schedule status to TMon service provider. ▪ Coordinating and determining adjustments and additions to the monitoring arrangement with the TMon service provider, including test parameters, target values, data preparation and transfer and procedural planning of trial operations, among others. ▪ Adoption of the monitoring arrangement and training in its requirements by the specialist planners.

Building surveillance [HOAI Phase 8]
▪ Coordinating and determining adjustments and additions to the monitoring arrangement with the TMon service provider, including test parameters, target values, data preparation and transfer and procedural planning of trial operations, among others. ▪ Considering the requirements of the monitoring arrangement in relation to building surveillance, especially guaranteeing the execution of trial operations and data transfer, as well as of repetitions as needed.

Facility support [HOAI Phase 9]
▪ Managing and updating documentation of defects arising after acceptance.

Appendix 3: Services in VOB Contracts (Boilerplates for Service Specifications)

To implement TMon, builders need to deliver certain services. In the following, sample texts are assembled for the implementation of trial operations, as are requirements for the storage and transfer of the operations data to be included in service specifications. In addition, there are further services for the implementation of monitoring that must be embedded in the VOB contracts and should be project-specifically defined.

Note:
Trial operations are part of the functional testing of technical systems. They include the temporary operation of individual systems in general interaction with related systems, without corrective manual intervention in the operation of the systems. During a trial operation, defined load situations can be generated in order to text the appropriate systems functions in the trial operation.

Trial operations should be carried out for different weather conditions, in order to test the behaviour of the systems under differing load conditions. In the context of TMon, the following trial operations should be performed, at minimum:

- *Heating systems: at least one week-long trial operation during the heating period.*
- *Cooling systems: at least one week-long trial operation outside of the heating period.*
- *Air conditioning systems: at least one week-long trial operation.*

For testing the compliance of the target values, it should be defined whether the values involve the minimal or maximal values or the set values. In the latter case, permissible tolerances should be defined in the monitoring arrangement.

Boilerplate for trial operations

The following text can be used as a basis for the description of requirements for the implementation of trial operations. Requirements marked in grey should be adjusted according to the specific project. The text should be adopted for each system for which a trial operation should be performed.

Execution of a trial operation for the _____ system

The client must verify the system functions as set forth in planning and their coordination with related systems in trial operations. The proof succeeds on the basis of the transmitted operations data and is a prerequisite for the acceptance of the work.

The trial operation should be executed within [outside of] the heating period.

The prerequisites for a trial operation are:

- *Coordination of the trial operation procedures with the responsible parties designated by the contractor, in particular*

    - *Dates*
    - *Participants*
    - *Prerequisites*
    - *Data transfer*
    - *Set values and parameters to be calibrated as well as*
    - *Load situations to be calibrated during trial operation*
- *Error-free 1:1 test of all hardware data points as well as the presence of documentation of the appropriate automated systems.*
- *Successful testing of data recording and preparation through transfer of the operations data to the client from building automation, for a time period of at least one day.*
- *Operational readiness of all other (related) systems necessary for the operation of the system, including of the automation and management levels of the building.*
- *Communication to the client that all prerequisites for trial operation have been fulfilled, with a suggestion of an appointment date.*
- *Confirmation by the client of the execution of trial operation.*

Trial operation of the system includes the following services:

- *Operation of the system over a time period of two weeks*
- *Two on-site visits (8h each) during trial operation, for adjustment of set values, parameters or time programmes, or other system parameters, according to the specifications of the monitoring arrangement.*

  Examples:
    - **Increasing a characteristic curve of the heating circuit (e.g. to 5 K)**
    - **Changing a time programme (e.g. of the air conditioning system on work days, 7:00am to 7:00pm)**
    - **Lowering a switching hysteresis (e.g. of the initial temperature for storage charging, to 9°C)**
    - **…**
- *During trial operations, systems must be run in automatic operation, if this is provided for in planning. Manual interventions – with the exception of the required changes, e.g. adjustments in set values and time programs on the managing operations level – lead to cancellation of the trial operation.*
- *Storing required operations data during trial operation.*
- *Transferring the stored trial data to the client after the completion of trial operation, within 24 hours.*

If cross-system functions are involved, trial operations of the affected systems should be executed at the same time, in order to be able to determine their interactions.

