

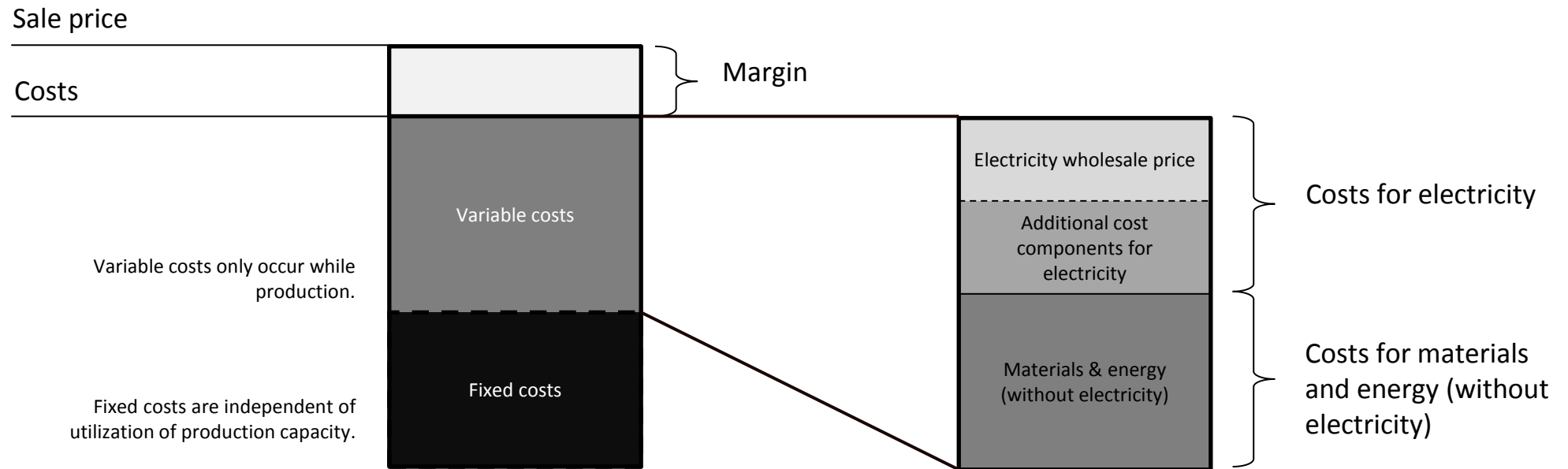
The Merit Order of Demand Response in Industry

ENERDAY –

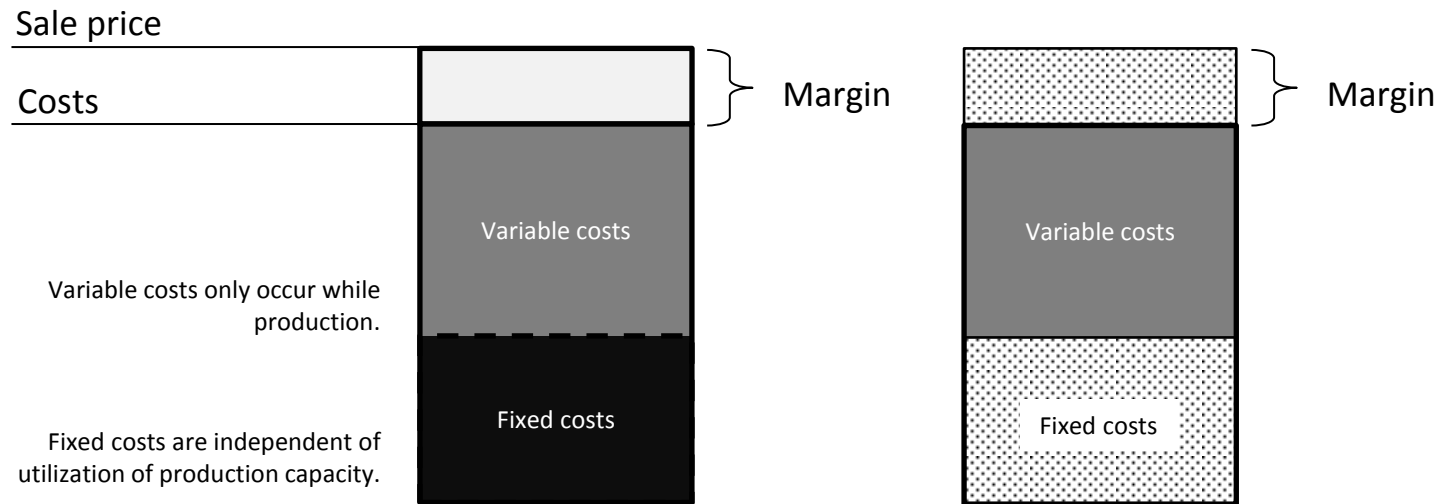
9th Conference on Energy Economics and Technology
2014-04-11, Dresden


