Summary report

AutoEffi

Research program: Zukunft Bau

Research project: IT-unterstütztes und automatisiertes Energiemonitoring der Technischen Gebäudeausrüstung in Echtzeit als Bestandteil eines zeitnahen und optimierten Energieeffizienzmanagements unter Berücksichtigung der Bauphysik und Nutzung

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The responsibility for the content of the report lies with the authors

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September 2017

The City of Munich (LHM) began in 1986 with initial considerations for the introduction of a central control system. With the help of the research project MEMS[1] funded by the BMBF, LHM developed a prototype for a company-neutral control center to support facility management in the nineties, which is successfully used in Munich for building and energy management with corresponding further developments.

The developments of the city are coordinated very closely with the Working Group Gebäudeautomation (AK GA) of the AMEV[2]. Thus, guidelines such as the GA2005 have emerged, which summarize the experience of the public sector in the planning, construction and operation of building automation and building management systems. The drivers used in Munich to connect proprietary or neutral bus systems of the automation stations to the company-neutral control center can generally also be used by other municipalities without license fees. The MEMS system is tailored to the needs of large municipalities or administrations with adequate staffing requirements.

The research project VeroGAK[3], funded by the Bundesamt für Bauwesen und Raumordnung, further developed the concept of MEMS for use in the housing industry and smaller municipalities. The special emphasis of the further development lay on the development and migration of the database system used in Munich to an open-source database system, which can be used without much follow-up costs in smaller administrations. The prototype developed as a test system until 2006 was adopted by AMEV as the first component of the AMEV-GA platform. Basically, even with a small budget, it was possible to set up a database-based control center for building services. However, the extensive functional possibilities could only be used profitably where there was a corresponding engineering understanding of buildings and technical facilities.

The modern building operation using a beneficial energy management system requires the timely feedback of the current state of technical equipment and consumption. In principle, an assignment from cause to effect succeeds. This interaction is a prerequisite for recognizing the need for action and developing measures for consumption that is not appropriate to the requirements or undesirable plant conditions. How can energy management be made more efficient by automated processes? In this research work, potentials for the development of automated processes are sought, discussed, prototypically implemented and tested.

The general stocktaking of today's practice has shown that linking an energy management system with the management level of a building management system still makes a lot of sense. Only in this way, in addition to the meter

[1] http://www.fnd-forum.de/publikationen/pdf/abschlussbericht-1.pdf

[2] AMEV – Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltungen. www.amev-online.de

[3] VeroGAK - Entwicklung eines verallgemeinerten offenen Gebäudeautomationskonzeptes. Abschlussbericht, 2006, Bau- und Wohnforschung, Band F 2479

reading of consumption measuring points, can further data such as flow and return temperatures, outside temperatures, operating conditions and other state variables be taken into account in the consumption analyzes. The relatively simple consideration of plausibility or fault and danger messages are in principle already fixed components in today's systems. They can be well integrated into the always necessary operating and organizational concept of the building operation.

The analysis of classical methods of analysis and statistics has shown the greatest potential for a systematic and as automated as possible plant and process analysis. In particular, the use of statistical methods such as the correlation analyzes can well prove in existing systems whether desired control tasks are fulfilled by the building automation and plausible system states are achieved. Incorporated in energy reports or, as implemented in the test system, as additional functions in the visualization software (here jLZHview), the plant operator can obtain an overview of the quality or quality of the operation of the building technology systems at the touch of a button. The developed methods also allow the simple and rapid assessment of a large number of systems and processes.

Various test runs have shown that the depth of the analysis increases proportionally with the parameterization effort of the user. Thus, a simple analysis can be almost completely automated, while a detailed analysis must first be parameterized by the user.

In a simple analysis, the user selects the time range to be analyzed as well as the desired flow and return temperatures in the system image via the symbolic addresses.

Procedure:

The program automatically finds the pairs of the flow and return temperatures (TV, TR) in the various heating circuits and determines from the measured values in the time domain the indicators for evaluating the heating circuits:

Mean and standard deviation of TV, TR and (TV-TR)

Correlation of TV with TR

Result:

Table with key figures and their evaluation by color highlighting.

Effect:

Red marked heating circuits should be checked by the user. The graphical representation of the measured values can be helpful for this. For a deeper view of the conspicuous heating circuit, a detailed analysis with further data points of this heating circuit can be carried out (for example outside temperature, valve position, operating message, etc.).

Conclusion:

With the help of such simple automatically executable analyzes, the specialist personnel can be pointed to those heating circuits that do not or no longer do what they should. The cause can be diverse and requires appropriate expertise from the user.

For example, a detailed analysis can be performed for various operating modes such as DAY / NIGHT or HEAT CIRCUIT ON / OFF.

The selection of parameters is saved and can be recalled for further analysis.