If the achievement of the target values cannot be verified in a trial operation, the trial operation appropriate to this position should be repeated. The builder bears the costs of the repetition.

Execution of a trial operation

1,0 unit UP _____ TP _____

Boilerplate "Storage and Transfer of Operations Data"

The following text can be used as a foundation to define the requirements of TMon for the specialist planners' collection of the operations data. Requirements marked in grey should be adjusted to the project-specific measurements.

Setup of Storage and Transfer of Operations Data

During launch, before, during and after trial operations as well as during operations in the use phase, stored operations data from the building's technical systems should be transferred from the building automations system (physical, communicative and virtual data points) to TMon service provider or contractor. All necessary services, costs for eventual licenses, for hard- and software and for technical clearances and installations that are required for the transfer of data to the AG should be considered by the server and the client.

Storage and transfer of the operations data should be calculated for e.g. 250 data points.

a) Data recording and storage

As a rule, data points should be saved as instantaneous values in 15-minute intervals. Averaging is not permitted. Instantaneous values should additionally be saved in 15-minute intervals for change-of-value logging.

The stored data should be transferred in a table with the following structure:

Datapoint address	DP001	DP002	DP003
Plain text	Outdoor air temperature	Vent position 17	Operating signal WP3
Unit	°C	%	–
Min	-10	0	0
Max	50	100	1
01.01.2014 00:00	5,3	0	0
01.01.2014 00:15	6,5	0	1
01.01.2014 00:30	7,2	25	1
01.01.2014 00:45	7,3	37	1
01.01.2014 01:00	7,5	52	0

Time stamps are always filed in the first column, in the format "DD.MM.YYYY hh:mm:ss". Other formats are only permitted with prior permission of the contractor.

Starting from the second column, columns contain the values of the data points at each time point. The decimal separator is the comma. Thousands separators are not allowed.

Lines 1 to 5 in the table contain information about each data point. Specifically, they are:

Line 1 (mandatory): The unique datapoint address in the form of a user address.
Line 2 (mandatory): Plain text for comprehensible description of the data point (max. 40 characters).
Line 3 (mandatory): SI Unit of the datapoint.

The following units should be used:

Thermal and electrical work	[kWh]	(1 decimal place)
Temperatures	[°C]	(1 decimal place)
Thermal and electrical power	[kW]	(1 decimal place)
Flow rates	[m^3/h]	(2 decimal places)
Control commands 0-100	[%]	(without decimal places)
Operating signals (Off/On: 0/1)	[-]	
Approvals (Off/Manual-/Automatic operation: 0/1/2)	[-]	

Further units and the description of switching conditions (on/off, percent, stages, etc.) should be agreed during the assembly planning stage.

Lines 4 and 5 (optional): Minimum and maximum of the technical-physical limits for each datapoint.

b) Data transfer

The data are to be transferred when appropriate as csv data files in the above format. The column separator is the semicolon (;). Spaces (except between date and time) are not permitted; nor are control characters (e.g. “Linefeed”) within a line.
Example of a permissible line: 01.01.2017 01:00:00;7,5;52;0
The names of the csv data files must contain the building description as well as an observation time period. The details thereof should be agreed with the contractor in advance. According to the extent of the data rows to be exported, a break in subsections should additionally be provided.

Example:
Data rows from 1 June to 30 June 2011 for Building XY

- *20110601 20110630_HZG_GebXY.csv.*

Data storage should be set up such that it can keep running continuously following the trial operation. Similarly, data transfer to the contractor must happen on an ongoing basis.
Set up storage and transfer of operations data for 250 data points during trial operation as specified.

1,0 St. EP _____ GP _____

Set up storage and transfer of operations data for additional data points during the trial operation as specified.