Anna Gruber, Franziska Biedermann, Serafin von Roon

Methodology – Structure of Costs and Earnings in the Manufacturing Industry

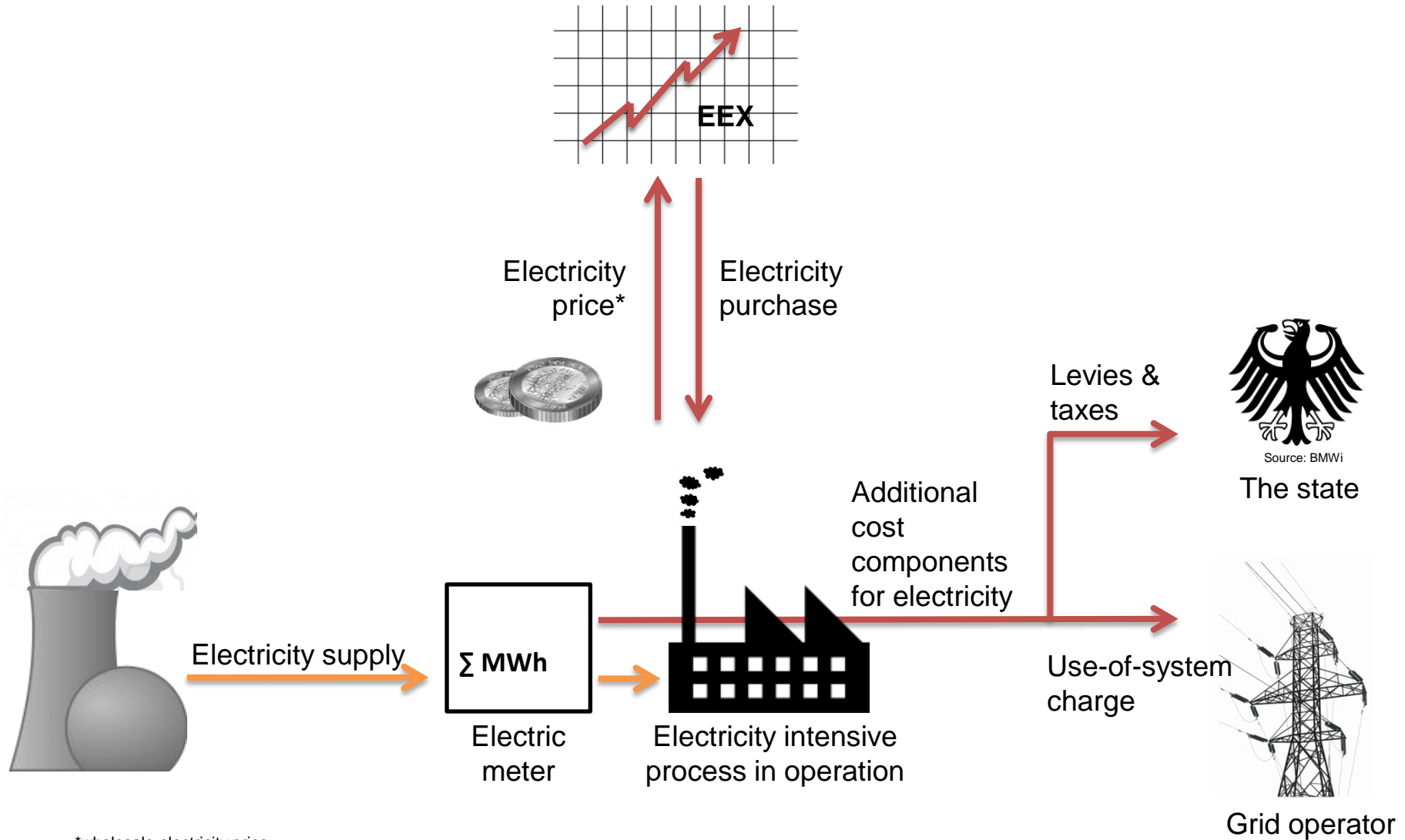


