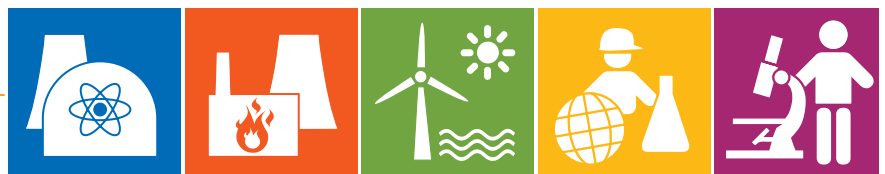


**Technical-Scientific
Reports**

**Analysis of
Unavailability of
Thermal Power Plants
2001 – 2010**

TW 103 A e

<http://www.vgb.org>
<http://www.eurelectric.org>



VGB Technical-Scientific Reports
"Analysis of Unavailability of
Thermal Power Plants 2001-2010"
- VGB-TW-103 Ae -

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The development of the KISSY Database was financed by the data providers and VGB PowerTech e.V. The report is free of charge for all data providers.

Further development and software extensions of the KISSY Database will be financed by allocations from the KISSY community.

For members either Eurelectric or VGB the price is: 90 €.

For non-members the price is: 180 €

Exclusion of Liability

The VGB-Guidelines and VGB-Instruction Sheets are recommendations which may be applied by everyone. Persons using this guideline must however ensure the right application for each case. They should consider the state of technological development at the time of the respective version. No one can be exempted of responsibility for his own actions by virtue of using the VGB-Guidelines or VGB-Instruction Sheets. This means that everyone acts at their own risk. Any liability on the part of VGB PowerTech or contributor's to VGB-Guidelines or VGB-Instruction Sheets is excluded.

VGB

Technical Scientific Reports

'Thermal Power Plants'

Analysis of Unavailability

of

Thermal Power Plants

2001 - 2010

- VGB-TW-103 Ae -

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 URL: http://www.vgb.org/media_data.html

I. Preliminary Remark

With the liberalisation of the energy markets the technical and economic assessment of power plants has gained more and more in importance. On the basis of the co-operation between Eurelectric and VGB it was decided to merge data collection for the availability and unavailability of power plants. Since 2008 the data of Eurelectric's TherPerf-Report and VGB's KISSY-Report are presented in one common report. According to the suggestions of the VGB Working Panel 'Performance Indicators' (WPPI) the database system KISSY is being retrofitted and upgraded in order to be able to generate technical benchmark reports in real time. As of summer 2010, all European utilities that are providing data will be able to analyse the data online within their companies and in their language. Apart from the existing parameters it will also be possible with the new online analyses tool to evaluate the parameters that were defined new by the WPPI. Commercial background information (e.g. EEX data) will also be involved in the KISSY system.

Apart from upgrading the KISSY database, the associated guidelines will also be published in the German, English and French language. The former VGB Guidelines 'Availability of Thermal Power Plants', 'Unavailability of Thermal Power Plants' and 'EMS Event Criterion Key Systems' were updated by the newly defined parameters and merged into one, completely revised guideline. The German and English version is ready for download on the VGB Homepage ('Information for Members'). According to current planning, the French-language version is to be published in Autumn 2011.

Apart from online evaluation, the annual evaluations, as published in the standard report at hand for the operating period 2001 to 2010, will be continued and published in an annual report.

In addition to the availability parameters of power plants, those systems and equipment of power plants are of particular interest which are responsible for weak points and thus causing unavailability events. VGB is drafting an unavailability analysis every year in order to identify such systems and equipment and to retrofit and upgrade them in order to avoid failures and unavailability. The systems and equipment will be specified according to the power plant identification system (KKS).

Data for the unavailability analysis are also collected annually by the VGB member companies similar to the data for the availability analysis. Since not all companies participating in the availability statistics are also recording unavailability data, the analysis is based on different plant collectives.

The operating results are described with the VGB event characteristics key (EMS). 13,453 unavailability events were recorded anew in the year 2010, i.e. in the period under review, 2001 to 2010, a total of 89,103 unavailability events were evaluated.

The EMS — introduced in the year 2003 — is replacing all former event-describing key systems. It avoids double and multiple recording of one event as well as different evaluation. Besides, unambiguous coding is guaranteed.

The evaluation of unavailability of thermal power plants at hand is covering the operating period 2001 to 2010 with operating parameters of a total of 243 power plants. The evaluation takes into account all data that were entered online by VGB member companies into the KISSY data base by 30th July 2011 for the period under review, i.e. until the end of 2010.

The planned part of energy unavailability in fossil-fired units amounts to 9.8 % in 2010 and thus increased by 1.9 % in comparison to the ten-year-average of the period 2001 to 2010. The unplanned unavailability of units is 7.0 % lower than the planned part of energy unavailability. The unplanned non-postponable part has the largest share with 5.2 %. In comparison to the ten-year average it increased by 0.8 %.

In the year 2010, the planned unavailability of nuclear power plants increased to 11.4 % and is thus 1.9 % lower than the ten-year average 2001 to 2010. The unplanned energy unavailability amounts to 7.4 %. The unplanned, non-postponable share amounts to 7.1 % and is thus 2.3 % higher than the long-term average value.

The tables of Chapter C.1 to C.4 'Analysis of Unplanned Unavailability' show the maximum data. The function key with the highest value is shown at the beginning of the table followed by the related function key 2 and 3. The smaller values, which can occur in high numbers, are not shown, because the mass of such data would expel the more significant values from the table.