10,0 St. EP _____ GP _____

According to the circumstances of the project, an automatic data transfer can also be specified, with a view to monitoring in the use phase. The transfer step must then fulfil the security requirements of the IT systems involved.

Appendix 4: Minimum Requirements for Trial Values for Buildings and Installations

The following section presents test parameters for typical components and systems to be at least considered for TMon, including individual extra values that can be useful for data analysis. Different values or characteristics can be defined to specify changing target values for different operating conditions.

The values collected in the following tables must be adjusted for all buildings or available technical systems for which technical monitoring is performed. As a rule, all values should be recorded as instantaneous values in 15-minute intervals.

Complementary values should be defined with each application, as well as for unspecified systems (cooling machines, heat exchangers, etc.).

Extent of testing for entire building

Building Trial Values	Target value	Measurement	[Unit]	Notes
Electr. energy consumption from grid	Maximum value per year	Meter reading	[kWh]	Measurement per feed
	Peak load	15-min mean power	[kW]	Measurement per feed
Elect. energy supply in grid	Minimum value per year	Meter reading	[kWh]	Measurement per feed
Total electr. energy consumption	Maximum value per year	Calculation	[kWh]	Sum of all individual records
a) Consumption without electr. energy user	Maximum value per year	Meter reading	[kWh]	(optional)
b) Consumption of electr. energy user	Maximum value per year	Meter reading	[kWh]	(optional)
Total electr. energy production	Minimum value per year	Calculation	[kWh]	Sum of all individual records
a) from KWK	Target value per year	Meter reading	[kWh]	(optional) per unit
b) from PV	Minimum value per year	Meter reading	[kWh]	(optional) per unit (unadjusted and adjusted for solar radiation)
c) from other systems	Target value per year	Meter reading	[kWh]	(optional) per unit
Heat consumption from a grid	Maximum value per year	Meter reading	[kWh]	Weather-adjusted
	Peak load per year	Avg. qtr-hourly load	[kW]	Recording at the transfer station
Heat supply in a grid	Minimum value per year	Meter reading	[kWh]	Weather-adjusted
Total heat consumption	Maximum value per year	Calculation	[kWh]	Sum of all individual records, weather-adjusted
a) heating system	Maximum value per year	Meter reading	[kWh]	(optional) per unit, weather-adjusted
b) Hot water	Maximum value per year	Meter reading	[kWh]	(optional) per unit
c) users and processes	Maximum value per year	Meter reading	[kWh]	(optional) per unit
Total heat production	Minimum value per year	Calculation	[kWh]	Sum of all individual records
a) producer 1	Minimum value per year	Meter reading	[kWh]	(optional) per unit
b) producer n	Minimum value per year	Meter reading	[kWh]	(optional) per unit
Cooling system consumption from a grid	Maximum value per year	Meter reading	[kWh]	
Cooling supply in a grid	Minimum value per year	Meter reading	[kWh]	
Total cooling consumption	Maximum value per year	Meter reading	[kWh]	(optional) per unit, weather-adjusted
a) room cooling	Maximum value per year	Meter reading	[kWh]	(optional) per unit
b) process cooling {{{{{TYPO? B not C}}}	Maximum value per year	Meter reading	[kWh]	(optional) per unit
Total cooling production	Minimum value per year	Meter reading	[kWh]	(optional) per unit
Total fuel consumption	Maximum value per year			Sum of all individual records, weather-adjusted
a) gas	Maximum value per year	Meter reading	[m³]	Weather-adjusted for heating purposes, separate recording for separate users
b) fuel oil	Maximum value per year	Meter reading	[l]	Weather-adjusted
c) wood / pellets	Maximum value per year	Meter reading	[...]	Weather-adjusted
d) other	Maximum value per year	Meter reading	[...]	Weather-adjusted
Drinking water consumption	Maximum value per year	Meter reading	[m³]	