The user selects the data points to be analyzed, the time range and cycle (e.g., 2017 - monthly), and the useful times or measured value filters (optional).

Procedure:

The program automatically finds the measured values of the selected data points in the specified time interval, applies filters or useful times and calculates the statistics as well as correlation matrices.

Result:

Tabular and graphical representation of the statistics and the correlation matrices with color highlighting.

In this way, the system operation Summer / Winter can be evaluated in an annual overview:

- Is the system outside temperature?
- Correlate actual values with their setpoints?
- Are the mean values and scatter of the measured values in order?

Effect:

Plant operation can be automatically checked in any time range.

Conclusion:

The detailed analysis gives a deep insight into the function of a plant or a process. Helpful in assessing the calculated statistical values are comparative historical results of the same analysis.

Especially the investigation of the potential of the detailed analyzes on the basis of real building data has shown that the quality of the implemented building automation varies greatly depending on the manufacturer. A bad control quality of a control loop is detected directly by the analysis, but cannot always be improved by better controller parameterization by the user. The diversity of the systems in their function, their structural implementation, their connection depth and in the data designations in the building control technology prevents the development of a generally applicable analysis tool. An adaptation to the concrete plant must always be made. However, this adaptation does not have to be reparameterized by every user, but can, once created, stored and automatically called up.

In addition to classical methods of analysis and statistics, methods of artificial intelligence have been developed and evaluated for the independent calculation of new mathematical models for controllers and tracks for the optimization of automation in research work. At first glance, Computational Intelligence seems promising in solving complex problems in the analysis and optimization of building services. In addition to the experimental analysis of systems and storage of input / output values using neural networks in black box models, even the automated generation of models in structure and parameters using genetic programming analogous to a theoretical model creation is possible. The concrete discussion of individual application scenarios showed that many tasks of the technical building management can be better solved with the help of classical methods of control technology due to suitable conditions. Thus, for almost all buildings appropriate planning documents on structure and dimensions are available, which lead for example in the heating design and demand calculation easier to accurate models. Where these are not present, a building reception can be easily carried out and results in a more precise statement. For example, a multilayer wall construction can hardly be identified unambiguously by means of evolutionary methods. The challenges of using evolutionary methods are the coding of the problem in suitable individuals as well as the development of suitable target and fitness functions for controlling the algorithms.

The prototypical methods developed in this research project are to be further developed for use in day-to-day operations. It is certainly necessary to further simplify the mathematical methods for the user in their handling and interpretation.

As an example of a possible result of an automated analysis, the heating circuit analysis presented below is in report form.

In the example, a seven-page result report of a "well set" heating circuit is shown in Figure 1 to Figure 7. The example was generated with the stored data of the control center building services of the district office Treptow Köpenick in Berlin and shows in figure 2 beside the monthly mean values also the correlation coefficients between different measured values and the outside temperature as well as between set and actual values.

Object BARB: H20 SG-O: School Building East

Heat generator is a condensing boiler, which supplies 5 heating circuits incl. ventilation and air conditioning. This object has been selected as a positive example for a heating circuit analysis, since

- the required archive metrics are available,
- the strategy for the calculated setpoint value of the flow temperature is known,
- The system is stable.

In the heating circuit H20 SG-O a weekly program is active (DAY / NIGHT). The two operating modes DAY / NIGHT were analyzed separately.

The annual analysis shows that the heating circuit was out of service during the summer months of June to September 2016, which is shown in Figure 2 as correlation coefficients displayed in blue. In the remaining months, the system reaches with a few exceptions a mediocre (yellow) to good (green) rating.

The return temperature is essentially constant, resulting in a rather poor correlation with the outside temperature. The mixing valve in the flow is often temporarily closed and reopened when switching between the operating modes DAY / NIGHT. These rapid changes lead to a partially poor correlation with the outside temperature.

Hints:

The heating circuit pump operates at constant pressure.

In JAN 2017, the condensing boiler started 3904 times, about 5 times an hour in monthly average. Condensing boilers should be operated as long as possible at about 30 to 40% power (not shown).

BARB **Objekt-Übersicht**
ZSG: G18 + VHS
Barbarossaplatz 5


```
Heizung + WWB + Lüftung
DDC: KP DDC3002 V2.93

CA-KNOTEN-HARDWARE: CA-Knoten-2.00-ISA
MSN-FND: '23630689
MSN-PPP: '23630690
MSN-LZH: '77326292
```

Wärmeerzeuger ist ein Brennwertkessel, welcher 5 Heizkreise incl. RLT+WWB versorgt.

Im Heizkreis H20 SG-O ist ein Wochenprogramm aktiv (TAG/NACHT).
Die beiden Betriebsmodi TAG/NACHT wurden getrennt analysiert.

Der Heizkreis ist in den Sommermonaten nicht in Betrieb und die Vorlauftemperatur ist mit 65°C nach oben begrenzt.