Abstract of Scientific Reports
Thermal Power Plants 2001-2010
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E-Mail: mark@vgb.org
URL: http://www.vgb.org/media_data.html

II. Definition of Performance Indicators

Time availability

$$k_t = \frac{t_v}{t_N}$$

$$= \frac{t_N - t_{nv}}{t_N}$$

The time availability is the quotient of the available time and the reference period (calendar time).

The available time is the difference between the reference period and the unavailable time.

Energy availability

$$k_w = \frac{W_v}{W_N}$$

$$= \frac{W_N - W_{nv}}{P_N \cdot t_N}$$

The energy availability is the quotient of the available energy and the nominal energy.

The available energy is the difference between the nominal energy and the unavailable energy.

The nominal energy is the product of the nominal capacity and the reference period (calendar time).

Time utilization

$$n_t = \frac{t_B}{t_N}$$

The time utilization is the quotient of the operating time and the reference period (calendar time).

The time utilization is a measure for the real temporal use of a plant. It is independent of the level of the corresponding operating capacity.

Energy utilization

$$n_W = \frac{W_B}{W_N}$$

$$= \frac{W_B}{P_N \cdot t_N}$$

$$t_{aN} = \frac{W_B}{P_N}$$

$$t_{aN} = n_W \cdot t_N$$

The energy utilization is the quotient of the energy generated and the nominal energy.

The nominal energy is the product of the nominal capacity and the reference period (calendar time). The energy generated is the product of operating capacity and operating time (numerator).

The energy utilization is a measure for the energy which a plant has really generated.

Frequently used are also the equivalent definitions "utilization duration" or "full load utilization hours"

The correlation between energy utilization and utilization duration

Classification of unavailability (NV)**planned unavailability**

The beginning and duration of the unavailability have to be determined more than 4 weeks before commencement.

Unplanned unavailability

The beginning of unavailability cannot be postponed or only up to 4 weeks.

Postponable

The beginning of unavailability can be postponed more than 12 hours up to 4 weeks.

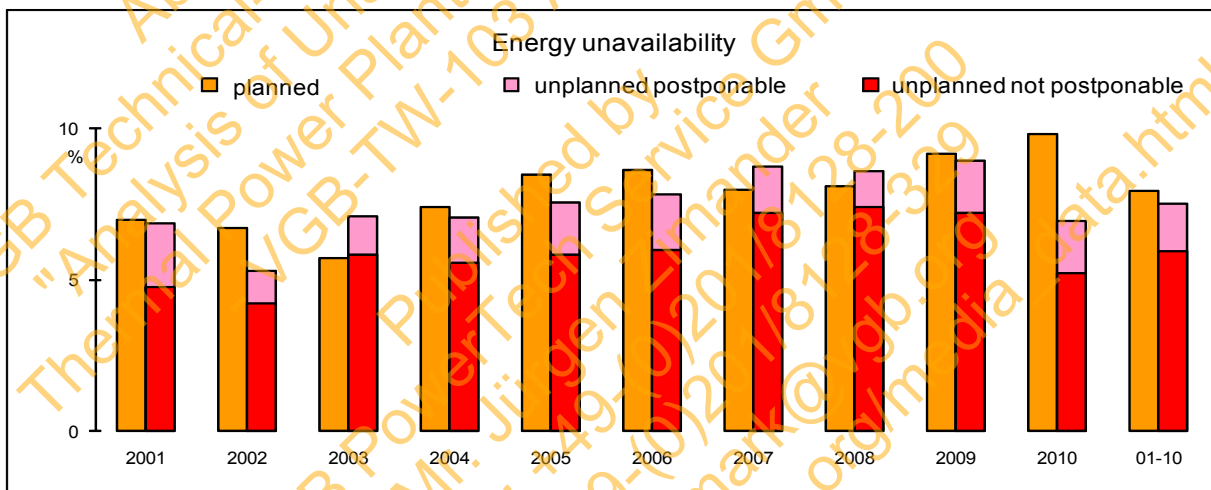
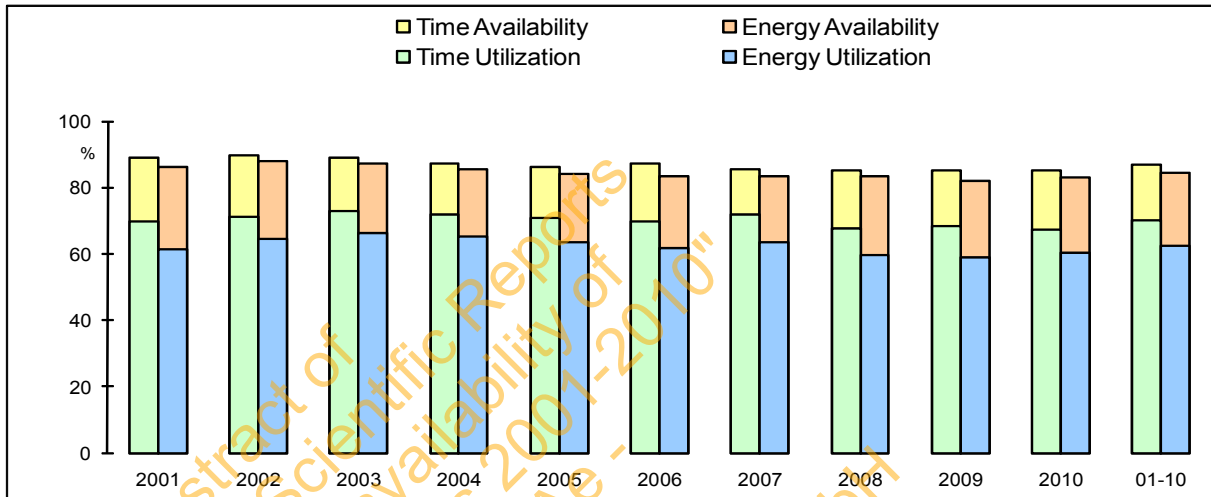
Not postponable

The beginning of unavailability cannot be postponed or only up to 12 hours.