Methodology – Structure of Costs and Earnings and Profit Contribution



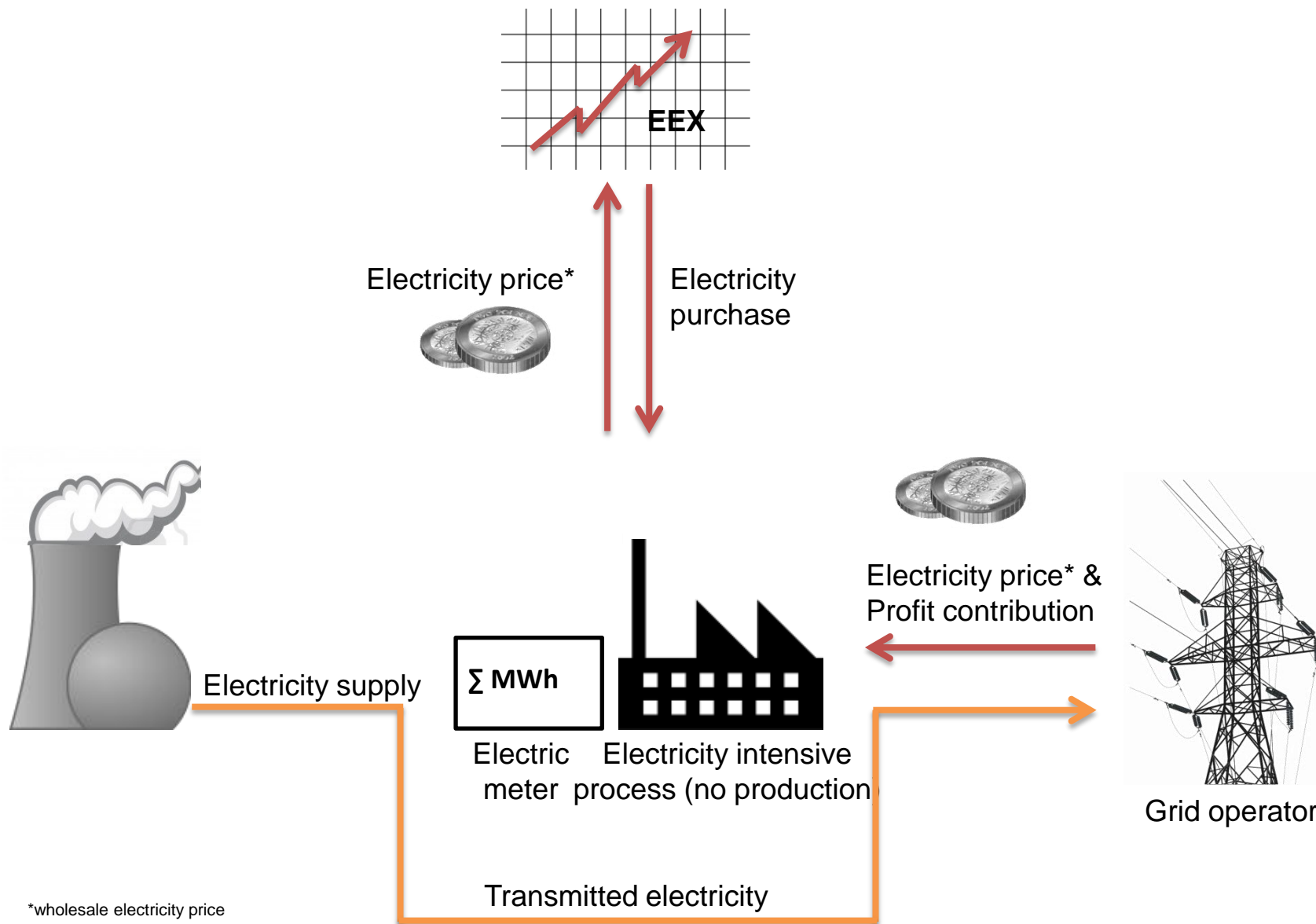
 Profit contribution = sale price – variable costs
= margin + fixed costs

