

Thermal Units Data

The thermal units data, giving the minimum and maximum power, ramp up/down values, start-up and shut-down ramp rate values, minimum up/down time, fixed and shut-down costs are shown in Table 1.

Table 1. Thermal units' characteristics.

Unit	p_i^{\min} (MW)	p_i^{\max} (MW)	RU_i (MW)	RD_i (MW)	SU_i (MW)	SD_i (MW)	UT_i (h)	DT_i (h)	A_i (Eur/h)	C_i (Eur/h)
U1	45	85	35	35	60	70	8	3	2450	100
U2	70	125	45	40	100	95	5	4	2900	170
U3	110	160	60	50	125	140	8	4	3150	215
U4	60	125	55	55	90	80	5	3	3060	120
U5	90	170	40	60	100	100	6	3	2995	155
U6	90	170	40	60	100	100	6	3	2995	155
U7	80	145	35	40	90	105	9	6	3225	120
U8	145	215	45	70	160	170	6	4	3810	110
U9	200	380	60	50	230	250	10	6	4235	160
U10	220	330	70	60	230	245	10	6	4490	135

The variable costs of the thermal units have been modeled through piecewise linear approximations with three segments, as shown in Table 2.

Table 2. Piecewise linear approximations of the variable cost and emission functions.

Unit	T_i^1 (MW)	T_i^2 (MW)	F_i^1 (Eur/MWh)	F_i^2 (Eur/MWh)	F_i^3 (Eur/MWh)	Ae_i (kg/h)	Fe_i^1 (kg/MWh)	Fe_i^2 (kg/MWh)	Fe_i^3 (kg/MWh)
U1	55	75	36.78	34.26	36.78	166	5.02	5.85	6.68
U2	100	115	33.22	34.81	35.61	173	3.31	3.78	4.26
U3	125	145	41.05	40.13	42.01	317	4.20	4.59	4.99
U4	90	115	43.98	39.77	42.12	95	1.80	2.10	2.40
U5	125	150	38.43	32.66	36.55	271	4.50	5.30	6.10
U6	125	150	38.43	32.66	36.55	271	4.50	5.30	6.10
U7	100	125	33.44	31.08	32.26	209	3.54	4.06	4.58
U8	160	195	30.02	34.83	34.83	1025	12.44	13.98	15.52
U9	250	330	29.71	28.63	28.12	1106	10.09	12.25	14.41
U10	265	290	28.04	29.76	31.25	1902	16.22	18.42	20.62

The start-up costs are modeled through stairwise approximations with ten intervals, as shown in Table 3.

Table 3. Stairwise approximations of the start-up costs (Eur/h).

Unit capacity (MW)	K_i^1	K_i^2	K_i^3	K_i^4	K_i^5	K_i^6	K_i^7	K_i^8	K_i^9	K_i^{10}
< 125	654	1347	1896	2254	2533	2684	2733	2767	2813	2853
≥ 125 and ≤ 215	1046	2155	3034	3606	4053	4294	4373	4427	4501	4565
> 215	2224	4580	6446	7664	8612	9126	9292	9408	9564	9700