III. Results

A. Available and Utilization

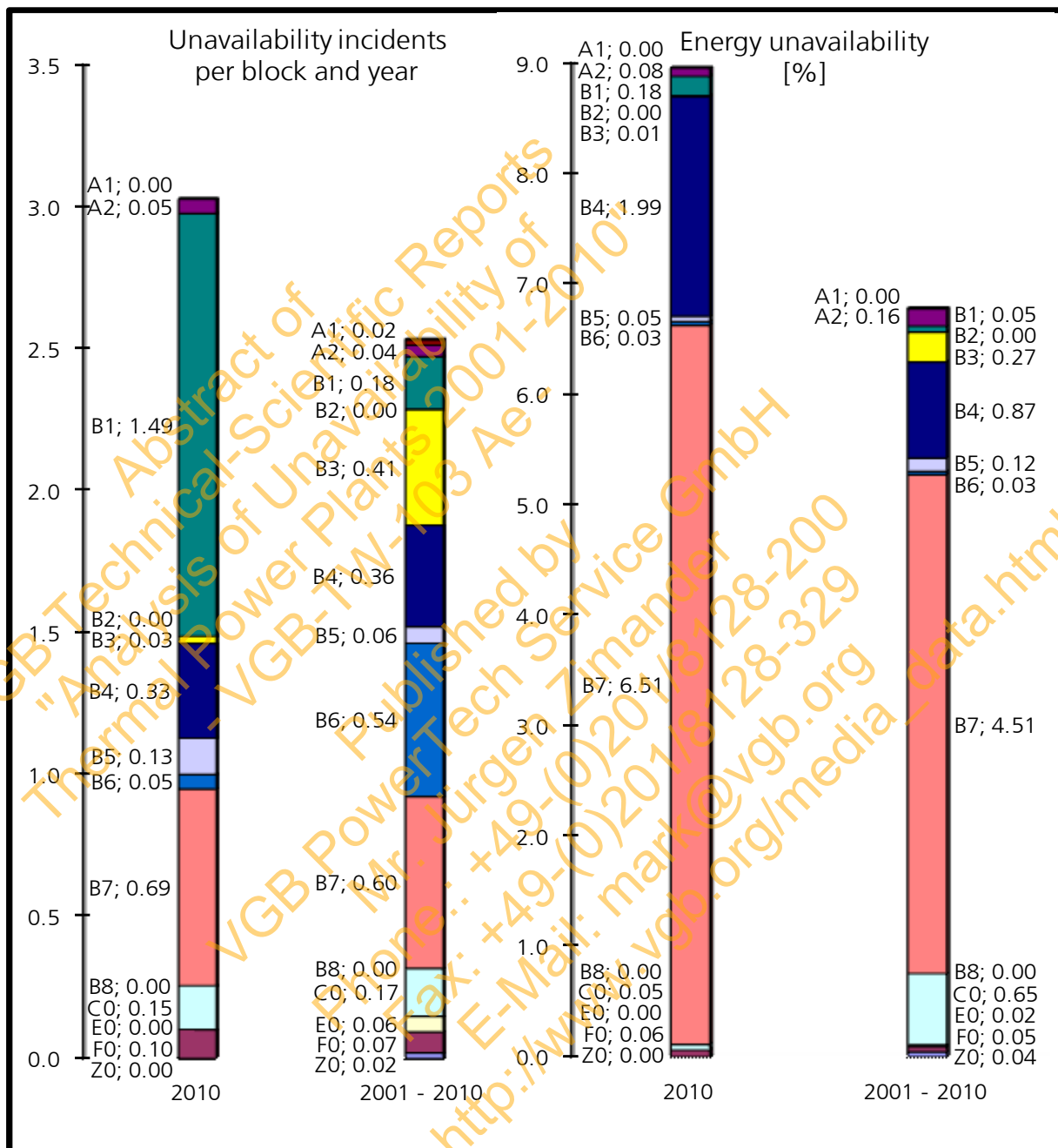
1. Fossil-fired Units



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	01-10	
Number/Unit Years	131	125	130	133	139	144	144	143	142	123	1,354	
Capacity (gross)	MW	47,424	44,866	46,098	49,260	51,950	53,066	52,623	51,710	52,616	47,081	496,694
Time Availability	%	89.0	89.7	89.1	87.3	86.2	87.1	85.3	85.1	85.1	85.2	86.9
Time Utilization	%	69.6	71.2	72.8	71.8	70.9	69.8	71.7	67.8	68.2	67.4	70.1
Energy Availability	%	86.2	88.0	87.2	85.5	84.0	83.5	83.3	83.3	81.9	83.2	84.5
Energy Unavailability	%	13.8	12.0	12.8	14.5	16.0	16.5	16.7	16.7	18.1	16.8	15.5
planned part	%	7.0	6.7	5.7	7.4	8.5	8.6	8.0	8.1	9.2	9.8	7.9
unplanned part	%	6.9	5.3	7.1	7.1	7.6	7.8	8.7	8.6	9.0	7.0	7.5
postonable	%	2.1	1.1	1.3	1.5	1.7	1.8	1.5	1.2	1.7	1.7	1.6
not postonable	%	4.8	4.2	5.9	5.6	5.8	6.0	7.2	7.4	7.2	5.2	6.0
Energy Utilization	%	61.4	64.6	66.1	65.3	63.6	61.6	63.3	59.7	59.0	60.5	62.5