Die Heizkreis-Pumpe arbeitet mit konstantem Druck.

Datenpunkt-Baum
Baum-Darstellung nach Datenpunkt-Adresse

DP_BAUM	BESCHREIBUNG
BARB	
Zentrale: S	
Gewerk: D	DDC
DA0 (1)	DA0 DDC-1 WP1 NZ_BM EIN
DA1 (14)	DA1 DDC-1 WP1.1 NZ_
DA2 (14)	DA2 DDC-1 WP1.2 NZ_
DB0 (1)	DB0 DDC-1 WP2 NZ_BM EIN
DB1 (14)	DB1 DDC-1 WP2.1 NZ_
DB2 (14)	DB2 DDC-1 WP2.2 NZ_
DC0 (1)	DC0 DDC-1 WP3 NZ_BM EIN
DC1 (14)	DC1 DDC-1 WP3.1 NZ_
DC2 (14)	DC2 DDC-1 WP3.2 NZ_
DD0 (1)	DD0 DDC-1 WP4 NZ_BM EIN
DD1 (14)	DD1 DDC-1 WP4.1 NZ_
DD2 (14)	DD2 DDC-1 WP4.2 NZ_
DD3 (14)	DD3 DDC-1 WP4.3 NZ_
DD4 (14)	DD4 DDC-1 WP4.4 NZ_
DE0 (1)	DE0 DDC-1 WP5 NZ_BM EIN
DE1 (14)	DE1 DDC-1 WP5.1 NZ_
DE2 (14)	DE2 DDC-1 WP5.2 NZ_
D00 (3)	D00 AP DDC TS_
D01 (10)	D01 SG DDC
Gewerk: H	Heizungsanlagen
H01 (23)	H01 K1
H03 (2)	H03 Druck
H04 (4)	H04 Vert. T
H10 (12)	H10 Lft.
H20 (48)	H20 SG O
H30 (48)	H30 SG-W
H40 (48)	H40 SG-TH
H50 (18)	H50 WW
intern: % (5)	

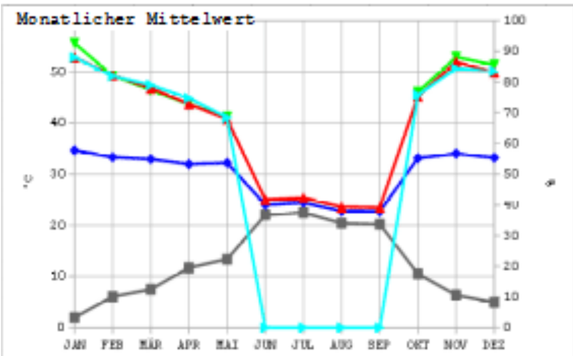
Abbildung 1: Example result report heating circuit analysis page 1

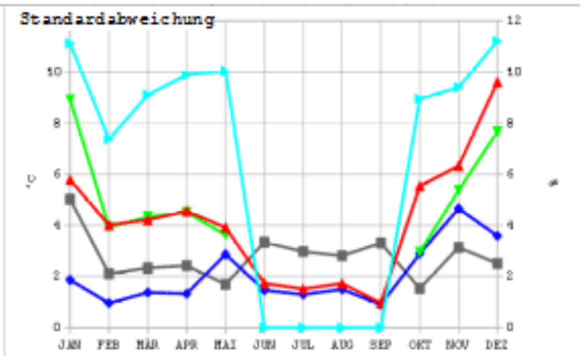
BARB: Barbarossaplatz 5 — **Jahresübersicht 2016 - Tagbetrieb**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Zeitlicher Verlauf der Messwerte





Vergleich mit Grenzwerten

Vergleich mit Grenzwerten: Mittelwert

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	AL_U	WA_U	WA_O	AL_O
TS_IST	1,950	6,069	7,454	11,732	13,372	22,049	22,51	20,419	20,213	10,508	6,347	4,947	-20	-10	20	25
TV_SOLL	55,624	49,279	46,493	43,659	41,216					46,064	52,93	51,397				
TV_IST	52,857	49,37	46,806	43,735	40,764	25,031	25,396	23,623	23,508	45,215	51,953	49,931	20	30	70	80
TR_IST	34,665	33,346	32,956	31,967	32,219	24,038	24,462	22,782	22,726	33,163	34,041	33,25	20	30	70	80
VV_SOLL	88,078	81,971	79,055	74,784	80,473	0	0	0	0	75,839	84,498	83,598				

Legende: Wert im Normal-Bereich (grün); Wert im Warn-Bereich (gelb); Wert im Alarm-Bereich (rot)
AL_U: Alarm unten
WA_U: Warnung unten
WA_O: Warnung oben
AL_O: Alarm oben