Gas condensing boilers

Gas condensing boiler test values (to be considered from a nominal capacity of > 50 kWth)	**Target value**	**Measurement**	**[Unit]**	**Notes**
Gas consumption	Maximum value	Meter reading	[m³]	Evaluation as monthly or yearly value
Excess heat produced	Maximum value	Meter reading	[kWh]	Evaluation as monthly or yearly value
Degree of utilisation (thermal) (minimum value)	Minimum value	Calculation	[-]	Evaluation per day
Use hours	-	Meter reading	[h]	
Launches	-	Meter reading	[number]	
Launches per use hour or duration per launch	Maximum value or minimum value	Calculation	[-]	Evaluation per day
Inlet temperature	Set value and tolerance	Measurement	[°C]	Evaluation per day
Return flow temperature	Set value and tolerance	Measurement	[°C]	Evaluation per day
Exhaust temperature	Maximum value	Measurement	[°C]	Evaluation per day
Condensate quantity	Minimum value	Meter reading	[l]	Evaluation per day [l/kWh]
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Extent of testing for heat pumps

Heat pumps trial values (to be considered from a nominal capacity of > 50 kWth)	**Target value**	**Measurement**	**[Unit]**	**Notes**
Electr. energy consumption	Maximum value per year	Meter reading	[kWh]	Evaluation as monthly or yearly value
Excess heat produced	Target value per year	Meter reading	[kWh]	Evaluation as monthly or yearly value
Degree of utilisation	Minimum value	Calculation	[-]	Evaluation as daily value
Inlet temperature (primary side)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Return flow temperature (primary side)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Flow volume (primary side)	Set value and tolerance	Measurement	[m³/h]	
Inlet temperature (secondary side)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Return flow temperature (secondary side)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Flow volume (secondary side)	Set value and tolerance	Measurement	[m³/h]	
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Extent of testing for thermal power stations

Thermal power station trial values (to be considered from a nominal capacity of > 50 kWth)	**Target value**	**Measurement**	**[Unit]**	**Notes**
Gas consumption	Maximum value per year	Meter reading	[m³]	Evaluation as monthly or yearly value
Electr. energy produced	Target value per year	Meter reading	[kWh]	Evaluation as monthly or yearly value
Excess heat produced	Target value per year	Meter reading	[kWh]	Evaluation as monthly or yearly value
Degree of utilisation (electr.) (minimum value)	Minimum value	Calculation	[-]	Evaluation as daily value
Degree of utilisation (therm.) (minimum value)	Minimum value	Calculation	[-]	Evaluation as daily value
Degree of utilisation (total) {{}}} (minimum value)	Minimum value	Calculation	[-]	Evaluation as daily value
Use hours	–	Meter reading	[h]	
Launches	–	Meter reading	[number]	
Launches per use hour or duration per launch	Maximum value or minimum value	Calculation	[-]	Evaluation per day
Inlet temperature (set value)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Return flow temperature (set value)	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Extent of testing for heating circuit

Heating circuit trial values	**Target value**	**Measurement**	**[Unit]**	**Notes**
Operating signal of circulation pump	Approval		[-]	Testing of continuous operation or absent heating limit
Inlet temperature (set value)	Set value and tolerance	Meter reading	[kWh]	Target value if necessary as characteristic line, with tolerance
Return flow temperature (set value)	Set value and tolerance	Meter reading	[kWh]	Target value if necessary as characteristic line, with tolerance
Transferred heat excess	Maximum value	Meter reading	[kWh]	optional
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Extent of testing for partial air conditioning system with supply air temperature regulation and waste heat recovery

Partial air conditioning system with supply air temperature regulation and cross-flow heat transfer trial values	**Target value**	**Measurement**	**[Unit]**	**Notes**
Electricity consumption	Maximum value	Meter reading	[kWh]	Evaluation as monthly or yearly value
Electric power input	Maximum value	Measurement	[kW]	
Flow volume	Set value and tolerance	Measurement	[m³/h]	
Specific fan output	Minimum value	Calculation	[W/m³/s]	Evaluation according to DIN 13779 classification {{{TYPO IN GERMAN}}}
Use hours	Maximum value	Meter reading	[-]	
Supply air temperature	Set value and tolerance	Measurement	[°C]	Target value if necessary as characteristic line, with tolerance
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Extent of testing for interior climate control (building and comfort monitoring)