Electricity and Cost Flow in Case of Production



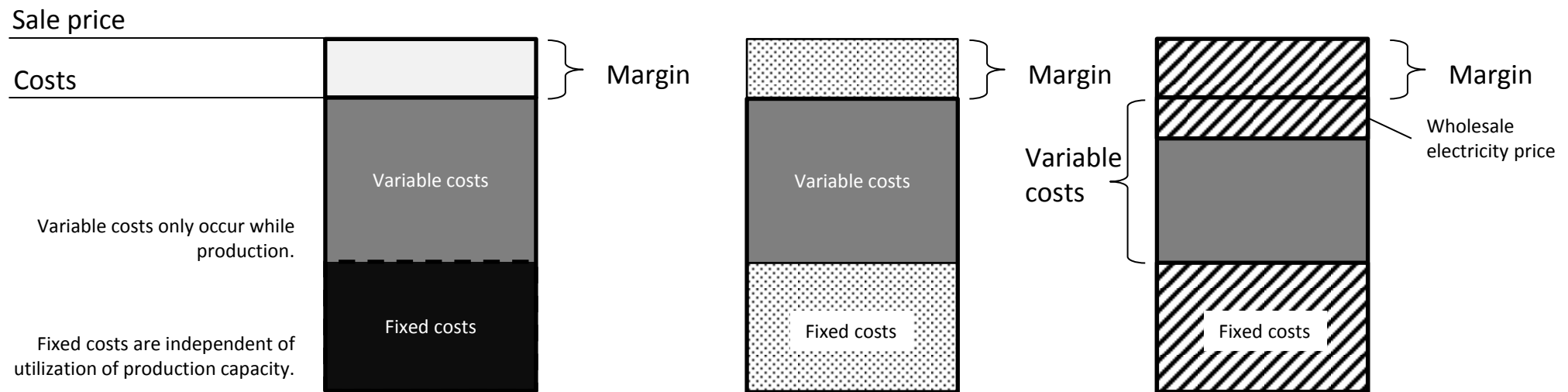
*wholesale electricity price


Electricity and Cost Flow in Case of Demand Response Activation




*wholesale electricity price

Methodology – Structure of Costs and Earnings and Opportunity Costs



 Profit contribution = sale price – variable costs
= margin + fixed costs

 Opportunity costs = profit contribution + wholesale electricity price
= sale price – variable costs + wholesale electricity price

Quantification of the Opportunity Costs

$$OC = \frac{(1 + r) - vc_{ma,e} - vc_{el} * \left(\frac{(VC_{el,eex} + VC_{el,a}) - VC_{el,eex}}{(VC_{el,eex} + VC_{el,a})} \right)}{\frac{vc_{el}}{(VC_{el,eex} + VC_{el,a})}}$$