Vergleich mit Grenzwerten: Standardabweichung

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	Stabw
TS_IST	5,021	2,104	2,338	2,423	1,688	3,342	2,972	2,81	3,308	1,53	3,135	2,509	4
TV_SOLL	8,926	3,921	4,336	4,513	3,626					2,946	5,37	7,668	
TV_IST	5,785	4,011	4,215	4,558	3,917	1,73	1,51	1,723	0,963	5,539	6,325	9,613	5
TR_IST	1,858	0,959	1,371	1,326	2,865	1,458	1,294	1,495	0,898	2,889	4,662	3,585	5
VV_SOLL	11,116	7,373	9,104	9,887	10,033	0	0	0	0	8,956	9,399	11,209	10

Legende: Wert < Stabw-Grenzwert (grün); Wert > Stabw-Grenzwert x1 (gelb); Wert > Stabw-Grenzwert x2 (rot)

Korrelationen

Korrelation mit TS_IST

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ
TV_SOLL	-0,946	-0,876	-0,743	-0,916	-0,989					-0,865	-0,962	-0,712
TV_IST	-0,786	-0,854	-0,803	-0,898	-0,724	0,248	0,333	0,004	0,353	-0,654	-0,704	-0,597
TR_IST	-0,786	-0,5	-0,511	-0,52	-0,096	0,322	0,369	0,076	0,556	-0,429	-0,217	-0,439
VV_SOLL	-0,796	-0,514	-0,58	-0,71	-0,824					-0,189	-0,768	-0,476

Legende: Betrag von Wert >= 0,8 (grün); Betrag von Wert >= 0,5 (gelb); Betrag von Wert < 0,5 (rot); Wert > 0 (cyan)

Korrelation mit Soll-Wert

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ
TV_IST	0,867	0,913	0,851	0,948	0,751					0,626	0,725	0,886

Legende: Betrag von Wert >= 0,8 (grün); Betrag von Wert >= 0,5 (gelb); Betrag von Wert < 0,5 (rot); Wert < 0 (cyan)

Bemerkungen

(1) Die Anlage ist außer Betrieb (TV_SOLL ist NULL und VV_SOLL ist 0%) in den Monaten:
JUN, JUL, AUG, SEP

Hinweise

(1) Die Korrelation mit TS_IST muss negativ sein, wenn die Anlage in Betrieb ist.
(2) Die Korrelation mit dem Soll-Wert muss positiv sein, wenn die Anlage in Betrieb ist.

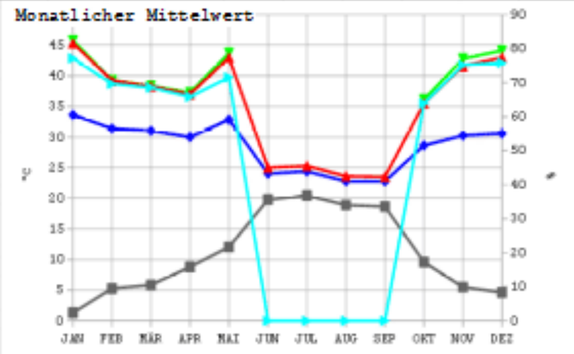
Abbildung 2: Example result report heating circuit analysis page 2

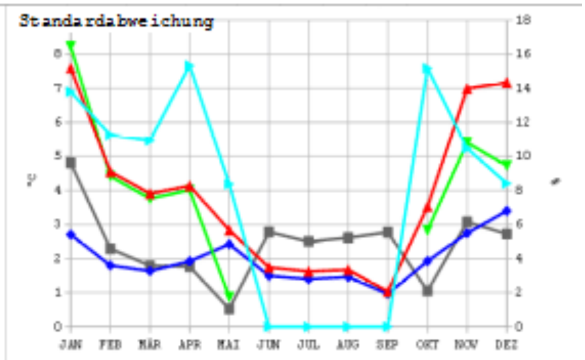
BARB: Barbarossaplatz 5 — **Jahresübersicht 2016 - Nachtbetrieb**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Zeitlicher Verlauf der Messwerte





Vergleich mit Grenzwerten

Vergleich mit Grenzwerten: Mittelwert

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	AL_U	WA_U	WA_O	AL_O
TS_IST	1,328	5,276	5,855	8,813	12,056	19,8	20,461	18,912	18,651	9,607	5,506	4,626	-20	-10	20	25
TV_SOLL	45,781	39,285	38,351	37,271	43,714					36,141	42,792	44,119				
TV_IST	45,344	39,24	38,268	37,009	42,974	25,011	25,29	23,616	23,52	35,499	41,6	43,013	20	30	70	80
TR_IST	33,634	31,424	31,043	30,021	32,862	24,039	24,385	22,781	22,762	28,644	30,27	30,632	20	30	70	80
VV_SOLL	77,144	69,655	68,507	65,864	71,522	0	0	0	0	63,898	75,159	75,859				

