**SUPPLEMENTARY MATERIAL**

**Table SM-1.** Electricity spot market prices (in €/kWh) seen by the retailers.

|  |  |
| --- | --- |
| Time intervals  [earliest interval, latest interval] | Prices  (€/kWh) |
| [1,8] | 0.050 |
| [9,16] | 0.035 |
| [17,24] | 0.045 |
| [25,32] | 0.065 |
| [33,40] | 0.075 |
| [41,48] | 0.080 |
| [49,56] | 0.090 |
| [57,64] | 0.100 |
| [65,72] | 0.110 |
| [73,80] | 0.085 |
| [81,88] | 0.080 |
| [89,96] | 0.100 |

P1, P2, P3, ...

**Table SM-2.** Minimum (), maximum () and average (*xAVG*) of the electricity prices (in €/kWh) that can be charged to the consumers by the retailer, in each sub-period .

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | P1  [1,28] | P2  [29,44] | P3  [45,56] | P4  [57,72] | P5  [73,84] | P6  [85,96] | *xAVG* |
| Prices  (€/kWh) |  | 0.0440 | 0.0848 | 0.1080 | 0.0804 | 0.1540 | 0.0920 | 0.1614 |
|  | 0.0996 | 0.2780 | 0.2836 | 0.2492 | 0.3240 | 0.1620 |

remodeled as

number\_of\_subperiods start end minimum maximum

1 1 28 0.0440 0.0996

2 29 44 0.0848 0.2780

3 45 56 0.1080 0.2836

4 57 72 0.0804 0.2492

5 73 84 0.1540 0.3240

6 85 96 0.0920 0.1620

Upper level, è del retailer

**Table SM-3.** Power level prices (in €) charged to the consumers by the retailer.

|  |  |  |
| --- | --- | --- |
|  | Prices  (€/day) | Maximum Power  (W) |
| 1 | 0.2047 | 2300 |
| 2 | 0.2206 | 3450 |
| 3 | 0.2834 | 4600 |
| 4 | 0.3492 | 5750 |
| 5 | 0.4198 | 6900 |
| 6 | 0.6280 | 10350 |
| 7 | 0.8302 | 13800 |
| 8 | 1.0324 | 17250 |
| 9 | 1.2351 | 20700 |

**Table SM-4.** Power requested to the grid (in W) in each unit of time (expressed in intervals of time [initial time, final time]) by (non-controllable) base load.

|  |  |
| --- | --- |
| Time intervals  [earliest interval, latest interval] | Power  (W) |
| [1,32] | 165 |
| [33,34] | 700 |
| [35,36] | 170 |
| [37,44] | 85 |
| [45,54] | 160 |
| [55,64] | 130 |
| [65,80] | 160 |
| [81,81] | 500 |
| [82,83] | 1600 |
| [84,85] | 750 |
| [86,86] | 250 |
| [87,87] | 450 |
| [88,90] | 280 |
| [91,91] | 1080 |
| [92,96] | 250 |

si lower level

**Table SM-5.** Comfort time slots, and for and , allowed for the operation of each controllable appliance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Shiftable Loads | | | Interruptible Loads | |
| DW | LM | CD | EV | EWH |
| [1,32] | [28,58] | [76,96] | [1,48] | [26,34] |

Lower level shiftable

constraint (c5)

**Table SM-6.** Operation cycles of the controllable appliances.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Appliance | Power required by the appliance at each stage of its operation cycle  (W) | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8-36 |
| Shiftable Loads | DW | 1750 | 1250 | 120 | 1600 | 640 | 220 |  |  |
| LM | 1840 | 980 | 160 | 220 | 300 | 340 | 120 |  |
| CD | 1660 | 1720 | 300 | 220 |  |  |  |  |
| Interruptible Loads | EV | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 | 2300 |
| EWH | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |  |  |

shiftable loads f(j,r)

**Table SM-7.** Parameters of the thermostatic load

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
| 24ºC | 18ºC | 20ºC | 12ºC | 1400W | 0 |