- OC – opportunity costs [€/MWh]
- VC – variable costs [€/MWh]
- r – percentage of margin [%]
- vc – share of costs [%]
- ma – materials
- e – energy (without electricity)
- el – electricity
- eex – wholesale electricity market
- a – additional cost components for electricity

Opportunity Costs Matrix

		electricity price for industrial clients [€/MWh]							
		155	129	103	77	51	51	51	51
VC _{ma,e}		VC _{el}							
		2.5 %	5.0 %	7.5 %	10.0 %	12.5 %	15.0 %	17.5 %	20.0 %
2.5 %	7175	2948	1556	873	473	394	336	294	
5.0 %	7020	2883	1521	854	463	385	329	287	
7.5 %	6865	2819	1487	834	453	377	322	281	
10.0 %	6710	2754	1453	815	443	368	315	275	
12.5 %	6555	2690	1418	796	433	360	308	269	
15.0 %	6400	2625	1384	777	422	352	301	262	
17.5 %	6245	2561	1350	757	412	344	294	256	
20.0 %	6090	2496	1315	738	402	336	287	249	
22.5 %	5935	2432	1281	719	392	328	280	243	
25.0 %	5780	2367	1247	700	382	320	274	236	
27.5 %	5625	2303	1212	680	371	312	268	230	
30.0 %	5470	2238	1178	661	361	304	262	223	
32.5 %	5315	2174	1144	642	351	296	256	217	
35.0 %	5160	2109	1110	623	341	288	250	210	
37.5 %	5005	2045	1075	603	331	280	244	204	
40.0 %	4850	1980	1041	584	320	272	238	198	
42.5 %	4695	1916	1006	565	310	264	232	191	
45.0 %	4540	1851	972	546	300	256	226	185	
47.5 %	4385	1787	938	526	290	248	220	178	
50.0 %	4230	1722	903	507	280	240	214	172	
52.5 %	4075	1658	869	488	269	232	208	165	
55.0 %	3920	1593	835	469	259	224	202	159	
57.5 %	3765	1529	800	449	249	216	196	152	
60.0 %	3610	1464	766	430	239	208	190	146	
62.5 %	3455	1400	732	411	229	200	184	140	
65.0 %	3300	1335	697	392	218	192	178	133	
67.5 %	3145	1271	663	372	208	184	172	127	
70.0 %	2990	1206	629	353	198	176	166	120	
72.5 %	2835	1142	594	334	188	168	160	114	
75.0 %	2680	1077	560	315	178	160	154	107	