Wert im Normal-Bereich
Wert im Warn-Bereich
Wert im Alarm-Bereich
AL_U: Alarm unten
WA_U: Warnung unten
WA_O: Warnung oben
AL_O: Alarm oben

Vergleich mit Grenzwerten: Standardabweichung

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	Stabw
TS_IST	4,81	2,29	1,793	1,767	0,525	2,782	2,503	2,616	2,776	1,054	3,075	2,726	4
TV_SOLL	8,224	4,417	3,76	4,012	0,871					2,832	5,408	4,729	
TV_IST	7,589	4,55	3,909	4,134	2,836	1,743	1,625	1,672	1,034	3,526	6,994	7,168	5
TR_IST	2,708	1,8	1,636	1,922	2,422	1,497	1,397	1,463	0,964	1,928	2,749	3,399	5
VV_SOLL	13,787	11,258	10,94	15,336	8,378	0	0	0	0	15,171	10,476	8,412	10

Wert < Stabw-Genzwert
Wert > Stabw-Genzwert x1
Wert > Stabw-Genzwert x2

Korrelationen

Korrelation mit TS_IST

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ
TV_SOLL	-0,967	-0,876	-0,814	-0,64	-0,999					-0,65	-0,943	-0,959
TV_IST	-0,952	-0,853	-0,798	-0,676	0,617	0,304	0,278	0,018	0,393	-0,642	-0,774	-0,761
TR_IST	-0,936	-0,931	-0,881	-0,659	0,849	0,381	0,311	0,094	0,574	-0,328	-0,523	-0,547
VV_SOLL	-0,822	-0,569	-0,486	-0,406	0,243					-0,267	-0,46	-0,436

Betrag von Wert >= 0,8
Betrag von Wert >= 0,5
Betrag von Wert < 0,5
Wert > 0

Korrelation mit Soll-Wert

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ
TV_IST	0,968	0,957	0,946	0,914	-0,619					0,661	0,776	0,774

Betrag von Wert >= 0,8
Betrag von Wert >= 0,5
Betrag von Wert < 0,5
Wert < 0

Bemerkungen

(1) Die Anlage ist außer Betrieb (TV_SOLL ist NULL und VV_SOLL ist 0%) in den Monaten:
JUN, JUL, AUG, SEP

Hinweise

(1) Die Korrelation mit TS_IST muss negativ sein, wenn die Anlage in Betrieb ist.
(2) Die Korrelation mit dem Soll-Wert muss positiv sein, wenn die Anlage in Betrieb ist.

Abbildung 3: Example result report heating circuit analysis page 3

BARB: Barbarossaplatz 5 **Januar 2016**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Zeitlicher Verlauf der Messwerte