**Table SM-8.** Outdoor temperatures for a period of 24h (*T*=96).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *t* |  | *t* |  | *t* |  |
| 0 | 9.45 |  |  |  |  |
| 1 | 9.45 | 33 | 8.96 | 65 | 12.92 |
| 2 | 9.40 | 34 | 8.92 | 66 | 12.79 |
| 3 | 9.35 | 35 | 8.92 | 67 | 12.64 |
| 4 | 9.30 | 36 | 9.00 | 68 | 12.50 |
| 5 | 9.25 | 37 | 9.19 | 69 | 12.40 |
| 6 | 9.20 | 38 | 9.43 | 70 | 12.35 |
| 7 | 9.15 | 39 | 9.66 | 71 | 12.32 |
| 8 | 9.10 | 40 | 9.80 | 72 | 12.30 |
| 9 | 9.05 | 41 | 9.81 | 73 | 12.29 |
| 10 | 9.01 | 42 | 9.75 | 74 | 12.27 |
| 11 | 8.96 | 43 | 9.72 | 75 | 12.25 |
| 12 | 8.90 | 44 | 9.80 | 76 | 12.20 |
| 13 | 8.83 | 45 | 10.06 | 77 | 12.13 |
| 14 | 8.78 | 46 | 10.48 | 78 | 12.02 |
| 15 | 8.76 | 47 | 10.97 | 79 | 11.88 |
| 16 | 8.80 | 48 | 11.50 | 80 | 11.70 |
| 17 | 8.91 | 49 | 12.00 | 81 | 11.48 |
| 18 | 9.06 | 50 | 12.43 | 82 | 11.25 |
| 19 | 9.20 | 51 | 12.78 | 83 | 11.05 |
| 20 | 9.30 | 52 | 13.00 | 84 | 10.90 |
| 21 | 9.32 | 53 | 13.09 | 85 | 10.83 |
| 22 | 9.28 | 54 | 13.07 | 86 | 10.85 |
| 23 | 9.19 | 55 | 12.99 | 87 | 10.94 |
| 24 | 9.10 | 56 | 12.90 | 88 | 11.10 |
| 25 | 9.02 | 57 | 12.82 | 89 | 11.31 |
| 26 | 8.95 | 58 | 12.78 | 90 | 11.52 |
| 27 | 8.91 | 59 | 12.77 | 91 | 11.67 |
| 28 | 8.90 | 60 | 12.80 | 92 | 11.70 |
| 29 | 8.92 | 61 | 12.87 | 93 | 11.56 |
| 30 | 8.96 | 62 | 12.95 | 94 | 11.18 |
| 31 | 9.00 | 63 | 13.00 | 95 | 10.52 |
| 32 | 9.00 | 64 | 13.00 | 96 | 9.50 |

**Table SM-9.** Electricity prices (in €/kWh) for the 10 solutions.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Solutions |  |  | Prices  (€/kWh) |  |  |  |
| P1  [1,28] | P2  [29,44] | P3  [45,56] | P4  [57,72] | P5  [73,84] | P6  [85,96] |
| 1 | 0.0996 | 0.2780 | 0.2836 | 0.0804 | 0.1540 | 0.1426 |
| 2 | 0.0996 | 0.2756 | 0.2757 | 0.0817 | 0.1553 | 0.1465 |
| 3 | 0.0996 | 0.2780 | 0.2836 | 0.0804 | 0.1751 | 0.1186 |
| 4 | 0.0996 | 0.2780 | 0.2805 | 0.0887 | 0.1554 | 0.1324 |
| 5 | 0.0996 | 0.2780 | 0.2836 | 0.0837 | 0.1618 | 0.1308 |
| 6 | 0.0996 | 0.2780 | 0.2831 | 0.0804 | 0.1698 | 0.1279 |
| 7 | 0.0996 | 0.2775 | 0.2776 | 0.0808 | 0.1541 | 0.1484 |
| 8 | 0.0986 | 0.2768 | 0.2778 | 0.0804 | 0.1540 | 0.1509 |
| 9 | 0.0986 | 0.2680 | 0.2776 | 0.0813 | 0.1540 | 0.1615 |
| 10 | 0.0996 | 0.2739 | 0.2828 | 0.0817 | 0.1548 | 0.1438 |