B. Types of Incidents of Planned Unavailability 2001-2010

B.4 Gas Turbine Units



Types of Incidents of Planned Unavailability (EMS 1)

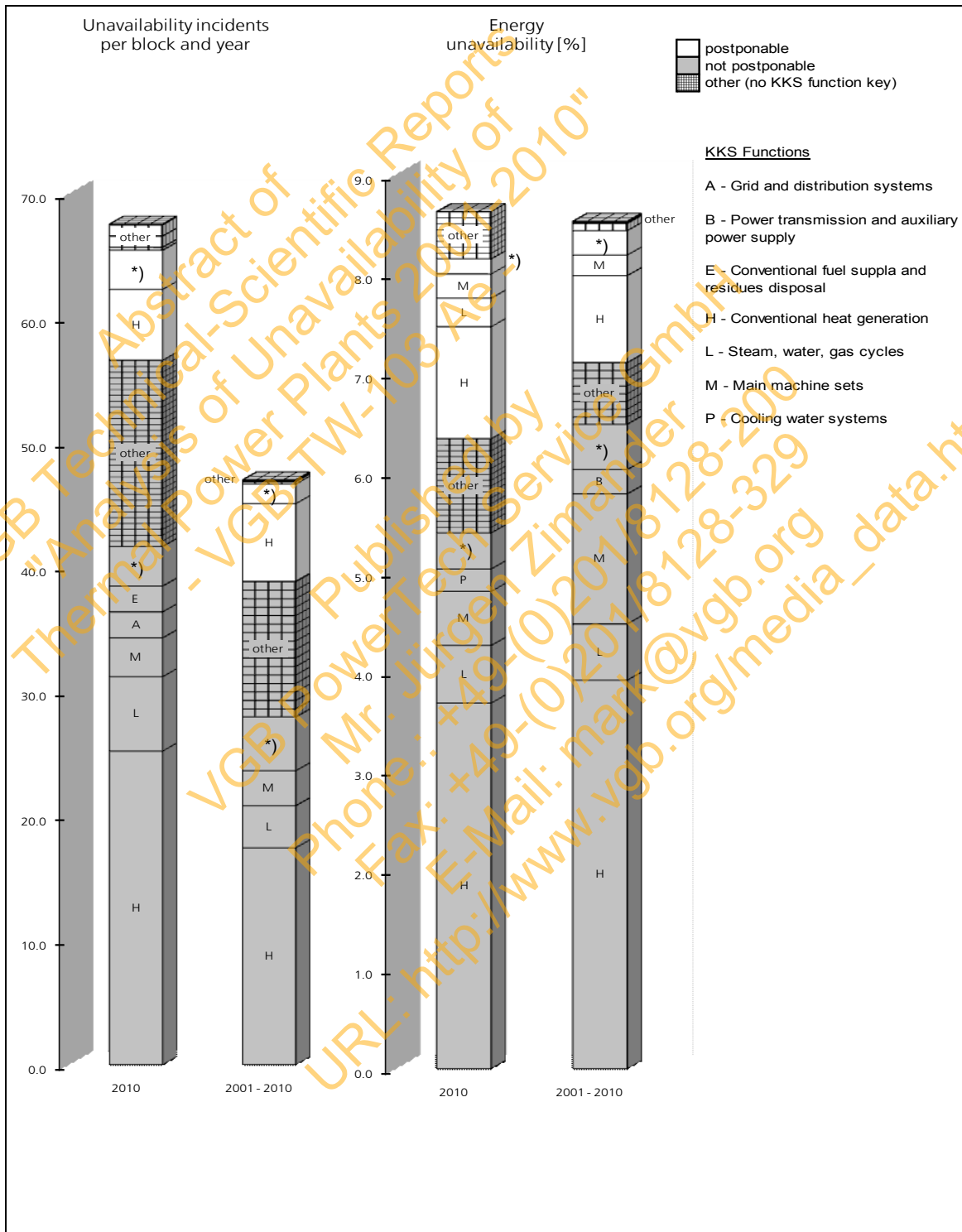
A1	failure without damage	B6	cleaning
A2	damage	B7	revision
B1	check/condition check	B8	refuelling
B2	lubrication	C0	reconstruction/refurbishment
B3	maintenance	E0	tests/functional tests
B4	inspection	F0	official test/measure
B5	preventive maintenance	Z0	other incidents

C. Analysis of unplanned Unavailability 2001-2010

1. Causers all areas

(KKS-Function key F1 for F1: A to Z)