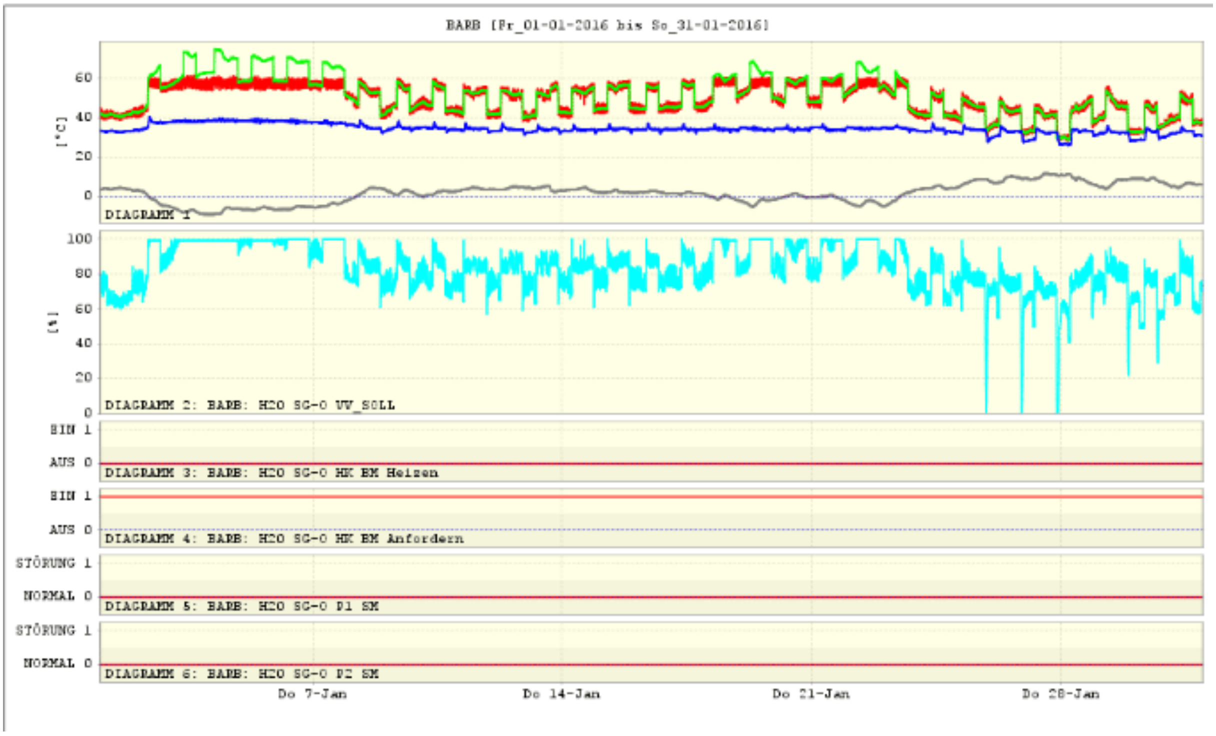


Abbildung 4: Example result report heating circuit analysis page 4

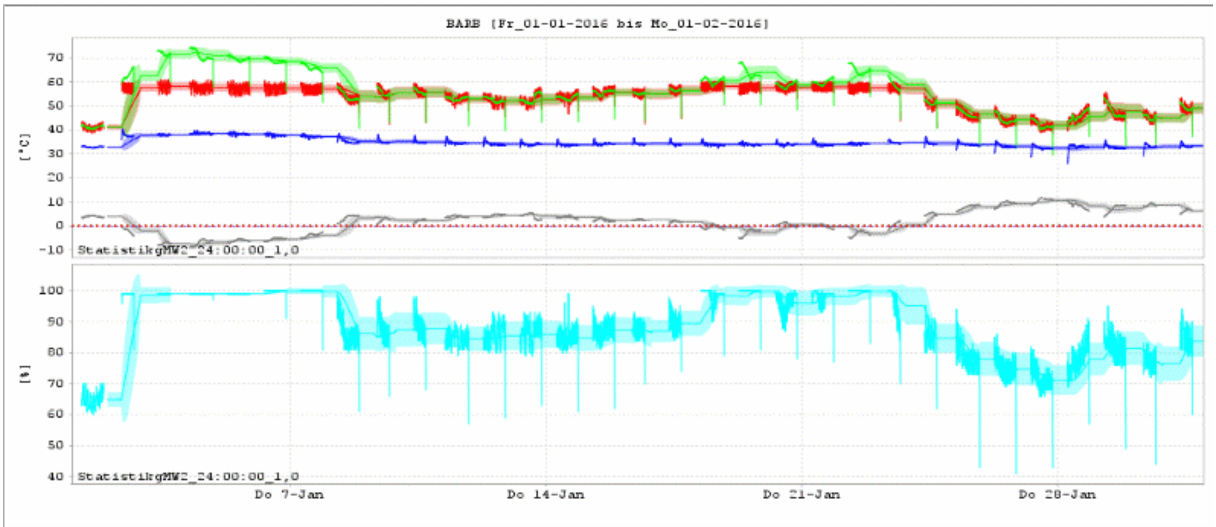
BARB: Barbarossaplatz 5 — **Januar 2016 - Tagbetrieb**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Zeitlicher Verlauf der Messwerte

24-Std-gleitender Mittelwert mit Standardabweichung



Statistik und Vergleich mit Grenzwerten

Grenzwert-Überschreitung in %

	Anzahl	Messwerte								Stabw. stdl.		Stabw. tägl.		
	GESAMT	AL_U[%]	WA_U[%]	WA_O[%]	AL_O[%]	AL_U	WA_U	WA_O	AL_O	x1[%]	x2[%]	x1[%]	x2[%]	Stabw
TS_IST	4464	0	0	0	0	-20	-10	20	25	0	0	0	0	4
TV_SOLL														
TV_IST	4465	0	0	0	0	20	30	70	80	1	0	1	0	5
TR_IST	4465	0	0	0	0	20	30	70	80	0	0	0	0	5
VV_SOLL	4465									4	2	1	0	10

Überschreitung <=20 %
Überschreitung <=50 %
Überschreitung > 50 %
AL_U: Alarm unten
WA_U: Warnung unten
WA_O: Warnung oben
AL_O: Alarm oben
Stabw: Standardabweichung