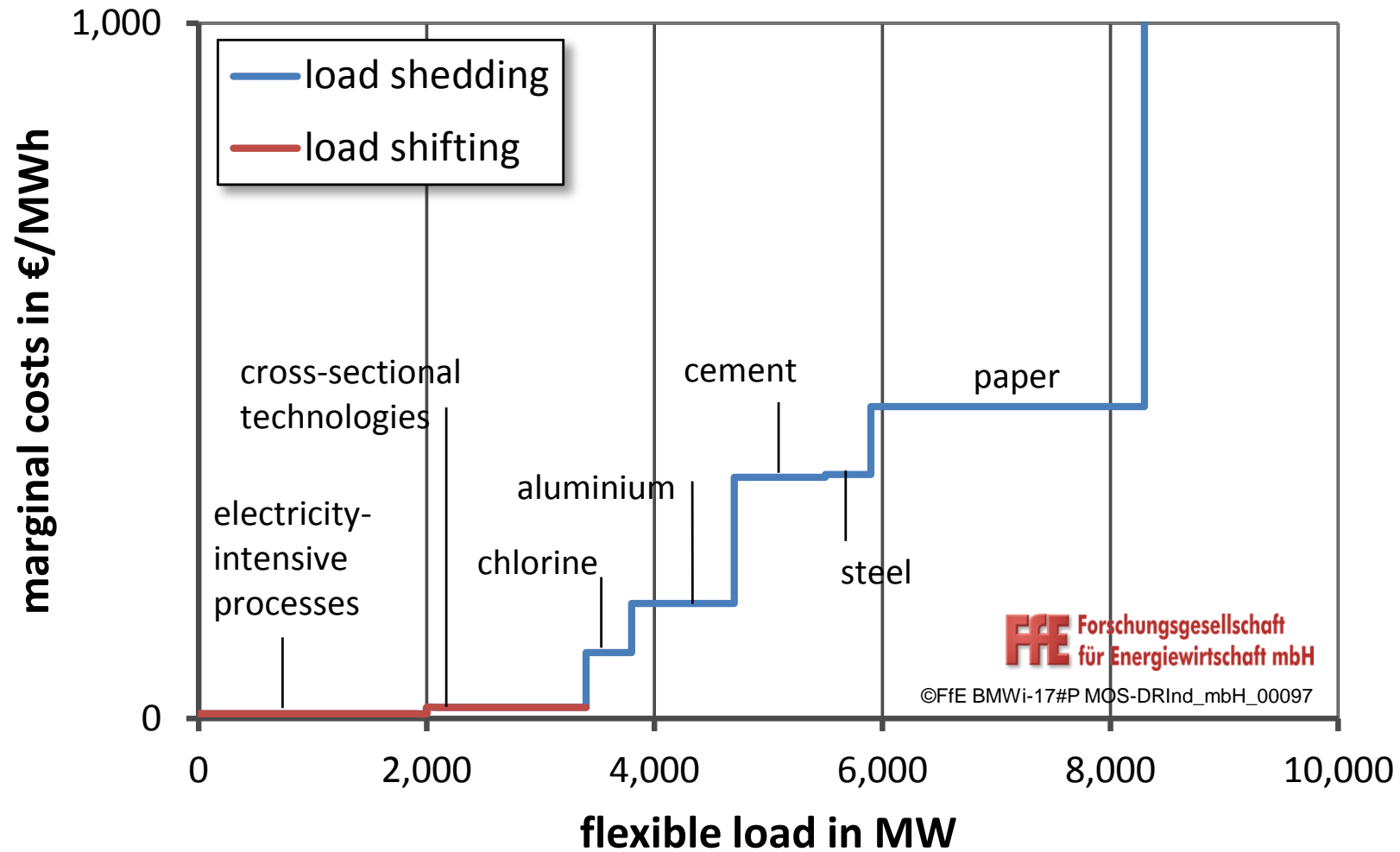


Opportunity Costs Matrix

		electricity price for industrial clients [€/MWh]																														
		155	129	103	77	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51			
		vc _{el}																														
		2.5%	5.0%	7.5%	10.0%	12.5%	15.0%	17.5%	20.0%	22.5%	25.0%	27.5%	30.0%	32.5%	35.0%	37.5%	40.0%	42.5%	45.0%	47.5%	50.0%	52.5%	55.0%	57.5%	60.0%	62.5%	65.0%	67.5%	70.0%	72.5%	75.0%	
VC _{ma,e}	2.5%	7175	2948	1556	873	473	394	336	294	260	234	212	194	178	165	154	144	135	127	120	114	108	103	98	94	90	86	83	80	77	74	
	5.0%	7020	2883	1521	854	463	385	329	287	255	229	207	190	174	162	150	141	132	124	117	111	106	101	96	92	88	84	81	78	75	72	
	7.5%	6865	2819	1487	834	453	377	322	281	249	224	203	185	171	158	147	137	129	122	115	109	103	98	94	90	86	82	79	76	73	71	
	10.0%	6710	2754	1453	815	443	368	315	275	243	218	198	181	167	154	144	134	126	119	112	106	101	96	92	88	84	80	77	74	71	69	
	12.5%	6555	2690	1418	796	433	360	307	268	238	213	193	177	163	151	140	131	123	116	109	104	98	94	89	85	82	78	75	72	70	67	
	15.0%	6400	2625	1384	777	423	351	300	262	232	208	189	173	159	147	137	128	120	113	107	101	96	91	87	83	80	76	73	71	68	65	
	17.5%	6245	2561	1350	757	412	343	293	255	226	203	184	168	155	143	133	125	117	110	104	99	94	89	85	81	78	74	71	69	66	64	
	20.0%	6090	2496	1315	738	402	334	285	249	221	198	179	164	151	140	130	122	114	107	101	96	91	87	83	79	76	72	70	67	64	62	
	22.5%	5935	2432	1281	719	392	326	278	243	215	193	175	160	147	136	127	118	111	105	99	94	89	84	80	77	74	71	68	65	63	60	
	25.0%	5780	2367	1247	700	382	317	271	236	209	188	170	156	143	132	123	115	108	102	96	91	86	82	78	75	72	69	66	63	61	59	
	27.5%	5625	2303	1212	680	372	309	264	230	204	183	166	151	139	129	120	112	105	99	93	88	84	80	76	73	69	67	64	61	59		
	30.0%	5470	2238	1178	661	361	300	256	224	198	178	161	147	135	125	116	109	102	96	91	86	81	77	74	71	67	65	62	60			
	32.5%	5315	2174	1144	642	351	292	249	217	192	173	156	143	131	122	113	106	99	93	88	83	79	75	72	68	65	63	60				