1.1 Fossil fired Units



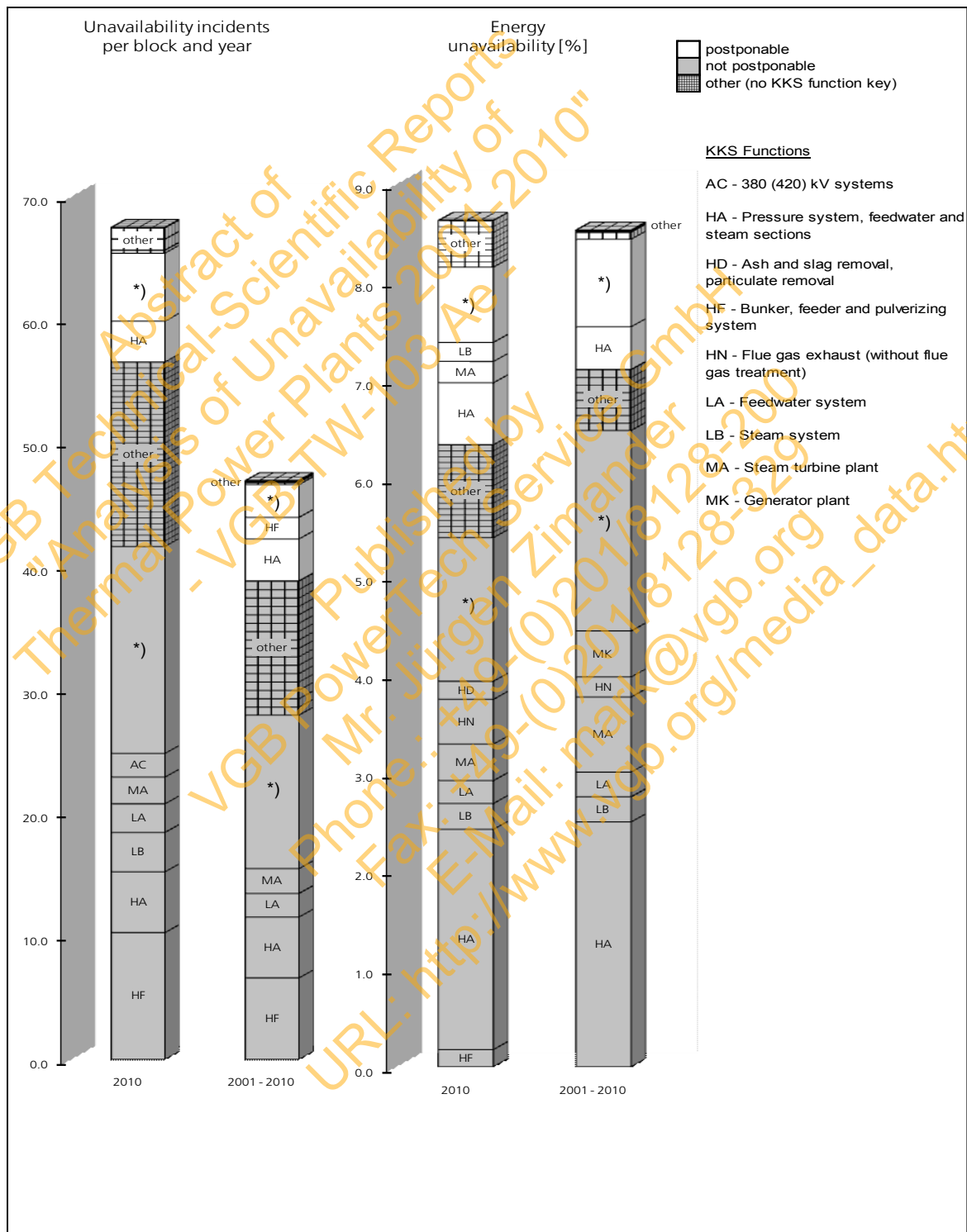
*) Sum of unlisted F1 keys

C. Analysis of unplanned Unavailability 2001-2010

1. Causers all areas

(KKS-Function key F1, F2 for F1: A to Z)

1.1 Fossil fired Units



*) Difference from F1 – F2

C. Analysis of unplanned Unavailability 2010

1. Causers all areas

(KKS-Function key F1, F2, F3 for F1: A to Z)