Abbildung 5: Example result report heating circuit analysis page 5

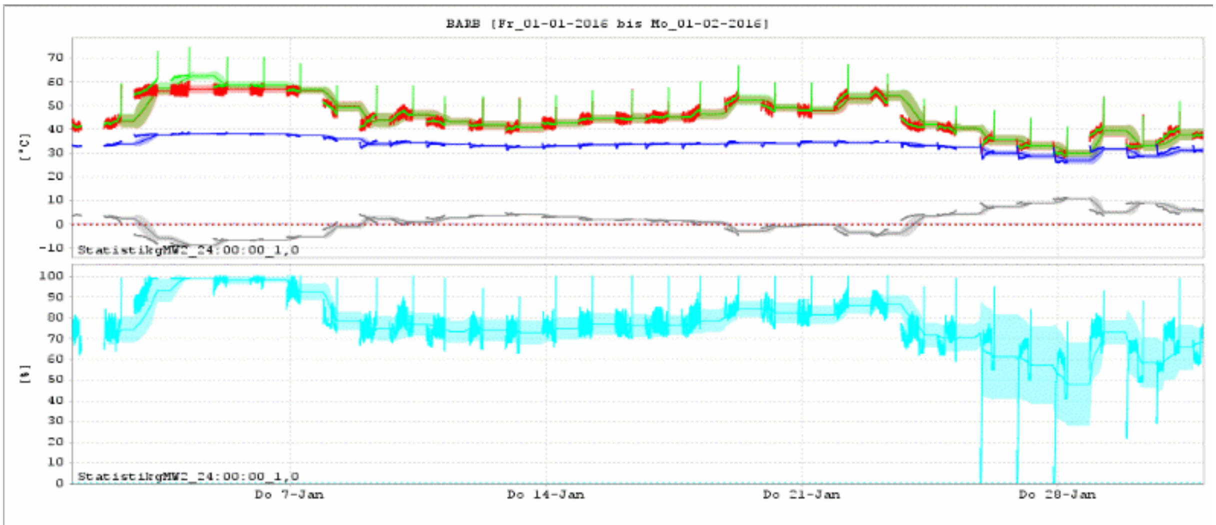
BARB: Barbarossaplatz 5 **Januar 2016 - Nachtbetrieb**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Zeitlicher Verlauf der Messwerte

24-Std-gleitender Mittelwert mit Standardabweichung



Statistik und Vergleich mit Grenzwerten

Grenzwert-Überschreitung in %

	Anzahl	Messwerte								Stabw. stdl.		Stabw. tägl.		
	GESAMT	AL_U[%]	WA_U[%]	WA_O[%]	AL_O[%]	AL_U	WA_U	WA_O	AL_O	x1[%]	x2[%]	x1[%]	x2[%]	Stabw
TS_IST	4464	0	0	0	0	-20	-10	20	25	0	0	0	0	4
TV_SOLL														
TV_IST	4465	0	0	0	0	20	30	70	80	1	0	2	0	5
TR_IST	4465	0	0	0	0	20	30	70	80	0	0	0	0	5
VV_SOLL	4465									3	0	10	6	10

Überschreitung <=20 %
Überschreitung <=50 %
Überschreitung > 50 %
AL_U: Alarm unten
WA_U: Warnung unten
WA_O: Warnung oben
AL_O: Alarm oben
Stabw: Standardabweichung

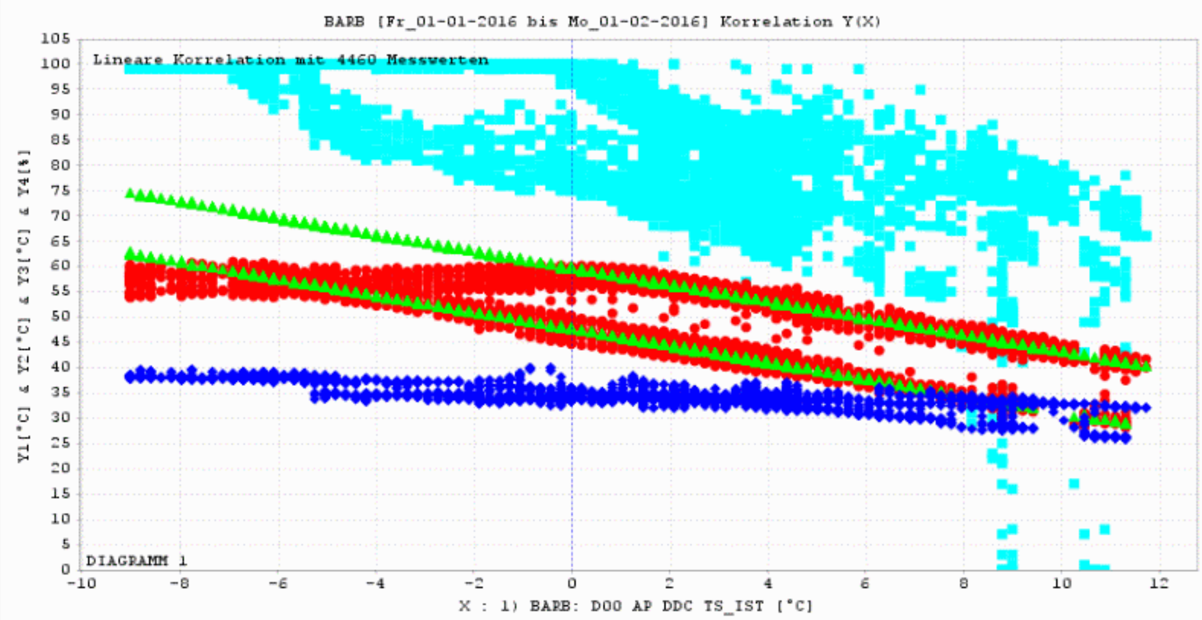
Abbildung 6: Example result report heating circuit analysis page 6