Interior climate control trial values	**Target value**	**Measurement**	**[Unit]**	**Notes**
Room air temperature	Dependent on the scheme: - Minimum/Maximum values, - permissible upper/lower deviations	Measurement	[°C] [h/a]	Random mobile measurement, if no available measurement in building automation
Relative humidity	Dependent on the scheme: - Minimum/Maximum values, - permissible upper/lower deviations	Measurement	[°C] [h/a]	Random mobile measurement, if no available measurement in building automation
CO2 concentration	Maximum value	Measurement	[ppm]	Only for single-room control and available recording via building automation
Presence in room	–	Measurement	[0/1]	Only for single-room control and available recording via building automation
Contact with windows	–	Measurement	[0/1]	Only for single-room control and available recording via building automation
Set room temperature (standard default)	–	Data point of single-room control	[°C]	Only for single-room control and available recording via building automation
Position of individual set point adjusters	–	Data point of single-room control	[K]	Only for single-room control and available recording via building automation
Outdoor air temperature	–	Measurement	[°C]	If needed, additional conversions necessary for regulation, e.g. as a moving average

Appendix 5: Additional Notes on Measuring and Recording Energy-, Utilities- and Operations Data and on the Security of Data Transmission

The planning and set-up of a property with measuring devices is primarily oriented according to application areas. For the areas of energy monitoring, management and supervision, only selected measured values are necessary, for the most part. Measuring systems relevant for billing (energy meters) can also be used. If these are used for billing purposes, particular specifications apply. They must convene to appropriate norms and have the necessary approvals.

Measuring devices used in the course of trade must be calibrated according to § 6 of Mess EG. The calibration should be administered in a limited time frame. It lasts from 5 years (for heat meters) to 16 years (for electricity meters), pursuant to § 34, Appendix 7 of Mess EG.

A calibration or accreditation of user-specific measuring devices can be waived, as a rule. However, the necessity of regular reconciliation or calibration persists, to ensure sufficient measurement accuracy in the long term.

For some areas, a legal obligation persists for the recording and billing of the energy consumption of a third party (e.g. heating cost regulations).

Measuring devices for the registration of usage quantities should be appropriate for automatic, remote reading (switching on of the building automation or energy management system) (see also VDI 3814, Page 5[5]). A permissible communication link is an important prerequisite for effective building and/or energy management.

To realise energy monitoring systems, the following points about hardware configuration should be observed, among others:

- What measured values are to be recorded, in what units?
- Definition of the necessary data points, measurement possibilities, evaluation systems.
- Integration of building automation.

[5] VDI 3814, Page 5: 2010-03 Building automation – Notes on system integration

- Use of meter types (electric utility meter, sub-meter, primary- and secondary meters) and meter technology (transformer ratios, remote reading capabilities, synchronisation).
- Battery-operated meters are generally unsuitable.
- What fault tolerances are required?
- What expenditures arise, e.g. for calibration and maintenance?
- What further values must be recorded (necessary sensors)?
- What (physical) media should be used for data transfer?
- What kind of communication is appropriate (protocols)?
- What specifications and characteristics should be defined for data exchange – what compatibilities should be produced?
- What data interfaces are required (import, export)?
- How do data storage and preparation of data occur, what reading intervals are necessary?
- What particulars should be heeded in assembly (installation location, preparations, adaptors, cables, etc.)?
- How will the information be documented?
- What evaluations and reports are planned?

Data transfer security

Data protection requirements should be heeded in relation to technical monitoring. In particular, secure data transfer in remote data reading should be guaranteed. To that end, an agreement with the responsible IT parties of the subsequent operator is usually necessary.

In sensitive areas, special security aspects are to be considered as appropriate; these can lead to limitations for access to monitoring data. For these cases, in which no direct external online access to the systems or to the monitoring data is possible, alternative solutions should be substituted. These include, for examples, the transfer of historical or logged data to an external server to which shared access is possible. Any questions that arise should be answered in a timely manner.

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