1.1 Fossil fired Units

Unavailability incidents per block and year						Energy unavailability			
not postponable			postponable			not postponable		postponable	
KKS	Count	%	KKS	Count	%	KKS	%	KKS	%
Σ H	25.20	37.32	Σ H	5.68	8.42	Σ H	3.68	Σ H	1.13
Σ HF	10.29	15.24	Σ HA	3.31	4.90	Σ HA	2.25	Σ HA	0.63
HFC	7.20	10.67	HAD	0.40	0.59	HAD	1.01	HAD	0.37
HFB	2.28	3.37	Σ HF	1.12	1.66	HAH	0.44	HAJ	0.10
Σ HA	4.93	7.31	HFC	1.07	1.58	HAJ	0.24	HAH	0.04
HAD	1.59	2.36	Σ HN	0.25	0.37	HAC	0.09	Σ HH	0.11
HAH	0.65	0.96	HNC	0.09	0.13	Σ HN	0.46	HHB	0.10
Σ HN	1.29	1.91	Σ HH	0.20	0.30	HNE	0.18	Σ HL	0.11
HNC	0.82	1.22	HHB	0.16	0.24	HNA	0.13	HLB	0.04
Σ HH	0.93	1.38	Σ HT	0.19	0.28	Σ HD	0.18	Σ HD	0.10
HHB	0.58	0.85	Σ HL	0.13	0.19	HDA	0.13	Σ HN	0.06
Σ HD	0.78	1.16	Σ HD	0.12	0.18	Σ HF	0.18	HNE	0.03
HDA	0.63	0.93	HDA	0.10	0.14	HFC	0.11	HNC	0.02
Σ HL	0.69	1.02	Σ HY	0.10	0.14	Σ HH	0.16	Σ HT	0.04
Σ L	5.98	8.85	Σ C	1.24	1.83	HHB	0.12	HTD	0.02
Σ LB	3.20	4.73	Σ CJ	0.16	0.24	Σ HL	0.10	Σ HS	0.03
LBG	1.01	1.49	Σ M	0.66	0.98	Σ L	0.58	Σ HF	0.02
Σ LA	2.33	3.44	Σ MA	0.42	0.63	Σ LB	0.26	Σ L	0.29
LAC	0.93	1.38	MAY	0.11	0.16	LBF	0.09	Σ LB	0.19
Σ M	3.11	4.61	Σ MK	0.18	0.26	Σ LA	0.23	Σ LA	0.06
Σ MA	2.16	3.20	Σ L	0.65	0.96	Σ M	0.54	LAB	0.02
Σ MK	0.71	1.05	Σ LA	0.31	0.46	Σ MA	0.37	Σ LC	0.02
Σ A	2.09	3.09	LAC	0.10	0.14	MAD	0.12	Σ M	0.24
Σ AC	1.93	2.85	Σ LB	0.22	0.33	Σ MK	0.13	Σ MA	0.22
ACE	1.91	2.83	Σ LC	0.10	0.14	Σ P	0.23	MAA	0.02
Σ E	2.07	3.07	Σ E	0.20	0.30	Σ PA	0.16	Σ MK	0.03
Σ P	1.23	1.82	Σ EK	0.15	0.22	Σ A	0.12	Σ E	0.07
Σ PA	1.11	1.65	Σ B	0.18	0.26	Σ AC	0.10	Σ EK	0.07
Σ C	0.96	1.42	Σ P	0.11	0.17	Σ E	0.09	Σ C	0.02
Σ B	0.74	1.10	Σ PA	0.09	0.13	Σ B	0.09	Σ P	0.02
total	41.6	61.7	total	8.8	13.1	total	5.4	total	1.8
other ¹⁾	15.0	22.2	other ¹⁾	2.1	3.1	other ¹⁾	0.9	other ¹⁾	0.5
Sum	56.6	83.8	Sum	10.9	16.2	Sum	6.3	Sum	2.3

Sum Number of Incidents	67.5	100.0
-------------------------	------	-------

Sum Unavailability	8.6
--------------------	-----

¹⁾ no KKS function key

C. Analysis of unplanned Unavailability 2001-2010

1. Causers all areas

(KKS-Function key F1, F2, F3 for F1: A to Z)

1.1 Fossil fired Units

Unavailability incidents per block and year					
not postponable			postponable		
KKS	Count	%	KKS	Count	%
Σ H	17.43	37.10	Σ H	6.24	13.27
Σ HF	6.62	14.09	Σ HA	3.40	7.23
HFC	4.64	9.88	HAD	0.32	0.68
HFB	1.36	2.89	HAH	0.10	0.21
Σ HA	4.94	10.51	HAJ	0.06	0.14
HAD	1.68	3.57	Σ HF	1.76	3.74
HAH	0.82	1.75	HFC	1.58	3.36
HAI	0.42	0.90	Σ HD	0.25	0.53
Σ HD	0.97	2.07	HDA	0.19	0.40
HDA	0.74	1.57	Σ HT	0.22	0.47
Σ HN	0.78	1.67	HTB	0.07	0.16
HNC	0.53	1.13	Σ HN	0.15	0.31
Σ HL	0.74	1.57	HNC	0.08	0.16
Σ HH	0.57	1.21	Σ HH	0.12	0.26
Σ HB	0.41	0.87	HHB	0.08	0.17
Σ L	3.38	7.20	Σ HL	0.10	0.22
Σ LA	1.92	4.08	Σ L	0.57	1.22
LAC	0.79	1.68	Σ LA	0.31	0.66
Σ LB	1.12	2.39	LAC	0.11	0.23
Σ M	2.81	5.98	LAE	0.06	0.12
Σ MA	2.01	4.28	Σ LB	0.19	0.40
Σ MK	0.50	1.07	Σ LC	0.06	0.12
Σ E	1.08	2.29	Σ M	0.50	1.07
Σ P	1.04	2.21	Σ MA	0.32	0.68
Σ PA	0.97	2.05	MAG	0.07	0.16
Σ A	0.69	1.47	Σ MK	0.13	0.28
Σ AC	0.56	1.19	MKC	0.05	0.11
ACE	0.55	1.16	Σ C	0.21	0.46
Σ C	0.68	1.44	Σ E	0.09	0.18
Σ B	0.50	1.06	Σ P	0.06	0.14
total	27.9	59.5	total	7.8	16.6
other ¹⁾	10.9	23.2	other ¹⁾	0.3	0.7
Sum	38.8	82.7	Sum	8.1	17.3

Energy unavailability			
not postponable		postponable	
KKS	%	KKS	%
Σ H	3.91	Σ H	0.87
Σ HA	2.50	Σ HA	0.43
HAD	0.92	HAD	0.20
HAH	0.54	HAH	0.05
HAI	0.27	HAI	0.05
Σ HN	0.20	Σ HT	0.05
HNC	0.10	HTB	0.02
Σ HF	0.17	Σ HL	0.05
HFC	0.10	HLD	0.03
Σ HD	0.12	Σ HF	0.04
Σ HL	0.11	HFC	0.03
Σ HH	0.09	Σ HD	0.04
Σ M	1.31	HDE	0.02
Σ MA	0.77	Σ HN	0.04
MAC	0.18	HNC	0.02
MAA	0.11	Σ HH	0.04
MAD	0.10	HHB	0.03
Σ MK	0.47	Σ M	0.21
MKA	0.20	Σ MA	0.12
Σ L	0.57	MAA	0.03
Σ LB	0.26	MAG	0.02
Σ LA	0.25	Σ MK	0.07
LAC	0.13	MKA	0.03
Σ B	0.25	Σ L	0.17
Σ BA	0.16	Σ LB	0.08
BAT	0.15	LBA	0.02
Σ P	0.15	Σ LA	0.08
Σ PA	0.12	LAB	0.02
Σ E	0.14	LAC	0.02
Σ EC	0.09	Σ E	0.02
total	6.5	total	1.3
other ¹⁾	0.6	other ¹⁾	0.1
Sum	7.1	Sum	1.4