BARB: Barbarossaplatz 5 — **Januar 2016**
H20 SG-O: Schulgebäude Ost (Hof)

Datenpunkte

OBJEKT	ADRESSE	BESCHREIBUNG	DIM	KÜRZEL
BARB	SD00TS003SGUGKP4	D00 AP DDC TS_IST	°C	TS_IST
BARB	SH20TVS03SGUGKP4	H20 SG-O TV_SOLL	°C	TV_SOLL
BARB	SH20TV003SGUGKP4	H20 SG-O TV_IST	°C	TV_IST
BARB	SH20TR003SGUGKP4	H20 SG-O TR_IST	°C	TR_IST
BARB	SH20VVS03SGUGKP4	H20 SG-O VV_SOLL	%	VV_SOLL

Korrelation mit der Außentemperatur (TS_IST)



Korrelationsmatrix Tag-Betrieb

KLARTEXT	N	BESCHREIBUNG	DATUM_VON	ANZAHL	MWERT	STABW	1	2	3	4	5
BARB_H20_SG-O_JULE_TEST_2016_TAG	1	D00 AP DDC TS_IST	2016-01-01 00:00:00	2.377	1,958	5,021	1	-0,786	-0,946	-0,786	-0,796
BARB_H20_SG-O_JULE_TEST_2016_TAG	2	H20 SG-O TR_IST	2016-01-01 00:00:00	2.377	34,665	1,858	-0,786	1	0,781	0,583	0,6
BARB_H20_SG-O_JULE_TEST_2016_TAG	3	H20 SG-O TV_SOLL	2016-01-01 00:00:00	2.377	55,624	8,926	-0,946	0,781	1	0,867	0,902
BARB_H20_SG-O_JULE_TEST_2016_TAG	4	H20 SG-O TV_IST	2016-01-01 00:00:00	2.377	52,857	5,785	-0,786	0,583	0,867	1	0,841
BARB_H20_SG-O_JULE_TEST_2016_TAG	5	H20 SG-O VV_SOLL	2016-01-01 00:00:00	2.377	88,078	11,116	-0,796	0,6	0,902	0,841	1

Korrelationsmatrix Nacht-Betrieb

KLARTEXT	N	BESCHREIBUNG	DATUM_VON	ANZAHL	MWERT	STABW	1	2	3	4	5
BARB_H20_SG-O_JULE_TEST_2016_Nacht	1	D00 AP DDC TS_IST	2016-01-01 00:00:00	2.087	1,328	4,81	1	-0,936	-0,967	-0,952	-0,822
BARB_H20_SG-O_JULE_TEST_2016_Nacht	2	H20 SG-O TR_IST	2016-01-01 00:00:00	2.087	33,634	2,708	-0,936	1	0,906	0,903	0,739
BARB_H20_SG-O_JULE_TEST_2016_Nacht	3	H20 SG-O TV_SOLL	2016-01-01 00:00:00	2.087	45,781	8,224	-0,967	0,906	1	0,968	0,849
BARB_H20_SG-O_JULE_TEST_2016_Nacht	4	H20 SG-O TV_IST	2016-01-01 00:00:00	2.087	45,344	7,589	-0,952	0,903	0,968	1	0,803
BARB_H20_SG-O_JULE_TEST_2016_Nacht	5	H20 SG-O VV_SOLL	2016-01-01 00:00:00	2.087	77,144	13,787	-0,822	0,739	0,849	0,803	1

Hinweise

(1) Die Korrelationsmatrix ist symmetrisch.

Abbildung 7: Example result report heating circuit analysis page 7

The application of analysis methods basically requires a sufficient amount of data, which ideally is stored in an archive database within a company-neutral and cross-trade control center building services (LZH). The LZH should

- measuring points (meters) of the media contain heat, gas, electricity, water,
- include at least the trades electrical, heating, air conditioning, ventilation, water heating,
- be able to unlock further tasks such as an electronic key system.

The more comprehensive the available data, the more extensive the analyzes can be performed. A technical system is optimally operated if the consumption exactly meets the demand. Defining the requirement based on defined plant conditions is a good way to make matching of consumption to demand measurable. A better way would be to dynamically define demand based on changing criteria such as weather.

The poor quality of control in various manufacturers of automation stations that has been encountered in the field tests has surprised the authors. The practical implementation of the rule task was sometimes so poorly resolved that the analysis tools had identified a mistake. Uniform quality control requirements for automation stations would be necessary in order to be able to clearly assess the analysis results.