	35.0%	5160	2109	1109	623	341	283	242	211	187	167	152	139	127	118	110	102	96	90	85	81	77	73	69	66	63	61					
	37.5%	5005	2045	1075	603	331	275	234	204	181	162	147	134	123	114	106	99	93	88	83	78	74	71	67	64	61						
	40.0%	4850	1980	1041	584	320	266	227	198	175	157	142	130	120	111	103	96	90	85	80	76	72	68	65	62							
	42.5%	4695	1916	1006	565	310	258	220	192	170	152	138	126	116	107	99	93	87	82	77	73	69	66	63								
	45.0%	4540	1851	972	546	300	249	213	185	164	147	133	122	112	103	96	90	84	79	75	71	67	64									
	47.5%	4385	1787	938	526	290	241	205	179	158	142	128	117	108	100	93	86	81	76	72	68	64										
	50.0%	4230	1722	903	507	280	232	198	173	153	137	124	113	104	96	89	83	78	73	69	65											
52.5%	4075	1658	869	488	269	224	191	166	147	132	119	109	100	92	86	80	75	71	66													
55.0%	3920	1593	835	469	259	215	183	160	141	127	115	105	96	89	82	77	72	68														
57.5%	3765	1529	800	449	249	207	176	153	136	122	110	100	92	85	79	74	69															
60.0%	3610	1464	766	430	239	198	169	147	130	116	105	96	88	81	76	71																
62.5%	3455	1400	732	411	229	190	162	141	124	111	101	92	84	78	72																	
65.0%	3300	1335	697	392	218	181	154	134	119	106	96	88	80	74																		
67.5%	3145	1271	663	372	208	173	147	128	113	101	91	83	76																			
70.0%	2990	1206	629	353	198	164	140	122	107	96	87	79																				
72.5%	2835	1142	594	334	188	156	132	115	102	91	82																					
75.0%	2680	1077	560	315	178	147	125	109	96	86																						

ordinance for interruptible loads (AbLaV)

Merit Order of Demand Response in Industry



Thank you for your attention and the support of



DAIMLER

Gefördert durch:



Bundesministerium
für Wirtschaft
und Technologie



Energie, die bewegt.



aufgrund eines Beschlusses
des Deutschen Bundestages



Verbund

Anna Gruber: agruber@ffe.de / +49-89-158-121-61
Forschungsgesellschaft für Energiewirtschaft mbH
Am Blütenanger 71
80995 München