Sum Number of Incidents	47.0	100.0
-------------------------	------	-------

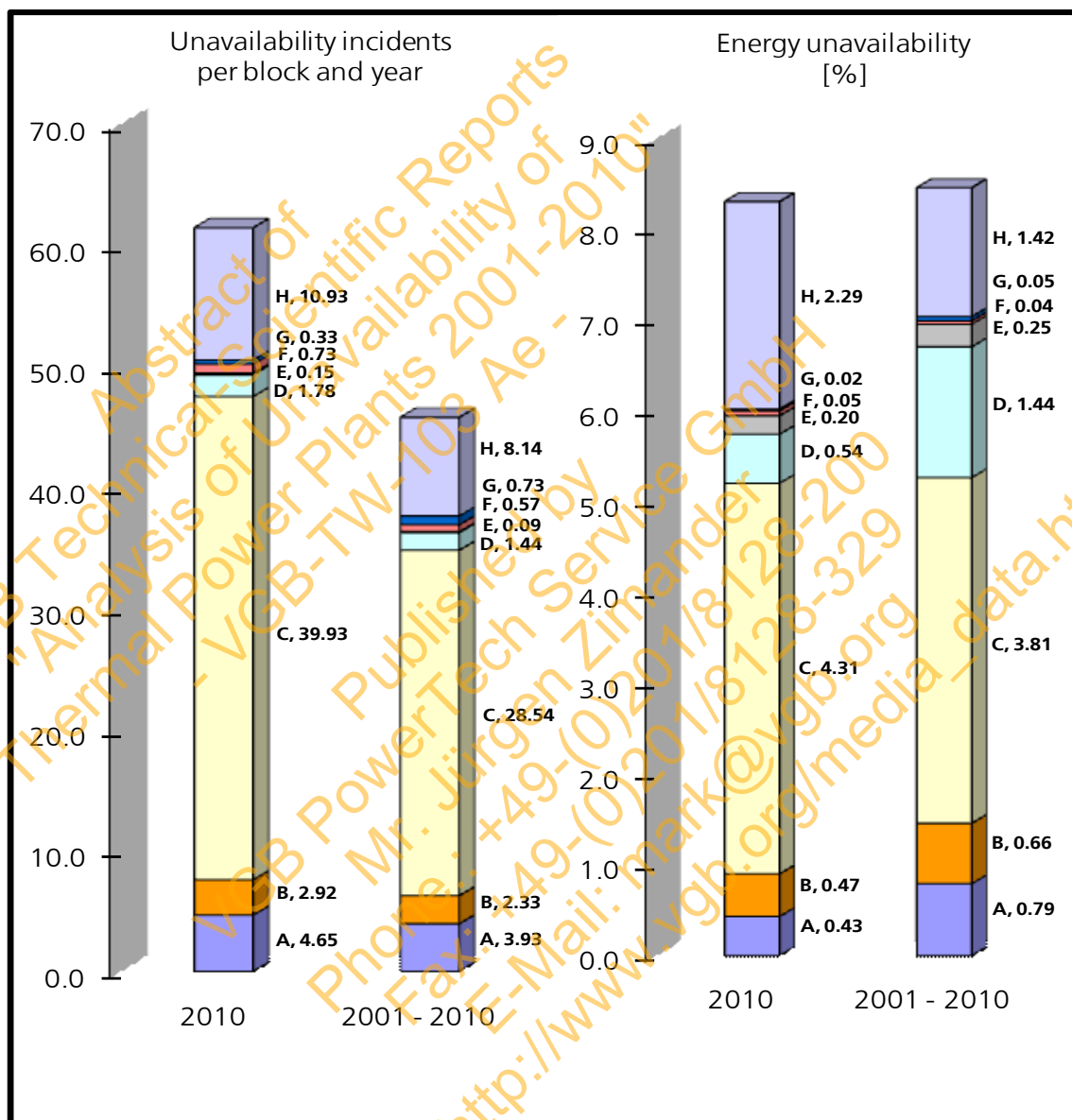
Sum Unavailability	8.5
--------------------	-----

¹⁾ no KKS function key

C. Analysis of unplanned Unavailability 2001-2010

5. Time Frame

5.1 Fossil fired Units



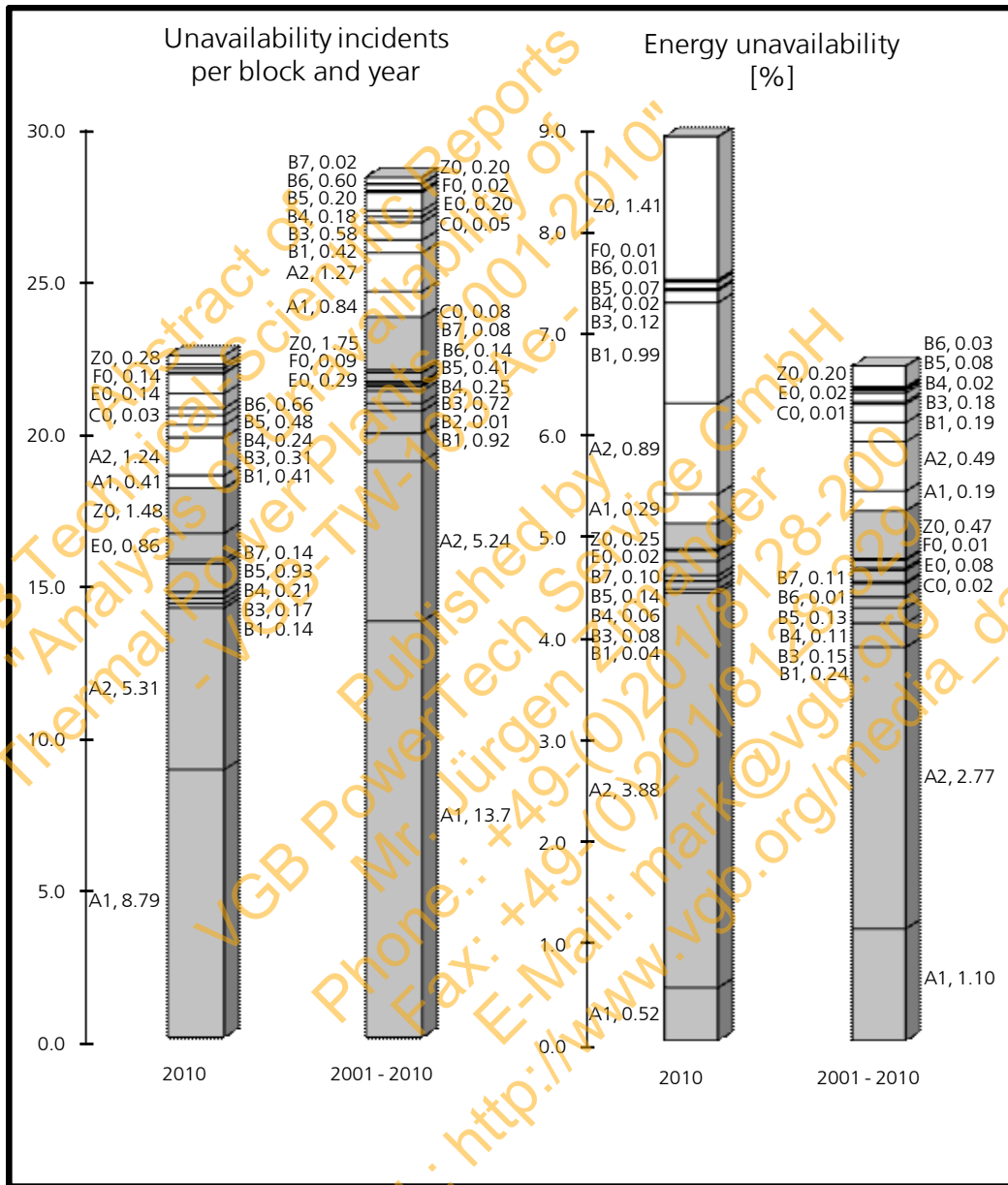
time-frame of unavailability (EMS 4/1)

- A automatic load-rejection/fast shutdown n
- B manual load-rejection/fast shutdown n
- C controlled shutdown n within 12 hours
- D start-up or recommissioning not possible (unless item E, K, L). Due to technical failure start-up-procedure cannot be induced.
- E Exceeding planned incident-time according to item J or K by unplanned measures (damage, failure,...)
- F start-up-time extension. Induced start-up-procedure cannot be brought to grid-hook-up within specified time.
- G start-up prolongation. after grid-hook-up power enhancement as specified in start-up-procedure/instruction-manual is not possible
- H postponable more than 12 hours

C. Analysis of unplanned Unavailability 2001-2010

6. Type of Incident

6.3 Combined Cycle Units



Types of Incidents of Unplanned Unavailability (EMS 1)

A1	failure without damage	B6	cleaning
A2	damage	B7	revision
B1	check/condition check	B8	refuelling
B2	lubrication	C0	reconstruction/refurbishment
B3	maintenance	E0	tests/functional tests
B4	inspection	F0	official test/measure
B5	preventive maintenance	Z0	other incidents

postponable
 not postponable

} Types of incidents with zero values are unlisted

V. References

1. VGB Power Plant Information System **KISSY**,
'Availability of Thermal Power Plants 2001-2010',
Report September 2011.
2. VGB Guideline '**Fundamentals and systematics of availability determination for Thermal Power Plants**', (VGB-RV 808), 7th Edition 2008.
This edition was published as part of the series
„Begriffe der Versorgungswirtschaft“, Part B, Booklet 3.
VGB PowerTech Service GmbH, Essen.

Note:

The below mentioned guidelines were revised and taken over in the above VGB guideline:

- I. VGB Guideline 'Availability of Thermal Power Plants – Fundamentals and Determination –', (VGB-RV 808), 6th Edition 1999.
This edition was published as part of the series
'Begriffe der Versorgungswirtschaft', Part B, Booklet 3.
VGB PowerTech Service GmbH, Essen and VWEW-Verlag, Frankfurt (Main).
- II. VGB Guideline 'Analysis of Unavailability of Thermal Power Plants'
(VGB-R 140e), 2nd Edition 1999,
VGB PowerTech Service GmbH, Essen.
- III. VGB Guideline EMS event-criterion-key-system
(VGB-B 109), 1st Edition 2003,
VGB PowerTech Service GmbH, Essen.